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An Archaeobotanical Onsite Approach to the Neolithic Settlements in Southern Regions of the Balkans: The Case of Vrbjanska Čuka, a Tell Site in Pelagonia, Republic of Macedonia

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A R T I C L E I N F O

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A B S T R A C T

This paper is focused on the Neolithic tell-site of Vrbjanska Čuka in Pelagonia, Republic of Macedonia, where the authors have been performing archaeobotanical research since 2016. Results of the analyses of botanical macroremains and microremains (starch, phytoliths) and faunal microremains collected in season 2016 are presented in the broader context of the Neolithic in the Balkans in order to estimate the bioarchaeological potential of this site. The first and final parts of the paper outline the bioarchaeological studies connected with Neolithic settlements in the southern regions of the Balkans. A substantial proliferation of environmental studies has been recorded in the last decade concerning the archaeobotanical and archaeozoological evidence. Here, most attention is paid to archaeobotanical studies which consider Neolithic settlements and their bioarchaeological context.

1. Introduction

1.1 Neolithic bioarchaeological knowledge from the Balkans in context

Current bioarchaeological research over the last two decades has comprised archaeobotany, archaeozoology and biological anthropology (human bioarchaeology) and in a broader concept of bioarchaeology, as postulated by J. G. D. Clark already in the 1970s (Clark, 1973). In current research, this broader perspective of bioarchaeology has been adopted mostly by European scholars (*e.g.* Beneš, Pokorný eds., 2008; Robb, 2014; Marinova *et al.*, 2013; Bouby *et al.*, 2013; Miladinović-Radmilović, Vitezović, 2016), because such an approach better reflects the current trend towards transdisciplinarity – compared to the narrower view postulated by Larsen for human bioarchaeology (Larsen, 1997; 2014). In this paper, we follow the former approach, a broader concept of bioarchaeology: one comprising the interaction between plants, animals and humans, as reflected in the archaeological record.

Neolithic research in southeast Europe has, for many years, offered rich assemblages of bioarchaeological objects: animal bones and other faunal remains, botanical macroremains and microremains (Ivanova *et al.*, 2018). The southern regions of the Balkans provide a rich and complex network of Neolithic sites (Müller, 2015; Raczky, 2015). Current research reflects the long and varied tradition here; however, archaeology in the last century was under the strong influence of artefactual archaeology during a period when the research paradigm was oriented towards cultural history (Souvatzi, 2008,

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pp. 47–51). This concept substantially favoured those studies dealing with material culture rather than ones addressing environmental and biological issues. Furthermore, the lack of local specialists led to a predominance of artefactual and architectural studies.

Bioarchaeological research was concentrated towards large systematic excavations made by international expeditions. This is clearly the case with the older research history of the site of Amzabegovo (Gimbutas, 1974; 1976), Sitagroi (Renfrew *et al.*, 1986; Näslund, 2009), Argissa (Reingruber, 2005), Nea Nikomedeia (Pyke, Yiouni, 1996; van Zeist, Bottema, 1971), Karanovo (Hiller, Nikolov, 1988) and Dikili Tash (Treuil, 1992) being the best examples.

The activities of bioarchaeologists have been oriented towards the *thematic* pioneer research of Neolithic palaeoeconomy. In this regard, R. Dennell studied the archaeobotanical assemblages of such Neolithic sites as Chavdar and Kazanlak in Bulgaria. Dennell established an alternative approach which suggested that the economic value of a Neolithic plant resource can be ascertained by considering its context within the crop-processing activities of a site or area (Dennell, 1972; 1974; 1976). The research of Dennell has opened up new avenues in onsite archaeological interpretations, certainly in comparison to the older common approach of recording the presence/absence of economic plant species in archaeobotanical assemblages. R. Dennell also worked with the archaeozoologist G. Kovačev and attempted to provide a complete onsite bioarchaeological picture of the plants and animals. Likewise, P. Halstead has contributed much to the research area of archaeozoology. He has published a series of papers focused on archaeozoological data of the Neolithic and Bronze Age (Halstead, 1981; 1989). In so doing he has attempted to ascertain the potential of archaeozoological material in helping to identify the part of large-scale pastoral specialization versus small-scale stock husbandry as a component of mixed farming. His concept has opened up such phenomena as the large-scale exchange of animals for meat and the identification of "producer sites" and "consumer sites", as well as the issues of milking, dairying and similar phenomena (Halstead, 1996).

In the southern regions of the Balkans in the 1980s and 1990s, local specialists were also active, such as E. Chakalova and Z. Popova in Bulgaria (see Kreuz *et al.*, 2017). A substantial shift has been recorded in the last decade towards the adoption of a multi-proxy approach: a new trend in the bioarchaeological research of Neolithic sites. In contrast to the best monothematic studies of the 1970s and 1980s, the multi-proxy approach is based on the synergy of two or more analytical methods. The combination of particular methods has been steeply increasing in number up until today (Marinova, Thiebault, 2008; Karkanas *et al.*, 2011; Pappa *et al.*, 2013; Garnier, Valamoti, 2016; Marinova, Ntinou, 2017; Kreuz, Marinova, 2017; Ivanova *et al.*, 2018; Whitford, 2018). In the last 10–15 years, the "critical mass" of specialists and awareness of the necessity to apply multi-proxy approaches has increased. Such synthesis should indeed become "state of the art" in the future (Allen *et al.*, 2017; Ethier *et al.*, 2017; Marinova *et al.*, 2016; Krauß *et al.*, 2017; 2018). Transdisciplinary studies constitute present-day research and the near future for prehistoric *onsite* archaeology.

Archaeobotanical research is still rare for archaeological excavation in this study region of the Balkans. It is due to the lack of specialists and the technical difficulty of sampling in archaeological field research – and the time-consuming work involved in the post-excavational phase. On the other hand, archaeobotany can contribute to resolving palaeoeconomical questions and trace the forms of human behaviour on a specific prehistoric site in great detail.

1.2 Natural setting of the southern Balkans and its Neolithic sites

Geographically, the southern Balkans region is very variable: its surface is predominantly mountainous. The climate of the coastal regions differs from that inland, it being more continental. Most of the southern Balkans is dominated by a Mediterranean climate, particularly for the area of Thessaly and Greek Macedonia. Towards the north the climate passes to a sub-Mediterranean environment with lower average annual temperatures in the valleys of the rivers Vardar, Haliacmon, Lower Struma and Maritsa (Trifunovski, 1998; Ivanova *et al.*, 2018). Altitude is an important influence on temperature and humidity. Due to the melting of the mountain snow cover and other sufficient sources of water, the Balkan region is rich in lakes, rivers and wetlands (Griffiths *et al.*, 2004).

The southern part of the region is today covered by evergreen sclerophyll vegetation, constrained by warm, dry summers and rainy winters (Prach *et al.*, 2009). The southernmost areas of mainland Greece and Greek Macedonia are covered by Mediterranean vegetation characterized by evergreen hardwood forest (with a diverse species composition) combined with alluvial forest (Bohn *et al.*, 2000/2003). In north-facing river valleys, including the area of Pelagonia, these Mediterranean habitats are alternated with sub-Mediterranean oak forests (dominated by *Quercus ilex, Q. coccifera, Q. trojana, Q. macedonica*) with hornbeam (*Carpinus betulus*) and ash (*Fraxinus ornus*). Higher altitudes include Sub-mediterranean Mountain forests dominated by beech and pine trees (Walter, 1985; Marinova, Ntinou, 2017). An important tree species in the study area is *Cornus mas:* used in the Neolithic period for the construction of fences and wattle-and-daub structures, while its fruits were also collected (Marinova *et al.*, 2013).

Palaeoecological research already offers much rich and well-structured data for the reconstruction of the Holocene vegetation – and the natural conditions of the Neolithic period in particular. The archaeobotanical data provides comprehensive knowledge about plant macroremains, pollen or charcoal, as well as many other aspects of palaeoecology (Marinova *et al.*, 2012; Cvetkoska *et al.*, 2014; Thienemann *et al.*, 2016; Lespez *et al.*, 2016; Marinova, Ntinou, 2017).

Neolithic settlements were concentrated near water and natural raw material sources. In southeast Europe, there are two types of Neolithic settlement (Figure 1). The

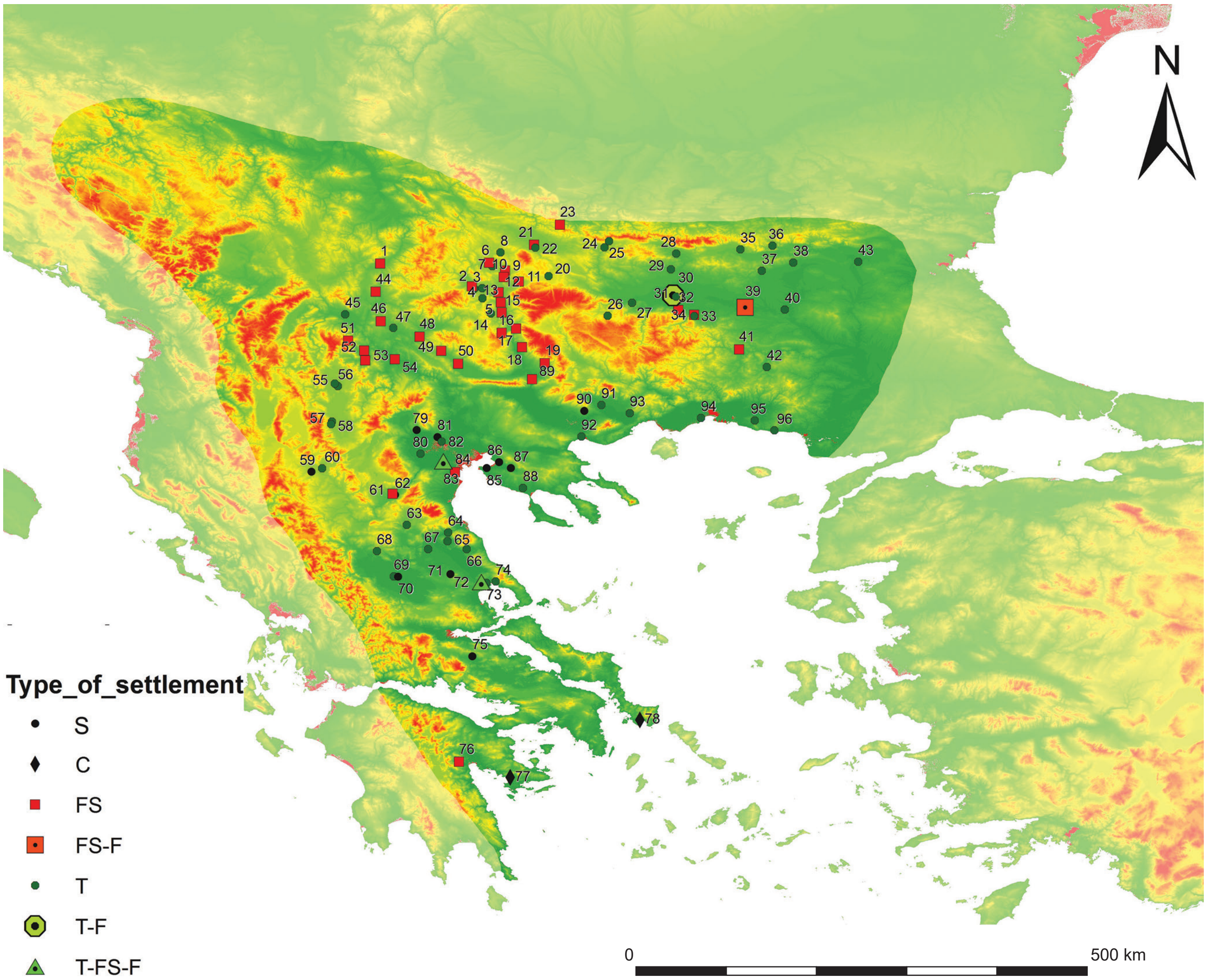

Figure 1. Location of Neolithic settlements in the southern Balkans. Settlements are divided by type. Explanatory notes: Legend explanations: S – unspecified type of settlement, C – cave, FS – flat settlement, FS-F – flat settlement with fortification, T – tell, T-F – tell with fortification, T-FS-F – Tell with surrounding flat settlement and fortification. Source: *EnviroBalkan* database (LAPE USB České Budějovice). Data and visualisation: T. Majerovičová, J. Bumerl.

1 – Pavlovac, 2 – Piperkov Chiflik, 3 – Bersin, 4 – Nevestino, 5 – Vaksevo, 6 – Priboy, 7 – Negovantsi, 8 – Pernik, 9 – Galabnik, 10 – Kremenik, 11 – Kraynitsi, 12 – Kamenik, 13 – Mursalevo, 14 – Drenkovo, 15 – Balgarchevo, 16 – Dobrinishte, 17 – Brezhani, 18 – Ilindentsi, 19 – Kovachevo, 20 – Kremikovtsi, 21 – Slatina, 22 – Slatina Gradini, 23 – Eleshnitsa, 24 – Chavdar, 25 – Ginova mogila, 26 – Rakitovo, 27 – Kapitan Dimitrievo, 28 – Dabene – Pishtikova mogila, 29 – Chernichevo – „Manastirya“, 30 – Plovdiv, 31 – Plovdiv – Yassatepe, 32 – Kuklen, 33 – Muldava, 34 – Muldava, 35 – Kazanlak, 36 – Azmak I, 37 – Stara Zagora, 38 – Karanovo, 39 – Yabalkovo, 40 – Chavdarova Chesma, 41 – Karadzhali, 42 – Krumovgrad, 43 – Veselinovo, 44 – Mlado Nagoričane, 45 – Tumba Madjari, 46 – Gorobinci, 47 – Amzabegovo, 48 – Vršnik, 49 – Kanli Čair, 50 – Stranata Angelci, 51 – Zelenikovo, 52 – Mramor, 53 – Dzuniver, 54 – Resava, 55 – Vrbjanska Čuka, 56 – Topolčani, 57 – Porodin, 58 – Veluška Tumba, 59 – Avgi, 60 – Dispilio, 61 – Servia, 62 – Servia, 63 – Platia Magoula Zarkou, 64 – Makrychori, 65 – Galini, 66 – Rachmani, 67 – Argissa, 68 – Sykeon, 69 – Prodromos, 70 – Myrrini, 71 – Tsangli, 72 – Sesklo, 73 – Dimini, 74 – Pevkakia, 75 – Elateia, 76 – Lerna, 77 – Franchthi, 78 – Agia Triada, 79 – Mandalo, 80 – Nea Nikomedeia, 81 – Yannitsa, 82 – Archondiko, 83 – Paliambela, 84 – Makriyalos, 85 – Stavroupolis,86 – Thermi, 87 – Vassilika, 88 – Mesimeriany, 89 – Promachon Topolnica, 90 – Dimitra, 91 – Sitagroi, 92 – Kryoneri, 93 – Dikili Tash, 94 – Lafrouda, 95 – Krovili, 96 – Makri.

first type is a horizontal settlement (in other words – flat, extended) with a single layer of settlement (Tolevski, 2009; Nikolov *et al.*, 2015; Pappa *et al.*, 2004; Vuković *et al.*, 2016). The second type is the tell settlement site, which constitutes several settled horizons, due to which the stratigraphy of the settlement is often high – sometimes up to several metres (Rosenstock, 2006; Nikolov, 2007; Darcque *et al.*, 2007; Naumov, 2016). Settlements are usually open; however, fortified sites have been registered as well (Kotsakis, 1999; Raczky, 2015). The considerable stratigraphy of tells demonstrates how deep was the attachment between the inhabitants of a tell and its settled area. However, some tells constitute only two settled horizons and the height of the entire tell is not particularly significant; these tells could therefore be a kind of transitional form between the flat site and the tell-type settlement (Kreuz, Marinova, 2017).

The Neolithic tell settlements are initially established in the region of Thessaly and further dispersed along the tributaries of the great river networks, such as the Haliacmon, Vardar, Crna, Struma, Mesta and Maritsa and the rivers of the Thrace area (Kotsakis, 1999; Bailey, 1999; Naumov, 2018; Ivanova *et al.*, 2018). There is also a high concentration of Neolithic tell sites in the Pelagonia valley (Naumov, 2016), a region that will be a case study focus in this paper. The extent of the observed region of the southern Balkans is bounded in the north by the Stara Planina Mountains in Bulgaria and the rivers South Morava and Western Morava that merge in southern-central Serbia. According to several authors, this is the area of the first wave of Neolithic occupation that spread through southeast Europe, dated to the period between 6700/6500 and 5500 BC (Bailey, 2000; Pèrles, 2001; Rosenstock, 2006; Raczky, 2015).

1.3 The tell of Vrbjanska Čuka

Vrbjanska Čuka is a tell located in the northern part of Pelagonia, the largest valley in the Republic of Macedonia. The site is positioned approximately 1.5 km south-east of the villages of Vrbjani and Slavej, in the alluvial plain partially surrounded by the Buševa, Dautica, Babuna and Selečka mountains, and separated from the southern Pelagonian part by the Topolčanska Greda hills (Figure 2). Nowadays the rivers Blato and Prilepska are major sources of water supply, but before the establishment of irrigation systems in the 1960s there were also a number of smaller rivers and marshes in this area (Trifunovski, 1998).

Vrbjanska Čuka was discovered at the end of 1970s when its location began to be exploited for sand extraction.

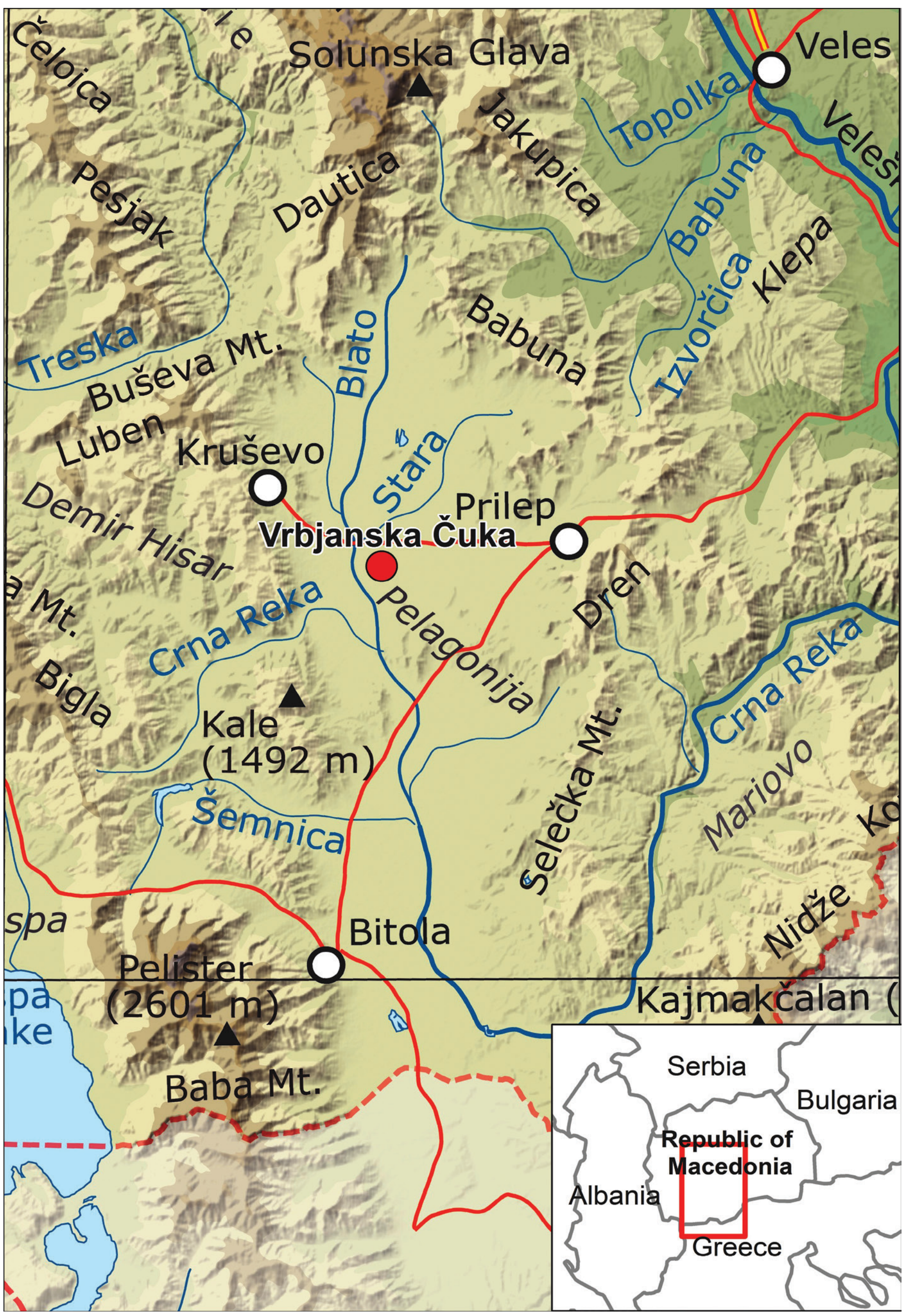

Figure 2. Map of Pelagonia with the location of the Vrbjanska Čuka tell. Visualisation: J. Bumerl.

Subsequently the damage to the site was halted and archaeological campaigns were initiated in 1979 that lasted until 1989, with an interruption between 1982 and 1987 (Kitanoski, 1989). The research, directed by the Museum of Prilep, was focused on the central part of the tell, where several trenches were excavated. These excavations provided some of the first information on the Neolithic in the northern part of Pelagonia and established this site as one of its major representatives. Study of the archaeological material has indicated that the site belongs to the Velušina-Porodin group, mainly due to the distinct features of the specific, white-painted patterns on its earliest pottery, anthropomorphic house models and tablet-"altars" (Mitkoski, 2005; Temelkoski, Mitkoski, 2005a; Temelkoski, Mitkoski, 2005b). In terms of its architecture, a large building was unearthed that was considered a "sanctuary" with a large daub installation referred to as an "altar" (Kitanoski *et al.*, 1990). Later, the identification of this building and structure has been reconsidered and its function discussed (Mitkoski, Naumov, 2008).

Due to its specific features and the potential for more comprehensive research on Vrbjanska Čuka, a new excavation campaign was initiated in 2016 and it is still ongoing (Naumov *et al*., 2016; 2018a; 2018b). The project is directed by the Center for Prehistoric Research and is focused on multidisciplinary research that integrates the work of several Macedonian and European institutions, such as: excavation, prospection, topography, GIS analysis, study of finds and architecture (Center for Prehistoric Research, Museum of Prilep and Institute for Old Slavic Culture); archaeobotany (University of South Bohemia); archaeozoology, 3D-modelling, isotope and lipid analysis (Biosense Institute); use-wear analysis and radiocarbon dating (Spanish National Research Council); geological research (Institute for Mining and Geology of Macedonia); building techniques analysis (Free University Berlin); geomagnetic scanning (Pryncipat-Krakow); digital measuring (University of Primorska); and radiocarbon dating (University of Bern). This multidisciplinary approach, with the involvement of various specialists, has provided an entirely novel perspective of the Vrbjanska Čuka tell and enabled a more thorough understanding of the first farming communities in Pelagonia and in the Republic of Macedonia in general (Naumov *et al.*, 2018a).

The recent study indicates that the tell was approximately 130 m wide and 4 m high, but with only 1.80 m of archaeological stratigraphy (Figure 3), thus confirming the natural bulk of sand from a lake of Neogene origin, on which the tell was established in the Neolithic (Naumov *et al*., 2016; Arsovski, 1997; Dumurdzanov *et al*., 2004). Such an elevated position was most likely used because of the frequent floods and marshy environment that have been demonstrated by the geological research in the region (Trifunovski, 1998; Naumov *et al*., 2018a). Geomagnetic scanning has demonstrated the presence of approximately 25 buildings enclosed by a ditch for the protection of the settlement from conflicts, fire, water or for the control of animals. The excavations have indicated seven buildings made of wattle and daub or wood, with some consisting of large constructions, such as Building 1 and Building 2 that have a system of bins, storage and cereal-processing installations, ovens and a high quantity of grinding stones, giving evidence of the dynamic activity related to the production of flour and bread (Naumov *et al*., 2018a).

The cereal-focused economy is further confirmed by the large number of flint tools that were used as harvesting sickles. Regarding its farming economy, the Vrbjanska Čuka community herded and consumed cattle as much as caprovines, and to a lesser extent pigs, the latter a rare practice among the many other Neolithic settlements in the Balkans. The specific features of this society are also evidenced in their material culture, mainly concerning its

Figure 3. View of the Vrbjanska Čuka tell from the south (after Naumov *et al.*, 2016).

pottery, figurines and anthropomorphic house models that have some visual elements uncommon for other settlements in Pelagonia. Radiocarbon dating of the site shows it to have been active at the very beginning of the 6th millennium BC, *i.e.* the end of the Early Neolithic (Naumov *et al*., 2018a). Recent research on Vrbjanska Čuka has also provided a large set of data regarding its spatial organization and relationship with neighbouring sites, landscape, farming economy, building techniques, use-wear, and lipid, isotope and AMS analysis, that are part of an ongoing study process, as well as the data from the archaeobotanical research that is the major focus of this paper.

The landscape setting of Vrbjanska Čuka and its archaeological features has stimulated a comprehensive archaeobotanical research programme in association with the Archaeobotanical summer schools (2016–2018). The aim for season 2016 was to estimate the bioarchaeological potential of the site through several bioarchaeological methods, in particular, archaeobotany (plant macroremains, plant microremains) and archaeozoology (malacological analysis).[1] Specific goals were targeted on the Neolithic layers content, such as the composition of useful plants in the macroremains record and plant use as reflected in the evidence of phytoliths and starch remains.

2. Material and Methods

Research on the organic remains from the Vrbjanska Čuka tell is being undertaken from two main methodological standpoints. The first one deals with the general archaeobotanical context within the framework of current bioarchaeological research. This was the main reason why a database of sites and the literature related to the Neolithic archaeology of southern part of the Balkans was prepared with particular attention to bioarchaeology and environmental archaeology (*EnviroBalkan,* see also Majerovičová, 2018).[2] This has formed the basis for the comparison of our data from Vrbjanska Čuka within the broader geographical context of the Neolithic period. The second methodological standpoint includes our own bioarcheological multi-proxy approach working with the synergy that comes from several analytical methods.

2.1 Multi-proxy approach in archaeobotany and the character of sampled layers and contexts

The multi-proxy approach in bioarchaeology is today the dominant mode of an onsite archaeological approach (*e.g.* Neumann *et al.*, 2009; Grabowski, Linderholm, 2014; Shillito, 2017; Devos *et al.*, 2017). The advantage comes from the synergy between its particular methods, which are able to record and explain crop and other botanical and biological remains from different perspectives and at various scales. The map (Figure 4) shows those settlements of the region that were explored by bioarchaeological analyses and have been recorded in international or other accessible literature. It indicates the analyses of phytoliths, starch, pollen, botanical macroremains, animal bones and molluscs. The most comprehensively researched settlements and best examples in the southern Balkans up to now are the sites of Sitagroi, Dispilio, and Argissa. The most frequent kind of bioarchaeological analysis concerns animal bones and botanical macroremains. Frequently a combination of both methods is used at one site; however, the combination of more methods is still comparatively rare.

The analysis of plant microremains is generally very rare. Several phytolith studies were performed within the excavations of the Neolithic period. At the pottery Neolithic village Makri in northern Greece, phytolith analysis was combined with an ethnographic study of the agropastoral community living in the same area, comparing samples from both archaeological and recent reference contexts (Tsartsidou *et al.*, 2009). Another study successfully examined the domestic and ritual use of plants in the Neolithic cave of Alepotrypa in the southern Peloponnese, with a focus on phytolith evidence, wood charcoal analysis and recent vegetation, which was processed for a reference collection (Ntinou, Tsartsidou, 2017). Along with geophysical methods and a micro-stratigraphic examination, phytolith analysis also played a role in understanding the formation processes of two Neolithic tell sites located by the ancient Sebes-Körös river on the Great Hungarian Plain (Parkinson *et al*., 2018). Although phytolith analysis can be successfully applied in various archaeological situations, there is still plenty of methodological issues which must be considered when sampling, analyzing and interpreting results (see Shillito, 2013).

2.2 Methodology of botanical macroremains analysis

Archaeobotanical material from the Vrbjanska Čuka 2016 field season was obtained by test sampling of archaeological contexts. Samples were taken from different contexts from the site and from a section in the western part of the excavated area (profile W1). Although Vrbjanska Čuka is a multistratigraphic site, the main effort in the pilot field season of 2016 was put into the sampling of Neolithic contexts. For the pilot analysis, 8 samples from various parts of four quadrants were sampled by the team of Macedonian archaeologists and a further seven control samples were taken by the Czech team from the western section (Figure 5, 6) of the trench. Profile W1 was primarily sampled for phytolith analysis, so the volumes of W1 samples were only 5–10 litres per sample. The number of identified seeds of the W1 profile was included in the total amount of all seeds, but due to their small predictive value, they will not be discussed in this paper. All the samples of dry sediment, with a total volume of 404 l, were processed by water flotation using

[1] The major archeozoological research (analysis of animal bones) is performed by specialists from the Biosense Institute and Beograd University (Novi Sad, Serbia) in a parallel project whose preliminary results are published in Naumov *et al.*, 2018a.

[2] EnviroBalkan is an internal database owned by the Laboratory of Archaeobotany and Palaeoecology USB comprising electronically stored literature as well as metadata concerning the environmental and bioarchaeological research in the Balkans.

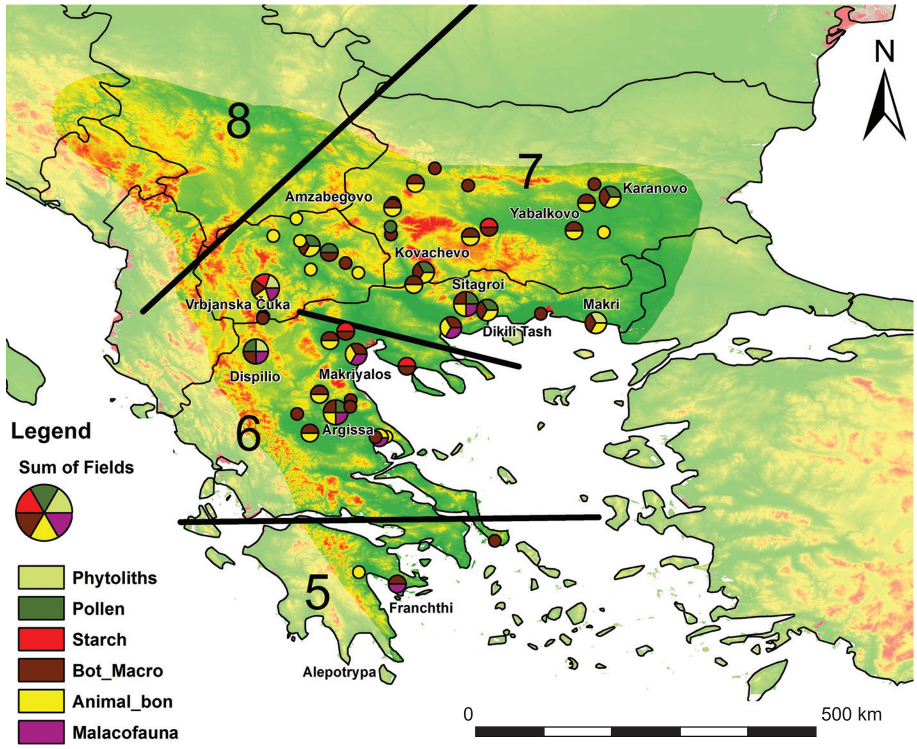

Figure 4. The map indicates settlement sites in the southern Balkans where onsite environmental analyses were conducted. The map displays settlements as graphs, which show where the analyses of macroremains, microremains (phytoliths, pollen, starch) and archaeozoology (animal bones, malacofauna) have been carried out. Black lines and numbers: archaeobotanical "phylogenetic" regions (after Coward *et al.*, 2008, see also Shennan, 2017). Source: *EnviroBalkan* database (LAPE USB České Budějovice). Data and visualisation: T. Majerovičová, J. Bumerl.

a modified version of an Ankara machine (Pearsall, 2015, pp. 50–51) with a sieve of 0.25 mm mesh size. The heavy fractions (residuals) from flotations were dried and inspected (Cappers, Neef, 2012, p. 231). Laboratory identification of the light fraction was carried out with a stereomicroscope using the standard determination approach (Jacomet, Kreuz, 1999) and subsequently compared with identification keys (Anderberg, 1994; Berggen, 1969; 1981; Jacomet, 2006; Cappers *et al*., 2006).

Anthracological material from the Neolithic levels of profile W1 was analysed. Charcoal was separated during plant macroremains processing. Analysis of charcoal pieces was carried out using the Nicon Eclipse 80i light microscope and the findings were compared with the anatomical atlas of microscopic wood (Schweingruber, 1978; 1990) and with the reference collection of LAPE USB České Budějovice. Charcoal was very rare among the macroremains (only 10 identifiable pieces) and thus the anthracological analysis only tested the possibilities for future research.

Archaeological units sampled for analysis of botanical macroremains:

- Unit 11 is compact sediment full with river shells and Neolithic red fine pottery.
- Unit 12 is compact sediment just above Building 2 that has been used due to occupation activities in the Neolithic after life at the level of Building 2.
- Unit 18 has the same features as 12, *i.e.* a level above the daub of Building 2 and below the daub of Unit 6, *i.e.* in between two Neolithic layers.
- Unit 26 is a pit with later origin that cannot be confirmed as Neolithic, although there is also Neolithic pottery, but Medieval as well.
- Unit 29 is a layer of soil beneath and around the pit Units 25, 26, 27, 28, *i.e.* the Neolithic level disturbed by these later pits.
- Unit 51 is white-greyish soil most likely of ash that is besides Building 2 and the one next to it and belongs to the Neolithic levels.
- Unit 58 is daub belonging to Building 4 associated with the wall of the bigger structure bin/silo that is also Neolithic.

2.3 Methodology of botanical microremains and character of sampled materials

Botanical microremains analysis is represented in Vrbjanska Čuka by phytolith and starch analyses. Phytoliths are microscopical particles of amorphous SiO_2 (biogenic Opal–A), which are created in cells, cell walls and the intercellular space of plant bodies (Piperno, 2006). They are formed in various shapes and due to their chemical resistance can provide information concerning decomposed plant material after thousands of years. Phytolith analysis is a method of optical microscopy which has been widely used for enlightening archaeological situations in recent decades (see, *e.g.* Pearsall, 1982; Rosen, 1995). Phytoliths can be extracted from the soil samples of various contexts and features, as well as from residues found on pottery, stonework and other types of artefacts.

On the Vrbjanska Čuka archaeological site, in 2016, sampling of a section (W1) in the western side of a trench was made to obtain material in order to recognise the presence and quality of phytoliths on the site. The section, 150 cm deep, was divided into seven samples, according to the archaeological knowledge of the stratigraphy of the

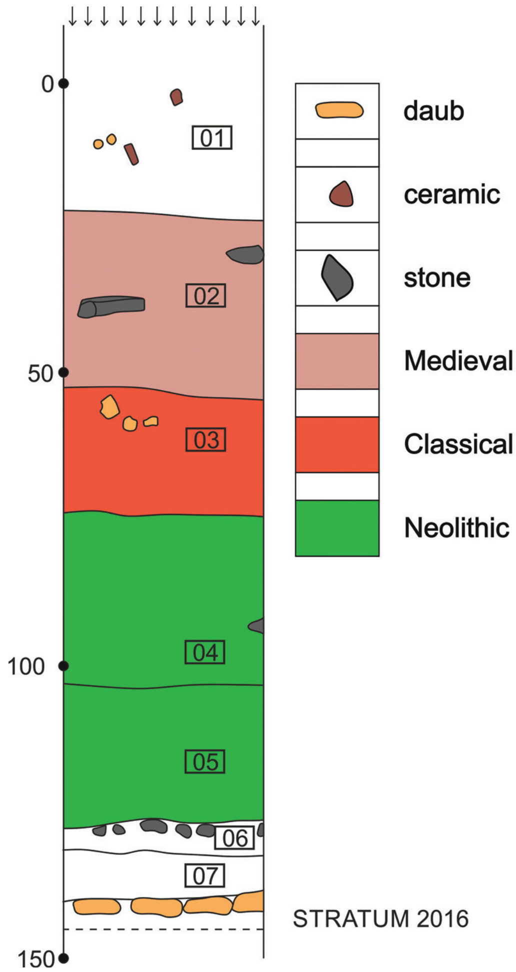

Figure 5. Section W1 in the western part of the trench. Visualisation: J. Bumerl.

tell. One sample from a related context (Unit 11) at the base level of the profile was also taken for initial analysis. From an archaeological point of view, the profile enters a space around the western edge of Building 2.

Samples from profile W1:

- Sample 01: 0 cm (603.64 m asl) – 23 cm, grey with orange daub + human bones.
- Sample 02: 23 cm – 53 cm, grey with pebbles + small daub, Medieval period horizon.
- Sample 03: 53 cm – 74 cm, light grey with artefacts, Classical period horizon.
- Sample 04: 74 cm – 103 cm, light grey with small gravel, Neolithic horizon.
- Sample 05: 103 cm – 126 cm, light grey powder, Neolithic horizon.
- Sample 06: 126 cm – 132 cm, light grey with pebbles, small fine, Neolithic horizon.
- Sample 07: 132 cm – 140 cm, above floor level, Neolithic horizon.
- Sample Unit 11: compact layer with content of river mussels and red painted Neolithic pottery.

Phytoliths were separated from soil samples following the principles of the methods designed by Albert and Weiner (2001), with the help of an ultrasonic cleaner used in between steps for better loosening of single particles (Lombardo *et al.*, 2016). Due to the potential-testing character of the initial analysis, the sediment was not dried and weighed throughout the process, thus the quantitative aspects of the analysis must, for now, be omitted. Most of the steps of separation were performed in 50 ml polypropylene tubes with two grams of sediment sieved on 0.4 mm and centrifugation at 2500 rpm. In between separation steps, the pellets were washed in distilled water by centrifugation several times, to make sure that different chemicals subsequently used in the process did not react with any residual chemical remaining. Content of calcium carbonates was detected by adding hydrochloric acid (6M HCl) to each sample and the level of fizzing was recorded on a scale 0–5. Clays were removed by binding on sodium hexametaphosphate (50g/1l solution, $Na(PO_3)_6$ and organic material was than dissolved by adding hydrogen peroxide (30% H_2O_2). The acid insoluble fraction (AIF) was obtained by putting concentrated nitric acid (65% HNO_3)

Figure 6. Section in the western wall of the Vrbjanska Čuka tell. Photo: J. Beneš.

and boiling the tubes in a water bath, after which a heavy liquid separation of phytoliths was performed by sodium polytungstate (SPT) calibrated at a density of 2.35 g/cm^3.

Phytoliths were observed and photographed at 400× or 200× magnification under a Nikon Eclipse 80i polarizing microscope, using distilled water or Euparal epoxide as a medium. Morphotypes were preferably described according to the International Code for Phytolith Nomenclature (ICPN) (Madella *et al*., 2005). The presence of morphotypes in the samples was recorded taking some effort to register all the morphotypes, but there were also many phytoliths present whose shape could not be determined to a satisfactory level of certainty, including particles too small to be described with 400× magnification, whose description is a matter of future analysis.

Sampling for starch analysis was carried out at the Vrbjanska Čuka site or at the Institute for Old Slavic Culture in Prilep. The material that was processed were stone tools (grinders). Some grinding stones were documented, packed by archaeologists at the site, and processed in a room, prepared for analysis. Samples were taken from the surfaces of chosen objects by a non-destructive method. The objects were cleaned from the remains of the soil in which they were preserved. Samples were mainly taken from small cavities and cracks in which there is theoretically the greatest chance of preserving the microscopic parts of the processed plant materials. They were collected using a micro-pipette and a dropper. Distilled water was dripped into the surface structure and then the dissolved material was taken from the surface by micro-pipette. The sampled liquid was then injected into a micro tube (Therin *et al*., 1997). Samples were stored in micro tubes with an alcohol solution. Samples were then transported to the refrigerator as quickly as possible (Therin *et al*., 1997). Due to the relatively short duration of the archaeobotanical mission and limited transport capacity, samples for starch analysis were primarily taken from stone tools.

Microscopic analysis of the chemically-treated and separated samples was performed on a light polarization microscope. The microscopic station is equipped with a digital sensor, recording device and software for processing and analysis (measuring). Identification was based on an optical assessment and digital measurement of the shape and size of starch grains (Reichert, 1913; Piperno, 2006; Torrence *et al*., 2006; Moss, 1976).

2.4 Method of malacological analysis from flotation samples

Malacological material, represented by small-scale snails obtained by flotation during analysis of plant macroremains (micro-molluscs) from season 2016, was observed and documented under a stereomicroscope and species were then determined (Ložek, 1964).

Hand-collected faunal remains, animal bones from the 2016 campaign, were analysed by a Serbian team from Belgrade from the Biosense Institute and are not the subject of this paper, but the preliminary results are provided (Naumov *et al.*, 2018a). In addition, faunal remains collected by archaeobotanical flotation were studied in order to gain more information on the taxon/element distribution with respect to sampling techniques, *i.e.* information on smaller taxa which were potentially used as food or inhabited the surroundings of the site.

3. Results

3.1 Plant macroremains

Floated samples of light fraction contained charred and uncharred plant remains, molluscs, and charcoal pieces, and some of them contained small animal bones and entomofauna. Most of the residuals contained pieces of ceramic, small animal bones, mussels, occasionally charcoal pieces and macroremains. A total of 7,770 macroremains were counted and determined (3,562 charred and 4,208 in an uncharred state). The charred plant macroremains represented a smaller part of the assemblage, and in general, lots of them were fragmented or did not exhibit important morphological characteristics for identification to species, thus they were determined to genus only. Wild plants of the recent vegetation growing around the site today represented most of the macroremains in an uncharred state. Therefore, only charred seeds will be commented on and presented in this paper. Given that the analysed material from the 2016 season will be discussed in the future with other experts, the results of the macroremains presented in Table 1 contain only the presence and absence of taxons. The complete results of the research seasons in 2016, 2017 and 2018 will be published separately together with statistical analyses in the future.

Although, as mentioned above, there was an attempt to sample the Neolithic contexts, some of the analysed species of cereals in the samples from Quadrant 23 (as you can see in Table 1, for example. samples 1, 3 and 6), are not typical cultivated crops of the Neolithic period in the Southern Balkan region. Sample 3 (Quadrant 23/Unit 26) was taken from the filling of the pit where the Neolithic and Medieval ceramic artefacts were found. The most numerous type of cereal (over 1200 grains) from this pit was *Panicum miliaceum* – millet (Figure 7f). Apart of this the grains (14 finds) of *Secale cereale* – rye (Figure 7e), one grain of *Triticum spelta* (spelt) and *Triticum* cf. *spelta*, more than 20 grains of free-threshing wheat *Triticum aestivum* (bread wheat), and lot of fragments of cereal grains were found here. Sample 1 (Quadrant 23/ Unit 29) was taken from the layer of the Neolithic level which was disturbed by younger pits, for example, by Unit 26. In the case of the cereals, a certain similarity was observed in this sample (*i.e.* five grains of *Panicum miliaceum* and two grains of *Secale cereale,* one grain of *Triticum* cf. *spelta* and *T. spelta/dicoccum*), with small differences in the presence of other useful species. A similar composition to that in sample 3 (*i.e.* the presence of over one hundred grains of millet, and a few grains of rye and bread wheat) was observed in sample 6 of the Neolithic Unit 58.

Table 1. Presence and absence of charred macroremains in samples. Note: g – grain; f – fruit; s – seed; e – endocarp; gb – glume base; sf – spikelet – fork.

Sample		**W1/1**	**W1/2**	**W1/3**	**W1/4**	**W/5**	**W1/6**	**W1/7**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Quadrant									**23**	**26**	**23**	**31**	**31**	**23**	**22**	**31**
Unit									**29**	**29**	**26**	**18**	**12**	**58**	**51**	**11**
Volume (L)		**5**	**5**	**10**	**7**	**5**	**5**	**5**	**75**	**69**	**35**	**37**	**50**	**40**	**44**	**12**
Plant taxa																
Cereals																
cf. *Avena*	g										x					
Hordeum vulgare	g			x			x	x	x	x	x	x	x	x	x	
Panicum miliaceum	g								x		x			x	x	
Secale cereale	g								x		x			x		
Setaria cf. *verticillata*	g							x								
Triticum aestivum	g										x			x		
Triticum cf. *aestivum*	g			x							x					
Triticum aestivum/compactum	g										x		x			
Triticum sp.	g			x		x					x	x	x		x	x
Triticum sp.	gb			x	x	x	x	x	x	x		x	x	x		x
Triticum sp.	sf								x				x			
Triticum monococcum	g									x	x	x	x			x
Triticum monococcum	sf							x		x		x	x			x
Triticum monococcum	gb							x	x				x		x	
Triticum cf. *monococcum*	g						x						x			
Triticum dicoccum	g										x	x	x			
Triticum dicoccum	sf							x	x				x			
Triticum dicoccum	gb								x	x						
Triticum cf. *dicoccum*	g			x									x			
Triticum spelta	g										x					
Triticum cf. *spelta*	g								x		x					
Triticum spelta/dicoccon	g								x				x			
Cerealia	g			x	x	x		x	x	x	x	x	x	x	x	x
Legumes/pulses																
Fabaceae	s	x	x					x	x	x	x	x	x	x	x	x
Lathyrus sp.	s			x												
Lens culinaris	s							x	x	x	x	x	x	x	x	x
cf. *Lens culinaris*	s										x		x	x		
Medicago minima	s										x				x	
Medicago cf. *minima*	s													x		
Medicago polymorpha	f												x			
Medicago sp.	s															x
Pisum/Vicia	s								x		x	x	x	x	x	x
Pisum sativum	s												x			x
Trifolium/Medicago	s														x	
Trifolium cf. *repens*	s													x		
Trifolium sp.	s								x	x	x			x		x
Possible edible wild plants																
cf. *Ficus carica*	s		x													
Fragaria/Potentilla	s												x			
Prunus sp.	e				x								x			x
Rosa sp.	s									x						
Rubus fruticosus agg.	s				x	x										
Rubus sp.	s								x				x			
Sambucus ebulus	s								x		x		x		x	
Sambucus cf. *racemosa*	s											x				

Table 1. Presence and absence of charred macroremains in samples. Note: g – grain; f – fruit; s – seed; e – endocarp; gb – glume base; sf – spikelet – fork. (*Continuation*)

Sambucus sp.	s										x	x		x		
Vitis vinifera	s										x					
Wild plants/weeds																
Agrostemma githago	s										x					
Ajuga chamaepitys	s											x				
Anthemis cotula	s										x					
Arenaria serpyllifolia	s												x			
Asteraceae	s								x							
Bromus sp.	g										x		x			x
Carex 2D sp.	s										x					
Carex 3D sp.	s					x					x					
Cerastium sp.	s								x							
Convolvulus arvensis	s												x			
Cyperaceae	s								x		x		x	x	x	
Fallopia convolvulus	s									x	x		x			x
Fumaria officinalis	s												x	x		
Galium aparine	s								x							
Galium cf. *aparine*	s	x	x											x		
Galium sp.	s	x	x		x		x		x	x			x	x	x	
Galium spurium	s	x							x	x	x			x	x	
Galium verum	s			x												
Galium cf. *verum*	s															x
Galium/Veronica	s		x													
Geranium pusillum	s		x								x				x	
Hypericum sp.	s								x							
cf. *Chelidonium majus*	s												x			
Chenopodium album	s						x			x	x		x	x		
Chenopodium sp.	s						x	x		x	x	x	x	x	x	x
Lamiaceae	s		x										x	x		x
cf. *Malva*	s													x		
Neslia paniculata	s	x							x	x	x					x
Panicum/Milium	g									x						
Panicum/Setaria	g										x					
Papaver rhoaes	s				x											
Papaver sp.	s									x				x		
Plantago sp.	s			x												x
Poaceae	s							x		x	x			x	x	x
Polycnemum arvense	s				x		x			x				x		x
Polygonum aviculare	s							x		x				x		
Prunella sp.	s										x					
Rumex sp.	s		x					x	x	x	x		x	x	x	
*Setaria*sp.	g										x		x			x
Silene viscaria	s								x							
Stellaria sp.	s												x		x	
Thymus sp.	s								x							
Verbena officinalis	s									x					x	
Veronica hederifolia	s	x							x							
Veronica cf. *hederifolia*	s														x	x
Veronica cf. *praecox*	s	x	x												x	
Veronica sp.	s								x				x	x		
Viola sp.	s											x		x		

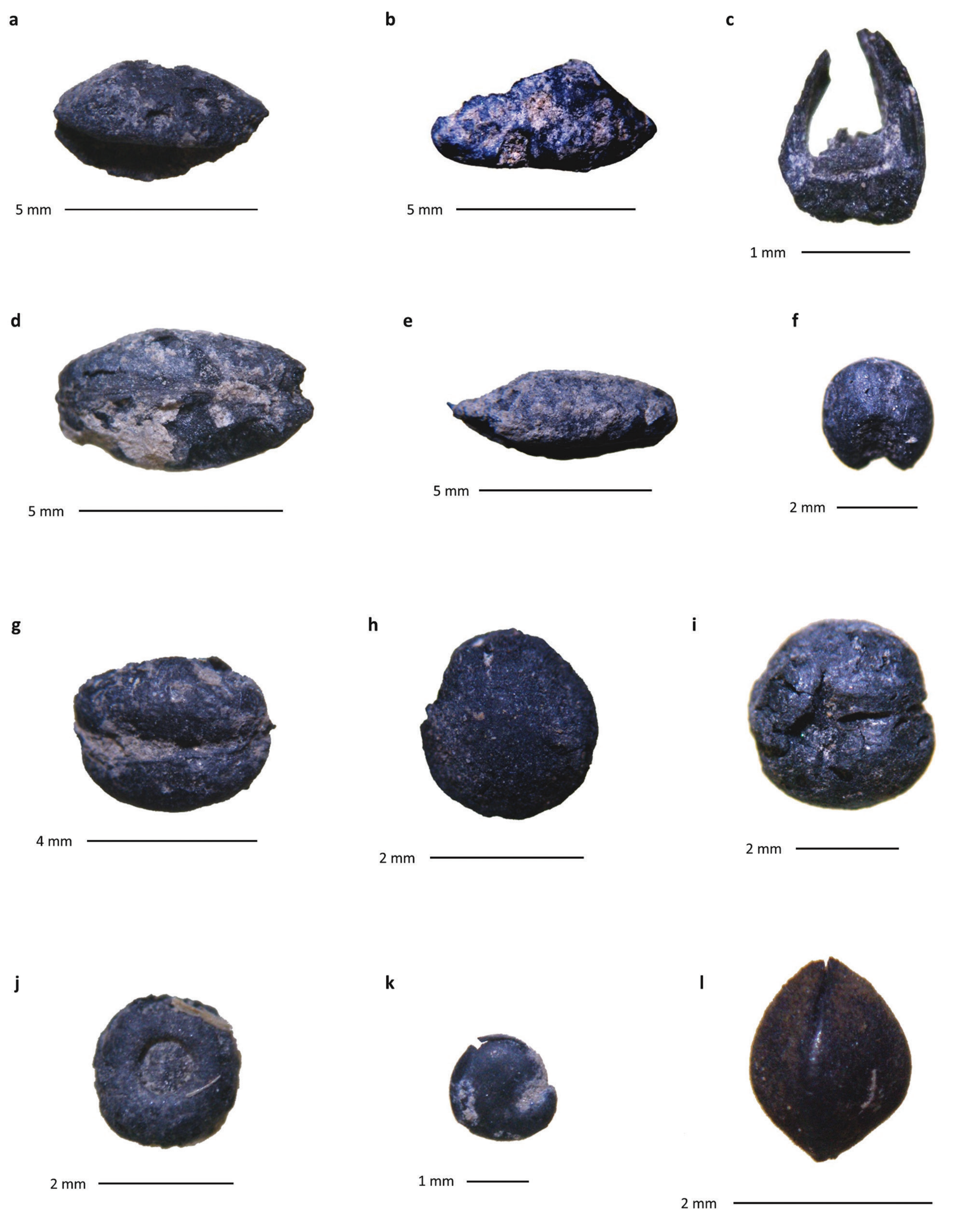

Figure 7. Charred macroremains: a – *Triticum monococcum* (lateral); b – *Triticum dicoccum* (lateral); c – spikelet fork of *Triticum monococcum*; d – *Hordeum vulgare* (ventral); e – *Secale cereale* (lateral); f – *Panicum miliaceum* (ventral); g – *Triticum aestivum/compactum* (ventral); h – *Lens culinaris*; i – *Pisum sativum*; j – *Galium* sp.; k – *Chenopodium* sp.; l – *Fallopia convolvulus.* Photos: M. Vychronová.

Table 2. Occurence of phytolith morphotypes and calcium carbonate content (0–5) in samples from W1 profile and a nearby floor level (U11). Data by K. Budilová.

Name/ W1 Samples	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**U11**
Grass phytoliths – *Poaceae* family								
dendritic	x	x	x	x	x	x	x	x
elongate echinate	x	x	x	x	x	x	x	x
inflorescence skeleton	x	x	x	x	x	x	x	x
papillae	x	x	x	x	x	x	x	x
rondel				x	x	x	x	x
saddle1	x	x	x	x	x	x	x	x
saddle2				x	x	x	x	x
trapeziform short cell	x				x		x	x
trapeziform sinuate/polylobate					x	x		
bilobate short cell	x		x	x	x	x	x	x
polylobate	x	x	x	x	x	x	x	x
elongate castellate	x				x	x		
elongate sinuate	x	x	x	x	x	x	x	x
elongate sinuate oblong	x		x	x	x	x		x
elongate psilate	x	x	x	x	x	x	x	x
stems/leaves skeleton psilate	x	x	x	x	x	x	x	x
stomata/ skeleton with stomata	x	x	x	x			x	x
cuneiform bulliform	x	x	x	x	x	x	x	x
conjoined bulliforms	x				x		x	x
rectangular/square bulliform/parallepipedal	x			x	x	x	x	x
shield-shaped trichome	x	x	x	x	x	x	x	x
cross	x				x			
Sedge phytoliths – *Cyperaceae* family								
cone/hat						x	x	x
Woody/dicotyledonous phytoliths								
trichome (unknown origin)		x	x	x	x			x
elongate oblong psilate	x	x	x			x	x	x
elongate prismatic psilate	x				x	x	x	
other skeleton	x		x	x	x	x	x	x
oval spherical psilate	x	x	x	x	x		x	x
tracheid	x		x					
extra long bulbuous psilate			x		x	x	x	x
small globular psilate	x		x				x	x
polyhedral								x
polyhedral pitted							x	
globular granulate						x	x	x
globular pitted dotted					x			x
long cell pitted - woody								x
blocky perforated rectangular psilate	x		x			x		x
Silicaeous Algae microfossils - diatoms	x		x					x
Number of described morphotypes	26	16	22	20	27	25	27	30
Calcium carbonate content (0-5)	0	0	5	3	5	3	3	4

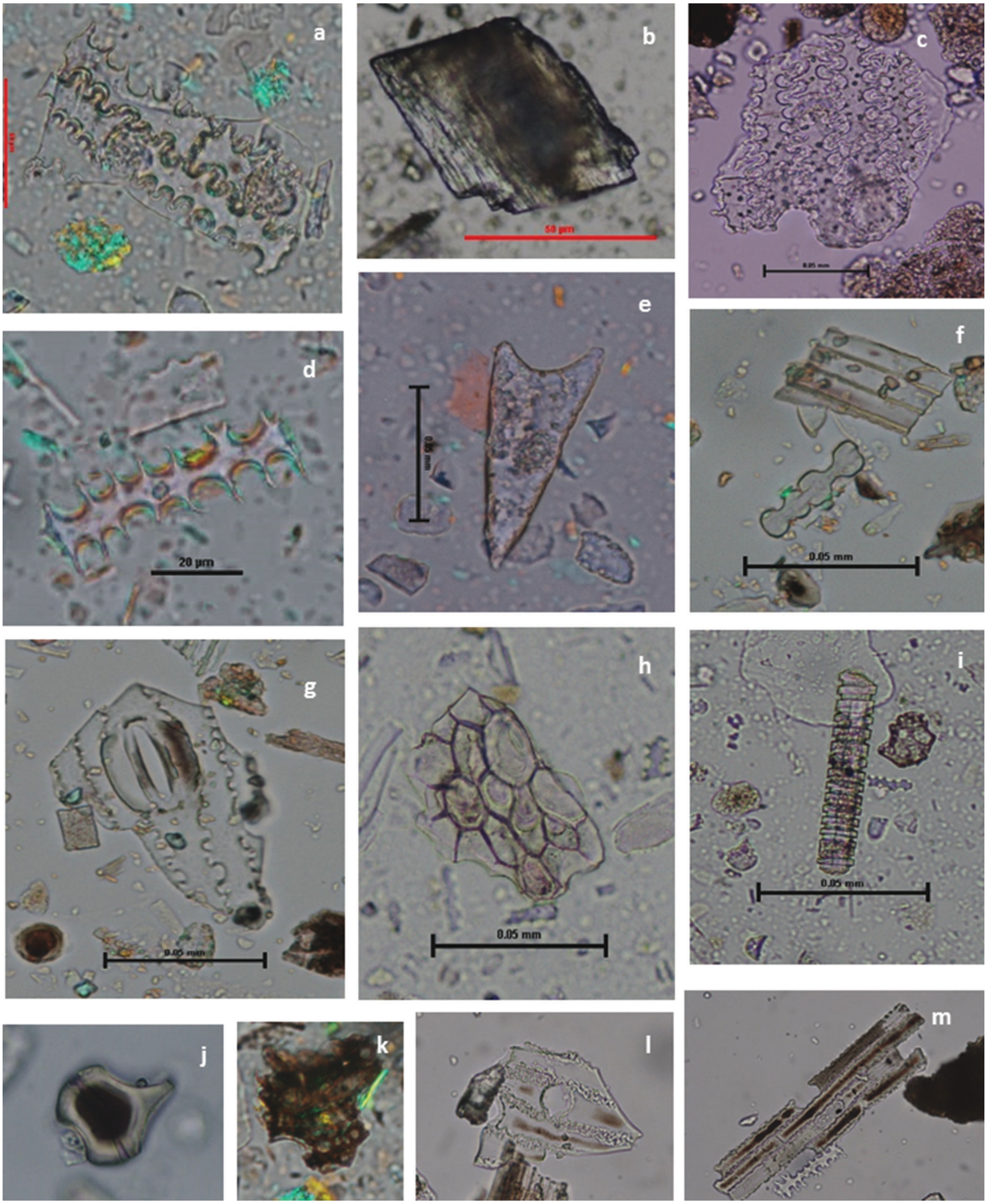

Figure 8. Phytoliths originating in the Neolithic layers of W1 profile: a, c, l, m – *Poaceae* inflorescences – skeletons; b – *Poaceae* stems/leaves; d – single dendritic phytolith, cf. *Triticum*; e – corroded shield-shaped trichome; f – *Poaceae* conjoined bilobates and stems/leaves skeleton; g – *Poaceae* inflorescence skeleton with stomata; h – epidermal silicified cells (dicots); i – possibly herbaceous phytolith (dicots); j – *Poaceae* stems/leaves, cuneiform bulliform); k – microcharcoal; all 400× magnification. Photos: K. Budilová.

In other sampled Quadrants, specifically in the sample from Quadrant 22/Unit 51, one grain of millet and in Quadrant 31/Unit 12, one grain of *Triticum aestivum/compactum* (Figure 7g) were also found.

The remains of the charred cultivated plants from the other contexts were in small numbers (a few finds) represented by the hulled cereal *Hordeum vulgare* – barley (Figure 7d), which was observed in almost each sample. Apart from a few grains of hulled wheats, such as *Triticum monococcum* – einkorn (Figure 7a) and *Triticum dicoccum* – emmer (Figure 7b), some parts of *Triticum* spikelets – glume bases and spikelets forks (Figure 7c) were identified, and the total number of T. spikelet parts exceeds the number of grains. Attention is currently focused on the possibility of the presence of spikelet forks of a "new glume type" wheat (Jones *et al*., 2000), whose determination is still questionable.

Pulses were represented by a single find of *Lens culinaris* – lentil (Figure 7h)*, Pisum/Vicia,* which could not be identified more closely, and a few seeds of *Pisum sativum* – pea (Figure 7i). The possibly gathered, edible wild plants were represented rarely by sporadic finds of a few fragments of *Prunus* sp., *Sambucus* spp. and *Rubus* sp. Seeds of *Potentilla/Fragaria* and *Rosa* sp. were also recorded. Wild plant taxa were also represented by single finds of arable weeds such as *Fallopia convolvulus* (Figure 7l), *Polygonum aviculare*, *Galium spurium,* or crop weeds/ruderals such as *Chenopodium* sp. (Figure 7k), *Galium* sp. (Figure 7j), *Rumex* sp. or *Polycnemum arvense*. Some potential grasslands species such as *Trifolium* sp., *Medicago* spp., *Plantago* sp. were also observed.

The state of the charcoal pieces was very bad, and the fragments were very small. The size of the charcoal fragments was on the lower limit for wood anatomic identification (2–5 mm) and only 2 fragments of *Pinus* sp. and 2 fragments of *Quercus* sp. were analysed. Such small amounts do not allow any conclusions to be drawn, except to state the presence of pine and oak in the Neolithic period around the Vrbjanska Čuka site.

3.2 Phytoliths

The presence of recognized specific phytolith morphotypes and the level of fizzing when dissolving calcium carbonates (on a scale 0–5) are noted in Table 2. Examples of phytoliths from layers dated to the Neolithic period are displayed in Figure 8.

From all of the processed samples we gained enough silica phytoliths for multiple observations and a successful analysis. The state of preservation of the phytoliths is generally very good and allows us to distinguish various characteristics and taphonomy.

The presence of *Poaceae* species morphotypes is continuous through the whole profile. The samples contain many single-cell phytoliths of Festucoid, Panicoid, Chloridoid and Elongate morphotype-classes (Twiss *et al*., 1969), indicating a wide spectra of grass species entering the archaeological sediment. Some elongate echinate/dendriform phytoliths and their skeletons recovered from the Neolithic levels closely resemble residues of *Triticum* (Ball *et al*., 1993; Berlin *et al*., 2003; Ball *et al*., 2017) and *Hordeum* (Madella, 2007), but many other skeletons of unidentified chaff were noticed during the analysis, including inflorescences of wild grasses, whose identification is not possible without a relevant reference collection. Inflorescence skeletons with stomata are sometimes referred to as the residues of common reed (Ntinou, Tsartsidou, 2017). Rondels, trapezoids and saddles (possibly trapezoids from top-view), whose presence is noticeable in the lower part of the profile, are morphotypes indicating rather xerothermic grasses (Solomonova *et al*., 2017). Attention should be paid to bilobates, as they have very good diagnostic potential; Panicoid bilobate shapes are most common in the sediment but there are also other bilobate variations, which cannot be simply attributed to millets (*e.g. Panicum milliaceum, Setaria* sp. for their phytoliths, see Lu *et al*., 2009) and along with some specific polylobates they could also have originated from grasses, whose reference material is not yet available. Phytoliths from leaves or stems of grasses are represented mainly by the morphotype cuneiform bulliform and regular elongate psilate long cells (Piperno, 2006), which also appear in the form of skeletons.

All the morphotypes and their variations which do not fit a description of known monocotyledonous (grasses, sedges) phytoliths must have been sorted as woody/dicot elements. They appear more often at the lowest levels of the profile and the variability in their shapes and constellations of non-grass skeletons is outstanding, which again points to the remarkably heterogeneous composition of the original plant material.

Concerning taphonomy, multiple burnt single cells and skeletons are present and many of the skeletons demonstrate some kind of specific type of breakage, with sharp edges and straight, zig-zagged or concave cuts, but skeletons with non-sharp or natural edges are also present. Despite the generally very good state of preservation, some visible corrosion of the phytoliths appears as well.

The resemblance between the Neolithic layers and sample nr. 01 (topsoil) can be explained as a consequence of the deposition of Neolithic soil (excavated in the 1980s) near the trench. The content of calcium carbonate in the sediment seems to be rather high (except for the first two levels, which demonstrated no fizzing during the test). Possible contamination of the Neolithic levels by the upper horizons will be discussed below.

3.3 Starch analysis

In total 19 grinding stones were investigated from the 2016 excavation season (Table 3, Figure 9). From each artefact were taken several samples. The samples contained 20 *Poaceae* starch grains, 4 structures with a *Fabaceae* shape, 1 starch grain probably *Quercus* (needing verification by further observation), and 48 damaged or unidentified structures. In this analysis samples from 2016 are processed and described, this being the first and preliminary assessment.

Table 3. List of grinding stones from field season 2016 sampled for starch analysis.

Grindstone ID	Quadrant	Unit
70	31	3 west
71	31	3
71	31	3
72	31	south
73	31	
75	31	3
100	23	24
101	23	24
102	23	24
112	23	23
113	23	24
134	23	23
151	14	3 III
153	27	1
154	27	1
185	30	36
242	22	23
248	23	23
262	23	29

3.4 Results of malacological analysis

Nine species of land snails and three species of freshwater snails were found (Tables 4 and 5, Figure 10). Most of the species of the land snails are indicative of an open landscape with short-stemmed vegetation, probably created by grazing. Three species of gastropods (*Monacha cartusiana, Oxychilus depressus* and *Vitrea contracta*) indicate a shadier habitat, probably with shrubs or trees. The detected freshwater gastropods can inhabit small water reservoirs, overgrown with macrophytes.

Animal remains (excluding micro-molluscs) are not treated here in this paper, as they are the subject of analyses by I. Živaljević and V. Dimitriević. The hand-collected faunal sample from the 2016 field season (determined by I. Živaljević), albeit small, is indicative of a predominantly stockbreeding economy at the site (Naumov *et al*., 2018a). The majority of elements originate from domestic animals – namely cattle and caprines, and to a lesser extent pig and dog. A single element of a wild boar suggests that occasional hunting also took place. Large shells of freshwater molluscs were also identified. The faunal sample collected by flotation consisted of smaller bone fragments and the isolated teeth of previously-identified mammal taxa. In addition, sporadic remains of rodents, amphibians (frogs), reptiles and smaller fish (small-bodied cyprinids and salmonids) were also found (Naumov *et al*., 2018a).

4. Discussion

The assemblage of plant macroremains from the 2016 field season from Vrbjanska Čuka has been subjected to a preliminary examination as a whole. The main question was to see to what extent the plant species represented a similar or different structure. Plant species occurrence at selected Neolithic sites were analysed by multivariate statistical analysis. The main body of data used came from the supplementary data published by Colledge *et al.*, 2004: this dataset comprises archaeobotanical assemblages from Neolithic sites of the Eastern Mediterranean (Levant, Turkey, Cyprus, Crete and Greece) to which our assemblage from Vrbjanska Čuka was attached and preliminarily tested (see the Supplementary material). Binary (presence/absence) data of agronomically-interesting plant species were analysed by correspondence analysis (CA) (Lepš, Šmilauer, 2016). To evaluate the experimental data, statistical software Statistica 13 was used, low-occurring species (less than 10) being excluded from the dataset (Meloun, Militký, 2011). Visualisation of the data through correspondence analysis (Figure 11) indicates the proximity of the Vrbjanska Čuka assemblage to those of the Greek regions, as well as Cyprus. The outputs from the statistical analysis are, at this stage of

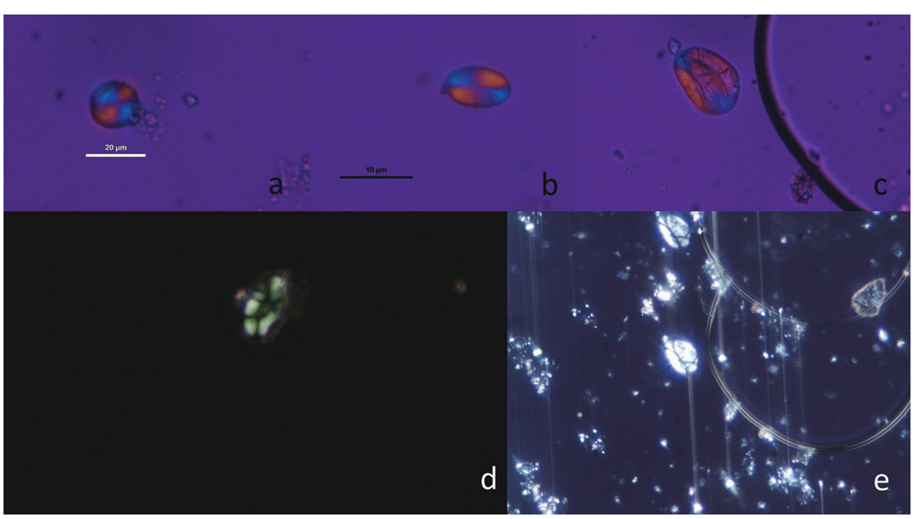

Figure 9. Starch grains from grinding stones: a, b – *Poaceae*; c – *Quercus*; d, e – *Fabaceae*. Photos: J. Kovárník.

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Table 4. Micro-mollusca finds from sampled quadrants in 2016 season.

species	Quadrant 22									Quadrant 23													
	Unit 51									Unit 26						Unit 58							
	9/1	9/2	9/3	9/4	9/5	9/6	9/7	9/8	9/9	3/1	3/2	3/3	3/4	3/5	3/7	7/1	7/2	7/3	7/4	7/5	7/6	7/7	7/8
Monacha cartusiana	9	2	3		2	1	1	1				1		1				1		1	1		1
Oxychilus depressus	13	11	8	6	7	7	8	7	3	5	6	8	4	5	7	5	5	6	2	3	6	3	5
Vitrea contracta										1													
cf. *Helicopsis* sp.										1			1										
Pupilla muscorum					1																		
Truncatellina cylindrica	2	4	3		1	1				2	1	1	8	3				2			1	2	2
Vallonia pulchella				1			1	1		3		2	2							1			
Vallonia costata						1				5	7	6	5	11	9			2				1	
Vertigo pygmaea															1							1	
Galba truncatula																							
Gyraulus laevis																							
Planornis planorbis	2	2		1		1													1				
Number of speciemns	26	19	14	8	11	11	10	9	3	17	14	18	20	20	17	5	5	11	3	5	8	7	8
Number of species	4	4	3	3	4	5	3	3	1	6	3	5	5	3	3	1	1	4	2	3	3	4	3

species	Quadrant 23														
	Unit 29														
	1/1	1/2	1/3	1/4	1/5	1/6	1/7	1/8	5/1	5/2	5/3	5/4	5/5	5/6	5/7
Monacha cartusiana	3	1	1		1		1	1	1	1	2		1	1	
Oxychilus depressus	4	4	4	1	5	10	7	5	7	4	9	9	1	7	12
Vitrea contracta															
cf. *Helicopsis* sp.															
Pupilla muscorum															
Truncatellina cylindrica	1			3		1					2			1	
Vallonia pulchella				1	1				1	1	2	2		2	2
Vallonia costata															
Vertigo pygmaea															
Galba truncatula			1	1											
Gyraulus laevis						1	2				1				
Planornis planorbis		2	1		1	2		1	1			1	1	1	1
Number of speciemns	8	7	7	6	8	14	10	7	10	6	16	12	3	12	15
Number of species	3	3	4	4	4	4	3	3	4	3	5	3	3	5	3

species	Qadrant 26													Quadrant 31									
	Unit 29													Unit SE11		Unit 18							
	2/1	2/2	2/3	2/4	2/5	2/6	2/7	8/1	8/2	8/3	8/4	8/5	8/6	1/2	2/2	4/1	4/2	4/3	4/4	4/5	4/6	4/7
Monacha cartusiana					1					1		1		3	2		1					
Oxychilus depressus	4	5	6	4	3	2	4	5	4	13	9	4	6	3	2	8	6	6	8	7	5	7
Vitrea contracta																1						
cf. *Helicopsis* sp.																						
Pupilla muscorum											2											
Truncatellina cylindrica	1	1	1				1	1				1			2			1				
Vallonia pulchella								2								1						
Vallonia costata																						
Vertigo pygmaea							1							1								
Galba truncatula																						
Gyraulus laevis																						
Planornis planorbis	1		3			1						1										1
Number of speciemns	6	6	10	4	4	3	6	8	4	14	11	7	6	7	6	10	7	7	8	7	5	8
Number of species	3	2	3	1	2	2	3	3	1	2	2	4	1	3	3	2	2	2	1	1	1	2

Table 5. Micro-mollusca finds from section W1.

Habitat	Species	1	2	3.1	3.2	4	5	6	7
shurb/parkland	*Monacha* cf. *cartusiana*	7	4	1					
	Oxychilus hydatinus	1	1	3	1	5	7	1	2
open country	*Truncatellina cylindrica*	1	10			1			
	Vallonia costata	1							
stagnant water	*Planorbis planorbis*						1		1

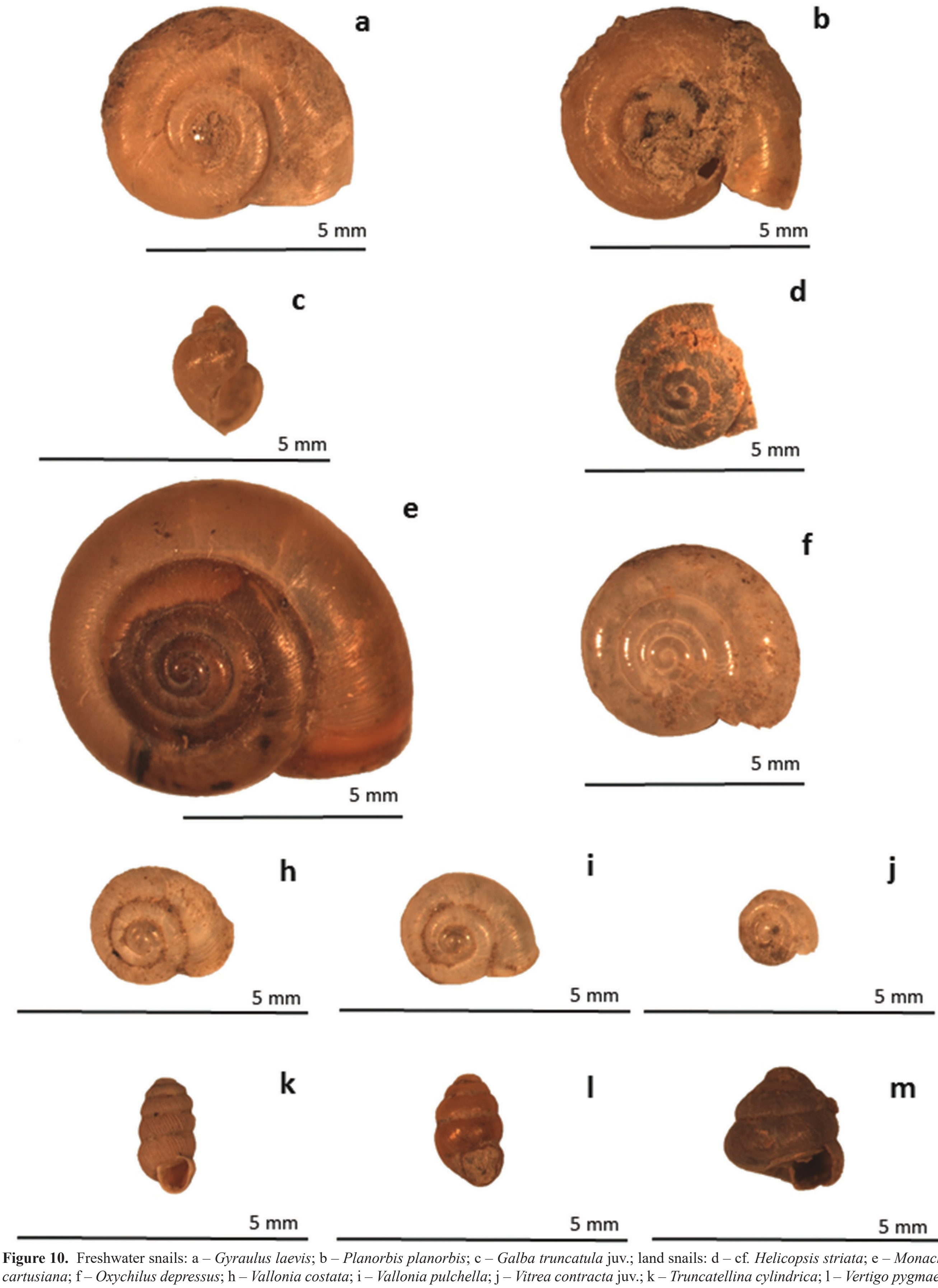

Figure 10. Freshwater snails: a – *Gyraulus laevis*; b – *Planorbis planorbis*; c – *Galba truncatula* juv.; land snails: d – cf. *Helicopsis striata*; e – *Monacha cartusiana*; f – *Oxychilus depressus*; h – *Vallonia costata*; i – *Vallonia pulchella*; j – *Vitrea contracta* juv.; k – *Truncatellina cylindrica*; l – *Vertigo pygmaea*; m – *Pupilla muscorum* juv. Photos: L. Juřičková.

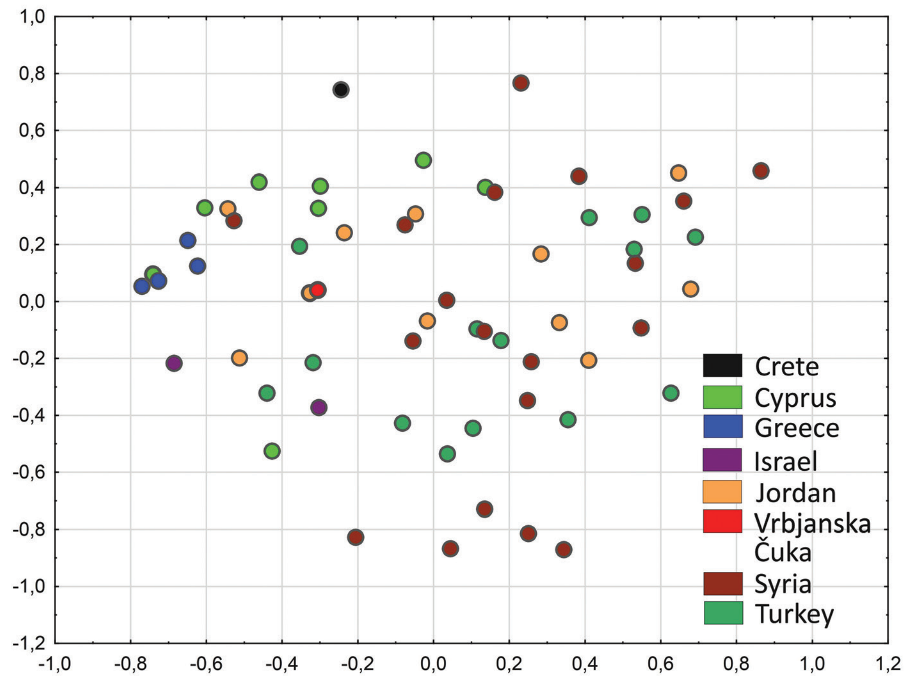

Figure 11. Correspondence analysis showing differences/similarities (this trend is only informative, not statically significant) among archaeobotanical assemblages from the Eastern Mediterranean (Colledge *et al.*, 2004) and Vrbjanska Čuka. Analysis and data visualisation: J. Kovárník.

research, informative and only indicate the trends (not being statistically significant) of the statistical and geographical similarity of these localities.

Comparison with other European regions is not possible at this stage of our research because data from Coward *et al.*, 2008 are not yet available; however, we count on this comparison in the next stages of our research on the Vrbjanska Čuka site. Figure 4 shows, for the area of southern Balkans, the regional details of the "archaeobotanical regions" in the Near East, Anatolia and Europe (black lines, large black numbers), which were postulated by Coward *et al*. (2008) and used by Shennan (2017) as an example of evolutionary phylogenic construction. The question as to whether the assemblage from Vrbjanska Čuka in its structure of represented charred macroremains is more or less similar with other "archaeobotanical regions" of southeast Europe looks to be resolvable. We hope to investigate this further in the next step of our archaeobotanical research.

Thanks to the first sampling season, some typical plants species of the "Neolithic package" *i.e.* einkorn, emmer, barley, lentil and pea, were confirmed at the site. The presence of hulled wheats (*i.e.* einkorn, emmer, barley) and legumes as lentil and pea have been identified as the basic Neolithic crops in the southern Balkan region in many studies (*e.g.* Marinova, Valamoti, 2014; Colledge *et al*., 2004; Zohary *et al*., 2012).

Some finds of *Panicum miliaceum* were recorded at Neolithic sites of the southern Balkans; however, evidence for them being of the Neolithic period is not clear and in general, the presence of this crop has had a more dominant role since the Bronze Age (Motuzaite *et al*., 2013; Marinova, Valamoti, 2014). The grain findings of millet in several contexts can belong to the younger settlement horizons of the Vrbjanska Čuka site. The finds of free-threshing wheat *Triticum aestivum/compactum/durum* are not an exception for the Neolithic period in the area of the Balkan Peninsula (Popova, 2009; Zohary *et al*., 2012; Marinova, Valamoti, 2014), however, in the case of the Vrbjanska Čuka site, the presence of free-threshing wheat in some sampled contexts could be another case of contamination from younger horizons. In any case, without direct radiocarbon dating of particular finds it is not possible to make conclusions. Finds of the cultural crops *Secale cereale* and *Triticum spelta* are also more common in later periods of Balkan prehistory (*e.g.* Kroll, 1991; Popova, 2009).

Charred plant remains at archaeological sites are the result of human activity and post-depositional processes. Due to the depositional and post-depositional process, we can observe here two cases of contamination: by plant macroremains penetrating from stratigraphically-younger sediments into archaeologically-older contexts; or the contexts could have been disturbed by recent activity (Schiffer, 1987; Mikuláš, 2000; Baines *et al*., 2015), both of which is the case for the Vrbjanska Čuka site. The preservation of uncharred plant macroremains (in very good states of preservation) was observed in all analysed samples. This recent plant contamination could have been caused by bioturbations in the soil with interactions with weather conditions (*e.g.* Cappers, Neef, 2012, p. 182). The problem of contamination in prehistoric settlements is a general one. The only possible solution is to choose to sample only those layers that had already been covered in the Neolithic period and thus protected against bioturbation. Such a case can be, for example, compact wall destruction, which is fortunately the case for several contexts at the Vrbjanska Čuka site, which were already sampled in season 2017–2018.

The findings of parts of the spikelet forks of glume wheat species provide us with information about the phases of crop processing that follow on after harvesting, either at the settlement itself or in its immediate vicinity (Hillman, 1981). The presence of arable weeds within the crop assemblage can be used as potential indicator of the height of the harvest, as well as helping to interpret the sowing time (*e.g.* Kreuz, Schäfer, 2011; Cappers, Neef, 2012, pp. 113–116). In the pilot samples from the 2016 season a very small number of arable field taxa (as well as cereal grains) were present. However, as they are often not identifiable to species level, it is not appropriate at this time to attempt to interpret more closely a farming system such as the crop-growing conditions, inferring seasonality, or other activities, related to the use of plants by the inhabitants of Vrbjanska Čuka. The few seeds of charred plant macroremains have provided some initial evidence of wild and edible species growing in a forest-edge environment, whereas some other charred plants have pointed to a rather drier environment (Blamey, Grey-Wilson, 2004).

A better understanding of the environment of the site might be gained by using the analyses of daub fragments from the walls of the houses/buildings. From personal observation, the daub mainly consists of imprints of chopped straw/stems and the chaff parts of probably wild weeds, which were used for tempering.

Due to the massive contamination of samples recovered during the analysis of macroremains, the possible level of contamination of the Neolithic layers in the section W1 by phytoliths from upper horizons needs to be discussed. First, the area of W1 sampling is approximately 3 metres distant from those samples which demonstrated an admixture of probably Medieval or Classical material (*e.g. Panicum miliaceum*) and the results of the macroremains analysis show no such contamination in the W1 samples. On the other hand, all of them contain some uncharred seeds, which points to bioturbation by plant roots or animals living in the soil; such a kind of contamination is common at archaeological sites and is not expected to be significant after the final quantification. However, special attention should be paid to those levels where the Neolithic and Classical horizons meet with no virgin soil in between, and the distinguishing of the early agricultural materials and technologies from those belonging to later periods is indeed another important challenge of the analysis.

Phytoliths recovered from the Vrbjanska Čuka section W1 samples attest to the great quality of the material for phytolith analysis. Multiple phytolith skeletons recovered from the Neolithic layers can be connected with anthropogenic activities. Phytolith skeletons with cut marks or breakages are often referred to as cereal-processing residues (Portillo, Albert, 2014; Dal Corso *et al*., 2017; Anderson *et al*., 2006). Many other skeletons were found with no specific breakage, but fitting the characteristics of what is called simply a “dung phytolith” in the literature (Delhon *et al*., 2008), including skeletons with non-sharp rounded edges which also suggests digestion by ruminants (Madella, 2007).

At the time of the Neolithic, crop-processing residues and animal dung were important commodities used at settlements for multiple purposes; residues alone could have been used as fodder for livestock (Valamoti, 2005) or as temper for pottery making (Szakmány, Starnini, 2007), or mixed with dung they could have been used as a fuel, but animal dung itself is also very suitable for fire-making purposes (Lancelotti, Madella, 2012). Both cereal residues and dung could have also been used for building purposes as an admixture in the architectural composition (Willcox, Tengberg, 1995; Shahack-Gross, 2011).

At the current state of the research on Vrbjanska Čuka, while only phytoliths from the profile W1 (and nearby U11) sampled in 2016 were analysed for these initial results, with the main aim to determine their presence and quality, it is hard to say which particular way the residues and animal dung were used; the fact that most of the phytolith material at Neolithic levels 5, 6, 7 and U11 is burned strongly suggests it’s use at least as a fuel. However, this conclusion cannot be stated for certain when building constructions are expected to have been burnt in the same area.

Starch microremains are a suitable source of information about plant usage that can be detected directly from artefacts. This method can help refine the results from other kinds of analysis such as pollen, macroremains and phytolith analysis (Pearsal, 2015; Kovárník, Beneš, 2018). The observed data can supplement the information from some other area of knowledge. In the following research various ways are shown of how starch grains were examined from material which came from several other sites in the southern part of the Balkans, as, for example, Kapitan Dimitrievo in Bulgaria (Valamoti *et al*., 2008). Starch identification from the Neolithic site Stavroupoli, Thessaloniki, Greece, shows records from cooking vessels where charred food crusts had adhered to the inner walls of middle and early Late Neolithic vessels (ca. 5600–5000 BC cal). Starch grains were particularly present in samples ST129 and ST192 with high concentrations of small Panicoideae and Triticeae grains (García-Granero *et al*., 2018).

Vlasac and Lepenski Vir are other sites from the Balkans relevant for this study. On these sites a method was used for the examination of starch granules from dental calculus (the thin layer which forms on teeth). This layer contains organic and chemical residues and it is a good source for analysis. Two sets of samples were investigated: first nine samples of dental calculus coming from Vlasac and three samples from Lepenski Vir (Cristiani *et al*., 2016). The research has provided direct evidence that already by 6600 cal. BC, if not earlier, the Late Mesolithic foragers here consumed domestic cereals, such as *Triticum monococcum*, *Triticum dicoccum*, and *Hordeum distichon*.

The use of starch analysis is still rather exceptional in European Neolithic sites. In Tiszasziget-Agyagbánya, in southeastern Hungary, a site belonging to the Late Neolithic Tisza culture (ca. 5000–4500 BC cal.), the results from research are comparable with our outcomes from Vrbjanska Čuka stone artefacts (Pető *et al*., 2013). Another examined site is Hrdlovka in the Czech Republic (Beneš *et al*., 2015), where samples for starch analysis were taken from a set of grinding stones, and starch grains from the *Poaceae* and *Fabaceae* families were found.

The analyses of plant macroremains, phytoliths and starch particularly reflect *onsite* bioarchaeological activity; however, some data also indicate the environmental characteristics outside of the Neolithic tell (and in younger occupational periods). This is the case for the malacological record, which well describes the near surroundings of the site. The detected species bear witness to surrounding shrub/ open woodland and open country grassland. Witness to the presence of stagnant water is interesting, as there are indications for such water patches in the vicinity of the Neolithic tell (Naumov *et al*., 2018a). However, the mollusc species indicate variable mosaics of micro-environments with mainly dryland prevailing. Either way, the malacological analysis seems to be a good tool for describing the area near to a site, but must be supported by other proxies.

5. Conclusions

The position of the Vrbjanska Čuka site, in the context of this part of the southern Balkans Neolithic from the point of view of the bioarchaeological knowledge, seems to bear prospects for further research in several ways. First of all, it is necessary to mention the quality of the bioarchaeological material itself. The botanical and zoological macroremains reflect a typical composition of Early Neolithic plant and animal husbandry with no surprises. The well-preserved phytoliths and starch grains offer some deeper insight into the spatial distribution of the onsite human activity as, for example, those activities connected with specific buildings and the spaces between them.

The correspondence analysis of species structure from the botanical macroremains indicates the potential position of Vrbjanska Čuka in terms of our knowledge of similarities/ differences in relation to the Eastern Mediterranean. The affinity of the assemblage to the structures of Greek and Cypriot origin is obvious; however, the comparison is a provisional one only, based on the first analytical season 2016. The outputs from the statistical analysis show only informative trends which are not statistically significant. New finds in species structure made in the 2017–2018 field season could change the general position of the site; notwithstanding, the affinity to those of Greek regions is not surprising.

A major problem of the site is the systemic, natural and recent contamination of the Neolithic layers by younger periods present on the site. Vrbjanska Čuka is a multistratigraphic site with Classical and Medieval layers, and thus the systemic contamination that exists here is extensive. The Vrbjanska Čuka tell is not quite an optimal site for bioarchaeological analyses of the Neolithic for this reason. On the other hand, some archaeological contexts that were covered by architectural remains from the Neolithic period (discovered in field seasons 2017–2018) promise an entirely uncontaminated Neolithic situation.

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