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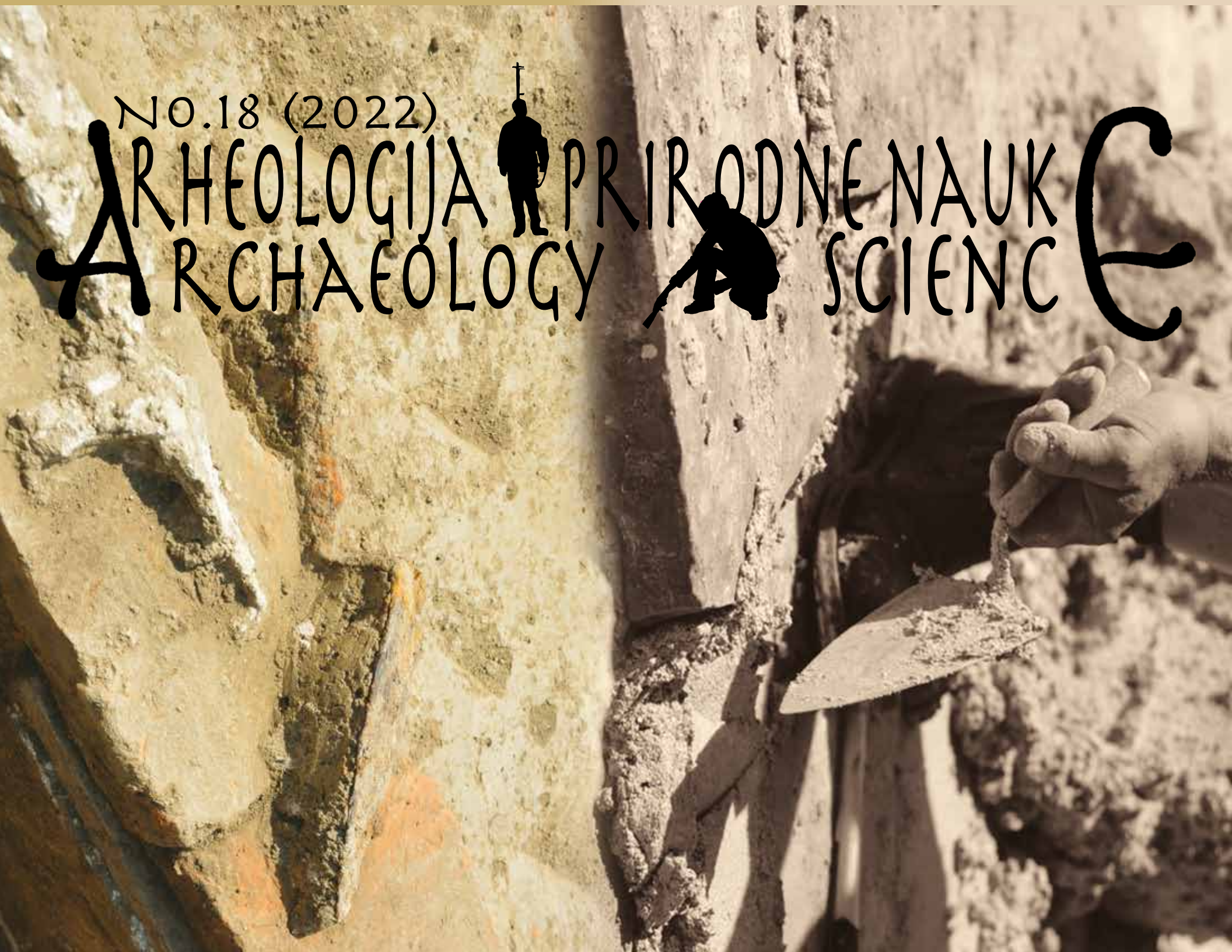

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Traditional building methods with lime mortar,
workshop in Viminacium
(photo documentation of the MoDeCo2000 project).
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THE FLOW PROJECT – A CONTRIBUTION TO THE STUDY OF THE CULTURAL TRANSMISSION OF THE CENTRAL BALKAN COMMUNITIES AND THE NEIGHBORING REGIONS IN LATER PREHISTORY[1]

ABSTRACT

The paper presents the basic research principles of the project THE FLOW (Interactions-Transmission-Transformation: Long-distance connections in the Copper and Bronze Age of the Central Balkans), which is carried by the Institute of Archaeology in Belgrade, the Institute of Nuclear Sciences "Vinča, and the Faculty of Philosophy, University of Belgrade. The theoretical and methodological perspectives of the project research engage an interdisciplinary approach based on analytical techniques incorporated within archaeology and natural sciences, such as physics and chemistry. The project's goal is to apply an exact method to the problems of the origin of raw materials for the production of four specific groups of objects made of obsidian, pottery, copper, and bronze. Each of those materials represents a unique problem and requires a specific treatment, presented within this paper, together with the existing practice, analytic techniques, and methodological procedures for the collected samples. Further, the project incorporates the collection of absolute dates through AMS and OSL dating, with the application of the latest OxCal 4.4. calibration. The acquired dates, combined with the disposition of samples and raw materials will serve as the backbone for the creation of spatio-temporal models and the formation of an SQL database, all with the goal of creating the interpretative basis for the study of local paleo-economies, long-distance connections, and social networks in the Central Balkans during the Copper and Bronze Age.

KEYWORDS: CASE STUDY, PROVENANCE STUDIES, OBSIDIAN, POTTERY, COPPER, BRONZE, ABSOLUTE DATING, SPATIO-TEMPORAL MODEL, SQL DATABASE.

1 This paper is the result of the project THE FLOW - Interactions-Transmission-Transformation: Long-distance connections in Copper and Bronze Age of the Central Balkans, funded by the Science Fund of the Republic of Serbia (Programme IDEAS, Grant no. 7750074).

The phenomena of the so-called imported objects – artifacts whose characteristics do not match the geographic region in which they are found, but rather a neighbouring one, or even a more distant region, has been recorded on archaeological sites from various periods and across the globe. This phenomenon has intrigued several archaeologists, anthropologists, and other scholars, who have, with more or less success, attempted and continue to attempt to explain and interpret it.

Likewise, the aforementioned phenomena have been observed in the Central Balkans, at archaeological sites from various periods, although its most notable manifestation is connected with those sites correlated with the later phases of the Early Iron Age (6th-3rd century BC). On those sites, especially in the territories of the South Morava and Vardar basins, the phenomena can often be observed through the appearance of the so-called Hellenized pottery, identical to examples from concurrent sites in Greece.[2] Those examples are represented by vessels typical of the classical and Hellenistic style in Greece (skyphoi, amphorae, oinochoai, etc.), decorated in black-figure painting, the so-called Saint Valentin vases,[3] and other objects characteristic of the ancient Greek culture. Interestingly, a similar setting can be observed in the far southwest of present-day Serbia, on barely excavated settlements in the vicinity of Novi Pazar, Sjenica, and Tutin.[4] Such an example firmly highlights the tight connections and contacts between the ancient communities of the Central Balkans and their southern neighbours. However, the question arises whether such pottery in the Central Balkans represents an "import" from the south, or rather a transfer of knowledge in pottery production and decoration between the local communities and their neighbours, which enabled them to produce pottery identical to the examples in Greece. Recent multidisciplinary research and analyses, which are being increasingly utilised in archaeology, have indicated that the presumed "Greek" pottery was made of local clay and most likely in local workshops.[5]

The successful collaboration of two disciplines, archaeology and materials science, resulted in the idea that such research could be "pushed" further to the past, to the Copper and Bronze Age (5th-2nd millennium BC), a time much less known to archaeology, especially regarding the questions of social contacts and interactions between populations that inhabited the Balkan Peninsula.

The ideal archaeological site for the analyses of pottery composition (provenance study) was the recently excavated Early Bronze Age necropolis in the village of Ranutovac near present-day Vranje (22nd-19th century calBC).[6] Interestingly, the stylistic and typological characteristics of the ceramic inventory from the necropolis resembled the pottery production of northern Greece and Pelagonia (the so-called Armenochori or Pelagonian cultural group),[7] rather than that from the Central Balkans. In order to determine the origin of such pottery, several different analytical methods were applied and the provenance study was conducted in line with the state-of-the-art archaeometry methodology.[8] A short overview of archaeometry methods in provenance studies that led to the results of the aforementioned study is to be highlighted. The determination of the origin of archaeological pottery represents an extremely complex procedure that includes the research into different levels of similarities between sherds within an archaeological context, comparison of the material composition of a selected group of ceramic sherds, comparisons with the potential source/sources of raw material (clay pit) in the vicinity of the site, and an examination into the production technology and other materials that were utilised during that process (pigments for decoration, tempers, etc.). The process of determining the origin of ceramic artifacts that includes all of the aforementioned aspects is called the provenance study. Besides the archaeological techniques, such as typological analyses, modern provenance studies universally include the examination of material using various instrumental tech-

2 Микулчић и Јовановић 1968; Alexandrescu 1978; Паровић-Пешикан 1992; Popović 2003;Крстић 2005; Булатовић, Филиповић и Капуран 2016; Вранић, 2022.

3 Соколовска 1986; Tonkova 1997.

4 Паровић-Пешикан 1992; Премовић-Алексић 1984; Премовић-Алексић 2014; Ljuština 2021.

5 Gajić-Kvaščev et al. 2014; Gajić-Kvaščev et al. 2015; Mirković et al. 2015.

6 Bulatović 2020.

7 Garašanin 1983.

8 Gajić-Kvaščev, Andrić, Vuksanović 2020.

niques. Modern archaeometry successfully applies both destructive and non-destructive analytical techniques, sometimes separately and sometimes complementary, in order to provide the answer to questions related to the origin of raw materials and/or the production technology.[9] Regardless of the analytical approach, modern archaeometry studies include the application of advanced mathematical techniques for processing the results of the analyses, including the state-of-the-art principles of machine learning and artificial intelligence.[10]

The aforementioned research concluded that all of the sampled ceramic vessels from the necropolis were made of clay from the local clay pit in Suvi Dol, which is being used by potters even today.[11]

Worthy of mention are petrographic examinations of ceramic inventory from the site of Zlatica in Omoljica and Najeva Ciglana in Pančevo, both attributed to the Vatin culture of the Middle Bronze Age. The results of the petrographic analyses have indicated that the pottery workshops from both of the researched sites prepared local clay in a similar, although specific, manner.[12] The valuable results of those pieces of research opened new insights and gave birth to new ideas, which were soon, with a good deal of joint work and constant "multidisciplinary" consultations, transformed into a project: THE FLOW - *Interactions-Transmission-Transformation: Long-distance connections in Copper and Bronze Age of the Central Balkans,* which is financed by the Science Fund of the Republic of Serbia (from 2022 to 2025, IDEAS Grant no.7750074), and which incorporates the joint work of archaeologists, physicists, and chemists.

The problem of the origin of raw materials within THE FLOW project will be examined through four case studies: pottery, copper artifacts, bronze artifacts, and obsidian artifacts.

The pottery will be analysed using several different analytical techniques (pEDXRFS-*Portable Energy Dispersive X-Ray Fluorescence Spectrometry,* rFTIR- *Fourier Transform InfraRed Spectrometry in reflection mode,* and XRD-*X-ray diffraction*), and the analyses will be focused on vessels and fragments of vessels, clay pits in the vicinity of origin sites, and the soil from the archaeological features in which the vessels were recorded. For the first time, THE FLOW project will apply the elemental analyses of soil to determine the potential discordances in the stratigraphy of the sites. The archaeological sites that will provide the pottery for the analyses have been carefully selected and represent well-researched sites with a finely determined stratigraphy and absolute chronology, such as Bubanj and Velika Humska Čuka near Niš, Ranutovac near Vranje, Hisar in Leskovac, Svinjarička Čuka near Lebane etc.[13] Following the collection of ceramic samples, they will be documented (photographed and marked). The pottery samples for this case study will be prepared according to current practice.[14] Suitable surfaces of samples will be mechanically scratched, washed, finely polished, rinsed, and dried. Samples prepared in such a manner are suitable for non-destructive examination of elemental composition using EDXRF spectrometry, and the analyses of the presence of chemical bonds using FTIR spectrometry. Following the non-destructive examination of samples, they will be examined using the diffractometry technique (XRD). This technique will require a small sample (approximately 1g) from suitable parts of sherds, which will serve for the examination of crystalline structure and the identification of crystalline phases in pottery, which should, besides the chemical composition, indicate the production technology. All of the instrumental techniques will be conducted within well-established and attested analytical procedures.[15] This will allow further mutual comparisons of the results, which will be treated in several different ways and processed in a manner that enables their application within the provenance algorithms. The algorithms to be applied are unique and have been developed from the long-term research by the team from the Vinča Institute of Nuclear Sciences.[16] The interpretation of the acquired results will represent the result of

9 Gajić-Kvaščev 2013; AndrićiGajić-Kvaščev 2017.

10 Kvaščev, Gajić-Kvaščev, Đurović 2012.

11 Gajić-Kvaščev, Andrić,Vuksanović 2020; Gajić, Kvaščev, Andrić i Bulatović 2022.

12 Gómez-Gras et al. 2021.

13 Bulatović and Milanović 2020; Bulatović and Milanović 2021; Bulatović 2020; Stojić 2001.

14 Gajić-Kvaščev et al. 2018.

15 Gajić-Kvaščev and Andrić 2013; Jančić-Heinemann at el. 2013.

16 Gajić-Kvaščev et al. 2012.

the multidisciplinary work of natural sciences researchers and archaeologists.

The second case study is focused on copper objects, the analyses of lead isotopes and other impurities within the copper, as well as the analyses of copper ores from mines or surface copper deposits located in those regions that display a higher concentration of copper artifacts. Such analyses have so far been conducted on copper finds from archaeological sites in eastern Serbia, attributed to the beginning of the Middle Bronze Age.[17] This case study is primarily focused on the Copper Age (Eneolithic), meaning the period between 4500 and 2500 calBC. However, isotopic analyses of lead will be conducted on copper from bronze artifacts as well, as it will be particularly interesting to compare the origin of copper and tin from bronze artifacts, for which the origin was sought beyond the Central Balkans.

The territory of north-eastern Serbia, one of the largest copper deposits in south-eastern Europe, bears exact evidence for the earliest copper extraction in Europe (c. 5000 BC) (Borić 2009, 204)[18] and, therefore, represents a logical starting point for research into the origin of copper during the Copper and Early Bronze Age. From an archaeological aspect, the territory of north-eastern Serbia represents a well-documented region, especially following the rescue archaeological excavations within the Iron Gates region during the second half of the 20th century. Unfortunately, locations in which mining and metallurgical activities were most likely conducted have been almost completely destroyed or at least largely devastated due to the flow of time and industrialisation. Such a scenario is understandable since the "hunger" for metals has always driven metallurgy based populations to increase production in search of profit, without preserving the technological traditions or cultural heritage.

One of the best pieces of evidence for the production of metal artifacts, both in the past and today, are casting moulds, which were based on examples from the Bulgarian Eneolithic, made primarily of stone (Tylecot 1992:13) and later of clay or sand. Within the territory of north-eastern Serbia, the only moulds originate from the Late Bronze Age and the Early Iron Age.[19] Several excavation campaigns on the metallurgical sites of Trnjane, Ružana, and Čoka Njica in the vicinity of present-day Bor, which bear evidence of copper metallurgy from the beginning of the Middle Bronze Age, yielded no finds of casting moulds. This indicates that the prehistoric communities that exploited the copper deposits of Tilva Roš in the vicinity of present-day Bor during the 2nd millennium BC engaged solely in the production of copper ingots, which were subsequently distributed to other centres, mixed with tin, and further transformed into bronze. However, the territory of Timok Valley in north-eastern Serbia yielded numerous finds of Copper Age shaft-hole axes, of which some were extremely large.[20] Also, the latest excavations of Kozija pećina (Goat Cave) near Rudna Glava, yielded a pit with pottery attributed to the Sălcuța culture, traces of burning, and fragments of metallic slags and copper particles, which represent the first solid evidence of copper metallurgy from the end of the 5th and the beginning of the 4th millennium BC (All of the relevant information and insight into finds were provided by courtesy of our colleague Prof. Dr D. Mihailović, the director of the aforementioned archaeological excavations).

Hence, the isotopic analyses of lead from copper axes in the territory of Timok Valley could provide us with exact evidence on the origin of such artifacts, and determine whether those were imported or locally produced during the 4th millennium BC.

The objects planned for those analyses are mostly Early Eneolithic shaft-hole axes of the *Jasladany* type, and chronologically younger axes of *Kozarac*, *Pădureni*, and *Pătulele* types (For questions of function, distribution, and chronology of such axes refer to Antonović 2014). Similar analyses have been previously conducted in the territory of Central Europe, therefore providing a significant database for the comparison of our results.

The third case study is focused on the isotopic analyses of tin (Sn^{124}) within bronze (Bronze is an alloy of copper and tin) objects from the Middle and Late Bronze Age (1900/1800-

17 Kapuran, Živković and Štrbac 2016; Mehofer et al. 2021.

18 Jovanović 1982.

19 Јевтић 1982; Лаловић 1976.

20 Гарашанин 1954: 51; Јовановић, Николић и Јовчић 2018.

1100/1000 calBC). This case study is based on the fact that copper deposits are known throughout the Central Balkans, while tin deposits, with their most common ore – cassiterite, are extremely rare. A decade ago, a higher concentration of bronze objects was highlighted on necropolises within western Serbia, in the immediate vicinity of Cer Mountain - a known source of tin ore cassiterite.[21] Such disposition and high concentration of bronze objects served as a basis for the formation of the international and multidisciplinary *Jadar* project, which has been ongoing for more than a decade. The project employs archaeologists, physicists, geologists, and other related researchers from the Institute of Archaeology in Belgrade and Brooklyn College in New York. The collaboration has yielded a significant number of scientific results, based on both the scientific and experimental methods.[22] The project has determined that the Milina River, which runs from biotite and biotite-amphibole granodiorites of the Cer Mountain, bears enough tin (Approximately 80% of tin in cassiterite from Cer Mountan) for the production of one bronze pin within several hours of panning.[23] Further, the isotopic analyses of tin have determined the existence of several unique "fingerprints" that separate bronze objects from the Balkans into several groups according to the origin of the tin.[24] These remarkable results, published in renowned scientific journals, have inspired us to further explore it as one of the case studies within THE FLOW project.

The isotopic analyses of tin will serve for the comparison of finds that belong to certain and/or several chronological, regional, or cultural-historical groups. This portion of the project will not be addressed solely through one problem, but rather several smaller case studies, of which some will combine the questions of the origin of both tin and copper within the same object, such as axes of the *Pătulele* type, which are certainly attributed to the Late Bronze Age, or Central European types of swords with a tang that occur in the Central Balkans at the end of the Bronze Age and the beginning of the so-called Transitional Period (12th-11th century BC).[25] Some of the Central European types, such as *Stätzling*, *Moškjanci*, *Novigrad*, and *Marina*, occur solely within the confluence zone of the Great Morava,[26] while their origin varies from northern Italy to the upper course of the Tisa river. The reason for such an occurrence of uncommon types of weapons far from the source territories has not been determined so far, especially considering that there is no "visible pattern" in their distribution, which is the case with swords of the *Reutlingen* type and flame-shaped spears. Another interesting question arises regarding the origin of slightly earlier Mycenaean types of swords, arrows, daggers, etc. Namely, it remains unknown whether such objects represent Aegean imports from the second half of the 2nd millennium BC or products/imitations from workshops within the hinterland of the Balkans.[27] Specific, and uncommon types for the Balkan Danube region are also two bronze cauldrons with double cross-shaped staples, which are connected with Central Europe and the Upper Danube region.[28]

In addition to the aforementioned, a particular focus will be placed on the origin of metals in several horizons of hoards in the Central Balkans, since those represent a Late Bronze Age phenomenon of the Central Balkans that originates from Central Europe. Hence, it is important to provenance copper and tin from hoards, and partially resolve the century-old question of their origin. Finally, one of the studies will be focused on bronze jewellery, since certain forms represent local tradition, while other forms suddenly occur without previous utilisation within local populations. The isotopic determination of the metal source could provide a peculiar relationship with a long-lasting utilisation of certain types of jewellery, and vice versa.

The final case study will be focused on the origin of obsidian artifacts from Copper and Bronze Age sites in the Central Balkans. In contrast to studies conducted for the obsidian finds from the Late Neolithic in the Central Balkans, primarily linked to the evidence from the Vinča site of

21 Muhly 1985; Durman 1997.

22 Bankoff et al. 2013; Huska et al. 2014; Mason et al. 2016; Булатовић et al. 2017; Powell et al. 2017; Powell et al. 2019.

23 Huska et al. 2014.

24 Powell et al 2018; Mason et al. 2016; Mason et al. 2020.

25 Филиповић 2015; Bulatović and Filipović 2017.

26 Filipović and Mladenović 2019.

27 Паровић-Пешикан 1995.

28 Jacanović 1995.

Belo Brdo, which were analysed in the scope of techno-typological and geochemical attribution,[29] chipped stones made of this raw material are not only rare in the later contexts but are still greatly lacking detailed analyses and contextualization. **THE FLOW** project, therefore, aims to address obsidian artifacts from the Copper and Bronze Age in its area of focus, bearing in mind their exotic origin (with the closest outcrops of obsidian being situated in the Carpathians, to the north, and in the Aegean islands in the south of the study area) and their distribution at a time when metals took the central role for the production of tools in prehistoric communities. Small collections deriving from the latest fieldwork or already partially recorded by colleagues (e.g., J. Šarić) studying the procurement, manufacture, and consumption strategies of lithics at major sites will be expanded with a new programme looking at the provenance, production, and function. Newly excavated or dated strata from Velika Humska Čuka, Bubanj, and Kalenić Livade will be used together with distinct museum collections in order to examine the role of imported objects in a range of domestic activities and their relationship in the production of local versus exotic raw materials, as well as to look at the reasons behind importing such objects into the local communities. Finally, the attempts of the long-distance exchange network reconstruction will benefit from the collaboration with the project partner M. Milić and the employment of pXRF analyses, to directly investigate obsidian provenance based on the study of trace elements like in previous studies.[30]

Results of all of the analyses from the presented case studies will be minutely analysed and mutually compared, both within these case studies and with the existing case studies. This step of the project will employ the *spatiotemporal* models, which serve to model absolute dates of sampled objects and the disposition of raw materials acquired through conducted analyses. This step requires the dating of all of the samples and/or archaeological features from which the samples originate. Therefore, **THE FLOW** project will acquire 30 AMS absolute dates (*Accelerator Mass Spectrometry*), and 14 OSL absolute dates (*Optically Stimulated Luminescence*) for pottery samples that do not originate from reliable archaeological features. Following the latest OxCal 4.4. calibration, the dates will undergo Bayesian modelling, and the locations of sampled objects will be georeferenced in GIS.[31]

The existing narratives and interpretations, and the fresh data acquired from **THE FLOW** project, including absolute dates, various analyses, georeferencing, etc., will allow the formation of an SQL (*Structured Query Language*) database, which enables operations between various relationships of the input data.

Such a research method will enable certain theoretical frameworks, as well as archaeological/anthropological concepts/models regarding the long-distance connections and social networks of the Central Balkans during the Copper and Bronze Ages.

During the entire course of the project, results will be presented on different scopes, from local educational workshops and scientific institutions to renowned international journals, which is, in fact, one of the main goals of the project.

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30 Milić 2014.

31 Bronk Ramsey 2009.

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REZIME

THE FLOW PROJEKAT – PRILOG STUDIJI KULTURNIH KONTAKATA POPULACIJA CENTRALNOG BALKANA I SUSEDNIH OBLASTI U POZNIJOJ PRAISTORIJI

KLJUČNE REČI: STUDIJA SLUČAJA, POREKLO SIROVINA, OPSIDIJAN, KERAMIKA, BAKAR, BRONZA, APSOLUTNO DATOVANJE, SPATIAL-TEMPORAL MODEL, SQL BAZA PODATAKA.

Rad prezentuje osnovne istraživačke smernice projekta THE FLOW (Interactions-Transmission-Transformation: Long-distance connections in Copper and Bronze Age of the Central Balkans), koji sprovode Arheološki institut, Beograd, Institut za nuklearne nauke "Vinča" i Filozofski fakultet, Univerziteta u Beogradu. Teorijske i metodološke perspektive istraživanja podrazumevaju multidisciplinarni pristup zasnovan na analitičkim tehnikama koje nude arheologiji prirodne nauke poput fizike i hemije. Cilj projekta je da se egzaktno pristupi problematici porekla sirovina za izradu predmeta korišćenih u praistoriji, koji će se odvijati kroz studije slučaja usmerene na nalaze izrađene od četiri vrste materijala: keramike, bakra, bronze i opsidijana. Svaki od navedenih materijala zahteva posebno tretiranje pa je u radu izložena osnovna istraživačka problematika, dosadašnje prakse, analitičke tehnike i metodološke procedure u ispitivanju prikupljenih uzoraka.

Analize vezane za poreklo sirovina u proizvodnji keramičkih predmeta podrazumevaju nedestruktivna ispitivanja elementnog sastava EDXRF spektrometrijskom tehnikom, kao i analizu prisutnih hemijskih veza korišćenjem rFTIR spektrometrije, nakon čega će uzorci biti tretirani difraktometrijskom tehnikom (XRD), kako bi se ispitale kristalne strukture i faze u keramici, što pored hemijskog sastava treba da ukaže i na tehnologiju izrade. Sledeća studija slučaja podrazumeva analizu predmeta od bakra, tačnije analizu izotopa olova i drugih nečistoća u bakru, što uključuje i komparativnu analizu sa rudom bakra iz rudnika ili površinskih kopova koji se nalaze u blizini regiona sa konstatovanom koncentracijom bakarnih predmeta, među kojima se u prvom redu izdvajaju sekire tipa Jasladany, Kozarac, Padureni i dr. Treća studija slučaja odnosi se na analizu izotopa kalaja (Sn^{124}) u predmetima od bronze na osnovu koje će biti izvršeno upoređivanje nalaza iz dobro definisanih hronoloških, regionalnih ili kulturno-istorijskih celina, što se posebno odnosi na Rojtlingen, Štacling, Moškjanci, Novigrad, Marina i Mikenske tipove mačeva, kao i sekire tipa Patulele i bronzana koplja plamenastog lista. Prisustvo predmeta od opsidijana retko je analizirano u kulturama bakarnog i bronzanog doba, iako je iz ranijih studija poznato da oni uvek predstavljaju import, s obzirom da se njihova najbliža ležišta nalaze na Karpatima i egejskim ostrvima, tako da će akcenat biti stavljen na rekonstrukciju mreža razmene putem pXRF analiza na predmetima iz muzejskih zbirki i novotkrivenih nalaza iz pouzdano datovanih celina.

Pored ovih analiza projektom je predviđeno dobijanje apsolutnih datuma za celine iz kojih potiču uzorci, putem AMS i OSL tehnike datovanja uz korišćenje najnovije OxCal 4.4. kalibracije datuma. Dobijeni datumi uz precizno određenu dispoziciju uzorka i sirovina biće upotrebljeni za stvaranje spatial-temporal modela i formiranje SQL baze podataka koje će rezultirati stvaranjem interpretativnih osnova u proučavanju lokalnih paleoekonomija, long-distance veza i socijalnih mreža kod populacija na centralnom Balkanu tokom bakarnog i bronzanog doba.

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