UNIVERZITA KONŠTANTÍNA FILOZOFA V NITRE

ARCHEOBOTANIKA

DOBY BRONZOVEJ NA SLOVENSKU

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NITRA 2012

Práca bola podporená Agentúrou na podporu výskumu a vývoja na základe zmluvy č. APVV-0598-10 a riešená v rámci projektov VEGA 1/0477/11, VEGA 2/7111/20, VEGA 1/0530/08.

Táto kniha vyšla s finančným príspevkom Carl Zeiss Slovakia, s. r. o.

ARCHEOBOTANIKA DOBY BRONZOVEJ NA SLOVENSKU
Štúdie ku klíme, prírodnému prostrediu, poľnohospodárstvu a paleoekonómii

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Obálka:	Beáta Jančíková
Rok vydania:	2012

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ISBN 978-80-8094-949-5

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10 SUMMARY

The Archaeobotany of Bronze Age Slovakia

This monograph is the first to deal with the use of plants and crops during one age in the territory of Slovakia, also presenting the most recent and modern results of research in a single book. In nine chapters it elucidates farming practices and crop husbandry of the Bronze Age (ca. 2200–750 cal BC)[84] and addresses the climate and natural vegetation of the period.

Over ten years ago, in their book on the Bronze Age Slovakia, Furmánek,Veliačik and Vladár (*1999*, 130) wrote that the information on cultivated crops and gathered fruits during the Bronze Age in Slovakia is very patchy; information on arable practices, harvesting techniques, further manipulation of crops and productivity is poor or negligible; and that it remains unknown how communities coped with short climate events, like draught periods, or major climate changes, and what is the ratio of animal to crop husbandry.

Since then a series of archaeobotanical (and archaeozoological) analyses have been carried out. This monograph presents all available archaeobotanical and archaeozoological data from finished research projects or other studies. The botanical data[85] are further analysed by means of a wide variety of research tools and methods. Interpretations of these analyses bring fresh understanding of the history of cultivated crops and the findings are evaluated in a wider socio-economic context.

The book, which is intended for a diverse audience to include archaeologists, botanists, agronomists and historians, presents archaeobotany as a complex discipline effectively tackling questions about the economy and social aspects of prehistoric communities. It seeks to explain the role of arable farming and crop husbandry, a vital part of the Bronze Age economy, because only better understanding of everyday life of farmers in the Bronze Age on a local level can move us toward understanding the role of Slovakian territory in European history.

Chapter 2 (Background setting) presents a general overview of the environmental and cultural situation. Published views on various aspects of the environment, life and societies of the Bronze Age are provided and novel research approaches (e.g. for palaeoclimate reconstructions) are introduced.

In the subchapter on the climate of Bronze Age Slovakia, the following points are stressed. Due to a lack of palaeoclimate research in Slovakia, researchers tend to use the results of palaeoclimate studies from distant parts of Europe. When these have been used, steppe elements present in some local palynologycal/archaeobotanical and/or malacological records, for instance, have not been taken into account, and the middle Holocene landscape is therefore usually considered to have been dense deciduous/coniferous forests.

Using distant and/or selective data is demonstrated to be inappropriate and instead macroclimate modelling is presented as a tool that more realistically reconstructs the palaeoclimate. How the model works is described in detail and models for six sites in different regions of Slovakia are developed.

Combining the limited but important published evidence and macroclimate models indicates that Bronze Age Slovakia included elements of open park-like landscape, with possible permanent grassland patches in the driest lowland areas. This is also supported by recent research on pollen profiles in Hungary. Magyari et al. (*2010*) describe the climate in the region as different from what is known elsewhere in Europe, documenting the persistence of wooded steppe from the early Holocene to the Iron Age.

The sections on the cultural background are provided mostly for non-specialists in archaeology. First, the absolute chronology of the period is shown as a prerequisite for understanding the cultural and environmental changes in the Bronze Age. Then, research on the society is discussed, explaining differences in the archaeological evidence available for the various subperiods and subregions in Slovakia (uneven distribution of graveyards, settlements, hillforts, hoards) and the limits of data retrieval and interpretation. Here, also views on the character and complexity of the society are presented, emphasising specific archaeological evidence upon which some common opinions circulating in Slovak archaeology rests. In general, Bronze Age society is thought to be a highly stratified society. Some evidence is thought to suggest the existence of specialised production and consumption sites, a question addressed towards the end of the book.

[84] Translator note: The Bronze Age in Slovakia is subdivided into four parts as follows: Early (with an early and a later phase), Middle (one phase only), Late (one phase only) and Final (one phase only). Together, the Slovakian/Bohemian Late and Final Bronze Age periods correlate roughly to the Western European Late Bronze Age. Here the Late and Final are distinct and were evaluated separately.

[85] At present, over 228.000 finds of charred and uncharred seeds are known from 234 contexts at 41 sites; and if 15.000 charcoal fragments are added, the total number of sites increases to 126.

Chapter 2 ends with a conclusion that agriculture is the underpinning of Bronze Age society, because animal and crop husbandry were the primary means of procuring food. The absence of evidence – installations (e.g. silo-pits), artefacts (e.g. sickles) or ecofacts (e.g. plant macro-remains) – is not considered evidence of the absence of certain farming, food procurement and crop-processing activities. Viewing the evidence (or lack thereof) of agriculture in this way may re-form the picture of Bronze Age society in Slovakia.

Chapter 3 (Methods) describes in detail the methods used for collecting soil samples in the field (judgemental vs. systematic) and their processing (wet-sieving, flotation), methods in–the laboratory analyses (sorting and species identification) and mathematical (counting) and statistical evaluations (selection of samples for quantitative and statistical analyses, data standardisation).

Chapter 4 (Material) is the catalogue of sites with archaeobotanical, osteological and malacological finds from Bronze Age sites in Slovakia, in which the sites are listed chronologically. For each site the basic facts and literature are given, followed by the list of plant and animal species identified in its analysed samples. Tables 4.1 – 4.20 in the Appendix detail the archaeological and archaeobotanical information for each sample (context, volume, botanical taxa and the counts of each plant taxon).

Chapter 5 (Plant macroremains – general results) features the spectrum of cultivated crops, and wild and gathered plants of Bronze Age Slovakia. Crops are evaluated in terms of their presence/absence and ubiquity through time. Eight cereal crops (einkorn, emmer, spelt, bread and club wheat; naked and hulled barley; millet), four pulse crops (lentil, sweet pea, Celtic bean, common vetch) and two oil/fibre plants (flax, gold-of-pleasure) were identified. Information on domestication and cultivation history in the Old World is given for each of the species, offering information on its time and place of domestication, and the route along which and when it came to East-Central Europe.

Rare finds of gathered plants, mostly edible berries of shrubs and trees (e.g. prune cherry, cornelian cherry, elderberry, raspberry, blackberry, etc.) indicate that they were a part of the diet. Special attention is paid to acorns, which were recovered from what seems to have been a cultic context. Given the accompanying finds (cereal grains and weeds, fish scales, bones, daub fragments, and pottery), it seems the acorns may have entered the context secondarily, as kitchen waste.

The main constituents of the samples (grain, chaff, seeds of legumes, weeds and gathered fruits) demonstrate that mostly burnt residues of crop stores, with some wastes from their processing, form the archaeobotanical samples. Arable weeds are mentioned in this chapter but are discussed in more detail in Chapter 8.

Chapter 6 (Taphonomic analyses) presents taphonomic analyses as a crucial step in further refining interpretation of the data. Processing crops is considered the most important taphonomic process, which strongly effects the composition of archaeobotanical deposits. In order to analyse the comparable variables in the entire assemblage, individual samples were investigated to determine whether they represent a product, by-product (waste) or the mixture of the two, and from which stage of the crop-processing sequence they came. Four methods (of taphonomic analysis) have been employed. The first two separated wastes (by-products) from stores. The third method enabled closer identification of crop-processed wastes, and the fourth more closely identified the contents of stores. Importantly, the third and fourth methods established also from which particular stage of the crop-processing sequence the wastes (third method) or stores (fourth method) originated. It is clear from the analyses that by-products (wastes) comprise only one quarter of the whole assemblage and the rest of the samples are residues of burnt crop stores. The wastes, for which the crop type could be identified, had mostly been a by-product of the processing of einkorn and emmer (glume wheats) and barley. In contrast, burnt crop stores are mostly of spelt, free-threshing wheats, millet, pulses and gold-of-pleasure (cameline). Half of the store samples had been fully cleaned (free of weeds) and half had been semi-cleaned. The latter, along with the waste samples, are used in further evaluation of agricultural practices in Chapter 8.

In **Chapter 7** (Palaeoeconomy - (Crop)Husbandry strategies of the Bronze Age in Slovakia) the results of taphonomic analyses are evaluated in economic terms aiming to classify the sites as places of production or consumption and to assess the scale of any identified production or consumption. Three models were used as theoretical frameworks for investigating the palaeoeconomy.

The first model 'Model A' is rooted in ethnography and claims that place of production and consumption can be distinguished by the presence/absence of residues (wastes) of the early crop-processing stages. Hillmann (*1984*) and Jones (*1984*) contend that these wastes would be present at places of production, while they would be absent at sites of consumption; samples containing unprocessed stores belong to the first group.

By application of this model, ten out of the seventeen evaluated sites could be considered places of production. However, the absence of wastes at the other seven does not mean they were sites of consumption. The available samples are limited and cannot be considered representative, thus the results are inconclusive.

The second model (*Fuller/Stevens 2009*), 'Model B', is based on the workforce requirements for processing crops and the ability to mobilise the necessary workforce during agricultural 'bottlenecks' (periods such as harvest time, when activity is greatest). For example, processing crops fully immediately after harvesting demands a larger workforce, and the ability to mobilise it at such a scale is considered to result from a relatively large communal (or centralized) organisation (usually in societies with some level of complexity). On the other hand, processing crops only through the early stages and during harvest time or immediately after requires a smaller workforce. Here, further crop processing takes place later in the year on a daily basis and is suitable for relatively small communities (larger than a household but not the larger communal or centralized organisation assumed above, and generally a marker of less complex societies).

Reviewing the analysed samples against Model B indicates that during the Early Bronze Age and Late/Final Bronze Age communities were unable to mobilise sufficient workforces to fully clean/process all stores; only some were fully cleaned. The portion of semi/fully cleaned stores suggests that the workforce included more than the members of a single household and involved some (communal?) organisation, but not that of a centralized society. The number of semi/fully cleaned stores increased in the Middle Bronze Age. This could (but need not) be a result of different types of storage practices (bulk vs. smaller storage, silos vs. granaries). Archaeobotany on its own, however, cannot determine whether the ability to mobilise labour was the result of a communal or centralized power. It must be combined with other, at present unavailable, archaeological information.

The third model (*Veen/Jones 2006*), 'Model C', analyses the archaeobotanical information in terms of the presence or absence of grain-rich samples, and the distribution of silo pits and above-ground granaries and fortified sites. The result of combining these sources of evidence can identify shifts in the organisation of farming, landscape and policy. This model could not be successfully applied because as yet there is only incomplete data on the distribution of silo pits and above-ground granaries and relationship between (small) open and fortified sites.

In **Chapter 8** (Weed ecology) ecological information on wild plants is used to reconstruct arable practices. Only samples with sufficient numbers of finds to meet the demands of mathematical and statistical calculations were used in the analyses.

First, exploratory multivariate statistical techniques (DCA, CA, DA) are used to find similarities and differences between storages and wastes of individual crops. All three techniques indicate that the differences are much greater between samples of stores and samples of waste than among individual crop types. In the waste samples glume wheats (einkorn, emmer) and barley are mostly present, while in the storage samples there are mostly millet, free-threshing wheats, spelt wheat and pulses, and there are some mixed storage samples with various crops. Most of the twenty-eight samples of wastes (all but three) are from the Early Bronze Age or the Middle Bronze Age, and the most of the thirty-one storage finds (all but three) are from the Late/Final Bronze Age.

The composition of weed species in wastes of einkorn, emmer and barley are similar. Furthermore, and surprisingly, the composition of weed species in stores of certain very different crops (like spring millet or winter spelt) is very similar to each other. But there are a few storage finds of naked wheat, spelt, millet and Celtic bean that are, in weed composition, more similar to wastes than to storage finds. This could be a result of the use of similar arable practices for various crops or the crop-processing techniques of the Bronze Age having a particular pressure on some weed seeds.

In the ecological analyses described below the complete data matrix (comprising all samples) was used with the aim to define whether similarities/differences between storages and wastes and individual crop types can be explained by differences in behaviour of the wild plants in regard to various ecological factors. Ecological characteristics for individual species were taken from local ecological studies (e.g. *Jurko 1992*). If these were unavailable, information from West-Central Europe was used (*Ellenberg 1979*).

The reaction of weed species to climatic factors (light, temperature and continentality) and soil (edaphic) factors (pH, moisture and nitrogen) were investigated. These have been analysed by means of DA and used for reconstruction of the conditions of the fields (light/shade, temperature, soil moisture, soil richness etc.). Biotic factors that were investigated addressed the time of sowing and the presence (or absence) and intensity of care (tillage/weeding) by using information on the time of germination and the life cycle, the beginning and the length of the flowering period, and the occurrence of a given crop in association with vegetation classes of Secalinetea (winter weeds) or Chenopodieta (summer weeds). Anthropogenic factors investigated were the height of harvest and the intensity and timing of tillage. The biotic and anthropogenic factors were also analysed by DA, some of them only by percentages of species with the same characteristic within the sample.

The ecological information led to proposing the following conclusions. Einkorn, emmer, spelt and free-threshing wheats were sown in autumn and were weeded in early spring. Spelt and free-threshing wheats were harvested in the middle of summer; einkorn and emmer later. Pulses, barley and millet were planted in this respective order in spring. Millet and barley were collected first, pulses later. The growing period of Bronze Age pulses was similar to modern varieties of fodder peas. Techniques for soil preparation did not disturb the soil deeply. The practices associated with intensive tilling are evident in all periods and for all crops. The presence of nitrophilous weed species in all crops indicates that soil quality was maintained. Extensive farming methods – fallowing – is also evident. A maximum five-year (grassland) fallow is proposed for the Early Bronze Age and the Middle Bronze Age. Later on, the fallow period is shortened and more intensive use of arable land is indicated. The use of manure is, on some fields, clear in the Early Bronze Age, but is more common in the Late and Final Bronze Age, mostly for the cultivation of free-threshing wheat, spelt wheat and millet. Cereals were harvested high on the stem. The straw was left in the field and grazed/burned (?). Ancient glume wheats (einkorn and emmer) and barley were also harvested low, probably for the use of straw. There were different agricultural practices used for the cultivation of various crops, but the changes over time described above were statistically insignificant. The reason might be the small assemblage (*59 samples*), but it might also be the use of very similar methods throughout the region and over time. Further new and systematically collected assemblages are needed to test the validity of the recognized differences and trends resulting from this study.

Chapter 9 (Conclusions) is a synthesis of the results within a wider archaeological context. It presents new findings, with implications for interpretation of the existing (and possibly future) archaeological evidence and understanding the cultural history of Bronze Age Slovakia. (The contents of this chapter are presented in more detail than Chapters 2–8 above, with almost the entire chapter translated.)

The aims were to analyse (using mathematical and multivariate statistics) and interpret (through theoretical frameworks) available archaeobotanical data from the territory of Slovakia, in order to better understand the role of arable farming and crop husbandry in the Bronze Age economy. The data used in this study comprise all published and unpublished carbonized seed assemblages from 41 archaeological sites distributed throughout the country, which were available to the author at the time of research and writing.

Although the database for this study consists of 234 samples, which is ca. 126.500 carbonized seeds, it still cannot be regarded as representative of the whole Bronze Age and all parts of the territory. Information for some subperiods/phases or localized cultures is under-represented or absent. With respect to settlement type there is a similar imbalance, with more plant remains collected from fortified settlements than unfortified. Moreover, the studied archaeobotanical remains are mostly residues representing crop storages, with only a few samples representing the wastes from crop processing. Therefore, comparisons and interpretations are hindered on various levels. Certain observations are (only) subregional, the crop cultivation history of any given (micro) region is partial and links between the practices (and economies) of fortified and open settlements remain unclear. Thus, the interpretations and conclusions drawn in this study should be taken as hypotheses, which need to be tested against further new and systematically collected data sets.

The archaeobotanical analyses indicate that, contrary to previously believed, crops were cultivated in all studied subcultures and phases of the Bronze Age, and crop husbandry was at all times fundamental to the society, which appears to be based on subsistence farming until possibly the Final Bronze Age. No site and no subperiod indicate that any culture or community within Slovakia was pastoralist, relying mostly or totally on animal husbandry.

Cultivated crops and arable practices

In the early phase of the Early Bronze Age, the Neolithic crop package of cereals (einkorn and emmer), flax and pulses (lentil and sweet pea) appears to have continued and use of the same arable practices and methods is suggested, even though plant samples are few.

In the later phase of the Early Bronze Age, finds of burned crop stores attest to continued cultivation of the same species. The sudden occurrence of numerous large silo pits in this phase is usually explained by increased productivity in arable farming resulting from new farming methods and better climate conditions of the period. However, the change in arable practices has not yet been archaeobotanically attested. Analyses of weed assemblages suggest that arable practices were (mostly) intensive, with crops cultivated on permanent fields, probably on small-sized individual plots, throughout both phases of the Early Bronze Age. For tillage the ard (and/or hoe) were used, thus the soil was 'scratched' not turned, and the soil disturbance was shallow, not deep. Both of the staple cereals of the period – einkorn and emmer – were sown in the autumn (see Chapter 8). Flax, pulses and probably barley at least in some places (it is found rarely and mostly in the eastern Slovakia) were sown in spring (see Chapter 8). The fields were kept free of weeds, probably by weeding and/or tilling in the spring. The cereals were mostly harvested high on the stem (under the lowest ear). Very few samples indicate harvesting close to the ground. The presence of low-growing weeds in storage samples indicates that straw and ears were harvested at the same time, and that there were not multiple harvests (first harvest of ears, second harvest of straw). The occurrence of nitrogen-loving weeds (of the rich soils) indicates that soil quality was maintained. Alongside intensive methods (such as the use of farmyard manure, repeated tilling and correct crop rotation), extensive methods (use of fallowing) appear to have been practiced to preserve soil fertility in some fields (see Chapter 8). The very few crops available, allowing only partial crop rotation, suggest that most probably a short fallow was used. The absence of any woodland species and the presence of a high number of plants that grow in permanent grassland communities (meadows) found with crops indicate that the fields were not fallowed for more than *ca* 5 years. Based on the data analysed, it is possible to reject the theory of shifting cultivation (with the use of fallow allowing woodland regeneration and consequent clearing by slash-and-burn) throughout this as well as the following phases of the Bronze Age.

During the Middle Bronze Age a new cereal – millet – was introduced and cultivated next to einkorn and emmer. Millet differs from the previously cultivated cereals mostly by its short growing season, relatively high and reliable yields, even under poor conditions and wider ecologic plasticity (it can grow in dry, rich and poor soils). As it is strictly a summer crop, the farmers of the Middle Bronze Age could experiment with new crop rotation techniques, aiming to increase the use and effectiveness of permanent fields and to secure higher yields in shorter time. The importance of millet in the life of the people of the Middle Bronze Age is also attested by its presence in the Lozorno (cult) hoard of ceramic vessels (*Bartík/Hajnalová 2004*). Unfortunately, very little is known about cultivation practices (e.g. intensity, use of manure, fallowing, etc.) in the Middle Bronze Age Slovakia as there only are very few samples, and those do not have a sufficient number of finds to perform the needed analyses.

During the Late but mostly at the beginning of the Final Bronze Age (that is in the middle of the European Late Bronze Age) the first significant change in arable farming of early prehistory occurred: at least four (possibly five) new staple crops – bread/macaroni wheat, club wheat, spelt wheat, Celtic bean and gold-of-pleasure – and new arable farming practices were introduced. Methods to intensify cultivation included greater use of farmyard manure and better crop rotation, but most significant was the further shortening of the fallow period. There are also indications for more widespread use of fallowing, which might suggest that larger areas of the landscape came under cultivation. Thus it seems that some fields were cultivated under intensive and some under extensive regimes, but the latter are not connected to particular crops. Data are insufficient to state whether the use of an extensive regime might be connected to (new?) spatial distributions of arable land (e.g. located a greater distance from home) or exploitation of other (new) soil types. The different sowing times and/or growing period for the various crop species enabled farmers to spread their work throughout the year, to stagger the aspects that demand greatest personnel and time (ploughing, sowing and harvesting). At the end of the Bronze Age and at the beginning of the Hallstatt period there is a certain change (regression?) in arable farming, shown in the disappearance of free-threshing wheats and the increased importance of pulse crops.

Field size, arable land extent and cultivated crop surplus

Bronze Age analyses in Slovakia demonstrate the use of permanent plots of arable land, which is similar to Neolithic findings in Central Europe (*Bogaard 2004*, 155). The delimitation of permanent fields is evident, for example, in the presence of wild plants species typical of hedges. This is particularly noteworthy for Slovakia, where, from the medieval period onwards, such is not apparent in the landscape.

The extent of arable land is influenced by more than one factor – among others the size and needs of a farming community, yields of the cultivated crops and conditions of the environment (soils and climate). The numbers obtained from ethnographic observations, experiments and theoretical calculations for the extent of arable land needed to support the basic needs of a household unit of 4-6 members vary, but only by very little. All sources agree they range from 0.8 to 1 hectare for an intensive ('Neolithic garden agriculture') regime to ca 3.75 ha if fallowing is practiced (see *Bogaard 2004*, tab. 2.1; *Dreslerová 2011*; *M. Hajnalová/Danielisová in prep*.; *Hajnalová/Dreslerová 2010*).

There is an often-stated hypothesis, that the introduction of the ard in the Late Eneolithic enabled the (tremendous) increase in farmed area, and therefore the production of surplus. P. Halstead (*1995*) argues more convincingly that only specialised animals (oxen) used for pulling an ard enabled farming larger plots to produce surplus. Given that oxen are rare in archaeozoological material before the Bronze Age (*Pollex 1999*) ard ploughing can only be seen as an invention of a little consequence (*Halstead 1995*). In faunal remains from Slovakia there is a visible increase in finds pointing to the use of cattle for pulling (*Ambros 1965*, 134-135) in the later phase of the Early Bronze Age. Ambros does not state, however, whether oxen finds are present among these faunal remains. In the concluding chapter of his work, he writes (*1965*, 212): "…*Based on the parts of the skeleton where sexual dimorfism can be demonstrated, we have observed that on the settlement sites* [of the later phase of the Early Bronze Age] *castrates were present, as well as bulls* *and cows. The main reason for castration was surely the change of utility (the use of the cattle as a working animal, higher level of meat production).*"

While the presence of oxen as a working animal allows proposing that the extent of arable land could have increased in this period, the narrow spectra of cultivated crops seems to have limited the scale of production. The ploughing/sowing and harvesting times are similar for winter einkorn and emmer and for summer pulses; therefore an increase in cultivated land would have only been possible with a larger workforce. Furthermore, the wild plants from the archaeological samples of this period in fact show that the extent of arable land did not increase. Weeds point to the use of 'garden' agriculture, connected to smaller fields. The size of farmed land probably did not increase until the Late Bronze Age, when the crop spectrum widened: their growing regimes allowed a more even distribution of farming works through the year and (probably) precluded the need for a larger workforce during what had been 'bottleneck' seasons. It is not known whether farming large areas with less intensive methods, like little or no weeding, and use of, probably grazed, fallow survived in the following Hallstatt period. The narrowed spectrum of crops suggests the opposite.

The approximate size of individual fields throughout the Bronze Age can be derived using ethnographic and archaeological data (e.g. stone walls surrounding plots known from Northern and Western Europe dating 1000 cal BC to 200 AD). The surviving ancient field complexes cover areas of more than several hundred hectares, with individual plot sizes usually ranging from 20 x 20 m to 20 x 40 m (see *M. Hajnalová/Dreslerová 2010*, here also further reading). These sizes fully correspond with ethnographic sources, where the size of an individual plot is stated to match the time it takes to sew it in one day (here 'sowing' means ploughing/tilling the soil, planting the seeds in the ground, and covering them with soil) and to harvest all plots in a given time. Einkorn (and other crops) is cultivated under traditional non-mechanised methods in a plot between 1 ar to 18 ares[86], with the average between 2 and 4 ares (*M. Hajnalová/Dreslerová 2010*).

One aim of the analyses performed in Chapter 7 was to determine whether fortified and open settlements could be characterized as places of production or consumption, and to define the scale of their production. The results show that all the settlement communities evaluated – fortified and unfortified, earlier and later, of the lowlands and the uplands – cultivated and processed their crops. Finds of unprocessed or only partially processed crop storages and wastes from early phases of crop processing are considered indicators of production by a local community, and they were present at all evaluated sites. Because unprocessed or unclean storages are undesirable (numerous weed contaminants shorten the possible length of storage time) they are seen also as possible indicators that a community was unable to mobilize a sufficient workforce during harvest time to proceed further in a crop-processing sequence, which would prevent losses. Semi-clean storages were also found at two hill forts, where arable soils are only available at a distance from them (over a 30-minute walk steeply downhill). At these sites, any waste from crop processing is missing (but only the storage finds were sampled); therefore, it could not be determined whether the stored crops were produced nearby, in the vicinity of the hillforts by their resident communities (and were destined for immediate consumption), or represented tribute (to the 'protector') paid by other communities. In either community such a store could be the result of an insufficient workforce to proceed further in cleaning the crop after harvest. To answer such questions, it is necessary to obtain and compare samples of crop-processing residues (wastes) from those hillforts as well as open 'farming' settlements in their vicinity, and to interrogate the new results against other archaeological data (presence/absence of luxury items at those sites, signs of permanent/temporary or seasonal settlement, etc.).

For reconstructing the scale of production, the results of several analyses are combined. Arable farming practices and methods used during the Bronze Age in Slovakia show that the extent of farmed land for each household unit was that which could be worked by the members of the household. The ability of households to produce surplus – more than the human members consume for subsistence – is questionable, or something that only happened on an irregular basis – e.g. the result of particularly favourable sowing time and growing conditions in a particular year. The probability of surplus production is higher from the end of the Late Bronze Age, but mostly from the beginning of the Final Bronze Age. However, there are as yet no finds that can be interpreted as crop surpluses, and no proof for settlements (or households) of a size or type that consumed them. While surpluses could be consumed at feasts, used as fodder, traded or left as reserve/security for bad years, environmental archaeology most likely would have detected that the studied settlements were of such complexity.

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[86] 1 ar = 10 x 10 m = 100 m^2

Crop cultivation and the climate

Whether or not recent findings in archaeology and environmental sciences enable us to define relationships between (possible) changes in human behaviour and recognized changes in the climate and natural environment is very much debated. A series of detailed analyses to address this issue was recently carried out by D. Dreslerová (*2011*, 200) who concludes: "…*If we are to evaluate the impact of palaeoclimate changes* [which is the most important factor influencing the natural environment] *on the evolution of past human societies, we come to a problem. On the one hand climate phenomena are limited to distinct, and often very small, areas; on the other hand there is limited knowledge of human behaviour in the past, and it was not necessarily driven strictly by economic or practical aspects of existence. Our modern concepts and understandings derive from an assumption, that man is (and always was) a rational being, and thus dealt with, or at least in some ways reacted to, climate changes, probably in ways similar to how we do/would today. This assumption, however, is not based on the truth* [this can be translated as 'not necessarily true' or, in another Czech sense, 'even if an assumption is not based on the truth it still can have (but does not have to have) the "correct" outcome']. *Moreover, as the historical examples demonstrate climate changes (and often also abrupt weather events like floods, hail storms, morning frosts, etc.) are not usually the real or the only cause of historic events, they are usually only a trigger mechanism during times of already accumulated problems* [in the society]. *However, if the society is in a secure state* [temporary equilibrium] *the reaction to climate change/an event will be much less dramatic and thus in archaeological sources usually not recognizable."*

In response to the work of Dreslerová, reconstruction of the relationship between climate and agriculture in prehistory is explored in Chapter 9. The climate reconstruction produced by the Macrophysical Climate Model (MCM) program of R.A. Bryson (*Bryson/McEnaney DeWall 2007*) has been used to answer the questions of whether there were in fact climate changes and whether the climate changes really influenced crop husbandry of the Bronze Age in Slovakia (and if yes, in what way). Reasons for choosing this source of past climate data and not the reconstructions based on different proxy data models are discussed in Chapter 2.

Looking at the MCM outputs for various sites, in the east, north, centre and west of the studied region, it is clear that the climate of (south and central) west Slovakia during the early phase of the Early Bronze Age was wet (and cold) oscillation (wetter than the climate of the Neolithic and Eneolithic periods), which from a modern perspective would optimize arable farming conditions – reducing the previous moisture deficit. It is unclear how/if the staple cereal crops of the time – einkorn and emmer (originating from dryer and warmer areas of the Middle East) reacted to this change. In the later phase of the Early Bronze Age, the climate became drier (and warmer) again, but never reached the very dry conditions of the Neolithic and Eneolithic.

Conditions in the east of the region were the reverse. The climate of the Neolithic and Eneolithic were wetter and colder (than the west) and became drier in the early phase of the Early Bronze Age. From a modern perspective this climate development again would produce better local farming conditions than in the Neolithic and Eneolithic.[87] However, during the later phase of the Early Bronze Age the climate deteriorates and becomes (from a modern perspective) 'too wet'. A similar development is seen in the modelled sites of northern Slovakia.

Because the crop spectrum from the Neolithic to the Early Bronze Age was the same and the cultivation techniques were very similar, a correlation between modelled climate change and recognized fluctuations in settlement patterns might be a fruitful line of future inquiry[88].

According to the MCM, the Middle Bronze Age is the period when climate conditions became again more optimal. In the (south)west, increased precipitation lowered the moisture deficit, in the east the climate became drier and the values of the precipitation and evapotranspiration equalized. The conditions resemble the situation from the early phase of the Early Bronze Age, but with smaller increments of change. Probably the introduction of a new crop – millet, which originates in the Central Asia and probably migrated westwards via the route along the northern shores of the Black Sea – can be seen as one of the adaptation strategies to the changes of climate and environment. It appears that (not only) Bronze Age farmers tended to experiment with new crops/techniques when the climate and natural environment were optimal and/or when there was social stability, rather than during periods of distress (of any kind). This hypothesis will be pursued in future work.

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87 It is always necessary to understand the climate and its changes within its local diachronic context. For example, it may be better when it gets wetter in some places because it was previously too dry, and in some places it may be better when it gets drier because it was previously too wet. For the starting climate conditions in Bronze Age Slovakia, which were different in the east and west, see Fig.2.1-2.6; the first three are for west (and west-central), and the last three are for east, and north of the studied territory.

88 Kopčeková (*2009*) and Demján (*2009*) have used large datasets and GIS methods for finding and defining changes in settlement patterns and settlement density in different time periods and cultures in relatively large areas. Combining their results with those of this study may lead to determining the ability and ways of past societies in Slovakia to produce crops for their subsistence or even surplus, and define the role it played (or did not play) in the process of social stratification and in societal development (see, for example, *Halstead 1989*), which could only be partially addressed at the present time.

The climate of the Late and Final Bronze Age seems to have been the most ideal for farming in the studied period. It is relatively stable, with good precipitation and temperature balance both in the east and in the west of the region. The only (minor) climate event happened 1100-1000 cal BC and is connected with a small drop in temperatures and slight decrease in precipitation in the west, and a slight drop in temperatures and moderate increase in moisture in the east. Also the pace and volume of precipitation during the year is favourable for cultivation through the period, with the precipitation maximum in June and a smaller one in November. The positive qualitative (and probably also quantitative) changes in arable farming occurred during this relatively long and stable climate period. The last climate change/event, similar to one in the 11^{th} century BC, is recorded in the 8^{th} century BC, when some regression/change in farming also took place.

In Slovakia there is a continuity of occupation through the Bronze Age, albeit with fluctuating intensity and shifts of settlement areas, which do not always correspond to the recognized changes in crop production. We can therefore assume that the strategies of the ancient farmers were usually successful, most probably in the same way that modern societies flexibly react to changes (cultural and climatic). Bronze Age societies had their own mechanisms (economic, social and cultural) that helped them to overcome their challenges.

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