DATA SYSTEMATIZATION IN THE NEO-ENEOLITHIC OF SOUTHEASTERN AND CENTRAL EUROPE:

Essays in honor of Sergej Ryzhov

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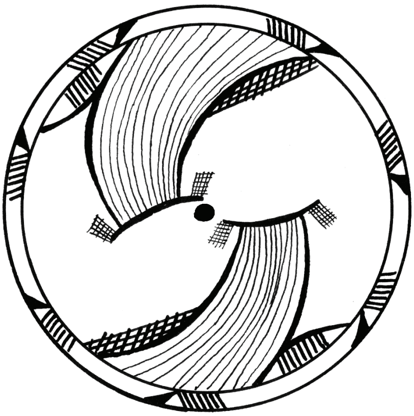

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This volume is dedicated to the 70th anniversary of the birth of Sergej Ryzhov, an eminent figure in the Ukrainian archaeological community whose body of work serves as an example to generations of scholars. Included are contributions that deal with archaeological data systematization, attempting to understand the available records and reconstructing complex socio-economic, migratory and cultural processes in the Neo-Eneolithic period of Southeastern and Central Europe.

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Збірку наукових праць присвячено 70-річчю видатного українського археолога Сергія Рижова, роботи якого стали взірцем для багатьох поколінь археологів. Збірка містить роботи із систематизації археологічних джерел і осмислення накопичених матеріалів, за якими стоять складні соціально-економічні, міграційні та культурні процеси неоліту–енеоліту Південно-Східної та Центральної Європи.

Рецензенти
Д. і. н., професор В. В. Отрощенко,
к. і. н. Д. П. Куштан

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ІНСТИТУТ АРХЕОЛОГІЇ
НАЦІОНАЛЬНОЇ АКАДЕМІЇ НАУК УКРАЇНИ

Для оформлення обкладинки використано матеріали площадки 40 у Тальянках (розкопки В. Круца, фото В. Шумової)

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НАЦІОНАЛЬНА АКАДЕМІЯ НАУК УКРАЇНИ
ІНСТИТУТ АРХЕОЛОГІЇ

СИСТЕМАТИЗАЦІЯ НЕОЛІТИЧНИХ І ЕНЕОЛІТИЧНИХ МАТЕРІАЛІВ ПІВДЕННО-СХІДНОЇ ТА ЦЕНТРАЛЬНОЇ ЄВРОПИ.

Збірка наукових праць на пошану Сергія Рижова

*За редакцією Олександра Дяченка,
Томаса К. Харпера,
Юрія Рассамакіна та
Івони Собковяк-Табаки*

КИЇВ–2021

CONTRIBUTORS

Sergiu Bodean
National Museum of Ethnography and Natural History
Chişinău, Republic of Moldova

John Chapman
Department of Archaeology, Durham University
Durham, United Kingdom

Dmitriy Chernovol
Institute of Archaeology, National Academy of Sciences of Ukraine
Kyiv, Ukraine

Valentin Dergachev
Institute of Cultural Heritage, Center for Archaeology,
Academy of Sciences of the Republic of Moldova
Chişinău, Republic of Moldova

Aleksandr Diachenko
Institute of Archaeology, National Academy of Sciences of Ukraine
Kyiv, Ukraine

Bisserka Gaydarska
Department of Archaeology, Durham University
Durham, United Kingdom

Thomas K. Harper
Department of Anthropology, Pennsylvania State University
State College, USA

Robert Hofmann
Christian Albrechts University at Kiel
Kiel, Germany

Sławomir Kadrow
Institute of Archaeology, Rzeszów University
Rzeszów, Poland

Viktor Kosakivskyi
Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University
Vinnytsia, Ukraine

Aleksander Kośko
Faculty of Archaeology, Adam Mickiewicz University
Poznań, Poland

Anna Krzywda
Independent Researcher

Jerzy J. Langer
Faculty of Chemistry, Adam Mickiewicz University
Poznań, Poland

Boris Magomedov
Institute of Archaeology, National Academy of Sciences of Ukraine
Kyiv, Ukraine

Ryszard Naglik
Archaeological Museum
Kraków, Poland

Eduard Ovchinnikov
Institute of Archaeology, National Academy of Sciences of Ukraine
Kyiv, Ukraine

Ivan Radomskyi
Institute of Archaeology, National Academy of Sciences of Ukraine
Kyiv, Ukraine

Yuri Rassamakin
Institute of Archaeology, National Academy of Sciences of Ukraine
Kyiv, Ukraine

Vitalii Rud
Institute of Archaeology, National Academy of Sciences of Ukraine
Kyiv, Ukraine

Sergej Ryzhov
Institute of Archaeology, National Academy of Sciences of Ukraine
Kyiv, Ukraine

Valentina Shumova
National University of “Kyiv-Mohyla Academy”
Kyiv, Ukraine

Ghenadie Sîrbu
Institute of Cultural Heritage, Center for Archaeology,
Academy of Sciences of the Republic of Moldova
Chişinău, Republic of Moldova

Iwona Sobkowiak-Tabaka
Faculty of Archaeology, Adam Mickiewicz University
Poznań, Poland

Marzena Szmyt
Faculty of Archaeology, Adam Mickiewicz University
Poznań, Poland

Stanislav Ţerna †
University “High Anthropological School”
Chişinău, Republic of Moldova

Andreea Vornicu-Ţerna
Botoşani County Museum
Botoşani, Romania

Piotr Włodarczak
Institute of Archaeology and Ethnology, Polish Academy of Sciences
Kraków, Poland

Dmitriy Zhelaha
Institute of Archaeology, National Academy of Sciences of Ukraine
Kyiv, Ukraine

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Частина 3. РЕЧІ, НАБОРИ ДАНИХ І ЩО ВОНИ ГОВОРЯТЬ НАМ

LATE NEOLITHIC CERAMIC PIGMENTS IN THE POLISH LOWLAND

Aleksander Kośko, Marzena Szmyt, Jerzy J. Langer

Keywords: *pottery-making, Funnel Beaker culture, Globular Amphora culture, Tripolye culture influences*

INTRODUCTION

This year witnesses the fortieth anniversary of the publication of the first, preliminary results of research into the use of pigments in pottery-making in Kujawy in the Late Neolithic. Pigments had been identified on materials discovered several years earlier, specifically in 1969 in Opatowice, site 12 (investigations by the Museum of Archaeology and Ethnography in Łodź; Grygiel 1979) and in 1969 and 1974 in Inowrocław-Mątwy, site 1 (investigations by the Kujawy Expedition of the Chair of Archaeology, Adam Mickiewicz University, Poznań; Kośko 1981). In both cases, pigments were identified on the pottery of the Funnel Beaker culture (FBC) coming from major settlement agglomerations: the first on the so-called Prokopiak's Mount in Opatowice, from a ritual feature known as a "pit with burnt wheat;" and the second in Inowrocław-Mątwy, from an island forming part of a ford in the Noteć Valley.

In 1980, the question of ceramic pigments was included in the program of research into the FBC Mątwy group. The program formed part of the study of the role of Southeastern European cultural patterns in the rise of Lowland FBC communities (Kośko 1981, 1988a, 1988b). This made for the quick introduction of the question of ceramic pigments into international academic debate. The debate focused primarily on the Pontic area, the study of which was spearheaded mainly by the staff of the Institute of Archaeology of the National Academy of Sciences of Ukraine, Kiev.

In 1982, on the concept of the FBC Mątwy group and its Tripolye topogenetic references, including – as a diagnostic argument – ceramic pigments, renowned Kiev experts on the Tripolye culture (TC) spoke during direct consultations with Aleksander Kośko. They were: Volodymyr Kruts, Mykhailo Videiko, Volodymyr G. Zbenovich and Sergey Ryzhov. This fact makes us dedicate this article to Dr. Sergey Ryzhov, as it draws on the memories of the intellectual cut and thrust at that time.

The other reason for writing this article has to do with major advances in the study of ceramic pigments used by Late Neolithic "megalithic cultures." These advances occurred after the year 2000, which is when the last published summary came out (Kośko et al. 2000). The advances were made in the following three key areas, inviting further studies:

- interdisciplinary study of a unique, in terms of archaeometry, FBC settlement assemblage from Opatowice 42 (Op42-B settlement phase; Kośko and Szmyt 2007b);
- prehistoric tar-making and the use of organic pigments viewed from the perspective of historical-comparative linguistics (Kowalski 2003, 2017);
- the bio-cultural background of the Late Neolithic settlement center on "Prokopiak's Mount" in Opatowice and, more broadly, in the Pagóry Radziejowskie microregion (Makohonienko et al. 2006; Makohonienko 2008; Żurkiewicz 2016).

CERAMIC PIGMENTS IN CURRENT RESEARCH PROGRAMS

During the 1980s and 1990s specialists charted the main directions of research into Late Neolithic pigments in Kujawy, covering: 1) documentation of their presence in the Baltic drainage basin; 2) commencement of their inter-regional comparative studies; and, finally and crucially, 3) their techno-archaeological analyses (more specifically physicochemical ones).

Areas and chronology of pigment application

There are three areas within different modes of pigment application distinguished in the drainage basins of the Vistula and Oder: the Upper Western Bug, Upper Vistula and Lowland (Kośko 1981: 116-117).

The first area, located in the physiographic borderland between the east and west of Europe, was the home of the FBC Bug sub-group (see Gurba 1967; cf. Rybicka 2017b). Relevant sources come from large FBC settlements at Gródek Nadbużny site 1, and Zimne site 1 (Gumiński 1989; Bronicki et al. 2003). Pottery types include both Tripolye imports (TC phase CII, dated to ca. 3500–2900 BC, following Diachenko and Harper 2016) and local "Beaker" adaptations (Jastrzębski 1985). Study of the origin and geographic distribution of these types has been carried fur-

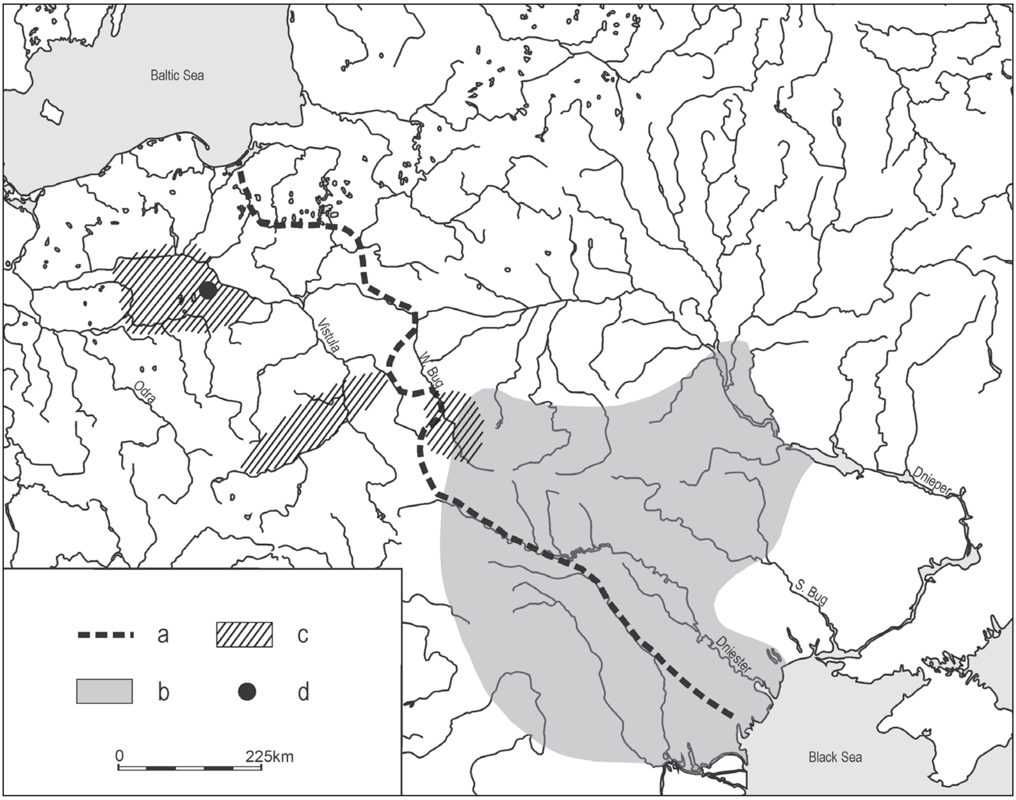

Fig. 1. The geographic distribution of regions of the Funnel Beaker culture influenced by the Tripolye culture in the drainages of the Vistula and Oder rivers. Key: a – Bug-Dniester eco-cultural borderline; b – range of the Tripolye culture; c – regions of the Funnel Beaker culture influenced by the Tripolye culture; d – Opatowice 42

ther since 2012 by the investigations into the FBC and TC borderland in western Ukraine conducted by the Institute of Archaeology, Rzeszów University (Rybicka 2015, 2017a, 2017b).

In the Upper Vistula area, only "Beaker" adaptations have been recorded. The oldest set of data comes from the large FBC settlement at Bronocice site 1 (Kruk and Milisauskas 1981, 1999). More recent observations from Bronocice show "ornaments borrowed from the TC circle," taking the form of irregular black painted bands, during phases BRIII, BRIV and BRV (ca. 3500–2900/2800 BC; Kruk and Milisauskas 2018). Perhaps continuity of this tradition may be suggested by the presence of ceramic pigments in the pottery-making of the local communities of the Corded Ware culture (CWC) ca. 2800–2400 BC (observations come from the sites at Smroków and Żerniki Górne; see Włodarczak 1998, 2006; Kośko et al. 2000).

The Polish Lowland is a region boasting a distinctive concentration of features in which ceramic pigments were identified (Pietrzak 2010, 2012). Relevant artifacts are found in abundance on the Kujawy Plateau, especially at Pagóry Radziejowskie. Diagnostic sites are located at Opatowice, a settlement complex situated on Prokopiak's Mount. Evidence for pigment application at Opatowice involves, in the vast majority of cases, pottery of the FBC (Kośko and Szmyt 1993, 2006, 2007a, 2007b, 2014, 2015a; Langer and Pietrzak 2006, 2007; Langer et al. 2006, 2007a, 2007b; Langer et al. 2014). Pigments were found on artifacts from the following FBC phases:

- IIIB-C, settlement phase Op33-A2 (3500–3400/3200 BC);
- IIIB-C/IIIC, settlement phase Op1-B/Op1-C1 (3500/3350–3150/3100 BC);
- IVB/VB, settlement phase Op42-B(3350–3100BC);
- IIIB-C/VA, settlement phase Op3-A1/Op3-B1 (3375–3025 BC);
- IIIB, settlement phase Op36-A (3475–3370 BC).

Additionally, at Opatowice 36, black organic pigments were identified on several Globular Amphora culture (GAC) sherds. These are assigned to settlement phase Op36-B and date to 2730–2510 BC (Szmyt 2015; Kośko and Szmyt 2015a).

Further evidence comes from FBC settlement sites recorded prior to the Opatowice excavation (i.e. before 1983; Kośko 1988a), proving the application of pigments to pottery from the following phases: IIIA (late portion, Jezuicka Struga site 17), IIIC (Inowrocław-Mątwy sites 1 and 5), IVB (Papros sites 6B and 6G) and IV–V (Bąkowo site 3).

Moreover, the use of ceramic pigments was also confirmed in pottery sets coming from rescue excavations at the end of the 20th century (Kośko 2000; Szmyt 2000, 2004; Langer and Pietrzak 2000, 2004b; Kośko and Przybył 2004). Pigments were identified on FBC pottery from phases IIIC (Piecki site 1) and IVA (Kuczkowo site 1 and Żegotki site 2), as well as on GAC pottery from phases IIb (Bożejewice site 22 and Kuczkowo site 1) and IIIa (Piecki site 8).

In summation, the evidence that has been gathered in Kujawy so far documents solely of ceramic pigments adaptation in local communities of the FBC and GAC. It comes from FBC sites from phases IIIA?/IIIB–V, dated to 3700?–2600 BC and GAC sites from phases IIb–IIIa, dated to 3200–2500/2250 BC (Kośko 1988a; Langer and Kośko 1999; Langer and Pietrzak 2000, 2004b; Kośko et al. 2000; for chronological context see Szmyt 2013).

From other parts of the Lowland, we know of only isolated cases of pigment application on FBC pottery. They come from Chełmno Land and Wielkopolska. In the first of these regions ceramic pigments have been identified at Brąchnówko site 1 – a settlement dated to phase IIIB-IIIC and Lisewo site 31 – a settlement dated to phase IIIB (Wawrzykowska 1981, 1991; Kośko 1988a). In central Wielkopolska there are two sites: Komorniki 42, a phase IIIB/IIIC-IIIC settlement (Kabaciński and

Sobkowiak-Tabaka 2004; Langer and Pietrzak 2004a) and Śrem 8, a Luboń phase settlement dated to the second half of the fourth millennium BC (Kośko 1988a; materials currently under research in the Archaeological Museum in Poznań). Among sites of the GAC in northern Wielkopolska, there is evidence for the use of ceramic pigments at Żuławka site 1 ca. 3500 BC (Langer and Rola 1997).

It is hard to assess the completeness of the recorded distribution of ceramic pigment use in the Lowland. On the one hand, taphonomic conditions in certain areas (especially covered with sandy soils) inhibit the preservation of pottery. On the other hand, there are large differences in knowledge about pigments among archaeologists conducting field research.

Scale of comparative studies

Ceramic pigments, specifically organic pigments, are present at Early Neolithic (sixth millennium BC) sites of the Eastern Linear Pottery and Bükk cultures south of Carpathians. However, according to the kind assessment of Professor Juraj Pavúk, the use of pigments in these cultural contexts was not continuous (see Langer and Kośko 1999; Kośko et al. 2006). The question of the very early transmission of the "Transcarpathian" practice of using organic pigments was raised by observations from Chełmno Land due to materials coming from the Linear Pottery culture settlement at Ryńsk site 42 (Kośko et al. 2006). For the time being, no further new evidence has been found there in support of such early pigment use.

Pigment use takes on a different character in the Eneolithic by becoming a diagnostic trait of that age, hence the popular term "Eneolithic painted ware." The earliest and best-developed (in terms of technology and composition) painted ware centers formed in the eastern Balkans during the early fifth millennium BC, within the milieu of the so-called Thracian Eneolithic (Todorova 1979). Beginning with the first half of the fifth millennium BC, their northeastern proliferation is believed to have been the Cucuteni-Tripolye cultural complex (CTCC; which includes the TC). Initially, however, pigment-covered pottery was absent from the oldest TC sites located in the forest-steppe on the middle Dniester and Southern Bug rivers (Tripolye A/Precucuteni III) (cf. "Precucuteni horizon;" Ursu 2016). The local tableware are described as being made from "pink-red clay with a temper of fine sand, smoothed, polished and well-fired" (Пассек 1949). Painted ware appears beginning with phase BI, i.e. from the middle of the fifth millennium BC ("pottery with multi-colored decoration;" Пассек 1949; cf. Маркевич 1981). Ornamentation covered entire vessel surfaces and was painted over top of a base coat of white pigment. Decorations usually took the form of sequences of spirals made with a red pigment and contoured in black. The distribution of painted ware covered the whole area of TC expansion in phases BII and CI, i. e. from the second half of the fifth millennium to the first half of the fourth millennium BC. It is worth noting that TC ceramic technologies survived the disintegration of the "protocivilization of the Thracian Eneolithic" in the late fifth and early fourth millennia BC, at the time of the "invasion of steppe cultures" (Kufel 2014; Govedarica 2016).

The practice of painting vessel surfaces underwent many modifications in the TC both in space and in time. For the application of ceramic pigments in the circle of megalithic cultures on the Polish Lowland, the years 3700/3500–2900 BC are crucial (see preceding section). This period corresponds to phases CI (its final part) and CII in the TC taxonomy. By and large, the array of colors and motifs diminished during this time.

According to the expert opinion given to us by Dr. Mikhailo Videiko, this general assessment may be made more specific in several aspects. Among phase CII groups/types (cf. Diachenko and Harper 2016) – apart from the Usatovo group/type, usually identified as a diagnostic taxon – painted ware is highly visible in such units as Horodiştea-Erbiceni, Gordineşti and Gorodsk (Дергачев 1980; Kruts and Ryzhov 2000). In the pottery-making of these units, two mineral pigments were used: black and red (Diachenko et al. 2019). Furthermore, in some regional groups/types (Sofievka, Trojaniv, Gorodsk), vessels were made where the entire surface was covered in a red pigment or engobe of the same color (Дергачев 1980). Recent specimens from the site of Vynnyky-Zhupan in the basin of the Upper Bug have surfaces painted with a red pigment (Verteletskyi 2019), as do materials from Kurgany-Dubova in the Horyn valley (Вертелецький 2016).

In the CTCC, local raw materials such as hematite, calcite, marl, magnetite and jacobsite were used to produce pigments (e.g. Constantinescu et al. 2007). The archaeometric analyses of pottery from settlements dated to the middle period of the TC (BI–BII, BII and BII–CI; Starkova and Zakościelna 2018; see Калинина и Старкова 2016) showed the use of kaolin with a small admixture of burnt bones (white pigment) in pottery-making, as well as a mixture of ochre and pyrolusite (i.e. natural manganese ore), and burnt bones (brown pigment).

The latest studies into the archaeometry of TC pottery involve physicochemical and microscopic examinations of engobe and paint application techniques (Constantinescu et al. 2007; Starkova and Zakościelna 2018; Гошко 2019). Little is known about the use of organic pigments; examinations of pottery specimens predating Tripolye CII identified only binders and coats containing organic substances – wax and eggs (Kalinina and Starkova 2009).

Program of physicochemical analyses

Physicochemical investigations of Late Neolithic raw material processing techniques have been carried out since the 1980s by the Laboratory for Materials Physicochemistry and Nanotechnology (LMPN) at the Faculty of Chemistry of Adam Mickiewicz University. Over the course of these investigations a separate tar-production analysis subprogram was launched, covering the study of "wood tar" in pottery-making (originally as a "ceramic binder") (Kośko and Langer 1986).

Our research was successively expanded to include another application of tar: as a source of ceramic pigments (Langer and Kośko 1992). This line of analysis was vitally important because of its close relation to comparative analyses examining connections between FBC and TC samples (see previous section). Nine sets of samples were originally selected (Langer and Kośko 1992): 1) Jezuicka Struga site 17 (FBC, phase IIIA); 2) Opatowice site 33 (FBC, phase IIIB); 3) Inowrocław-Mątwy site 1 (FBC, phase IIIC); 4) Inowrocław-Mątwy site 5 (FBC, phase IIIC); 5) Opatowice site 42 (FBC, phase IVA); 6) Papros site 6B (FBC, phase IVB); 7) Bąkowo site 3 (FBC, phase IV–V); 8) Biały Potok (TC, phase CI); and 9) Volodymyrivka (TC, phase BII). Physicochemical analyses revealed that ceramic material from these sites contained four types of ceramic pigments (Langer and Kośko 1992):

I – Mineral pigments were identified on TC pottery from phases BII and CI (sample sets 8 and 9) (cf. Bilcze Złote, phase BI/BII [Stos-Fertner and Rook 1981; Kadrow 2013] and Biały Potok, phase CI [Rauba-Bukowska 2016]);

II – Mineral-organic pigments (mineral pigments with blood added) were identified on FBC pottery from phases IIIB and IIIC (sample sets 2 and 3);

II/III – Organic pigments (blood and tar) were found on FBC pottery from phase IIIC (sample set 4);

III – Organic pigments (tar) were identified on FBC pottery from phases IVA–V (sample sets 5, 6 and 7).

These findings were expanded by further analyses carried out by the LMPN, in which more numerous FBC pottery fragments were used. They came from Prokopiak's Mount in Opatowice and were dated to 3500–3025 BC (Langer et al. 2006; Langer and Pietrzak 2007; Langer et al. 2007b; Langer et al. 2014).

CERAMIC PIGMENTS IN THE POLISH LOWLAND DURING THE LATE NEOLITHIC: PRODUCTION AND APPLICATION

The pigments identified on the pottery of "megalithic culture" societies can be roughly divided into mineral pigments, of which few were found, and organic (and mineral-organic) pigments, which were clearly predominant in Lowland pottery. What is known of the production and application of the latter category shall be discussed first.

Organic and organic-mineral pigments: their raw materials, colors and application in Late Neolithic pottery-making in the Polish Lowland

Pottery covered with organic pigments (types II/III and III) was identified in the settlement assemblages of the Kujawy FBC from the second half of the fourth

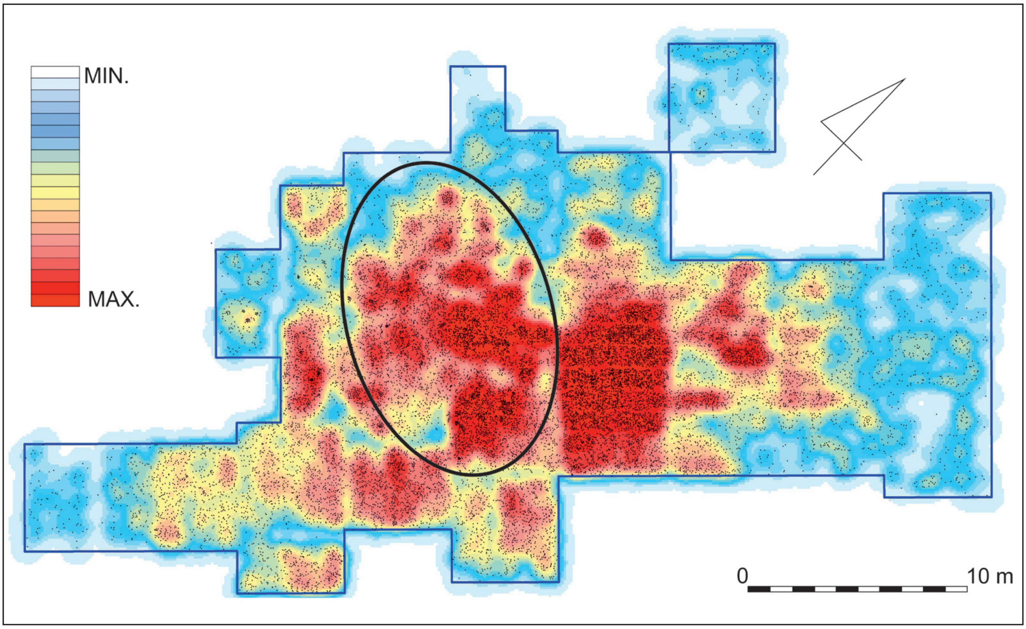

Fig. 2. Opatowice site 42, Radziejów district, Kujawy-Pomerania voivodeship. The concentration of sherds with traces of organic pigments, plotted against the general qualitative distribution of Funnel Beaker culture pottery (modified from Kośko and Szmyt 2007a). Key: red – maximal density; blue – minimal density; black oval – concentration of pottery with black organic pigments

millennium BC, coming mainly from the central portion of the mesoregion (i.e. the Kujawy Plateau), specifically so-called "Black Kujawy" (Radziejów-Kujawy and Bachorza-Kujawy; after Kukier 1963). This restriction of the territorial range is justified not only by older observations, but also by the latest publications of FBC and GAC settlement materials from Black Kujawy (Brześć-Kujawy) and White Kujawy (Vistula-Kujawy), where pigment-covered pottery was not found (Grygiel 2016; Kośko and Żurkiewicz 2016, 2018; Szmyt 2016).

For Radziejów-Kujawy, there are detailed records of the location of organic pigment-covered pottery within the settlements of FBC populations on Prokopiak's Mount in Opatowice. The context of the pottery from Opatowice 42 is very well-understood, specifically referring to the settlement phase Op42-B, dated to FBC phase IV/VB, 3350–3100 BC (Kośko and Szmyt 2007b). This justifies designating it as a diagnostic assemblage for the presentation of physicochemical assessments of both organic pigment production techniques and organic pigment use in pottery-making (Langer et al. 2007b). The techniques identified with respect to this assemblage may have also been used by other Kujawy (or more broadly, Lowland) communities of "megalithic cultures."

a. Raw materials and colors

The pottery assemblage of 33,420 sherds (total weight: 241.835 kg) from Opatowice 42 included 382 sherds with traces of organic substances on their outer surfaces (380 sherds) or inner surfaces (2 sherds). The entire series was macroscopically examined and divided into four groups:

Group A (20 sherds in total) is characterized by a thin uniform layer of a black substance, covering the outer surface of the sherd;

Group B (57 sherds) is characterized by a uniform layer of a black substance, slightly thicker than that observed for Group A, covering the outer surface of the sherd; the layer comes off in small pieces, forming pockmarks in places;

Group C (32 sherds) is characterized by a thick layer of a black substance, unevenly applied, covering the outer surface of the sherd; the layer peels off in large pieces;

Group D (2 sherds) is characterized by lumps of a black substance stuck to the inner surface of the sherd.

Other fragments (271) were too damaged, making it impossible to classify them within any of the defined groups.

Altogether, 41 samples were selected for physicochemical analysis at the LMPN, of which two represented Group A, 21 represented Group B, 16 represented Group C and two represented Group D. The examinations included melting point measurement (using a PHMK apparatus), determination of solubility in organic solvents of varied polarity (in water and in acidic and basic solutions of HCl and NaOH, respectively) , microscopic observations (PZO optical polarizing microscope and Philips SEM 515 scanning electron microscope), absorption measurement in infrared light (FTIR, Bruker IFS 113v) and electron paramagnetic resonance (EPR). In respect to samples soluble in organic solvents, we employed comparative chromatographic analysis (TLC) with reference to contemporary standard samples of birch and pine tar obtained at the LMPN.

The obtained results show that the properties of all examined preparations indicate affinity to wood tars – in particular, birch tar – enriched with admixtures of mineral substances and thermally modified. The Group B samples, along with one Group A preparation, have a composite character; they contain wood tar with an addition of mineral substances. Group C samples for the most part contain the heavy ends (the fraction of the tar with the highest melting point) typical of birch tar, with a minor addition of mineral substances similar to the post-production residue observed in Group D.

The raw material used in a portion of the samples from Groups B, C and D was birch wood and bark. On a single occasion, in Group B, a substance was found to have been purposefully neutralized. This is evident during FTIR analysis by a strong absorption typical of carboxylic acid salts and non-absorption of free acids and their esters. Neutralization lowers the chemical reactivity of tar with respect to the basic components of the ceramic substrate, thus increasing the durability of the layer. Two samples from Groups B and C demonstrated absorption characteristic of aromatic acids, which attests to the presences of relatively high temperatures during their production and/or use. Most tars contained unsaturated organic acids, while only two samples (from Group C) contained saturated acids. In these cases, a lower temperature of production and use is expected. On account of the considerable absorption of CH_3 and CH_2 groups, many samples may have a certain excess of fat, probably resulting from a chance contamination of vessel surfaces with fat. A purposeful use of fat additions in colorant layers seems rather improbable. This could have been the case with post-production residues when tar was being prepared for other uses.

The raw material for these pigments consisted of the heavy ends of wood tar, mainly birch tar. It was applied hot and thermally set (in our experiments, none of the samples melted at temperatures below 300°C). The heat of the production process disintegrated organic substances and produced the black color. Eight samples from groups B, C and D had been subjected to a very high temperature, which produced a full thermal resistance (they did not melt or soften at a temperature of 300°C). The other samples softened in a rather broad range of temperatures: below 150°C (7 samples from groups B, C and D), about 150°C (9 samples from groups B and C) and above 150°C (16 samples from groups A, B and C). The temperature of ~150°C is a frequently encountered melting point for wood-tar intermediate fractions. The fact that the samples did not melt at a point lower than 300°C can be explained by the presence of mineral additions. What is more, the mineral additions improved the mechanical durability of pigment layers by increasing their wear resistance.

b. Use in pottery-making

Macroscopic examinations showed that the analyzed pigments had survived on various vessel parts:

- in the upper portions of vessels, evenly covering the lip and rim on the outer side and sometimes extending to the upper surface of the rim;
- in the belly and handle portions of vessels, at handle roots and even in places almost hidden from view during vessel use (because they were covered by a handle);
- on bellies, with traces showing that pigment had been evenly applied;
- next to bases (an organic layer had been evenly spread over vessels, going over to the outer surface of their bases).

In rare cases, an organic layer coincided with an incised decoration but did not cover the ornament itself. Only in a single case was an incised ornament found to have been made on a surface covered earlier with an organic layer.

Microscopic examinations, in turn, showed that the pigment preparation had a rather high viscosity and set relatively quickly (two samples from group B and one from group C displayed traces of a “brush”). It was applied to the ceramic substrate in a thin layer. In most cases, coatings were less than 1 mm thick (Group B) and showed traces of erosion where pigment had come off in spots. In some cases, there were also uneven, thicker layers (about 1 mm, observed in Group C). In two Group A samples, the layer was very thin (about 0.5 mm or less) but adhered well, being strongly bound to the underlying ceramic.

Eighty percent of pigment-covered vessels represented the “everyday type” of vessels, mainly storage pots and containers made from “coarse-grog” ceramic bodies and covered with an organic coating. This coating was a layer of pigment with a thickness of 1 mm or more (Kośko et al. 2007). Some vessels showed an even and complete coating on the outside, from rim to base (see Kośko et al. 2007, fig. 4.77).

Mineral pigments: their raw materials, colors, and application in Late Neolithic pottery-making in the Polish Lowland

In contrast to the organic pigments, which are known from relatively many sources, our knowledge of mineral pigments relies on single sherds or vessels bearing traces of coloring that were identified in FBC and GAC inventories.

The LMPN analyzed a total of five pottery samples bearing mineral pigments. The samples were examined under a microscope (a PZO polarizing microscope and a scanning electron microscope, in the case of one FBC sample) and, with respect to GAC samples, chemically studied. Due to the small amount of available material, chemical analyses were qualitative in character and covered the determination of solid sample content by spectral emission analysis (AES) on a Q-24 apparatus, as well as examination of acid extracts using inductively-coupled plasma spectral emission analysis (AES-ICP).

a. Raw materials and colors

A red or possibly red-brown pigment was identified on a FBC sherd from Inowrocław-Mątwy 1, dated to phase IIIC (Langer and Kośko 1992), and on four GAC sherds from the following sites: Bożejewice 22, Piecki 8 and Żegotki 2, dated to phases IIb and IIIa (Langer and Szmyt 2000). Due to the highly fragmented nature of the recovered sherds, no form of a vessel covered with a mineral pigment could be reconstructed. All that was learned about the vessels’ construction was that they had been made following the “classic” GAC recipe, i.e. from a ceramic body tempered with coarse and fine broken stone (Szmyt 2004). It may prove important to note that two sherds were found in a settlement context (Żegotki 2, within the habitational layer of the settlement) while two others were deposited in ritual features: one with an animal deposit (Bożejewice 22, Feature A2) and another in a human grave (Piecki 8, Feature 18).

GAC pottery samples were chemically analyzed, in a qualitative sense, using the AES method (Langer and Szmyt 2000). Significant amounts of iron (Fe), silicon (Si), aluminum (Al) and chromium (Cr) were identified in both the pigment

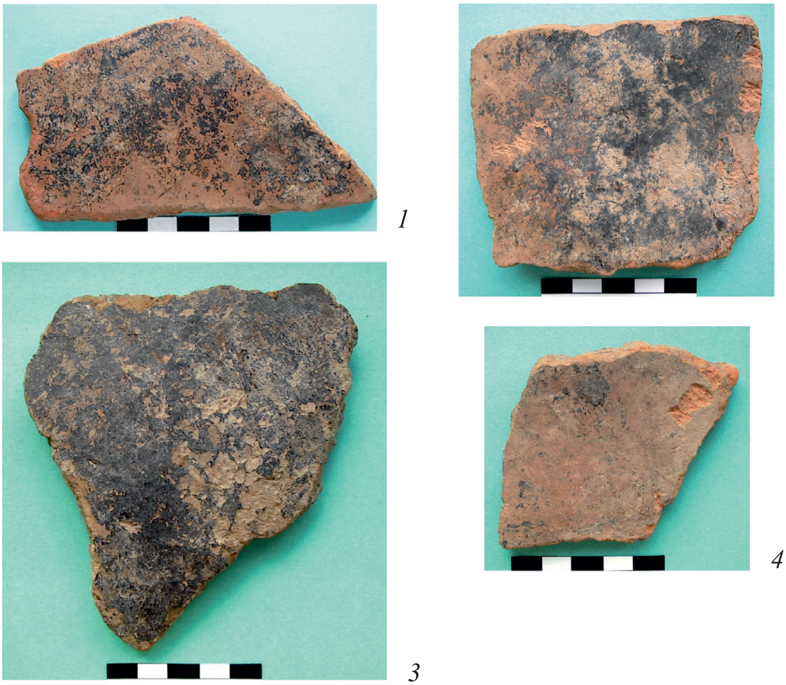

Fig. 3. Opatowice site 42, Radziejów district, Kujawy-Pomerania voivodeship. Pottery with black organic pigments and residues, distinguished by typological group (Photo by S. Pietrzak). Key: 1 – Group A (sample Sr 12); 2 – Group B (sample Sr 405); 3 – Group C (sample Sr 429); 4 – Group D (sample Sr 433).

layer and the ceramic substrate. Similarly, the examination of acid extracts using the AES-ICP method showed the presence of iron (Fe), chromium (Cr), aluminum (Al), copper (Cu), calcium (Ca), lead (Pb), sodium (Na) and potassium (K) in similar amounts in all analyzed samples; only one sample was found to contain cobalt (Co) on the inner black surface of a shard. This means that the pigments used are ferric, having iron oxides as their base. When pottery is fired under oxidizing conditions, the iron oxides turn into a stable red-colored compound (hematite, or Fe_2O_3). The identical composition of the pigment layer and the base layer may result from the former being very thin and thus impossible to remove during analysis without disturbing the underlying material.

b.Use in pottery-making

Microscopic examinations of GAC samples showed the mineral red/red-brown pigment to have been applied in a thin layer to the surface of a fired vessel (Langer and Szmyt 2000). It was applied to either the slip (engobe) covering the ceramic base or the surface made from the same material during firing. In the examined cases, the slip was bright (beige) or dark (brown) in color.

Two types of slip layers were distinguished: I) thin (0.2–1.0 mm), fine-grained and bright-colored; and II) slightly thicker (1.5–3.0 mm), darker and built of material with larger grains (the same material as the rest of the vessel wall).

The technology of making the bright base layer (I) on an outer vessel wall involved, at least in the case of three samples, appropriate thermochemical treatment while firing a vessel, i.e. providing oxidizing conditions. Another treatment was shown to have been used in the case of a sample from Piecki 8. In it, a bright base layer was applied as an additional thin layer to the outer surface of a vessel that had already been preliminarily fired. This could be seen in the thinness of the outer layer (0.2 mm) and a sharp border separating it from the dark interior. Additionally, the fracture showed another very thin bright layer (about 0.1 mm) about 0.5 mm from the surface. It attested to the preliminary firing of the vessel before the application of the outer layer. The chemical composition of the bright base layer does not differ from the composition of the vessel fabric, which suggests that this layer was made from the same material (for instance, by separating and using its fine-grained fraction). The bright color was achieved through repeated firing in an oxidizing atmosphere.

PIGMENTS WITHIN A BROADER CULTURAL CONTEXT

As we mentioned in our introduction, study of the pigmentation of Late Neolithic vessels to date has run up against the barrier of its meaning (Langer and Kośko 1992, 1999; Kośko et al. 2000). The following comments are an attempt to collect arguments that may encourage others to try to overcome this barrier.

Pigment-covered pottery in everyday life: chances for, and limitations to, advancing our knowledge

What we presently know about the position of pigment-covered pottery in the everyday and ceremonial life of FBC and GAC communities is inadequate for making inferences regarding its cultural significance. For instance, very little continues to be known about potential differences in the use contexts of mineral pigment-covered pottery, and its possible co-occurrence with pottery covered with organic colorants.

Organic pigment-covered pottery is dominant in Kujawy and has a strong presence in FBC settlement inventories from the second half of the fourth millennium BC, mainly in the central part of the mesoregion (the so-called Black Radziejów Kujawy). It is from there that an especially informative record of the pottery's usage comes, from Opatowice 42, settlement Op42-B (3350–3100 BC). In this case, complete data are available on everyday settlement life (Kośko and Szmyt 2007b, 2015b). This is also true of innovative practices, like the suggested "Opatowice invention" in the application of organic pigments.

In turn, a set of data from another FBC settlement at Opatowice, Op33-A2 (phase IIIB-C, ca. 3400–3200? BC; Kośko and Szmyt 2006), may initiate future studies of a "new kind of organic colorants" identified there (Langer et al. 2006). It has been preliminarily identified as being distinct from those pigments that were based on wood tars (defined here as Types II and III).

The innovation in pottery-making under discussion emerged in 3350–3100 BC, when the processes of the "mythologization of the Opatowice promontory" are believed to have culminated (Żurkiewicz 2016). However, while the quality of the archaeometric data from Op42-B offers ample opportunities for further research advances, it is also important to note the barriers that inhibit a full reading of this source complex. They are formed chiefly by the devastation of a substantial part of the "Luboń-Radziejów" settlement context on Prokopiak's Mount, which dates to the same period (3350–3100 BC; see Kośko and Szmyt 2006: fig. 1.4; Kośko et al. 2006: fig. 2.14).

The geographic origins of organic pigment: directions for future research

Organic pigments applied to pottery were already present in east-central Europe during the late sixth millennium BC, among the Transcarpathian "Eastern Linear Pottery" societies. While there is presently temporal discontinuity between corpora of pottery with organic pigments, it is possible – in light of up-to-date macroscopic taxonomic examinations – that these pigments could have been continuously applied during the fifth and early fourth millennia BC in the circle of Late Linear Pottery cultures (Kośko et al. 2006). Thus, a research program to verify this hypothesis would not be out of place. It should review sources from across the Baltic drainage basin, with an eye to uncovering a possible discreet continuation of pigment application to "Linear" and "post-Linear" pottery types. Evidence of such a continuation is likely to be found on sites located along the trail of the northern (Lowland) echoes of the East Slovakia Linear Pottery culture. This trail's final destination can be considered the Kujawy cultural mesoregion, in the addition to the Chełmno Land (Grygiel 2001; Kośko et al. 2006).

The study of the geographic origin of Late Neolithic Kujawy ceramic pigments has been dominated so far by what we term a "Pontic-continuative" approach, one that presumes continuity with the cultures of Southeastern Europe. This justifies the assumption that both kinds of pigments, mineral and organic, should be studied jointly, as both had a permanent place in the tradition of inter-regional ties in east-central Europe in the fourth millennium BC. In consequence of this approach, the TC milieu was chosen as the presumed original source of all Lowland applications of ceramic pigments (Kośko et al. 2000). It must be stressed that this research approach can be effectively continued, provided that Tripolye sources are included on a broad basis – as a general rule – in the program of physicochemical analyses. This should be done for the purpose of both chronological and chorological identification of changes in pigment technology and the detailed exploration of organic pigments. A study of Tripolye ceramic pigments should focus on the reception of external impacts (e.g. Subneolithic, "Pre-Yamnaya" and "Yamnaya" technological influences).

As we discussed, a revision of the Pontic-continuative approach was triggered by the investigations of settlement Op42-B (dated to FBC phase IVB/VB), which revealed innovations in pigment application that were novel to this microregion (Kośko et al. 2007; Langer et al. 2007b). The chronologically latest (Luboń-Radziejów) sources constituted a substantial share of organic coatings. These were relatively thick layers (~1.0 mm or more) of an organic substance applied to the outer vessel surface (Groups C and D in our typology of pigment application). A crucial observation was the fact that in the assemblage of pigment-covered pottery from settlement Op42-B, as many as 80 percent of sherds/vessels (classified as "everyday" forms) bore such coatings (Kośko et al. 2007: 239).

The following observation is still valid: *The pottery treatment under discussion is not known on this scale among other (neighboring on the inhabitants of Prokopiak's Mount) communities of Late Neolithic cultures, which is true for the TC of phase CII as well. This exceptional trait may be an argument in favor of the existence of an "Opatowice microregional (?) invention" drawing on [...] the "Tripolye" experience of pigment use in the production of occasional pottery (in the TC, serving pottery)* (Kośko et al. 2007: 239).

A broader interdisciplinary analysis of this assemblage may be necessary; another interpretation of these later materials is possible owing to the presence on Prokopiak's Mount, albeit only after ca. 2600 BC, of a Subneolithic community of the Neman culture (Czebreszuk and Szmyt 1999). The technology of covering outer vessel surfaces with wood tar layers was also present in this culture (Józwiak et al. 2001; see also Langer et al. 2005). However, FBC pottery from Opatowice 42 bears no stylistic evidence of Subneolithic borrowings (Kośko et al. 2007; for a broader treatment see Józwiak 2003), a point which precludes continuing the search for possible inspirations among those groups.

What has to be noted instead is the synchronicity of the "Opatowice invention" in the application of organic coatings to vessels (3350–3100 BC) with analogous treatment observed in the sequence of "kurgan" cultures in the Ponto-Caspian Steppe. These cultures, which can be distinguished into Pre-Yamnaya and Yamnaya phases, were later the successors to the TC. The treatment is observed on funerary (ceremonial) pottery, mainly on pots, which is of interest given the role of kettles and cups as libation vessels in the Pre-Indo-European circle. The end of the fourth millennium BC witnessed the westward migrations by steppe "kurgan" communities identified as Indo-European (waves no. 2 and 3, following Gimbutas 1977) that reached the middle Dniester (and quite possibly the upper Dniester and Bug as well) ca. 3200/3100 BC (Włodarczak 2017).

In the expert opinion of Professor Viktor I. Klochko: *Carbon deposits on the outer surface of vessels or charred food remains inside them, traces of liquid bulges and sediments were quite often recorded during the mass explorations of steppe barrows in the 1970s and 1980s. Such deposits, remains and sediments were found on pottery attributable to various Bronze Age units but especially the Yamnaya and Catacomb cultures (see, from the Baltic drainage basin: a "Yamnaya" vessel found on the San River, bearing traces of a pigment on its lip; Kośko et al. 2018: Fig. 30). Specialist analyses of such sources were initiated by the late Professor Bratchenko; however, there are no publications available on the effects of work undertaken then* (V.I. Klochko, personal communication).

Opatowice ceremonial life, 3350–3100 BC: the social and cultural context of pigment application

The use of organic pigments in the pottery-making of communities settling Black Radziejów Kujawy in the Late Neolithic, in particular the pigments designated above as the "Opatowice invention," can now be studied in several analytical spheres. These spheres can be delineated as:

a) functional – palaeo-aesthetic (examining their physicochemical inspirations);

b) linguistic – mythological (examining their social roles based on analogies from historical-comparative linguistics); and

c) adaptive – environmental (examining their technological basis from the point of view of the ecology of the communities settling the Polish Lowland in 3350–3100 BC, in particular at Prokopiak's Mount).

Regarding sphere (**a**), as we previously wrote in 2007: *Covering the entire surface of vessels with tar substances, found to have been practiced in settlement Op 42-B, may suggest, on the one hand, that the potters were after aesthetic values (black shiny surface) and, on the other, that they had practical reasons in mind. For instance, the intention might be making the container tight and protecting its contents (food, liquids) against microorganisms or insects ('raw' coatings retain an insect-repelling smell, which can be removed by annealing when volatile components evaporate). Annealing in a temperature of 150 °C increased at the same time the homogeneity and stability of an applied layer. In addition, a black coating makes a vessel accumulate heat better, including solar radiation. In turn, the use of hybrid layer technology, involving other organic materials than wood tar, made for the greater wear resistance of coatings and got rid of the characteristic smell of wood tar* (Langer et al. 2007b: 357).

Regarding sphere (**b**), the remarks of Andrzej P. Kowalski are particularly inspiring: *The special value of wood tar in the production pursued by early traditional* *communities was reflected in Indo-European vocabulary. It appears that some tree names were formed from the names of bark, resin or tar obtained from them. However, a purely "technological" aspect of the cultural motivation behind the semantics of such nomenclature is only apparent. When this semantics were developing, both bark and tar had non-utilitarian uses as well; they carried pro-aesthetic senses. […] The decoration of ceramic vessels with wood tar may be included in the same category of actions as the application of engobe to pottery or smearing leather containers and baskets with tar to make them tight. In ancient Egypt and Mesopotamia, various kinds of putty and tar (bitumen) were frequently used to make vessels tight or to polish them* (Kowalski 2003: 8-9).

In this context Kowalski – following Rudolf Meringer – stresses the lasting quality of "the maxim *fat is beautiful*: it is one of the oldest, implemented already since the Palaeolithic, aesthetic principles (*see* the relationship between the Polish words *okrasa* [pork fat for seasoning dishes] and *krasić* [to adorn]" (Kowalski 2003: 10).

This line of thought is continued in the mainstream of contemporary Indo-European studies. *T.V. Gamkrelidze and V.V. Ivanov (Гамкрелидзе и Иванов 1984: 631-632) tried to trace the connection between the lexeme *piks [tar, resin] and the name of pine as a tree supplying resin and one from which tar can be produced. They believe that the Indo-European *peuka [pine] is an extension of the root *phey-*phi-, and especially *pey ( )-, *pī- [to be fat] […] These authors point to the connection between the name of pine as a tree supplying tar and the Indo-European lexeme *peik denoting painting, colouring or writing. Behind the semantic identification or contamination they postulate, of the lexemes *peuka [pine], *piks [tar, resin] and *peik [to colour, paint], there lies the suggestion that tar and wood tar may have been used for decoration. It thus appears that tar was used in the past as 'black vegetable paint' to make specific symbolic pictographs or drawings and later for writing* (Kowalski 2003: 10-11).

An important complement to the cultural context of the "Opatowice invention" is the motif of "pot = kettle" an object having both functional and ritual uses. This can be applied to pots and storage vessels known from settlement Op42-B. They were made from a coarse-grog ceramic body and had their outer surfaces covered with organic pigments/coatings (Kośko et al. 2007). When viewed from the perspective of Indo-European studies, with respect to the kettle, "It is assumed that the Indo-Iranian-Italo-Celtic range of these lexemes attests to the specific, sacred function of [these] vessels," i.e. as libation vessels (Kowalski 2017: 176-177).

Regarding sphere (**c**)**,** detailed settlement analyses centered on both Prokopiak's Mount and Pagóry Radziejowskie (as well neighboring areas) led to the conclusion that the development of the Opatowice agglomeration came to a climax in 3400–3100 BC (Żurkiewicz 2016). The conclusion is supported by palynological studies that point to the period of 3400–2900 BC as the apogee of an anthropogenic impact seen in the maximal shares of the pollen of herbaceous synanthropic plants and cereals (Makohonienko 2008). According to the interpretation offered by Danuta Żurkiewicz (2016), the Mount, which rises 20 m above the surrounding ground, was the hub for communities settling the surrounding plains. It was perceived as the elevated center of the local "microcosm." This special status made it the site of ceremonies and inter-group meetings, and it is in this context that the "Opatowice invention" should be viewed.

CONCLUSIONS

Our update presented in this chapter, regarding the issues related to ceramic pigments, permits two conclusions. They take the form of research recommendations and refer above all to Polish-Ukrainian program initiatives.

The first conclusion stresses the need for further application of physicochemical analyses for identifying organic pigments on TC pottery. The application of such methods should be preceded by careful selection of sites diagnostic of Pontic-Baltic Eneolithization routes. Ceramic inventories from such sites should be macroscopically examined (as was done with material from Prokopiak's Mount) and pottery samples prepared. They should include examples of "painted" pottery and other specimens presumably bearing remains of pigments. Subsequent tests should follow the established LMPN methodology. The suggestion made almost 15 years ago that similar studies be carried out along the Carpathian-Baltic route still remains a valid one (Kośko et al. 2006).

Secondly, it is recommended that attempts should be made to learn more about the regional functions of organic pigments. The apparent autogenesis of a line of colorants made from organic substances in Kujawy should stimulate researchers to make efforts to learn more about this "Opatowice invention." In this context, one of the major questions refers to the use of motifs made from scraps of birch bark. Any answer to this question should complement the semiotic concept discussed above (cf. von Gonzenbach 1959; Langer and Kośko 1992).

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