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Prehistoric cereal foods of southeastern Europe: An archaeobotanical exploration

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ABSTRACT

This paper addresses for the first time a large body of archaeobotanical data from prehistoric Southeastern Europe, ~~mostly published for the first time,~~ that correspond to cereal food preparations. The evidence presented here comes from 20 sites situated in Greece and Bulgaria, spanning the Early Neolithic through to the Iron Age (7th millennium B.C.-1st millennium B.C.). The remains correspond to cereal fragments or agglomerations of fragments that resulted from ancient food preparation steps such as grinding, boiling, sprouting/malting, mixing in bread-like or porridge-like foodstuffs. The article builds on previous pilot studies and with the aid of stereomicroscopy and scanning electron microscopy offers a first classification and possible interpretations of the finds leading to the recipes that might have generated them. At the same time the article highlights the significance of retrieving and studying in depth such rare archaeobotanical finds, points out the interpretative problems stemming from such material and suggests ways forward to address similar archaeological finds in different parts of the world. The paper demonstrates the potential of the systematic study of cereal-based food remains, in our case prehistoric Southeastern Europe, to reveal a wide variability in cereal food transformation practices, suggestive of the interplay between available ingredients, cultural traditions and the complex interaction between society and environment.

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1. Introduction

Studies targeting ancient food have begun to acquire a significant position in archaeological inquiry, building up on what Sherratt (1991) had very perceptively argued for, nearly 30 years ago, that *people do not eat species, they eat meals*. Conferences, papers and books have addressed food preparation and consumption, focusing on luxury foods (Van der Veen, 2003), particular consumption practices like feasting on meat and alcohol (Jones, 2007; Wright, 2004; Miracle and Milner, 2002) or variable social, economic and symbolic dimensions of food across the globe (Gosden and Hather, 1999). Research projects have investigated food globalisation in prehistory (Martin Jones et al., 2011), the role of the environment into shaping Early Neolithic food ingredients of Southeastern Europe (Ivanova et al., 2018; Kreuz and Marinova, 2017) or the consumption of particular foods, e.g. dairy products (Craig et al., 2005; Evershed et al., 2008). At the same time, edited volumes on the subject of food, embraced a wide array of methods, approaches and case studies in various regions and time periods, including methods and analytical tools like chemical residue and isotopic analysis, often innovatively combined with experimentation ethnoarchaeology and associated processing equipment (e.g. Anderson et al., 2013, Capparelli et al., 2011; Chevalier et al., 2014; Hastorf and DeNiro, 1985; Parker-Pearson, 2003; Renard and Mee and Renard, 2007; Tzedakis et al., 2008; Voutsaki and Valamoti, 2013). Yet, the culinary transformation of plants has rarely been the focus of a systematic inquiry and even less so as regards more integrated approaches (cf. Mesnil and Fechner and Mesnil, 2002).

The importance of plant foods has been underlined in recent archaeological discourse with special emphasis placed on cereal staples, luxury foods and diet enhancers such as wine and oil, condiments and spices or hallucinogenic plants like opium poppy (e.g. Fuller and Rowlands, 2011; Hamilakis, 1996; Sherratt, 1995; Van der Veen, 2003). Prehistoric culinary and food consumption practices have been at the heart of discussions on the emergence of Bronze and Iron Age elites in prehistoric Europe (e.g. Arnold, 1999; Renfrew, 1972; Wright, 2004), wine and oil in particular, relating power appropriation and access to certain types of plant foods and associated processing technologies. Species selection and their transformation into meals involves the interaction of natural vegetation and human culture, whereby the former is shaped, named and incorporated in each society's belief systems, transliterated into daily and life experiences, collective memory and identity. Food preparation and consumption form arenas where social roles are learnt, power relations forged, negotiated and renewed (e.g. Dietler and Hayden, 2001; Jones, 2007). Yet, ancient plant foods, despite their major dietary role, as staples or for special contexts of consumption, remain underexplored as regards individual recipes and processes underlying the preparation of specific prehistoric foods. They are little discussed in terms of their contribution to social cohesion and differentiation through daily, communal or special contexts of consumption, as well as their role in elite emergence and cultural transformation through time. Moreover, culinary practices have been poorly integrated on a regional and temporal scale that would allow for culinary trends and their change through time to be observed in a coherent way. As a result, the dynamic role of culinary transformation of plant ingredients into shaping social and cultural identity in prehistory remains little explored and comprehended.

Archaeobotanical research in Southeastern Europe over the last 20 years has brought to light a wealth of new evidence on actual plant food remains based on cereals, pulses and fruit. In this paper we focus on prehistoric cereal foods from southeastern Europe, offering an overview of the types of food remains encountered in the archaeological record and a first discussion of the potential recipes that led to their production. Cereals have formed the staples of prehistoric communities of the area since the appearance of the first farming communities in the 7th millennium B.C. The ways into which cereals were transformed into food we believe are closely linked to the interplay of environmental and cultural parameters. They can be consumed whole, smoked, roasted, boiled, ground coarsely or finely, then further processed through the intervention of fire and liquids such as milk or water. There is ample ethnographic evidence from Europe, Western Asia and Northern Africa to suggest that human societies have devised many ways of transforming cereals into food, either for short-term or long-term consumption (Capparelli et al. 2011, d'Andrea and Mitiku-Haile 2002). Moreover, ancient texts reveal a wealth of cereal food preparations, varying not only in terms of the ingredients but also in terms of the steps involved in the preparation of the recipes (cf. Dalby, 1996; Valamoti et al. in press). Inevitably, archaeological finds of cereal foods are classified on the basis of our current knowledge of potential ways of food transformation. Pilot studies and preliminary publications on such types of foods have suggested food preparations like bulgur and/or trachanas, corresponding to pre-cooked, ground cereal fragments (Marinova, 2006; Valamoti, 2002, 2011; Valamoti et al., 2008). Other types of cereal food remains retrieved have been described as bread or porridge (Nikov et al., 2018; Popov et al., 2018; Popova, 2016; Gonzalez-Carreterro et al., 2017; Heiss, 2008) and exciting new investigations have further explored the contents and structure of these 'bread/porridge'-like remains, yielding promising results (Heiss et al., 2017; Primavera et al., 2018). At the same time alternative interpretations for cereal-based lumps are emerging, pointing towards the direction of brewing a cereal based alcoholic produce, possibly beer (Valamoti et al., 2017).

Building upon the pioneering work on processed cereal foods by Hansson (1994, 1996) extant works on cereal bran identification (e.g. Winton and Winton, 1932; Körber-Grohne and Piening, 1980, Dickson, 1987), Heiss et al. (2015) applied a detailed SEM analysis for the identification of the cereal components of a Gallo-Roman bread find. They used specific traits such as drying cracks and pore diameters as well as identification of plant tissue preserved in the bread to decipher the preparation steps involved in its making. Pore size distribution and the presence of fissures was associated to leavening and baking conditions. No experimental observations were taken into consideration in this paper and the inferences were made on the basis of criteria describing modern flat and raised breads, respectively. Information about the processing techniques, like grinding and sieving, could also be drawn based on bran and chaff size measurements, while quantification of pore/bubble size was proposed as a method for identification of fermented dough. González-Carretero et al. (2017) also used SEM analysis, building upon the suggestions put forward by Heiss et al. (2015), in an attempt to investigate amorphous charred food remains from Neolithic Çatalhöyük, with similar goals: To determine the plant components and potential processing and cooking methods. They applied qualitative estimations of size and number of visible plant material, as well as air bubble size and their distribution in the food matrix, comparing archaeological food remains with experimental cereal preparations. They examined the archaeological material together with a series of experimentally generated cereal-based preparations: dough, bread, porridge. In building their methodology they recorded voids in the amorphous mass matrix and visible plant components.

This ambitious new work by Gonzalez-Carretero et al. (2017) that aspires to offer a methodological tool for analysing ancient cereal food remains from archaeological sites reveals the manifold problems involved in attempting to decipher ancient cereal based recipes. The experimental material used to build the methodology in this work is based on assumptions that in part at least lack support from the ethnographic literature or ancient sources, e.g. boiling the grain for the production of fine flour, associating coarse meal with porridge and fine meal with bread, assuming that bulgur is just any coarsely ground grain. Pore size and shape in the experimental and ancient food matrix are used in this study as a main tool to detect cooking processes. It is unclear, however, how pore-size was indeed measured on irregular surfaces and the fact that the authors use pore-size average rather than the size-range, obscures any understanding of the potential variability in the size of pores in individual specimens. Moreover, the effects of charring as regards pore formation are not taken into consideration and therefore it is unclear whether the characteristics recorded are the result of charring or leavening. Thus, although in principle the features that the authors select to record in ancient food remains are potentially indicative of different cereal food preparation methods, the methods used to explore these features are problematic and need rigorous re-assessment, taking into consideration a wide range of experimental variables as regards the food preparation steps, the charring temperatures and the methods of describing and measuring the shape of pores in the cereal food matrix. It is imperative that a range of experimental variables are taken into consideration before a widely applicable method can be developped and used to study similar archaeological material. Recently, Primavera et al. (2018) applied SEM analysis on exceptional finds of ritual 'cakes' deposited in the Sanctuary of Oria in Monte Papalucio offering novel insights into ritual bread preparation practices thanks to the integration of archaeobotanical, artefactual and textual evidence. This ongoing research could potentially offer fascinating information as regards past culinary practices, yet, no systematic methodology exists to facilitate the study of archaeological cereal food remains. In some of the previous studies, for example, it has been assumed that a) pore size is related to the use of yeast and b) the size of particles visible on the Scanning Electron Microscopy image reflect the entire inclusion. The latter, however, in reality, might be largely hidden in its most part in the interior of the observed surface. The main problem with all the work conducted so far is that many of the variables that might have influenced the structures observed in archaeological cereal foods still remain poorly investigated and understood. At the same time there is inadequate consideration in the literature of alternative possible food preparation steps and subsequent depositional taphonomic processes that would result in similar-looking food products, for example cracked wheat, bulgur and trachanas or bread, flat-bread, porridge, dough. Building on the suggestion put forward by Heiss et al. (2017) we here combine macroscopic and microscopic structure analysis in order to provide insights as regards aspects of prehistoric cereal food preparation and to raise awareness of the variability of food preparations that might have existed in prehistoric times and opens up the way towards classifications beyond the two "global" categories suggested previously, i.e. 'cereal product' and 'bread-like object' (Heiss et al., 2017), at the same time trying to avoid over-interpretation of the structures visible in the material.

Our paper offers for the first time a systematic and comprehensive examination of archaeological finds of cereal based foods originating from 20 sites situated in Northern Greece and Bulgaria spanning the Neolithic through to the Iron Age, i.e. the 7th millennium through to the 1st millennium B.C. This exceptional material, examined in the context of ERC funded project PLANTCULT (Valamoti et al., 2017, http://plantcult.web.auth.gr/index.php/en/) forms the basis for a first attempt to classify these objects taking into consideration a wide range of alternative cereal foodstuffs recorded ethnographically or in ancient texts. Based on a combination of macroscopic and microscopic observations, aided by SEM, we argue that this classification is the first necessary step towards deciphering ancient recipes and the processing steps that led to their preparation, in the context of a wider exploration of prehistoric culinary practice in Southeastern Europe.

2. Materials and methods

Cereal based food remains from prehistoric sites in Northern Greece and Bulgariaare presented in a systematic and comprehensive way. The material originates from nine Greek and eleven Bulgarian sites spanning the Neolithic through to the Iron Age, while one has a Classical-Early Hellenistic dating (Table 1, Fig. 1).

The Greek sites with rich archaeobotanical assemblages that include cereal food remains are located in Northern Greece and span the Late Neolithic through to the Late Bronze Age. The Neolithic finds derive from the sites of Limnochori II, Anarghiri III, Limnochori III, situated in the Amindeon Basin, Western Macedonia, at the northern shore of Lake

Table 1
Basic qualitative classification categories used for the cereal foods from northern Greece and Bulgaria discussed in the paper.

Overall Appearance: morphological criteria			Potential Food Type
Macroscopic	Stereomicroscopic	Microscopic	
Loose fragments	*fracture surface characteristics*	*Features observed under SEM*	*cracked wheat/ bulgur/trahanas/ ground malt*
	bulging	gelatinised endosperm	
	flat	other	
	concave		
Fragment agglomerations			*cracked wheat/ bulgur/trahanas /ground malt cakes*
Fragments clearly visible	*fracture surface characteristics*	*Features observed under SEM*	
	bulging	gelatinised endosperm	
	flat	other	
	concave		
	components	*components (metallographic and SEM)*	
	grain		
	chaff		
	other		
Fragments in amorphus matrix	Fragments		*bread/porridge/*
	fracture surface characteristics	*Features observed under SEM*	*cooked food containing cereal fragments*
	bulging	gelatinised endosperm	
	flat	other	
	concave		
	size		
	components	*components (metallographic and SEM)*	
	grain	species/type identification and size	
	chaff	species identification and size	
	other	species identification and size	
Amorphus matrix	*components*	*components (metallographic and SEM)*	*bread/porridge*
	grain	species/type identification and size	
	chaff	species identification and size	
	other	species identification and size	

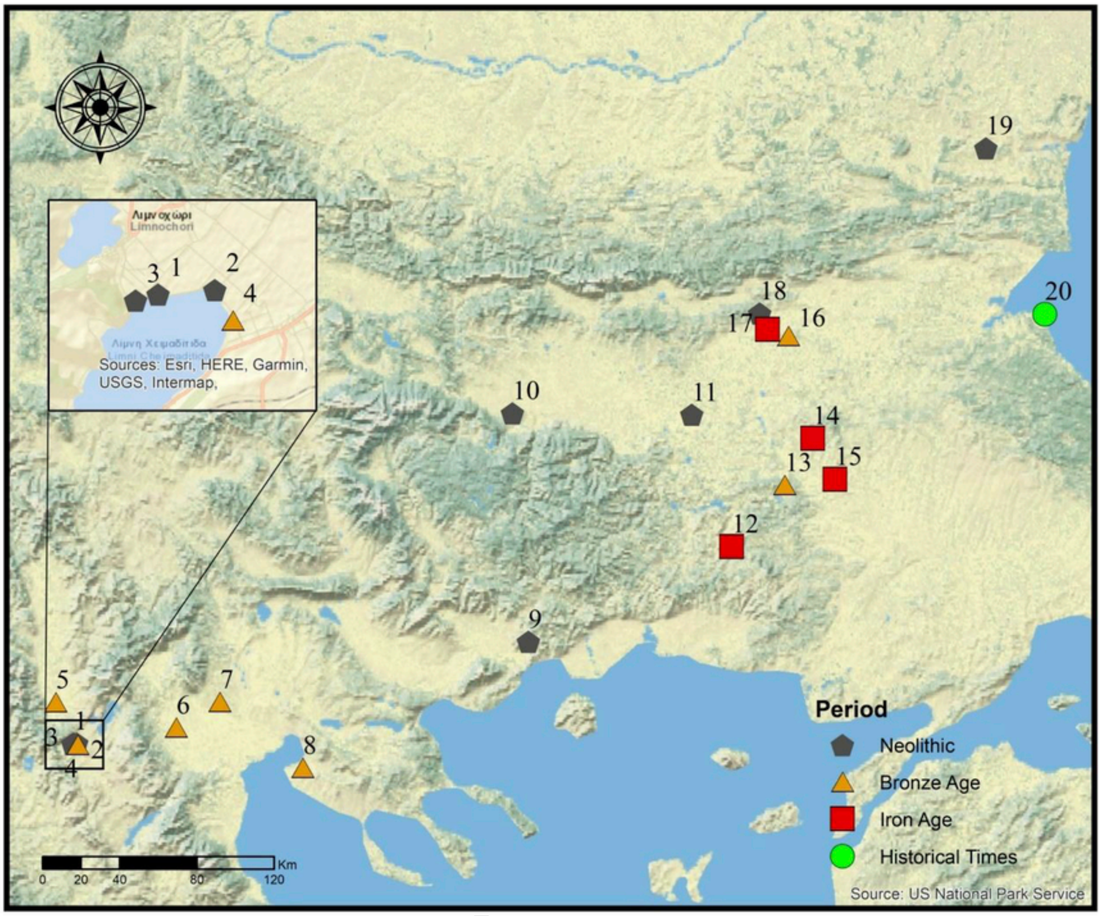

Fig. 1. Map of study area indicating Greek and Bulgarian sites that yielded cereal food remains presented in this paper. 1. Limnochori II, 2. Anarghiri III, 3. Limnochori III, 4. Anarghiri I, 5. Armenochori, 6. Angelochori, 7. Arhcondiko, 8. MesimerianiToumba, 9. Dikili Tash, 10. KapitanDimitrievo, 11. Yabalkovo, 12. Ada Tepe, 13. Kush Kaya, 14. Vaskovo, 15. KapitanAndreevo, 16. Sokol, 17. Yurta, 18. Karanovo, 19. Provadia, 20. Apollonia Pontica.

Chimaditis (Chrysotomou et al., 2015) and Dikili Tash in Eastern Macedonia (Darcque et al., 2007; Darcque, 2013; Kokkidou, 2018; Koukouli-Chryssanthaki and Treuil, 2008; Matterne, 1993; Valamoti, 2004, 2015). Cereal based food remains dating to the Bronze Age from Northern Greece have been retrieved from a number of sites: Anarghiri I (Chrysotomou et al., 2015) Armenochori (Chrysotomou, 1998), Archondiko (Papadopoulou et al., 2010; Papaefthymiou-Papanthimou, 2010, Pilali-Papasteriou et al., 2001), Mesimeriani Toumba (Grammenos and Kotsos, 2002) and Angelochori (Maniatis, 2010; Stefani, 2010; Stefani and Merousis, 2010; Valamoti, 2010), located in Western and Central Macedonia. The Bronze Age sites are all tell settlements, with the exception of the lakeshore settlement of Anarghiri I at Lake Chimaditis. Both the Neolithic and Bronze Age assemblages considered here originate from the burnt destruction layers of buildings while the artefactual and other contextual evidence suggest crop storage.

The Bulgarian Neolithic/Chalcolithic sites that have yielded cereal food remains and are included in the paper are Early Neolithic Kapitan Dimitrievo (Nikolov, 2000) and Yabalkovo (Leshtakov, 2014), Late Neolithic Karanovo (Nikolov, 2002), and Early Chalcolithic Provadia-Solnitsata (Nikolov, 2008). The food remains presented here are retrieved from house interiors. The vast majority of the Bulgarian sites which yielded actual food remains in our study area is dated, however, to the Bronze and Iron Age periods. The Bronze age sites included in the study are Sokol in Southeastern Bulgaria (Leshtakov et al., in preparation) and Kush Kaya in the Eastern Rhodope Mountains (Popov, 2016; Popov et al., 2018). The Iron Age Bulgarian sites are as follows: Vaskovo (Iliev, 2015), Kapitan Andreevo (Popov et al., 2007; Popov and Grozdabova, 2008), Ada Tepe (Nikov et al., 2018) and Yurta (Kancheva-Ruseva and Koleva, 2011).

Besides the prehistoric finds, the study also expands to slightly later food remains from the Necropolis of Apollonia Pontica (present day Sozopol) on the Western Black Sea coast of Bulgaria, dating to the 4th century BC (Panajotova et al., 2006).

The archaeobotanical cereal food remains from the above mentioned prehistoric sites have been retrieved by flotation using a variant of the Ankara machine (French 1971) for Greek sites and manual flotation and hand picking for Bulgarian sites where they were recognized during excavation as concentrations of plant remains or possible plant food. All the specimens presented in this paper are preserved through charring and in their majority were mostly found in rich, dense concentrations corresponding mainly to stored products while some correspond to lumps contained in pits with food and other 'refuse' (Table 2). As the analysis of each specimen is a very time consuming process, only representative specimens were subject to a detailed SEM examination and imaging with microphotographs.

The suspected cereal food remains were initially examined using a binocular stereomicroscope with magnifications X8-X80. They were subsequently examined with the aid of a metallographic microscope and on the basis of these observations the selected specimens were subjected to SEM imaging. SEM analysis was carried at the Aristotle University of Thessaloniki using a JEOL JSM-840A and a JEOL JSM-6390LV scanning electron microscope. Samples were coated with carbon – average thickness of 200 Å – using a vacuum evaporator

Table 2
Overvi[illegible]archaeobotanical finds of cereal food remains discussed in the paper.

Country	Site	Period	Date range	Site type	Preservation conditions	Context	Taxon component(s)	Overal consistency	Fragment characteristics	Suggested food category
Bulgaria	Kapitan Dimitrievo	Early Neolithic II	5650-5450 BC	tell	charred	storage vessel	cereals (einkorn, barley)	loose grain fragments	flat	bulgur/trachanas
Bulgaria	Yabalkovo	Early Neolithic	5650-54500 BC	flat site	charred	pithoi interior	cereal (wheat, barley)	loose grain fragments		bulgur/trachanas
Greece	Limnochori II	Late Neolithic	5500-3300/3200 BC	lakeshore settlement	charred	house destruction layers (associated with pots, clay structures)	cereal	agglomerations of fragments/ porous mass/ porous mass with fragments		bread/ porridge
Greece	Anarghiri III	Late Neolithic	5300-4000 BC	lakeshore settlement	charred	house destruction layers (associated with pots concentrations)	cereal	porous mass/ porous mass with fragments		bread/ porridge
Bulgaria	Karanovo	Early Chalcolithic	4900-4700 BC	tell	charred	vessel	cereals	agglomerations of fragments		bulgur/trachanas
Bulgaria	Provadia-Solnitsata	Middle Chalcolithic	4700-4600 BC	tell	charred	vessel	cereal	agglomerations of fragments	flat	porridge
Greece	Limnochori III	Final Neolithic	4500-4000 BC	lakeshore settlement	charred	house destruction layers/ pot interior	cereal	porous mass/ porous mass with fragments		bread/ porridge
Greece	Dikili Tash	Late Neolithic	4400-4200 BC	tell	charred	house destruction layers	cereal	porous mass with fragments		bread/porridge
Bulgaria	Sokol	Early Bronze Age	3500 – 1900 BC	tell	charred	pot interior	cereal (wheat)	porous mass with fragments		bread/ porridge
Greece	Mesimeriani	Early Bronze Age	2196-1925 BC	tell	charred	pot interior	cereal	loose	bulging	bulgur/trachanas
Greece	Archondiko	Early Bronze Age	2135-2020 BC	tell	charred	house destruction layers (floors, postholes, clay structures)	cereal	loose/ agglomerations of fragments/ porous mass/ porous mass with fragments	bulging/flat	bread/ porridge/ bulgur/ trachanas/malt
Greece	Anarghiri I	Early-Middle Bronze Age	2000 BC	lakeshore settlement	charred	house destruction layers	cereal	porous mass/ porous mass with fragments		bread/ porridge
Greece	Angelochori	Late Bronze Age	1630-1495 BC	tell	charred	burnt layer	cereal	porous mass with fragments		bread/ porridge
Bulgaria	Kush Kaya	Late Bronze Age	1500-1375 BC	hiltop site	charred	vessel	cereals	porous mass with fragments		bread/ porridge
Bulgaria	Ada Tepe	Early Iron Age	1100-850 BC	hiltop site	charred	dwelling	cereals	porous mass		bread/ porridge
Bulgaria	Kapitan Andreevo	Early Iron Age	1000-850 BC	pits	charred	pit	cereals	porous mass		bread/ porridge
Bulgaria	Vaskovo	Early Iron Age	1000-850 BC	farm	charred	dwelling	cereal	porous mass		bread/ porridge
Greece	Armenochori	Early Bronze Age		tell	charred	storage room	cereal	porous mass		bread/porridge
Bulgaria	Yurta	Late Iron Age		settlement	charred	ritual pit	cereal/parenchyma?	porous masses		bread
Bulgaria	Necropolis of Apollonia	Classical period	first half of 4th century BC		charred	ritual hearth	cereal/parenchyma?	porous masses		bread

JEOL-4X. Few specimens from Karanovo and Kush Kaya were observed under JEOL JSM 840, coated with 20–25 nm of goldat [illegible]Royal Belgian Institute for Natural Sciences.

The material examined in this paper could correspond to a range of cereal-based food remains both in terms of their components as regards a) species, b) overall size and c) type of processing (e.g. sprouting, boiling, grinding etc) as well as in terms of the intended end product. The categories we have adopted to classify our material, however, are broad and encompass a range of possible cereal food preparations. For the purposes of this paper we have selected from each site under consideration those specimens that were most likely to correspond to different broad categories of cereal food preparations in order to provide the full range of variability present in our assemblages. The material presented in this paper is representative of each type of food remains and not exhaustive, a task impossible to achieve given the time consuming process of SEM imaging. We believe, however, that by our selective approach and basic classification categories, we offer for the first time a thorough overview of the range of potential cereal food preparations of prehistoric south-eastern Europe, emphasizing the significance of similar finds in the archaeobotanical record.

3. Results and interpretation

3.1. Classification of cereal food remains

The archaeobotanical material examined here can be grouped in different categories on the basis of the various morphological characteristics of its components, macroscopic and microscopic. Different components or combinations of components visible in the archaeobotanical specimens could signify different categories of food products, on the basis of our current knowledge regarding the ways in which cereal ingredients can be transformed intocereal [illegible]l preparations. In order to explore this variability in the archaeob[illegible]cal cereal food finds, the macroscopic observations performed on the archaeobotanical material, together with the SEM micrographs, formed the basis for grouping the archaeological food remains in different categories according to a) macroscopic appearance, i.e. whether the remains preserve loose or in lumps, b) microscopic features of surface and internal structure/ composition (Table 1). Category (b) is only presented here on a coarse, qualitative level and needs further refinement that will only be possible when a sound methodology has been developped that will allow a better understanding of such archaeological finds. This is work in progress aiming ultimately to the preparation of an open-access data-base comprising detailed SEM images of a wide range of experimental cereal food preparations charred under controlled charring conditions (in preparation by the PLANTCULT project team), informed by ethnography and ancient texts, along the lines proposed by Valamoti (2002), Valamoti et al. (2008), Heiss et al. (2015) and Heiss et al. (2017). The groups we have established here allow an 'inside' view of the components and structure of the archaeological finds without imposing assumptions based on what 'bread' or 'porridge' should look like. These categories of finds we have identified can be associated with different possible food types to which these finds could correspond, inferred with the aid of ethnography and experimental pilot studies. Thus the archaeological specimens could belong to some of the following food categories: a) ground cereals used as such, b) ground pre-cooked cereals (bulgur/trachanas type, see Valamoti, 2011 for a detailed description of variants), c) 'bread' remains (in the broader sense of the word), d) porridge remains, e) ground malt, f) malt 'buns' for the preparation of beer (Table 2). Other preparations and combinations of ingredients are also possible but here we limit ourselves to some common, basic cereal food categories. In most cases it is still impossible to distinguish among the different categories, e.g. between bulgur and trahanas (see Valamoti et al., 2008) or between bread and porridge (see Heiss et al., 2017). These classifications constitute working analytical categories which may be modified in the process of ongoing research, depending on future, more detailed analyses of this and similar material. In the absence of a detailed and tested methodological tool that will 'unlock' recipes of the past we adopt a cautious approach to the archaeological material considered here, an approach that combines macroscopic observations and a first level of analysis using Scanning Electron Microscopy to describe the overall structure of the observed surface. Our proposed categories avoid the pitfalls of projecting to the prehistoric past practices that are closer to our modern cereal food classifications (e.g. bread made of fine flour-cf Gonzalez-Carretero et al 2017) [illegible]eover they offer an analytical tool that can be easily applied in routine mainstream archaeobotanical work without the need for sophisticated analytical techniques. Needless to say that some of the food categories we use could have constituted ingredients themselves (see discussion below) used towards the preparation of other recipes, increasing thus the food categories to which our finds potentially could correspond to.

3.2. Category 1: loose cereal fragments

This category includes cereal fragments generated prior to charring on the basis of previous research that has shown that the main criterion for identifying grinding prior to charring is the characteristic bulging observed on the fracture surface of the cereal grain (Valamoti, 2002). Such cereal fragments, generated through deliberate actions in prehistory, could correspond to at least three different types based on grain treatment prior to the actual cooking/food preparation: a) cereal grain that appears to have been broken prior to charring without any evidence for further processing, b) ground cereal grain that has been boiled/parboiled/simmered in some form of liquid, milk or water, c) cereal grain that has been converted into malt by sprouting, then ground. Furthermore, in category (b) the relationship between boiling and grinding can vary: grain can be first parboiled whole, then ground or the reverse. Boiling of grain can be identified in the archaeobotanical record through the macroscopic observation of shiny, glassy surfaces (Valamoti, 2002) and gelatinised grain endosperm (Valamoti et al., 2008).

In the assemblages we have studied from Greece and Bulgaria, we have identified loose cereal fragments at the following sites: Kapitan Dimitrievo, Yabalkovo, Archondiko and Mesimeriani (Fig. 2, Fig. 3, Fig. 4, Fig. 5). On the basis of the previous pilot studies referred to above, the Mesimeriani finds, stored inside a pot, correspond to precooked wheat grains, probably einkorn, as some of the larger grain fragments were identified as such: The shiny bulging surfaces of the grain fragments, indicate that they had received some kind of treatment with some liquid, like boiling or soaking in water, before grinding (Valamoti, 2002).

The Kapitan Dimitrievo fragments include a) fragments with bulging surfaces with SEM micrographs showing a gelatinised endosperm (after Valamoti et al., 2008) as well as b) fragments with no visible diagnostic features that need further investigation. As it was a dense rich concentration of fragmented cereal grains kept inside a storage vessel, it has been interpreted as intentionally processed and deposited there (Marinova, 2006). At the sites of Yabalkovo and Archondiko, it is observed that fragments with different morphologies of the fracture surface usually coexist in the same samples: the fragments might demonstrate either a bulging, flat, or slightly concave surface. Unlike the finds from Mesimeriani and Kapitan Dimitrievo, these particles have matt surfaces. It is therefore important to explore the possible

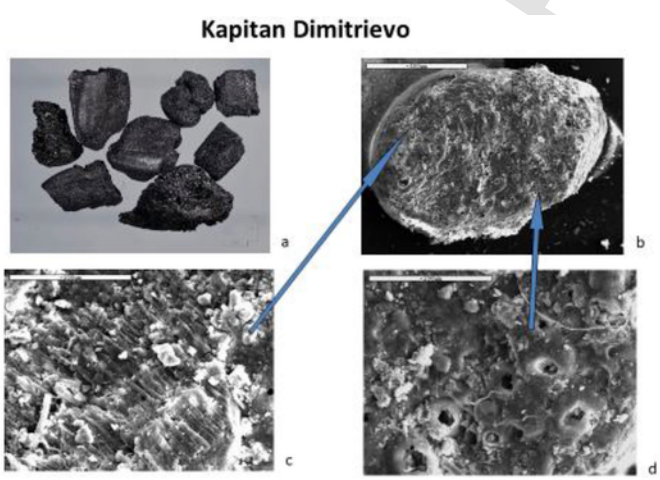

Fig. 2. Loose cereal fragments from ~~Early NeolithicKapitanDimitrievo~~. a)macroscopic overview of food fragments under low magnification binocular, b)macroscopic overview of a food fragment under SEM (x30 magnification), c) and d) a view of the microstructure under SEM (x400 magnification).(working distance for SEM images 20 mm).

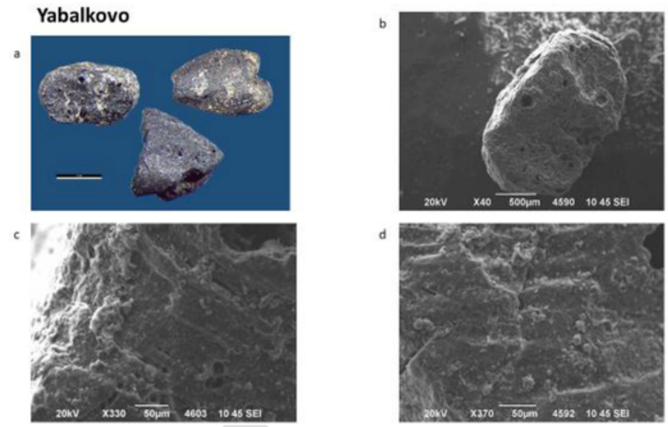

Fig. 3. Loose cereal fragments with bulging fracture surface from Early Neolithic Yabalkovo. a) the grain fragments under low magnification binocular (scale bar 1 mm), b) overview of a grain fragment under SEM, c) and d) view of the fracture surface microstructure under SEM.

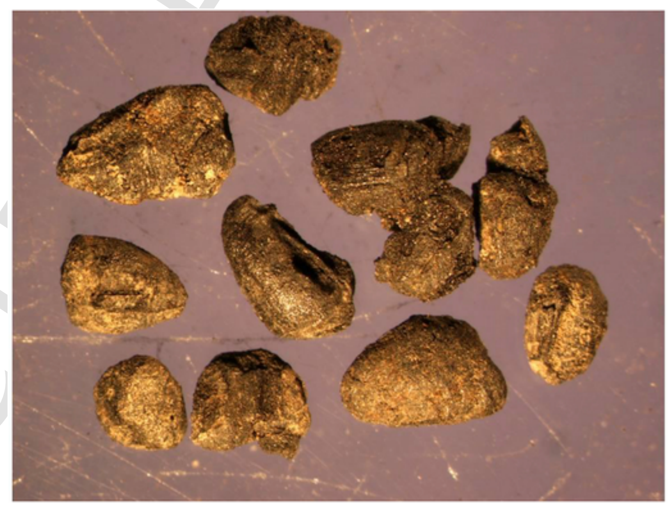

Fig. 4. Loose cereal fragments with bulging non-shiny fracture surface from Early Bronze Age MesimerianiToumba.

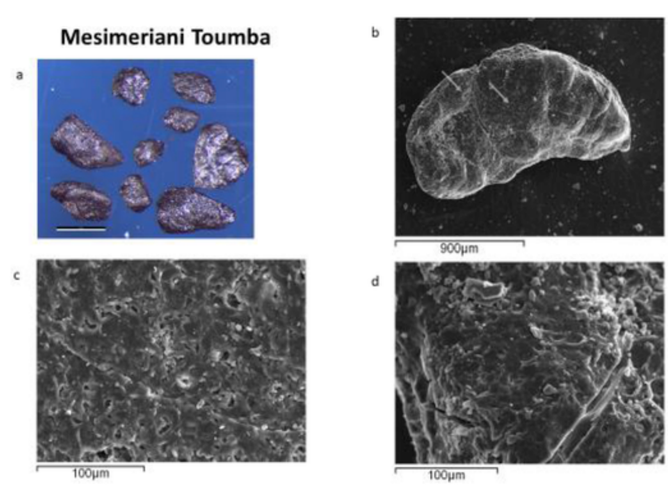

Fig. 5. Loose wheat/barley fragments with bulging/shiny fracture surface from Early Bronze Age MesimerianiToumba. a)the grain fragments under low magnification binocular (scale bar 1 mm), b) overview of a grain fragment under SEM (x60 magnification), c) and d) view of the fracture surface microstructure under SEM (x650 magnification).(working distance for SEM images 20 mm).

pre-depositional processes related to cooking as well as the possible taphonomic factors (e.g. charring) that might have resulted in these assemblages through further experimentation considering more variables (currently under way in the context of ERC project PLANTCULT, Valamoti et al. in preparation). Further analysis of more archaeological fragments with the aid of SEM, informed by experimental material will help understand the processes that led to these assemblages.

At Archondiko different types of ground fragments have been retrieved and their combined examination of morphological characteristics and spatial distribution, informed by ethnography and experimentation will potentially reveal different ways of transforming cereals for food (Valamoti, 2002, 2017a; Valamoti et al., 2008). One possibility raised in the past was that they might correspond to some form of bulgur/trachanas (Valamoti, 2002, 2011; Valamoti et al., 2008). Alternatively or in addition to this, some of these steps may be related to beer making, a suggestion recently put forward in a re-examination of the archaeobotanical finds from Archondiko (Valamoti, 2017a). Although ground cereal fragments are often uncritically described as 'bulgur', this is a hasty and potentially wrong interpretation. Depending on surface characteristics, it could correspond to cracked wheat, bulgur, trachanas and in light of recent finds, pontentially ground malt. This possibility has not been previously raised in the literature, yet recent rich finds of charred malt, together with contextual evidence for facilities where malting was possible, raise ground malt as an alternative interpretation of such fragments. Thus some of the cereal fragments encountered at Archondiko could be considered as ground malt, a possibility currently investigated in detail, stemming from the recent finds of sprouted cereal grains in the same archaeological contexts as the ground fragments (Valamoti, 2017a; Valamoti et al. in preparation). Future research may help refine these categories, add new ones and develop criteria for their identification in the archaeological record.

Similar finds of possible ground/cracked cereal grains reported for the Neolithic site of Avgi in Northern Greece (Margariti, 2007) and Drakaina Cave in Kephalonia (Sarpaki, 2009), as well as Late Bronze Age Akrotiri in Santorini (Sarpaki, 2001), constitute further indications for the processing of cereal foods in the study area. These are not included in Table 2 as little information is provided in the preliminary publications, lacking images of the fracture surfaces. The Akrotiri finds demonstrate a shredded fracture surface that does not match any of the archaeobotanical material we have considered here and the available, published experimental specimens.

The range of the materials that we have examined and correspond to cereal fragments indicate that grinding of cereals may not always result to bulging of the fracture surface, as previously suggested (Valamoti, 2002) and the taphonomic and/or processing parametres involved in this are currently investigated experimentally in the context of the PLANTCULT project.

3.3. Category 2: agglomerations of cereal fragments or food 'lumps'

The second category includes agglomerations of cereal fragments a) fused together but still clearly visible as distinct fragments and b) embedded in a more or less homogeneous matrix.

3.3.1. Agglomerations of fragments

Cereal fragments of small size are found lumped together at Karanovo as the contents of a vessel. They consist of small fragments (between 0,5 and 1 mm) and they could correspond to pre-cooked cereals or simply ground cereals that were lumped together during charring. (Fig. 6). SEM images of individual fragments show the modified starchy endosperm observed in experimentally boiled grains (Valamoti et al., 2008) thus they could correspond to cooked cereals. It is impossible, however, on present state of the art to determine whether the gelatinised endosperm was generated as part of a pre-treatment (as in parboiling to make bulgur) or during an accident (destruction by fire or cooking accident) during the preparation of some foodstuff.

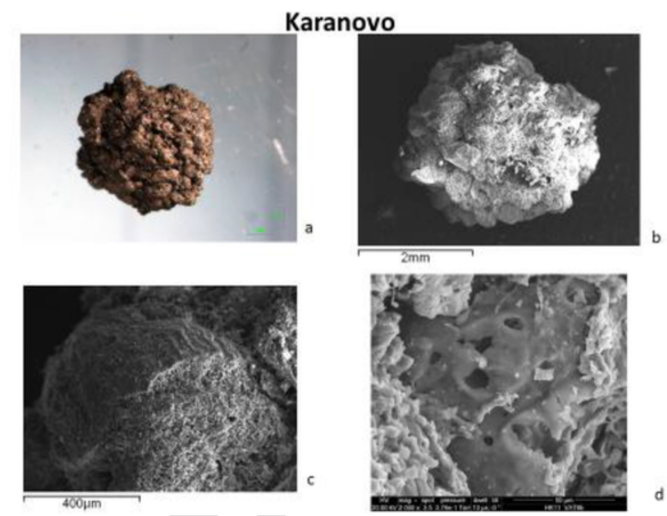

Fig. 6. Microphotographs of the finds of food remains from ~~Late Neolithic~~ Karanovo. a) macroscopic overview of a food fragment under low magnification binocular, b)macroscopic overview of a food fragment under SEM (x23 magnification), c) close view on the surface of a food remain with preserved grain fragment (x120 magnification), d) microstructure of the food tissue with indications for boiling.(working distance for SEM images 20 mm).

The Provadia-Solnitsata (Fig. 7) material is very interesting as it clearly shows cereal fragments fused together and a homogeneous surface that indicates a discrete lump of fragments. Therefore the Provadia-Solnitsata specimen corresponds to grain that had been ground and most likely formed into a lump or the lump is the result of some cooking process. We should, however, also consider the possibility that the loose fragments became fused together due to charring.

At Archondiko, some of the samples consist of lumps of cereals processed by grinding, with relatively large fragments of cereal grains and chaff (Fig. 8). These lumps of ground grain could have resulted either from intentional processing or could be the outcome of fusing of grain fragments due to charring conditions. If intentionally formed, they could correspond to some form of processing/cooking steps such as grinding, mixing with some liquid and forming lumps of the

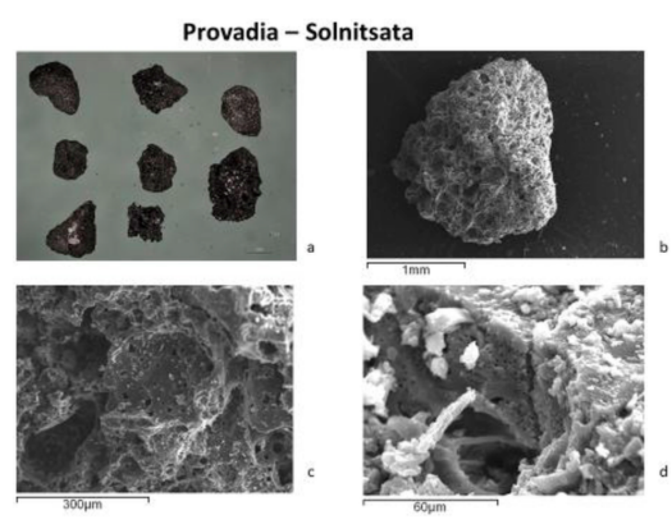

Fig. 7. Microphotographs of the finds of food remains from Chalcolithic Provadia-Solnitsata. a)macroscopicoverview of food fragments under low magnification binocular, b)macroscopic overview of a food fragments under SEM (x40 magnification), c) close view on the surface of a food remain (x180 magnification), d) preserved multi-layered aleurone (x900 magnification).(working distance for SEM images 20 mm).

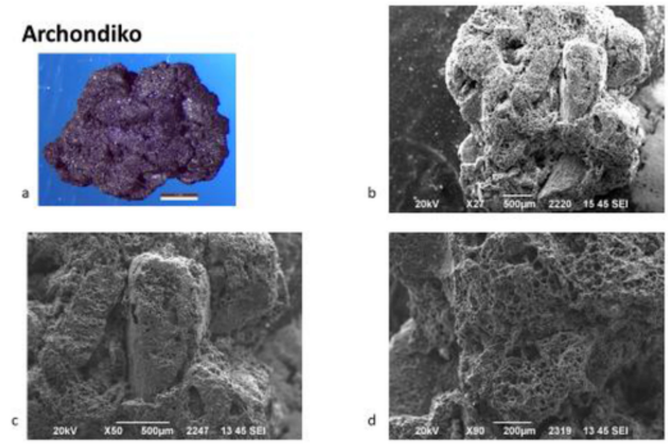

Fig. 8. Early Bronze Age Archondiko, agglomerations of cereal fragments. a) overview under low magnification binocular, b) overview under SEM, c) and d) closer view of the food fragment structure.

xinochondros/kishk type (see Valamoti, 2011 for an overview of the different types of food preparations consisting of cereal fragments and water/or milk). The shiny glassy surfaces of boiled specimens have not been identified on this material. A new possibility of interpretation has recently emerged in light of recently published evidence from Archondiko (Valamoti et al., 2017) and these finds could alternatively correspond to dried malt cakes, used as starters for the preparation of a fermented beverage. Experimental investigations underway may help clarify these alternative processes generating this type of archaeobotanical food remains.

3.3.2. Agglomerations of fragments in an amorphous matrix

Our second group in this category includes mixtures of a fine, amorphous matrix with cereal fragments embedded in it, when examined with stereomicroscopy. Mixtures that may include fragments generated from the steps described above, together with more finely ground material may constitute more complex preparations such as 'breads', porridges, thick soups or other foodstuffs of similar consistency. These food remains could be interpreted as possible bread/porridge remains and are the most common category (regarding plant food remains), encountered in most of the sites from Northern Greece and Bulgaria, considered in the study.

Neolithic finds corresponding to this category come from the sites of Limnochori II and Limnochori III and Anarghiri III (Figs. 9–11)in regions of Western and Eastern Macedonia in Northern Greece. In the

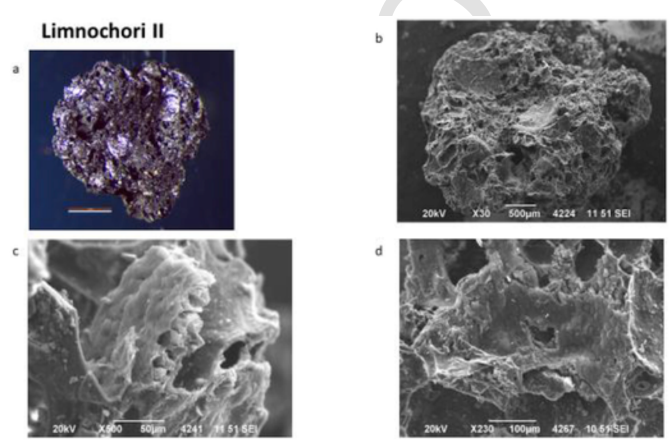

Fig. 9. Porous mass of plant foods form Late Neolithic Limnochori II. a) overview under low magnification binocular (scale bar 1 mm), b) overview under SEM, c) and d) SEM micrographs showing cereal pericarp longitudinal cells and single-layered aleurone.

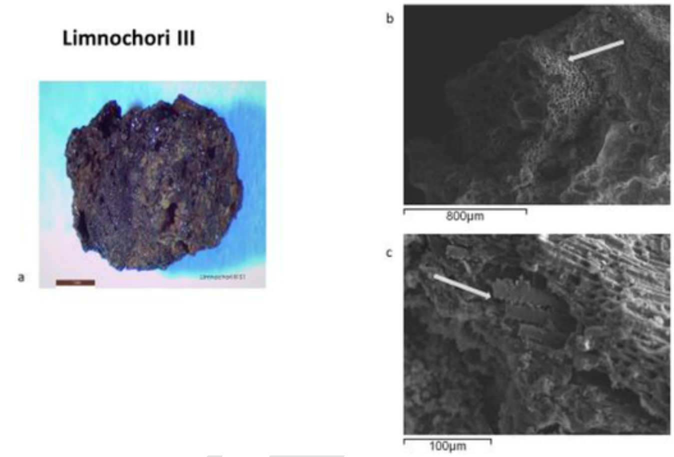

Fig. 10. Fragment of plant food from Final Neolithic Limnochori III. a)overview under low magnification binocular (left). SEM micrographs showing b) aleurone layer remains (x65 magnification) and c) wheat species glume fragments (x370 magnification).(working distance for SEM images 20 mm).

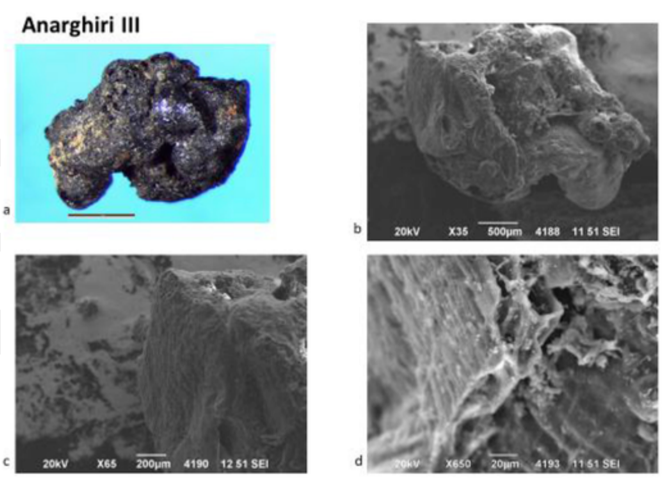

Fig. 11. Fragment of processed cereal food from Late NeolithicAnarghiri) overview under low magnification binocular (scale bar 1 mm), b) overview under SEM, SEM images showing c) cereal grain fragment and d) multicellular aleurone layer.

Bronze Age, similar finds come from Archondiko, Armenochori and Angelochori in Northern Greece (Figs. 12–14) and Sokol and Kush Kaya in Bulgaria (Figs. 15 and 16). Further Bulgarian finds from Ada Tepe, Vaskovo, Kapitan Andreevo and Yurta belong to the Iron Age while the Necropolis of Apollonia to the Classical period (Figs. 17–21). At Archondiko, grain and chaff fragments are embedded in a porous, starchy matrix. Among the most common finds of identifiable tissues are parts of the aleurone layer, found in the pericarp of cereal grains (Fig. 12). Both single-layered (as in wheat, millet, oat and rye), and multi-layered aleurone tissue, found in barley, were visible. Food fragments with similar structure of coarsely pounded or ground cereal grain fragments embedded in a starchy matrix were also found in Limnochori II, Limnochori III, Anarghiri III and Armenochori (Figs. 9–11, 13). In the food fragments from Angelochori (Fig. 14), barley was recognized as the main component. In the cases where parts of the original outer surface were preserved, no differentiation between crust and crumb could be detected.

The Bulgarian finds that demonstrate this feature of an amorphous matrix including cereal fragments are dated to the Bronze and Iron Age. Food fragments from Early Bronze Age Sokol consist of masses with fragments of cereal grain and chaff. Some of the grain fragments

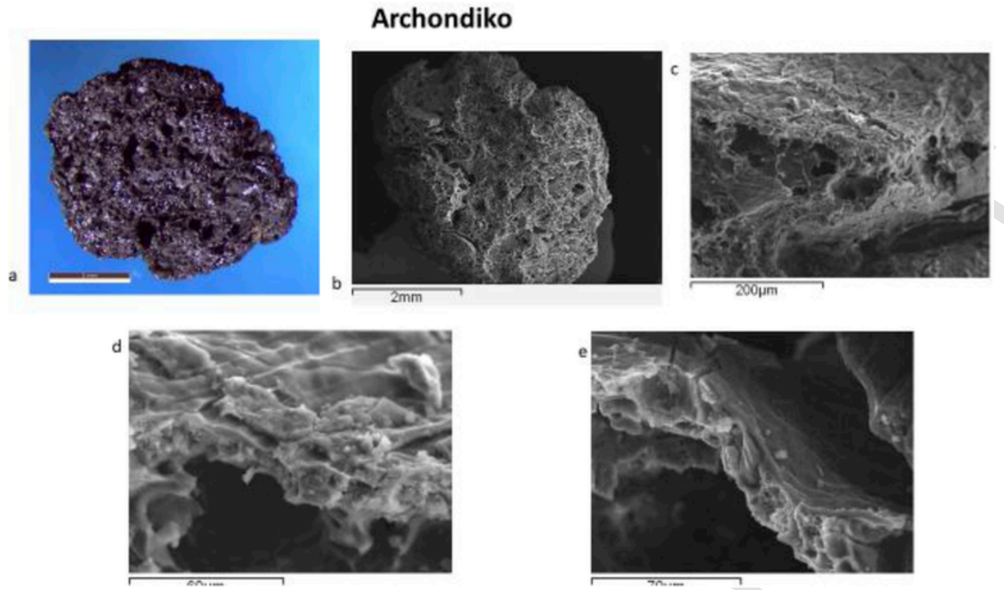

Fig. 12. Fragment of food remains from Early Bronze Age Archondiko. a) overview of the fragment under low magnification binocular, b) overview under SEM (x23 magnification), c) part of cereal grain showing at least sinlge-cell aleurone layer (x250 magnification), d) magnification of c (x800 magnification), e) remains of aleurone layer, possibly multi-layered (x850 magnification).(working distance for SEM images 20 mm).

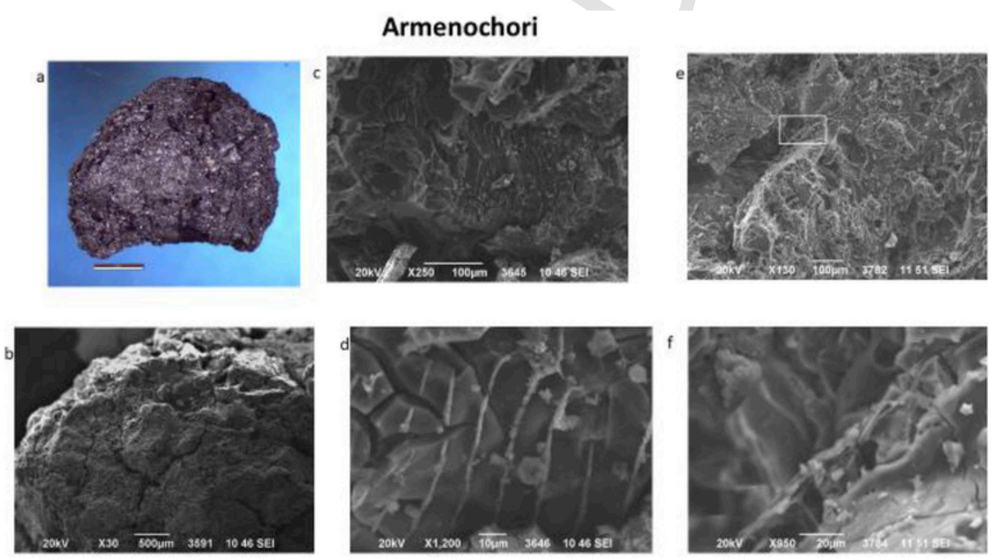

Fig. 13. Finds of food remains from Early Bronze Age Armenochori. a) overview under low magnification binocular (scale bar 2 mm), b) View of the find under SEM, c) patch of *Triticum* sp. transverse cells, d) Magnification of c., e) Remains of sinlge-layered-aleurone, f) Magnification of e.

have been recognized as wheat. The porous matrix appears to be shiny and somewhat vitrified in some parts (Fig. 15).

Agglomerations of cereal fragments were found in the LBA layers of the site of Kush Kaya *in situ* in a deep vessel in a dwelling. The crust has a porous texture, which contains whole and fragmented cereal grains (millet and barley). Less frequent but well recognizable is linseed (Fig. 16). The fragmented grain and chaff of millet indicate that some processing related to dehusking or pounding/grinding took place prior to charring. Similar to the millet grains, also the barley remains indicate that they were partly fragmented or ground before mixing and becoming charred. This is attested by a variety of barley pericarp fragments, some still associated with multi-layered aleurone, which is typical for barley (Koërber-Grohne and Piening, 1980). Linseed was added to the mixture for its high content of oil, which would increase the nutritional value of the porridge.

Few samples with preserved cereal pericarp fragments were found in the Early Iron Age site of Ada Tepe (Fig. 17) and Kapitan Andreevo (Fig. 19). The texture of the fragments is quite homogenous which could be evidence of more controlled grinding and perhaps sieving of the ingredients prior further processing/cooking. In the material of Ada Tepe the preserved pericarp was identified as wheat (*Triticum* sp.) while that from Kapitan Andreevo was most probably barley.

Food fragments from Late Iron Age Yurta and classical period Necropolis of Apollonia are characterized by a similar homogeneous structure. Cereal bran fragments, most commonly aleurone layer remains, were found in the SEM samples (Figs. 20 and 21).

Several very small fragments (approx. 0,5 cm) from the Early Iron Age site of Vaskovo were studied (Fig. 18). These possible food remains represent a homogenous structure. The texture is very similar to those from the other Early Iron Age sites KapitanAndreevo and Ada Tepe, but traces of preserved cereal pericarp and/or aleurone layers were barely

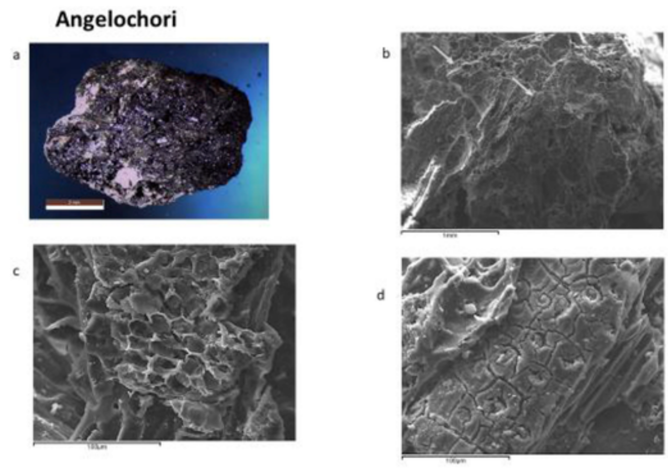

Fig. 14. Cereal fragment agglomeration in matrix from Late Bronze Age Angelochori. a) overview under low magnification binocular (scale bar 2 mm), b) view under SEM (x50 magnification). Arrows indicating areas of interest: c) remains of (possibly multi-layered) aleurone (x650 magnification), d) barley glume fragment (x550 magnification).(working distance for SEM images 10 mm).

found (Fig. 7). hould be noted that in some of the fragments a wooden structure was also identified. Having in mind that the samples come from a house floor near the fireplace, most probably wood fragments have been mixed with the food remains.

3.3.3. Amorphous masses with 'bubbles'

The material in this category corresponds to a fine structure with no cereal fragments visible. This group of remains is quite frequently encountered at sites like Dikili Tash and Anarghiri I and consists of featureless masses of homogeneous structure with large bubbles or small pores (Figs. 22 and 23). In some fragments, possible remains of cereal pericarp could be observed under SEM, but their poor and fragmented state of preservation does not allow for a conclusive identification of cereals as a component of the food remains. In most cases, their examination has not revealed any identifiable plant tissues, it is therefore not certain that they are cereal based. In several of the presented here sites (Kush Kaya, KapitanAndreevo, tepe and Vaskovo) amorphous matter portions are available together with recognizable plant tissues. However when no morphological structures are visible such amorphous material is more difficult to interpret and the possibility that parenchyma or other kinds of tissues of plant origin are present has not yet been excluded. An aid to solve this question could be further methodological approaches like residue or chemical analyses..

4. Discussion

A wide range of possible plant food ingredients could have been used as food components, including various cereal and pulse species as well as oil plants, fruits, nuts, medicinal and aromatic plants in Southeastern Europe during the Neolithic and the Bronze Age. Turning to cereal ingredients in our study area, the main component of the material studied here, glume wheats, einkorn (*Triticum monococcum*), emmer (*Triticum dicoccum*) and the "new glume wheat-type", as well barley (*Hordeum vulgare*) are the most common finds (Hansen, 2000; Jones et al., 2000; Marinova and Valamoti, 2014; Sarpaki, 2000; Valamoti, 2009). Free threshing wheat, although very sporadically encountered in Neolithic sites from Greece it has been found in rich concentrations in Bulgarian Chalcolithic sites, especially in the Eastern part of Bulgaria (Gleser and Marinova 2018).

The Neolithic prevalence of the glume wheats in our study area continues into the Bronze Age. The presence of free-threshing wheat increases, and it is present as a prominent crop in Archondiko, yet it is absent from the archaeobotanical assemblages of Bulgaria (Marinova and Valamoti, 2014; Valamoti et al., 2008). Barley also emerges as the dominant crop at sites such as Mesimeriani Toumba (Valamoti, 2002) and Agios Athanasios (Moniaki, 2009). To the species known from the Neolithic, two more are added: spelt wheat (*Triticum spelta*) during the Early Bronze Age and millet (*Panicum miliaceum*) during Late Bronze Age (Valamoti 2002; 2013; Marinova and Valamoti, 2014). Among the sites with rich finds of millet are Archondiko and Angelochori (Valamoti, 2010, 2013), while in Kush Kaya it appears as a dominant crop along with hulled wheats (Popov et al., 2018).

During the Early Iron Age, cereal crops include millet, barley, hulled wheats, especially einkorn, and free threshing wheat (Hristova et al., 2016; Valamoti et al., 2018). Regional differences between Greece and Bulgaria are observed, for example unlike Greece, free-threshing wheat makes a limited appearance in Bulgaria with the exception of some sites such as Ada Tepe (Nikov et al., 2018) and Bresto (Marinova unpublished data).

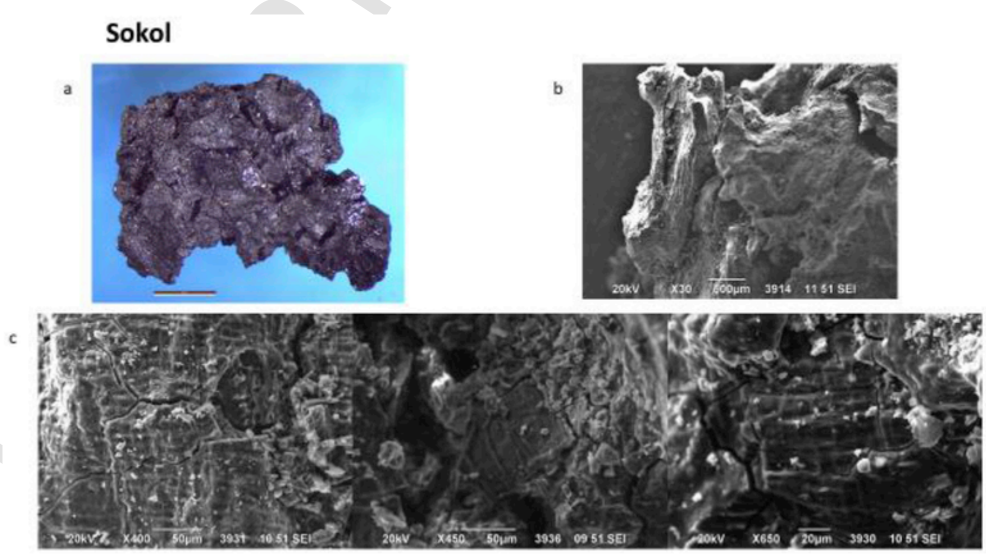

Fig. 15. Fragment of food remain from Early Bronze Age Sokol. a) overview of food fragment under low magnification binocular (scale bar 2 mm), b)view of food fragments under SEM, c)patches of cereal bran embedded in the matrix.

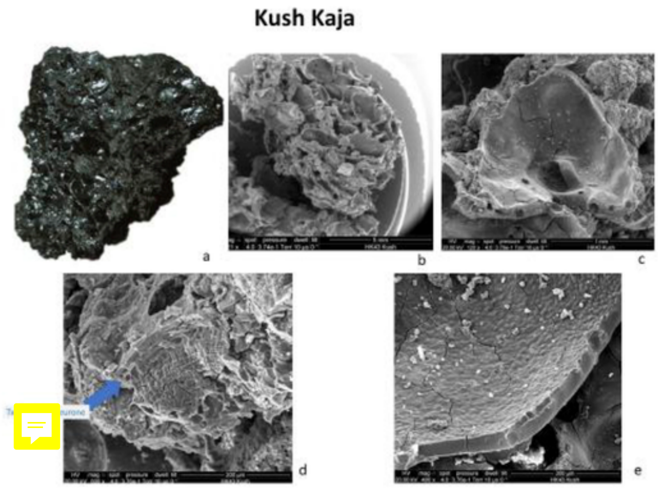

Fig. 16. Microphotographs of the finds of food remains from Late Bronze Age Kush Kaya. a) macroscopic overview of a food fragment under low magnification binocular, b) macroscopic overview of a food fragment under SEM, c) common millet – glumes fused with pericarp, d) preservation of cereal pericarp with multicellular aleurone, e)linseed – seed coat surface fragment.

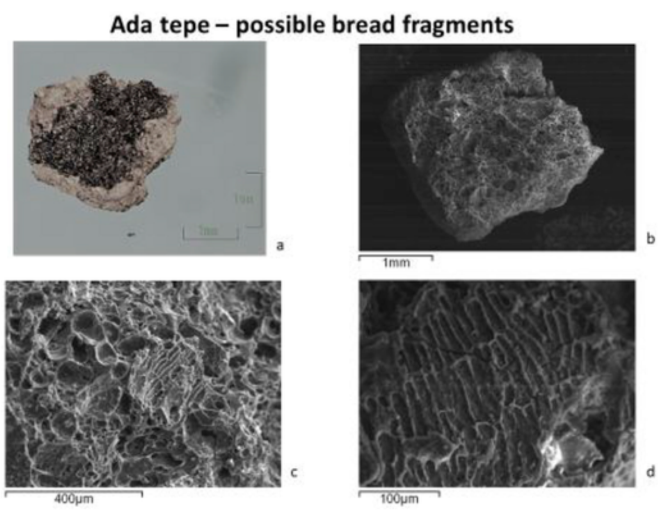

Fig. 17. Microphotographs of the finds of food remains from Early Iron Age Ada Tepe. a) macroscopic overview of a food fragment under low magnification binocular, b) macroscopic overview of a food fragment under SEM (x30 magnification), c) close view of the porous structure of a fragment with preserved pericarp cells (x140 magnification), d)detailed view of transverse cell layer of wheat (*Triticum* sp.) pericarp (x330 magnification).(working distance for SEM images 20 mm).

Already since the Neolithic we observe variability in our study area as regards the forms in which cereals were transformed into food in prehistoric SE Europe. Cereal fragment concentrations and agglomerations of fragments in an amorphous matrix could correspond to various forms of cereal preparations such as bulgur or trachanas, bread, porridge or other forms of preparations. When fragments are loose, they could represent some form of cracked wheat, bulgur, trachanas or ground malt, depending on the particular features of the fragments (e.g. glassy, bulging endosperm). When the finds correspond to lumps of fragments they could be either some form of food like bread or porridge or an accidental conglomeration of a coarse meal or a fine meal with coarse inclusions, generated through charring. On present evidence it is not possible to differentiate between bread, porridge or accidentally formed lumps on the basis of morphological features of the archaeological finds. Moreover there is inadequate published comparative experimental material to facilitate a fine resolution categorisation of these ancient food remains. Therefore such lumps or masses are provisionally grouped in a broad category of 'bread/porridge'. The chronologically earliest finds (5650-5450 BCE) are cereal fragment concentrations (Table 2), but very soon after that period (from 5500 to 4000 BCE) also finds of bread/porridge occur in the study area (Table 2).

The Early Neolithic loose fragments from Bulgarian sites are either bulging (Kapitan Dimitrievo) or undiagnostic (Kapitan Dimitrievo, Yabalkovo). The ~~Late Neolithic~~ remains from Karanovo and ~~Early~~ Chalcolithic from Provadia-Solnitsata demonstrated some traces of cooking (Figs. 6 and 7). It is not known whether a lack of bulging on cereal fragments can be generated under certain processing or charring conditions something that is currently being explored through systematic experimentation in the context of project PLANTCULT.

During the Bronze Age, the same variability continues as regards the types in which cereals are found in the form of food preparations, both in Bulgaria and Greece, with fragments and porridge/bread finds identified in both regions. The ingredients identified in the cereal food remains are in agreement with the appearance of millet as a new ingredient introduced during the Bronze Age in the area. Iron Age food remains are at present reported only from Bulgaria (Kapitan Andreevo, Ada Tepe, Vaskovo, Yurta) and may suggest standardised grinding and/or sieving prior to cooking.

Any regional differences observed between the different periods, e.g. the later occurrence of 'bread/porridge' finds from Bulgarian sites, is still difficult to evaluate, as such finds corresponding to cereal foods are quite rare and their preservation in the archaeological record depends on a series of taphonomic factors that may vary from site to site. Therefore, before enough data has been collected, it would be premature to discuss regional differences in culinary practices in respect to the cereal food preparations presented in this paper.

Despite the difficulties encountered in interpreting the material we have studies and deciphering the underlying 'recipes', we can safely argue that a range of different ways of transforming cereals into food were used in our study area. The variability observed concerns both ingredients and forms of food remains and would have served different requirements, seasonal, nutritional and social. The ethnographic record of our study area and beyond, offers a wealth of options as regards converting plant ingredients, in our case cereals, into foods. Solid forms with a long shelf life include ground cereals, precooked cereals in various forms known as bulgur or trachanas/kishk (see Palmer 2002 and Valamoti, 2011 for a review of the literature as regards nutrient properties and variability in the ethnographic record), unripe grain roasted or smoked known as frikee and Grünkörn (Palmer 2002; Bayram, 2008, Berihuete-Azorin in preparation), barley or other cereal based rusks (Procopiou, 2003). Cereals can also be transformed into liquid forms in fermented or alcoholic drinks as is the case of beer and millet boza (e.g. Valamoti, 2009, 2013) and such practices may well be represented by the material under consideration here (e.g. beer, see Valamoti, 2017a). Parboiling and grinding cereal grain in a coarse form in a bulgur/trachanas preparation as identified at Mesimeriani would have taken advantage of seasonally available ingredients and the hot summer sun to convert these ingredients into an ~~ingredient~~ with a long shelf life, easily transformed into a nutritious meal throughout the year (Valamoti, 2011). Grinding grain into fine or coarse meal could have taken place piecemeal throughout the year to produce bread or porridges. The potential range of cereal food preparations that may correspond to the archaeological specimens we have examined so far might have had different advantages in terms of nutrient content, nutrient uptake and shelf-life as well as of labour investment in preparation, seasonality of cooking activities, ease of cooking etc. Transforming cereals into foods in different ways would have allowed not only a variety in cuisine *per se* but a means to better manage the available ingredients in terms of cooking time, nutrient availability,

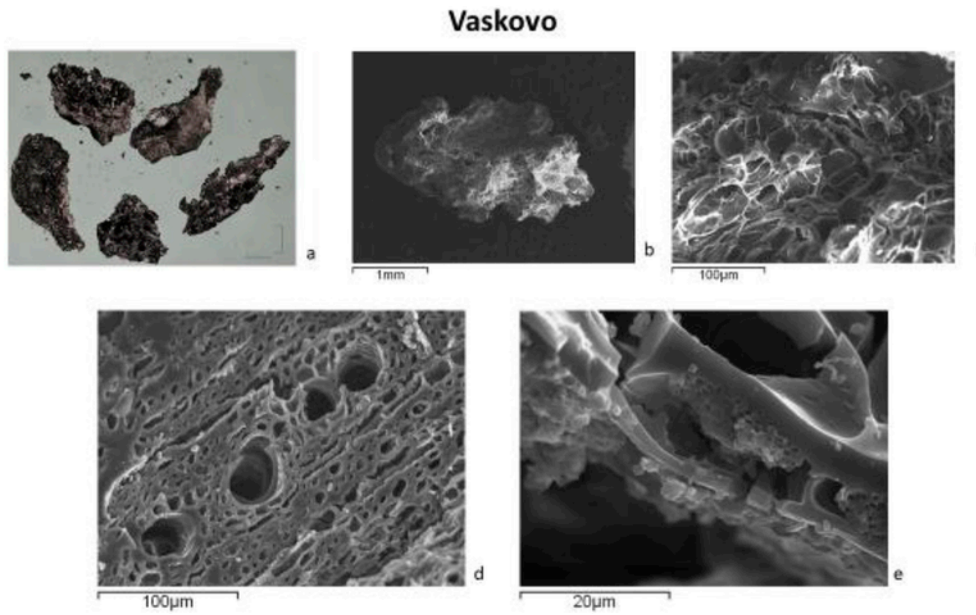

Fig. 18. Microphotographs of the finds of food remains from Early Iron Age Vaskovo. a) macroscopic overview of possible food fragments under low magnification binocular, b) macroscopic overview of a food fragments under SEM (x30 magnification), c) close view of the porous structure of a fragment (x400 magnification), d) close view of wood structure (x430 magnification), e)preserved aleurone layer (x2300 magnification).(working distance for SEM images 20 mm).

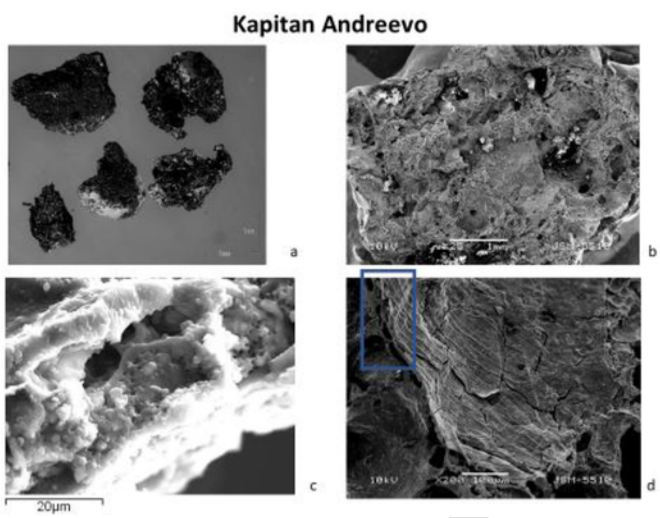

Fig. 19. Microphotographs of the finds of food remains from Early Iron Age KapitanAndreevo. a) macroscopic overview of food fragments under low magnification binocular, b) macroscopic overview of a food fragment under SEM, c) and d)view of preserved aleurone layer and cereal pericarp (possibly barley) (c: x1900 magnification).

seasonal distribution of tasks, e.g. bulgur making in the summer, beer making in winter.

Which of these preparations correspond to the material we have examined remains unclear for most of them and apart from bulgur/trachanas, the other food remains could correspond to one or a range of pre-processed cereals (e.g. of the kishk/trachanas type, ground malt, dry bread) or of foodstuffs that happened to be charred as left overs or during cooking porridge and baking bread. However, several of them (Table 2) were found in contexts which strongly suggest their relation to processed food products. As already stated above the materials we have studied correspond to an extremely small portion of the foods prepared in prehistoric times in the region and consumed as food. In our discussion we should not forget that particular tastes might have prescribed regional preferences in the ingredients used and the ways those ingredients were transformed into foods. This interplay of available and selected ingredients and recipes would have contributed to the creation of regional culinary identities (Valamoti, 2017b). The ground cereal food ingredients we have investigated in the archaeobotanical record of Southeastern Europe could, in themselves, have been very flexible ingredients as they could have been converted into a savory or sweet meal, depending on what is added in the dish, e.g. cheese or dried fruit.

5. Conclusions

At the level of our analysis attempted here, the food products found could correspond to two broad categories: ground/pounded grains and bread/porridge preparations. These could correspond to many food products attested ethnographically. On current evidence the potential foodstuffs represented by the studied material could correspond to a) cracked wheat, b) bulgur/trachanas, c) ground malt, d) conglomerations of a-b-c-d, accidental or intentional, e) bread/porridge like preparations. Whether indeed such a variability in preparations existed in prehistoric times, is the subject of future research. Our paper offers a coarse-grained classification of archaeologically found cereal foods on the basis of morphology, informed by ethnographic studies. This classification provides a tool for routine archaeobotanical examination of such finds, avoiding at the same time the projection of modern perceptions about cereal foods to the prehistoric past. This is a first step in classifying such remains, in agreement with the wide range of possibilities in transforming cereals into food. Our work has shown that the characterisation of such cereal food preparations as bread or bulgur should be done with great caution or even be avoided, before reliable methodological steps for the examination of the different food processing stages has been developed.

As stated in the beginning of our paper it is crucial to carefully record the different forms of the archaeological specimens that are currently lumped under general categories such as cereal food, bulgur, bread/porridge. It is also very important to note that these general categories widely used in the literature, sometimes interchangeably, mask a multitude of recipes leading to similar looking preparations in the archaeobotanical finds, thus further ethnographic data backed up by experimental data will help understand the nature of the ancient cereal

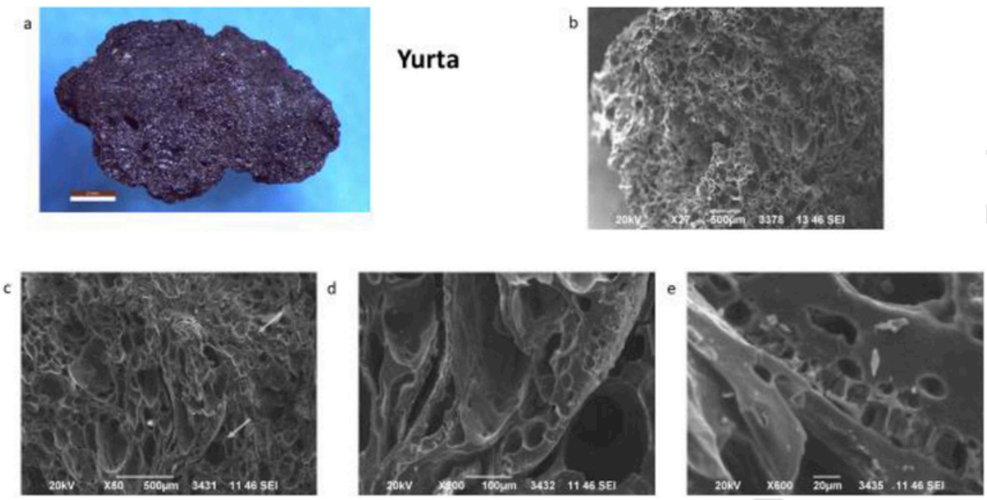

Fig. 20. Fragment of food remains from Late Iron Age Yurtasettlement. a) overview of food fragment under low magnification binocular, b) view of the food fragment under SEM, c) remains of aleurone layer embedded in the matrix, d) and e) details of c.

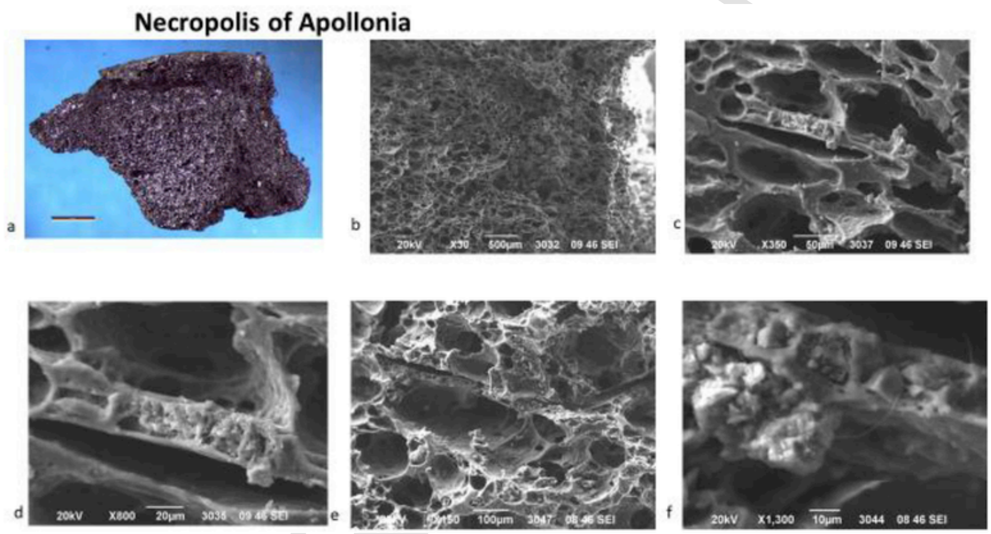

Fig. 21. Fragment of food remains from Necropolis of Apollonia, classical period. a) overview of food fragment under low magnification binocular (scale bar 2 mm), b) view of food fragment under SEM, c) and e) remains of aleurone layer embedded in porous matrix, d) and f) magnification of c and e respectively.

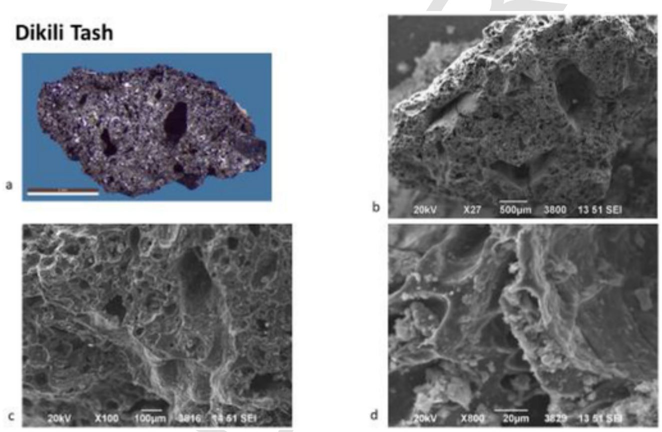

Fig. 22. Fragment of processed cereal food from Late Neolithic Dikili Tash. a) overview of food fragment under low magnification binocular (scale bar 2 mm), b)and c) view of food fragment under SEM, d) possible remains of aleurone layer.

foods examined under the microscope. A systematic key for classifying such objects is much needed and is currently under way in the context of ERC project PLANTCULT (Heiss et al. in preparation). Detailed classification categories of archaeological finds of cereal foods, backed up by experimental replications will allow more refined interpretations of the processing steps involved in their preparation. It is probably uncertain that experimental replication could cover the full range of types of fragmented grain, pre-cooked cereals, flours or fermented cereal products that were used in prehistoric times or the ways in which they were further mixed and cooked. Moreover, our study has shown that behind the visible surface observed each time, there will always be an underlying matrix that is invisible and non-quantifiable. Yet, this coarse grain classification we offer here, based on 'internal' evidence provided by this rarely preserved archaeobotanical material, is a first step towards the classification of archaeological cereal foods that allow associations between these finds and a range of possible food categories. Devising detailed classification categories opens up the way to decipher prehistoric cereal based recipes. Our work presented here highlights a multitude of possible cereal-based food products that may correspond to the finds analysed. The food remains we have identified and presented in a first regional overview of prehistoric cereal food preparations open up

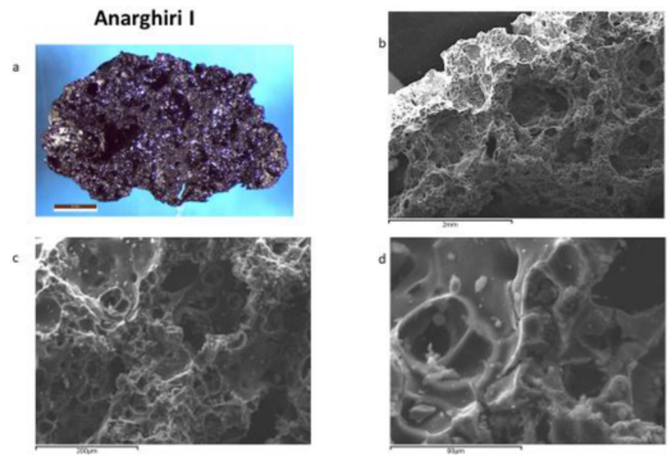

Fig. 23. Fragment of food remains from Early-Middle Bronze Age Anarghiri I. a) overview of the fragment under low magnification binocular (scale bar 2 mm), b) and c) view of the fragment under SEM (x30 and x250 magnification respectively), d)possibleremains of aleurone layer from food fragment (x800 magnification).(working distance for SEM images 10 mm).

the possibility to explore and comprehend the factors that may have led to this wealth of food preparations, the complex outcome of interactions between the natural and cultural environments of these farming communities over a long period of time. Integrating the archaeobotanical macro- and micro-remains with the available food technologies used for grinding, cooking/baking etc, informed by residue and use-wear analyses, will hopefully facilitate our understanding of the cereal food preparations discussed here (Valamoti et al., 2017).

Further analysis of these finds, integrated with evidence from functional analyses of pottery, residue analyses and ethnography, underway in the context of ERC project PLANTCULT will hopefully reveal in detail the particular characteristics of the prehistoric forerunners of foods that still survive today in the traditional cuisines of the study area. The refinement of the methods and variables that need to be taken into consideration will allow in the future the exploration of shared culinary trends and their potential changes over time opening the path towards an investigation of the factors that led to culinary traditions and innovations in this part of Europe.

Uncited references

Hansson and Isaksson, 1994; Hansson, 1996 [illegible] ~~stova et al., 2017~~; Leshtakov et al., 2014; Lespez et al., 2013; Pearson, 2003; ~~Popov and Grozdabova, 2008~~; ~~Valamoti and Voutsaki, 2013~~; Carretero et al., 2017.

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