

Salt detection in neolithic pottery from Gornja Tuzla, BH

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It is generally known that without water (H₂O) and oxygen (O), there is no life on Earth. The next element in this series is definitely sodium chloride - NaCl, better known by its common name *salt*, without which life would certainly be possible yet at a cost of health and the development of both humans and animals. What is not known is when the humans first understood the importance of salt. Although the earliest evidence of salt exploration dates back to the period of the Late Stone Age, particularly from the Late Neolithic, today it is considered that it was consumed even before its exploitation by using salt water, halophytic plants, etc. It is also considered to be the first commodity exchanged during the prehistory, i.e. which was traded.

Systematic archaeological research on the territory of Bosnia and Herzegovina began with the accidental discovery of the Neolithic site Butmir in 1893, prompted by the previous establishment of the National Museum in Sarajevo (1888), the first scientific research institution in Bosnia and Herzegovina. Historical events (I and II World War) greatly affected the archaeological work during the first half of the 20th century. After the stabilisation in the territory of B&H, during the second half of the 20th century, a number of important archaeological discoveries were made. In the frame of the large scale systematic archaeological investigation with clearly defined goals of testing the Neolithisation process, the first systematic research from the previously known site in the municipality of Tuzla was performed. Even today, the territory mostly famous for rock salt ores, with numerous sources of brine, through rare archaeological works it has provided abundance of material evidences relating to earlier prehistoric occupation. Researches' initial understanding on the continuity of life during the Neolithic period traced at the town of Tuzla and Gornja Tuzla sites, was later disproved and the site was dated as middle Neolithic (around 5700 BC). The most important and most interesting findings however, were those that pointed to the early exploitation of salt spots and the evaporation of the brine, i.e. to

the process of obtaining salt by boiling rock salt or salty water (Baum, 1957, Puš, 1957, Čović, 1961, Benac, 1955, 1966, 1972, 1978). Aside from highlighting evidence for potential exploitation, no further analyses were ever conducted during these initial investigations. This offered a unique opportunity to examine evidence for what could be the earliest systematic exploitation of salt in Eastern Europe, through application of chemical analyses of pottery. Topic of this research is thus the examination of the above indications of the oldest salt exploration in Eastern Europe, using a chemical analysis for the determination of sodium and chloride content in remains/fragments of ceramic vessels. Following the process of analyses done in Japan (Horiuchi A., Ochiai N., Kurozumi H., Miyata Y., 2011), China and North America (Raad D., Li S., Flad R., 2014) and Germany (Daszkiewicz Malgorzata, Bobryk Ewa, Bonisch Eberhard, 2016), all carried out completely independent of each other, two of the studies sharing similar findings very different to those from the third study, we wanted to apply the same principle on material from Tuzla sites. The aim of the analyses was to verify the possibility of the actual realisation of the before mentioned process, and after obtaining results to verify their authenticity in the interpretation, concerning the use of certain ceramic vessels shapes in the process of salt evaporation and salt gathering, as well as to compare the obtained results with the results of the aforementioned analyses. By proving that a particular type of vessel was used in the process of evaporation, it would bring us to the very way of carrying out the process of exploitation and evaporation, its realization and functioning during prehistory. In the case of ceramic vessels from Tuzla, from the beginning we were not sure which containers could have been used for the salt exploitation, and which did not, except on the basis of earlier quotations and earlier assumptions (Benac, 1978). Based on this, for the purpose of prehistoric pottery analysis it was decided to sample all material with as many diverse forms as possible, and from archeological materials from different deposits.

The study has had two stages: the theoretical and the practical research. The theoretical research was carried out through the literature sources which we concluded in-depth study of the importance of salt, in general, with the archaeological data on the production and use of salt during prehistory in Europe as well as archaeological data on the process of salt evaporation during Neolithic and Eneolithic period on the territory of Bosnia and Herzegovina. The case of

Bosnia and Herzegovina is further researched through the state of the research of prehistoric sites in the area of Tuzla and Gornja Tuzla and methods of salt production before industrialization in (micro) region according to archaeological and ethnographic sources. The practical part, on which we focus here, consists of the history of conducting chemical analyses on prehistoric materials and the process of detection of sodium chloride in ceramic vessels with our study case, the experimental part of chemical analysis of ceramics and selection of prehistoric materials from the Tuzla and Gornja Tuzla sites which we all analyzed. All samples were tested for sodium and kaolin content at the Faculty of Mining, Geology and Civil Engineering of University of Tuzla in Tuzla (B&H), while the ratio of chloride was tested at the Department of Physical Chemistry at the Faculty of Chemistry and Chemical Technology of University of Ljubljana, Slovenia. Final analysis of all obtained data was made, i.e., results, their interpretation and placement of obtained results into existing frames, which means we did the comparison of material analysis results with the same or similar results of prehistoric sites with salt extraction in the region and Europe is also recorded.

The scientific significance of the study lies in the existing knowledge of the salt exploitation in Tuzla (Puš 1957; Čović 1961; Benac 1978), which we wanted to test using a multidisciplinary approach - by introducing historical, ethnographic and experimental observations, and to use the archaeological material of the mentioned site to chemical analyses: Horiuchi A., Ochiai N., Kurozumi H., Miyata Y., 2011: Detection of chloride from pottery as a marker for salt: A new analytical method validated using simulated salt-making pottery and applied to Japanese ceramics, *Journal of Archeological Science* 38, 2011, pp. 2949-2956; China and North America: Raad D., Li S., Flad R., 2014, Testing a novel method to identify salt production pottery via release and detection of chloride ions, *Journal of Archaeological Science* 43, 2014, pp. 186-191; Germany: Daszkiewicz Malgorzata, Bobryk Ewa, Bonisch Eberhard, (2016) Salz aus Halle. Natriumchlorid an Niederlausitzer Briquetage nachgewiesen, in *Ausgrabungen im Niederlausitzer Braunkohlenrevier 2013/2014*, Branderburgisches Landesamt für Denkmalpflege und Archäologisches Landesmuseum, Wunsdorf, 2016, 77-89. To date, there were no attempts to carry out any analyses of this type on archaeological material from the region with a view to address the question of the importance of salt as a valuable nutritional element within the

framework of the new Neolithic diet (Weller, 2015: 186). The above research provided more detailed information on the salt exploitation in Tuzla, the most significant salt-rich territory of the inner Balkans. It was also hoped that the results will shape our understanding of the emergence of new salt exploitation strategies, when occasional salt collection no longer represented a sustainable solution and before the start of the production of solid and portable salt.

Analysis of the determination of sodium content and the chloride content on prehistoric fragments from the Tuzla sites failed to confirm the presence of retained sodium and chloride ions in any of the sample fragments of prehistoric vessels analysed. On the other hand, an increased proportion of sodium and chloride was observed in fragments of experimental vessels - replicas made for analysis purposes, in which salty water was cooked in order to perform an analytical procedure with samples of prehistoric vessels, and later with the results presented by Horiuchi et al. 2011 and Raad et al. 2014. We have carried out procedures that we believe are applicable but cannot be used in any way for the purpose of determining retained salt ions in ceramic vessels; it was possible to make a comparison between the analyses. Despite the fact that the readings were negative (no salt traces were found in the containers), we cannot exclude possibility that the communities at Tuzla used to exploit and produce salt by cooking salty water during the Late Neolithic, at least for the needs of the local population and potentially for a particular type of trade. The element of trade was evident from comparison of pottery assemblages of Tuzla and Gornja Tuzla with sites from across B&H that were away from salt spots, including a level of similarity recorded between our Tuzla sites and the site of Provadia Solnitsata in Bulgaria, which has confirmed salt exploitation during the Late Neolithic.