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Landscape Transformed: Archaeological, Historical and Environmental Dating of the Early Modern Field System in Valštejn, Czech Republic

Ivana Šitnerová^{a,b*}, Jaromír Beneš^{a,b}, Ivana Trpáková^c, Jiří Bumerl^{a,b}, Veronika Komárková^a, Tereza Majerovičová^{a,b}, Lenka Hrabáková^b, Kristina Janečková^c

^aLaboratory of Archaeobotany and Palaeoecology, Faculty of Science, University of South Bohemia, Na Zlaté stoce 3, 370 05 České Budějovice, Czech Republic

^bInstitute of Archaeology, Faculty of Arts, University of South Bohemia, Branišovská 31a, 370 05 České Budějovice, Czech Republic

^cDepartment of Land Use and Improvement, Faculty of Environmental Sciences, Czech University of Life Sciences, Kamýcká 129, 135 00 Prague-Suchbát, Czech Republic

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ABSTRACT

The historical field system of Valštejn represents one of the most extensive historical landscape complexes in the Czech Republic. Archaeological excavation of a former agricultural terrace (now a meadow) revealed the elaborate construction of a wall and stone foundation under the former arable field. This construction probably served for drainage and for soil protection. Archaeobotanical sampling facilitated the use of the charred plant material for radiocarbon dating of the soil profile, supported by the measurement of radionuclides ²¹⁰Pb and ¹³⁷Cs activity in order to estimate the age and stratigraphic integrity of the soil. An interesting record was obtained by archaeobotanical analyses of the lowermost layer, where wood charcoal and needles of fir (*Abies alba*) were identified and dated by AMS ¹⁴C. A discrepancy between the younger needle and much older charcoal could indicate an example of the old wood effect in archaeological chronology. The study has brought comprehensive results using environmental archaeology methods and sheds light on one of the stages of historical landscape transformation of the Early Modern Ages in central Europe.

1. Introduction

There are several main types of arable field systems across the world. The most common are terraced fields, then field systems with visible boundaries between parcels, followed by open fields (Agnoletti *et al.*, 2015). Field systems called open fields mostly dominate in Great Britain. These unhedged fields have a wide variety of forms. They can be made up as a system of long strip parcels grouped into blocks, they could be in the form of dispersed strips, or they could comprise compact blocks (Pollard *et al.*, 1974; Rackham, 1986; Williamson, 2018). Terraced fields, especially typical for Asia (called “paddy fields”) (Iiyama *et al.*, 2005; Fukamachi,

2017), are also found in South America (Goodman-Elgar, 2008), and in the African mountainous regions of Ethiopia, Uganda and Rwanda (Tarolli *et al.*, 2014). In a European context, terraced fields are most common in southern Europe and in Alpine regions (Varotto *et al.*, 2019; Tarolli *et al.*, 2019). In western and central Europe, the most common types of field systems are defined by visible boundaries, usually without significant terracing. These are referred to as “bocage” and “hedgerow landscapes” in western Europe (France and Great Britain) (Baundry *et al.*, 2000). A similar type of this landscape is also found in the Czech Republic, where this agrarian hinterland of villages is called “plužina”. It is defined as an economically usable part of the landscape belonging to a single village settlement, and it is the sum of all the fields, meadows and pastures interconnected by

*Corresponding author. E-mail: ivana.pravcova@gmail.com

a network of paths (Gojda, 2000). The visible parts of this hinterland can be typical field strips and agrarian terraces.

The agrarian hinterland of a village came to be defined in central Europe by the traditional concept of German historical geography (in German “die Flur”: Krüger, 1967; Born, 1979; Denecke, 1979; Sperling, 1982). This school defines “die Flur” as the historically-developed structure of a village’s landholding, whose current layout is the result of many changes in dynamics, local economy and property ownership. The term “die Flur” was a big topic in German historical literature of the 19th century, frequently enriched with a certain ethnic significance. Attention has been paid in the last decades to the origins of different types of agrarian hinterland associated with various historical villages. Recent studies omit the ethnical meaning underpinning the historical circumstances of settlement activities (Žemlička, 2014). The German schools of agrarian history and historical geography were followed by ethnographic and historical research in Czechoslovakia and in the Czech Republic (Pohl, 1934–1935; Dohnal, 2003; Klír, 2003). Transformation of the landscape is observed primarily through the prism of

medieval colonization (Klápště, 2005; 2012; Žemlička, 1997; 2014). Field systems and their patterns are, of course, an integral part of medieval and Early Modern villages to which they belong.

The archaeology of medieval and Early Modern villages has primarily focused on their residential area, particularly on abandoned medieval settlement zones with buildings. Such interest in agrarian hinterland dates from the second half of the last century. New methods of remote sensing (Gojda, John eds., 2013; Holata *et al.*, 2018) and environmental archaeology (Houfková *et al.*, 2015; 2019; Hejzman *et al.*, 2013a; 2013b) have contributed much to the research of the agrarian hinterland of villages. Thanks to this new research, it is now possible to resolve questions of dating, function and the characters of agrarian background effectively.

One of the first archaeological studies focusing on the identification of the village agrarian hinterland in Bohemia was taken in the Kostelec nad Černými lesy region by Z. Smetánka and J. Klápště (Klápště, 1978; Klápště, Smetánka, 1979; Smetánka, Klápště, 1981), and in Moravia by V. Nekuda in the abandoned village Pfaffenschlag

Figure 1. 1a: The map section with the Czech Republic within central Europe and the location of Valštejn (red dot) and others field systems under research (green dots: field systems around Oblik hill near Louny; Malonín near Mičovice; field systems around Rokštejn castle near Panská Lhota; and Debrné near Trutnov). 1b: Valštejn village illustrated on the first military mapping which took place from the 1760s to 1780s. The village had the German name of Wallstein. The scale of the map is 1:28000. Sources: Laboratory of Geoinformatics FE UJEP, Ministry of the Environment of the Czech Republic and Austrian State Archive/Military Archive in Vienna. 1c and 1d: Current landscape around Valštejn. Photo by T. Jůnek.

(Nekuda, 1975). The field systems were more systematically identified thanks to the aerial survey and aerial laser scanning of the landscape (Gojda, 2000; Gojda *et al.*, 2011). The first direct archaeological research of field systems was carried out in the Šumava Mountains near Vlachovo Březí (Beneš *et al.*, 1999). The direct excavation of field strips and hedgerows is still an exceptional activity in Czech archaeology. One example is the former arable hinterland around the abandoned village of Sloupek in West Bohemia (14th–15th century AD), where hedgerows were constructed by an accumulation of stones without any systematic building trait or design (Vařeka, 2018). From an historical-geographical point of view, Ervín Černý was the first to collect knowledge concerning abandoned villages and their agrarian hinterland and who divided it into several types and shapes (Černý, 1973; 1979).

Historical field systems have also been the focus of natural science disciplines, such as pedology (Hejman *et al.*, 2013a), hydrology (Bayer, Beneš, 2004) and geochemistry (Horák *et al.*, 2018; Horák, Klír, 2017; Janovský, Horák, 2018). The first detailed multi-proxy analysis of abandoned terraced fields in the Czech Republic was undertaken in Malonín in South Bohemia. The aim of this research was to date the hedgerow of the past field system. The radiocarbon data obtained demonstrated the chronology of the hedgerows, which substantially preceded the first written sources regarding the village (Houfková *et al.*, 2015).

From the standpoint of landscape ecology, field systems and agrarian terraces enhance some important landscape functions, providing landscape connectivity and serving as important animal and plant habitats, especially in landscapes with otherwise low ecological stability (Forman, Godron, 1986; Wilson, Forman, 1995). The hedgerows and agrarian terraces also significantly affect the microclimate of fields, and control soil erosion (Burel, Baudry, 1995), prevent uneven stream flow through the year (Mérot, 1999), reduce pesticide drift and fertilizer misplacement (Ucar, Hall, 2001; Marshall, Moonen, 2002), and serve as a buffer against nitrates (and much else) for water protection (Caubel-Forget *et al.*, 2001).

This project focuses on the identification and description of all remnants of historical field systems in the open landscape and on providing detailed data on selected types and cases. These systems represent various kinds in different Czech landscape types (lowlands, highlands and mountain areas). The main task of this detailed field research is the dating of these remnants and the collection of other data for their detailed description and landscape reconstruction (Figure 1a).

The first chosen field system belongs to the village of Valštejn in Zlaté Hory Highlands, in the region of Silesia, where extensive long field strips offer one of the best-preserved historical agrarian systems in the Czech Republic (Figures 1c and 1d). The Valštejn field system was selected for this study because of its outstanding historical integrity. Previous research (Molnárová *et al.*, 2008) indicates that both the pattern of field ownership and the hedgerows delineating

this ownership have been preserved to a remarkable level. The size and geomorphological setting of the Valštejn field system offer a wide range of habitats with variable ecological conditions, thus providing an opportunity for studying its effect on biodiversity.

The main goal of the research in the village Valštejn and its hinterland is to gain new archaeological information about these particular former long field strips and their hedgerows enabling an informed view of their construction, stratigraphy and dating. There is a general gap in our archaeological knowledge concerning these types of landscape features in central Europe. To date, only the fields system around the village of Malonín have been dated by scientific methods (Houfková *et al.*, 2015). Therefore, we decided to systematically sample different types of these features across the Czech Republic. One specific task was to test the accuracy of dating in comparison with the general “time-lag” model postulated in a recent study by Fanta *et al.* (2020). They describe a systematic bias between the first mention of villages in historical sources and their archaeological dating. Our study could offer a comparison with the field system of the medieval village of Malonín and a specific time-lag (if indeed it exists) for an Early Modern village and its hinterland in a different type of central European landscape.

2. Materials and methods

2.1 History of the study site

The village of Valštejn was founded according to written records (Kořínek, 2018) in 1618 AD by Jan Kryštof of Wallenstein (Valdštejn in Czech). The settlement was a medium-sized village, consisting of Greater and Smaller Valštejn (Wallstein in German). The first representation of the village on a map is found on the Müller Map of Moravia from 1716 AD, and subsequently Valštejn appears in the First Military Mapping, where it is described as Alt and Neu Wallstein (Figure 1b). Greater Valštejn was a parish village with a church built in between 1793 and 1795 AD. The church was destroyed in 1984 AD, but the parish house is preserved to this day and its oldest part dates approximately to 1610 AD. There is also evidence that Valštejn did not exist before 1602 AD (Kořínek, 2018). Thanks to this information it is obvious that Valštejn was built in between the years 1602 AD and 1610 AD and that it is older than the first written sources (Kořínek, 2018; Historický lexikon obcí ČR, 2006; Hosák, 2004; Bartoš *et al.*, 1994).

Valštejn is an agrarian mountainous village in Silesia situated at an altitude of 517–550 m asl. The soil is loamy-sand of an inferior quality, shallow in depth on its original base of phyllite (slate) or on its basalt geological substrate. The main crop planted here was rye, oats and barley, and people produced hay for cattle and used wood from the forest, according to the protocols of Joseph’s cadastre from 1787 (Josefský katastr 1785–1792, č. 1518). The total area of the arable fields in the 18th century was 269 ha, meadows accounting for only 23.5 ha, forests for 27.5 ha, pastures

Figure 2. The orthophoto map presenting Valštejn village and its agricultural background. The yellow line represents the current built-up area, the green line represents the area of agrarian hinterland, and the red line limits the cadastre area of Valštejn. The red dot marks the site of the archaeological excavation of the hedgerow (trench S1).

for 78.5 ha, and orchards approximately for 30 ha. The settlement zone indicates wooden houses with orchards. The long narrow strip fields above the valley were separated by pathways, belts of barren soil or pastures (Bartoš *et al.*, 1994; Josefský katastr 1785–1792, č. 1518; Figure 2).

2.2 Valštejn village and its field system as an object of study

The choice of the Valštejn agrarian hinterland for detailed archaeological and environmental study is based on a representation of landscape types across the Czech Republic. The field systems were selected according to their variability and geographical setting. They comprise a lowland type (systems around Oblík hill in Northwest Bohemia), sub-mountainous region (colline zone) type (Rokštejn by Panská Lhota in the Bohemian-Moravian Highlands), Debrné in the Krkonoše (Giant Mountains) Foothills, and two mountainous villages (Valštejn and Malonín) (Figure 1a). Fully forested landscapes were not included, being out of the scope of the project.

The field system of Valštejn lies in the Zlaté Hory Highlands ranging in altitude from 500 to 700 m asl. (Figure 3). It falls into the 5th vegetation zone dominated by fir-beech woodland

according to Zlatník (Zlatník, 1956; 1976). This vegetation type was confirmed by pollen analyses from several sites in the Jeseníky Mountains (Abraham *et al.*, 2017). This zone is today typical for its mosaics of forests, meadows, pastures and fields with scattered built-up areas of villages. Humans did not significantly affect this type of landscape until the 13th century. The main colonisation took place during the 16th and 17th century. It led to the deforestation of the landscape and the creation of pastures. Now these areas are mostly used as meadows (Löw, Michal, 2003; Chytrý, 2017).

2.3 Archaeological excavation

Appropriate place for archaeological excavation and environmental sampling was selected according to the methodology of Houfková *et al.* (2015). The second horizontal terraced belt was chosen for the digging of trench labelled S1 through the hedgerow and the sampling of soil. It is situated to the north-east of the Valštejn stream at an altitude of 540 m asl. The boundary of this field strip was made with a stony wall stretching that runs in a northwest-southeast direction. Due to the specific nature of its construction, the trench was divided into two parts – an area under the wall and an area above the wall. The final trench

Figure 3. The elevation model of landscape relief shows the altitude of field systems at Valštejn from 500 to 700 metres asl. Red dot illustrates the site of excavation at altitude 540 m (trench S1).

was 11 m long, 1 m wide and the bedrock was at a maximum depth of 1 m (Figure 4).

The area under the wall consisted of a shallow stony base; stones were therefore only cleaned up and photographically documented. Soil samples were taken from the space between stones just for comparison. The area above the wall was systematically uncovered in mechanical layers of 10 cm. Each mechanical layer was prepared by hand, sampled and photographed. The trench was excavated to the bedrock. The whole trench was documented by photogrammetry. Each step of the excavation was recorded in writing. The trench was positioned by GPS and photographed by a drone.

2.4 Archaeobotanical and anthracological analyses

Samples were taken from the mechanical layer situated 40 cm below the ground surface (–40 cm) and below,

because of the contamination and too fresh sediment of the upper layers above. From –40 cm, samples were then taken at every 10 cm of the mechanical layers of trench S1 up to 1 m depth. There was a concentration of bigger stones at the level of –90 cm, and due to this, samples were taken both between and under the stones, the bedrock being reached at –100 cm.

Samples (10 l each, total amount 100 l) were extracted by water flotation, using a flotation tank of ANKARA type. The light fraction was collected on sieves with mesh size 0.25 mm. Uncharred and charred remains were used for this study (Anderberg, 1994; Berggren, 1981). Anthracological samples were acquired from the floated bulk samples. The charcoals and wood fragments obtained had a total weight of 29.031 g. Charcoal analysis was carried out on completely burned charcoal with a total weight of 10.49 g. Botanical

Figure 4. Stratigraphic section across a hedgerow of the agricultural terrace (trench S1) with a description of the archaeological layers.

macroremains were observed by a standard binocular microscope Nikon C-LEDS at magnification 10× to 50×. The charcoal fragments were identified using an optical microscope Nikon Eclipse 80i and an anatomical atlas of wood (Schweingruber, 1990). Data obtained regarding the individual taxa were expressed in number of charcoal fragments and the charcoal anthracomass (Figure 7a). The specific anthracomass, as in this case, is defined by the ratio between total mass of selected charcoals and the total mass of soil particles smaller than 5 mm (Thinon, 1992; Carcaillet, Thinon, 1992).

2.5 Radiocarbon dating

The key method used in the research of the Valštejn field system was radiocarbon dating of the botanical macroremains already effectively used in our older investigation elsewhere (Houfková *et al.*, 2015). Charred seeds with optimal short-life intervals are suitable for radiocarbon dating and are usually present in sediments of historical fields at very low concentrations. Charred wood, contrary to short-lived seeds, could give an older date for an archaeological context than the situation really is. The “old wood effect” (Schiffer, 1986, Kim *et al.*, 2019 with more recent literature) results from the fact that a wood fragment can originate from part of an older fallen tree. However, dating of such charred wood fragments can be useful; they can indicate the presence of older biological materials in the soil. Therefore, both charred seeds and charred wood fragment were used for radiocarbon dating. Five macrofossil samples and one charcoal sample were sent for radiocarbon dating. It was not possible to send the same species of macroremains and therefore two seeds of *Rumex*, from a depth of 60–70 cm and 80–90 cm, and three needles of *Abies*, from a depth of 40–50 cm, 70–80 cm and 90–100 cm, were chosen for dating (Figure 8a). The charcoal sample came from the lowest layer 90–100 cm. These samples were measured by a spectrometer 1.5 SDH-Pelletron Model “Compact Carbon AMS” in Poznań Radiocarbon Laboratory in Poland. The data results were calibrated online using OxCal 4.2 (Bronk Ramsey, 2009) based on the IntCal 13 atmospheric curve (Reimer *et al.*, 2013).

2.6 Dating of modern soil by radionuclides

The sampling of soil in the archaeological trench was aimed at acquiring the stratigraphic order of samples for detection of soil age (Chen *et al.*, 2020). The analysis of the radionuclide ^{210}Pb and ^{137}Cs activity can offer information as to whether topsoil sedimentation was gradual or if it was disturbed by agricultural or other more recent activity. The radionuclide ^{210}Pb is an isotope in the environment with a half-life of 22.6 years (Gaspar *et al.*, 2013). Dating of a soil profile can also indicate if the sediment in the profile is older than ca. 100 years (already not containing this isotope), which is the limit of this ^{210}Pb method (Wintle, 2007, p.25). The isotope ^{137}Cs is widely used in environmental soil science (Owens *et al.*, 1997; Evans *et al.*, 2017; Huisman *et al.*, 2019). The radionuclide ^{137}Cs with a half-life of 30 years does not occur naturally; it was introduced by atmospheric

nuclear detonations from 1952–1962, and by the Chernobyl nuclear disaster in 1986, which deposited ^{137}Cs over a vast area of Europe. This artificial radionuclide can be used in geoarchaeology as a marker for the very recent age of a soil and as a tracer for (sub-)recent soil erosion (Huisman *et al.*, 2019).

The aim of dating the soil in trench S1 is age estimation. An absence of radionuclides, or their very low concentration, can also control for the sedimentary integrity of the soil profile in the trench. The main task was therefore to verify the radiocarbon dating of the charred remains and exclude contamination and local disturbances.

Samples for determination of modern soil deposits from the agricultural terrace were collected from the profile of a trench. Samples were collected at 5 cm intervals and taken at accurate positions down the 1 m deep profile. About 7 grams of each sample were completely dried by lyophilisation. Gamma-decay counts of the radionuclide (^{210}Pb , ^{226}Ra , ^{137}Cs) concentrations were measured at the CEN Radiochronology Laboratory, Canada, using a High-Purity Germanium detector (HPGe).

2.7 Archaeological artefacts

The counting and analysing of archaeological artefacts is a useful tool for the relative dating of soil layers in agricultural terraces (Beneš *et al.*, 1999; Houfková *et al.*, 2015). Artefacts can also be used as a marker of extensive manuring activity on past arable fields and on former arable soils (Beneš, 1998; Kuna *et al.*, 2004; Jones, 2004). This soil trait is recognizable by the counting of small artefacts using residual material determination after soil sample flotation.

3. Results

3.1 Archaeological excavation and sedimentary description

The soil profile shows the sediment compositions, which do not change much in their natural layers. Any differences are mainly in the amount and type of clastic admixtures. The first natural layer (0–10 cm) contained a brown-grey humus clay with a small admixture of a fine clastic slate. The second natural layer (10–50 cm) mainly contained a light brown-grey clay with an admixture of a fine clastic slate. The third natural layer (50–90 cm) contained a light brown-grey clay with an admixture of a coarse clastic slate. The fourth natural layer (90–100 cm) contained a brown-yellow clay with an admixture of charcoal (Figure 4).

One of the most significant and surprising archaeological observations was detected at the bottom of the trench. Here, we found an artificially composed stone basement at the level of –90 cm, consisting of stones intentionally placed immediately next to the internal wall construction of the hedgerow. This construction bears evidence of elaborated intentional construction using larger flat stones fitting together in several layers. Spaces between these stones were filled by smaller stones resembling gravel. The entire construction

Figure 5. View of trench S1 (11×1 m) across the hedgerow of the agricultural terrace. The bedrock is situated at a depth of 1 m. The picture shows two areas, one above the wall and one below the wall. In the area below the wall there is noticeably greater accumulation of stones.

Figure 6. 3D model of trench S1. A sophisticated construction of stones, which served as a protection from landslide and probably as an effective drainage element, is visible at the model.

probably had a stabilizing and drainage function, serving the purpose of soil erosion control and prevention of landslides (Figures 5 and 6).

3.2 Archaeobotanical and anthracological analysis

Botanical macroremains were present in samples at very small concentrations. The charred macroremains formed a

Total weight of sample (g)	Total weight of analyzed charcoal (g)	Average weight of charcoal (g)	Average density of anthracomass (g/l)	Number of charcoal fragments	Abies	Abies (%)	Pinus	Pinus (%)	Alnus	Alnus (%)	Populus	Populus (%)
29,031	10,49	0,05	1,049	211	188	89,1	1	0,5	10	4,7	12	5,7

Figure 7. a) Basic quantitative anthracological data from the trench S1 soil deposits. b) Graph of representation of individual taxa (in perc.): *Abies* 89.1%, *Populus* 5.7%, *Pinus* 0.5% and *Alnus* 4.7%.

smaller part of the assemblage; however, their appearance is important for both dating and reconstruction of past vegetation cover. The macroremains from the layers –40 to –80 cm have only an indicative role, while the charred macroremains in the lowest strata of soil (–80 to –100 cm) could be related to the building activity during the terrace construction event. The dominant macroremains type in the lower strata are charred needles of fir, following by *Cerealia* in a bad state of preservation, charred raspberry (*Rubus idaeus*), and probably red elderberry (*Sambucus* cf. *racemosa*) (see Supplementary Online Material).

Uncharred botanical macroremains were found in the samples and form part of the seed bank. The most frequent originated from the mechanical layer –40 to –50 cm (Figure 10). The majority of finds belong to ruderals

(*Chenopodium album*, *Chenopodium* sp., *Urtica dioica*), but grassland species are present as well (*Ajuga genevensis*, *Fragaria vesca/viridis*, *Alchemilla* sp.) The quantity of uncharred macroremains decreased with depth. The ruderals and weeds remains (*Chenopodium album*, *Chenopodium* sp., *Verbascum blattaria*, *Polygonum aviculare*, *Veronica hederifolia*). *Rubus fruticosus* and *Sambucus* cf. *racemosa* indicate a forest edge in the deepest layer (–90 to –100 cm). Given the small number of finds it is difficult to make broader conclusions.

The lowermost “construction” layer (–90 to –100 cm) contained a large amount of wood charcoal. A total of 211 fragments were analysed. Altogether only four tree taxa were identified. The quite dominant species was fir (*Abies alba*), which was determined in 188 cases. Other identified tree taxa were alder (*Alnus* sp.) and poplar (*Populus* sp.) – with almost the same number of determinations – and pine (*Pinus sylvestris*) in one case. The average density of anthracomass (1.049 g/l) was calculated from the total weight of the analysed charcoal (10.49 g). The average anthracomass was not calculated from the total weight (29.031 g) due to the presence of unburned fragments in the sample (Figure 7). All the mentioned tree taxa correspond to the vegetation composition of a beech and fir forest, which is assumed in the area from the map of natural potential vegetation (Neuhäuslová *et al.*, 2001) and generally recorded by palaeoecological data in the Jeseníky mountain area (Dudová *et al.*, 2018).

Samples for ¹⁴C analysis from locality Valštejn (Czech Republic)

Number of sample	Type of material	Species	Depth
4050	needles	Abies	40–50 cm
6070	seed	Rumex	60–70 cm
7080	needles	Abies	70–80 cm
8090	seed	Rumex	80–90 cm
90100	needles	Abies	90–100 cm
90100A	charcoal	Abies	90–100 cm

Figure 8. a) Botanical macroremains, samples for ¹⁴C. b) Radiocarbon dates diagram. Intervals of calendar age are given, where the true ages of the samples are encompassed with a probability of ca. 68% and ca. 95%. Samples were dated in the Poznan Radiocarbon Laboratory. The dates were calibrated in the OxCal software.

A similar pattern was shown by the activity of isotope ^{137}Cs . The entire top of the soil deposit expressed a high activity of ^{137}Cs (0.199 Bq/g), whereas at the levels –5 cm and –10 cm activity still remained relatively high (0.066 and 0.084 Bq/g). Lower soil samples below –20 cm showed values at almost a zero level. This structure fully corresponds with the values of isotope ^{210}Pb . The results of the ^{137}Cs measurement indicate that the soil below 20 cm in the profile has no signal of nuclear events after 1952 and could have been sedimented before this date. The values of both isotopes demonstrate that, except for the topsoil, which was contaminated in the 20th century, all the soil deposit is older and undisturbed.

3.5 Archaeological artefacts

The soil samples contained a small amount of very small ceramic sherds (5–10 mm) and iron nails (Figure 10). Ceramic fragment finds in the flotation residuum from trench S1 do not exceed ten units per sample (see Supplementary Online Material). The entire assemblage is comprised of hard, well-fired, orange, ceramic fragments, then very hard sherds with yellow glazing. These types of artefacts are present in the upper layers and can be generally dated according to their technological characteristics to the 18–19th century AD. The same ceramic fragment types are also present in the lower strata of trench S1, where grey-white sherds are also present. These grey-white sherds can be dated a little bit earlier within the early modern period. The finds of iron nails and glass fragments are not chronologically significant. The lowermost layer adjacent to the stone construction of terrace did not contain any sherds.

4. Discussion

The village of Valštejn was founded shortly before 1618 AD by Jan Kryštof of Wallenstein according to the written sources. There is evidence that the village did not exist in 1602 AD, so with high probability the evidence of its existence suggests the second decade of the 17th century AD (Kořínek, 2018; Historický lexikon obcí ČR, 2006; Hosák, 2004; Bartoš *et al.*, 1994). The settlement moved to a higher mountain area in this century and new villages and their agrarian backgrounds have been established (Kuča, 2014). Radiocarbon data obtained from one of the hedgerows of the agrarian background of the former Valštejn village could confirm this date of foundation. There is a very short time lag in the 17th century AD, as far as the establishment of the village is concerned, between the historical and archaeological/environmental dating (Fanta *et al.*, 2020). The similar study for the former village Malonín provides a comparison. This village in the Šumava Mountains was first mentioned in 1349 AD. The radiocarbon data obtained from the bottom of a trench through a hedgerow showed a date of 1154–1271 AD. These radiocarbon dates preceded the first written mention by about ca. 150 years (Houfková *et al.*, 2015). It has been shown that the older village Malonín demonstrates a longer time lag between the historical and

archaeological dating than was postulated in the general “time lag” model (Fanta *et al.*, 2020). Despite these facts we must be very critical with these results: only one trench was dug in one part of the very large field system of Valštejn so far and these results may not apply for other parts of the field system. On the other hand, the results of excavation in Valštejn trench S1 and associated analyses are fully in agreement with the written sources and with the above-mentioned general “time lag” model.

The key observation in the archaeobotanical analyses is the determination of the macroremains of fir (*Abies alba*). This taxon was determined as charred needles, and also as charred wood fragments, directly from the layer immediately covering the basement stone construction at the depth of –90 to –100 cm. This evidence could indicate a forested area before the establishment of the village and its agrarian hinterland, and the action of tree fires during the landscape transformation and construction of the field system. The composition of the past forest in the Jeseníky Mountains and its surrounding developed after 3500 BP towards a dominance of *Fagus*, *Abies* and *Carpinus*, partially initiated by human activity in later agricultural prehistory (Dudová *et al.*, 2018). Burning activities called *slash-and-burn* were common practice to obtain land for agriculture from the Neolithic period onwards (*e.g.* Emanuelsson, Segerström, 2003; Rösch, 2013) and it is probable it happened during the landscape transformation around Valštejn at the beginning of the 17th century. A similar situation was found in the case of the four-hundred-year earlier Malonín village field system (Houfková *et al.*, 2015). *Abies alba* is a typical mountain and submountain conifer growing usually at altitudes of 400 to 800 m asl. (Culek *et al.*, 2005). The main expansion of *Abies alba* was between the 13th and 16th century and it grew mainly in forests near villages, on pastures and on abandoned agrarian land. The wood of fir was favoured for construction timber and it was one of the reasons for the start of the decline in its population. Another reason was its intolerance of intensive and long-lasting human pressure. The population of *Abies alba* started to decline very significantly from the 18th century and it was replaced by *Pinus* and *Picea* (Kozáková *et al.*, 2011).

One fragment of charred fir wood from the bottom layer (–90 to –100 cm) was dated by the AMS radiocarbon method (Valštejn 90100A 95.4%, probability 66.1%: 1299 AD–1370 AD and 29.3% probability: 1380 AD–1415 AD) to the High Medieval Period. The date is two hundred years older than the expected construction of the agricultural terrace. It seems to be an example of a typical “old wood” effect as reported already for the first time by M. Schiffer (1986) in the case of a southwestern USA pueblo chronological discrepancy and reported later by other scholars (Zilhão, 2001; Kim *et al.*, 2019). The fragment of charcoal at the bottom of trench S1 at Valštejn could have originated from an old large tree from the near surroundings, felled and burnt on site during the construction of the agricultural terrace. It is one possibility of how to explain the discrepancy between the charcoal and charred needle of the same species. It is not

quite excluded that the needle, as an annual living part of the fir, and the charcoal from the same species, could have originated from the same individual, or perhaps the same fir tree cohort.

The soil around Valštejn contained a high proportion of stones. This fact must have been a problem during ploughing. The stones had to be collected and piled up in agrarian mounds, something very common in this region. Stones were also used as material for construction purposes. The main features were stony walls as the boundaries of fields, which also protected the flushing of the topsoil (the Czech expression for this feature is “kamenice”). The historical field system of Valštejn belongs to one of the best-preserved in the Czech Republic. The stony walls are still visible and they still fulfil their ecological function. The length of one stone belt reaches approximately 1.4 km – and they are already mentioned in describing the boundaries of the village in the Joseph’s cadastre (Kořínek, 2016). Hedgerows themselves were also made by the intentional activity of peasants. As recorded on several other sites, they built a stony construction on the bedrock with soil on it, and continued building it regularly everywhere during the high medieval and early modern landscape transformation. The same, or a very similar system of hedgerow construction, can also be found on other field systems in the Czech Republic – for example around the Oblík hill near Louny (northwest Bohemia), and in Debrné (Krkonoše Mountains foothill; unpublished site report of our research team). The above-described system of landscape transformation generally shows very thoughtful and extraordinarily exacting work during the building activity, which probably took quite a lot of energy and time of village people.

5. Conclusion

The Valštejn field system, founded at the beginning of the 17th century AD, belongs to one of the best-preserved historical landscape units in the Czech Republic. The field system itself is quite remarkable, because the multifaceted field belts cover around 90% of the cadastre. The archaeological and environmental research of Valštejn is part of a broader field investigation and of the testing of chosen systems over the entire Czech Republic. The key points of this study are the following:

The village of Valštejn was founded shortly before 1618 AD according to historical written sources. The archaeological excavation has been targeted to obtain material for its exact dating and environmental reconstruction. Radiocarbon data obtained from botanical annual macroremains (charred fir needle) in the bottom layer of trench S1 coincide with the time of the foundation of village. This radiocarbon date is in concordance with a small “time-lag” probability (Fanta *et al.*, 2020). This time-lag between the written sources and the archaeological record could already be only several decades for the Early Modern Period in comparison to the Medieval Period, where a time-lag can reach several centuries.

The bottom layer also contained a certain amount of charcoal, probably originating from old wood burned during the initial building activity and reflecting the tree canopy elements from before the hedgerow’s construction. Radiocarbon data from the charcoal of the fir from the bottom of trench S1 indicates a typical “old wood” effect. Thanks to the younger (more realistic) ¹⁴C interval obtained from the fir needle, both data suggest the burning of an old element of forest felled due to the long-strip field and hedgerow construction.

The conclusions of this study provide new insights into the design and function of agrarian terraces, illustrating their possible role in soil and water protection. The chosen excavated hedgerow embodies its demanding construction – requiring a large investment of labour and human effort. The most important item of knowledge made by these archaeological observations is the evidence concerning the elaborated building stone elements. Such construction probably served for the purposes of drainage and soil protection.

The study has also made a further contribution to the method for dating historical field patterns. As these valuable landscapes are not yet protected by any legal measures in the Czech Republic, this information creates a much-needed basis for policies and protection guidelines aimed at their conservation and sustainable management.

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References

- ABRAHAM, V., NOVÁK, J., HOUFKOVÁ, P., PETR, L., DUDOVÁ, L., 2017. A Landscape Reconstruction Algorithm and Pedaanthracological Data Reveal Late Holocene Woodland History in the Lowlands of the NE Czech Republic. *Review of Palaeobotany and Palynology*, 244, 54–64.
- AGNOLETTI, M., CONTI, L., FREZZA, L., SANTORO, A., 2015. Territorial Analysis of the Agricultural Terraced Landscapes of Tuscany (Italy): Preliminary Results. *Sustainability*, 7, 4564–4581.
- ANDERBERG, A. L., 1994. *Atlas of seeds and small fruits of Northwest-European plant species with morphological descriptions. Part 4 Resedaceae – Umbeliferae*. Stockholm: Swedish Museum of Natural History.
- BARTOŠ, J., SCHULZ, J., TRAPL, M., 1994. *Historický místopis Moravy a Slezska v letech 1848–1960, sv. 13., okresy Bruntál, Jeseník a Krnov*. Olomouc: Univerzita Palackého.
- BAUNDRY, J., BUNCE, R.G.H., BUREL, F., 2000. Hedgerows: An international perspective on their origin, function and management. *Journal of Environmental Management*, 60, 7–22.
- BAYER, T., BENEŠ, J., 2004. Středověká terasová pole na Šumavě jako hydropedologický fenomén a archeologický problém. Medieval terraced fields in the Bohemian Forest as a hydropedological phenomenon and problem of landscape archaeology. *Archeologické rozhledy*, 56, 139–159.
- BENEŠ, J. 1998. Keramika, ornice a reliéf. Výzkum polykulturního osídlení

- v Kozlech, o. Louny (SZ Čechy). Ceramics, plough zone and relief. Field research into settlement activity near village of Kozly (NW Bohemia). *Archeologické rozhledy*, 50, 170–191.
- BENEŠ, J., HRUBÝ, P., MICHÁLEK, J., PARKMAN, M., 1999. Kamenná hrazení na hořejším vrchu a vrchu Kokovci u Vlachova Březí. Příspěvek ke studiu agrární krajiny šumavského podhůří. *Zlatá stezka*, 6, 271–296.
- BERGGREN, G., 1981. *Atlas of seeds and small fruits of Northwest-European plant species with morphological descriptions. Part 3 Salicaceae – Cruciferae*. Stockholm: Swedish Museum of Natural History.
- BORN, M., 1979. Acker- und Flurformen des Mittelalters nach Untersuchungen von Flurwüstungen. In: H. Beck, D. Denecke, H. Jankuhn, eds. *Untersuchungen zur eisenzeitlichen und frühmittelalterlichen Flur in Mitteleuropa und ihrer Nutzung I*. Abhandlungen der Akademie der Wissenschaften in Göttingen, Philologisch-Historische Klasse 3/1. Göttingen: Akademie der Wissenschaften in Göttingen, pp. 310–337.
- BRONK RAMSEY, C., 2009. Bayesian analysis of radiocarbon dates. *Radiocarbon*, 51, 337–360.
- BUREL, F., BAUDRY, J., 1995. Social, aesthetic and ecological aspects of hedgerows in rural landscapes as a framework for greenways. *Landscape and Urban Planning*, 33, 327–340.
- CAUBEL-FORGET, V., GRIMALDI, C., ROUAULT, F., 2001. Contrasted dynamics of nitrate and chloride in groundwater submitted to the influence of a hedge. *Comptes Rendus de l'Académie des Sciences-Series IIA-Earth and Planetary Science*, 332(2), 107–113.
- CARCAILLET, C., THINON, M., 1996. Pedoanthracological contribution to the study of the evolution of the upper treeline in the Maurienne Valley (North French Alps) : methodology and preliminary data. *Review of Palaeobotany and Palynology*, 91, 399–416.
- CHEN, J., ZHANG, X., NAVAS, A., WEN, A., WANG, X., HANG, R., 2020. A study on a 210Pb accumulation-decay model for dating moraine soils to trace glacier retreat time. *Journal of Environmental Radioactivity*, 212. DOI: 10.1016/j.jenvrad.2019.106124
- CHYTRÝ, M., 2017. Physical Geography of the Czech Republic. In: M. Chytrý, J. Danihelka, Z. Kaplan, P. Pyšek, eds. *Flora and Vegetation of the Czech Republic*. New York: Springer, pp. 1–23.
- CULEK, M., BUČEK, A., GRULICH, V., HARTL, P., HRABICA, A., KOCIÁN, J., KYJOVSKÝ, Š., LACINA, J., 2005. *Biogeografické členění České republiky II. díl*. Praha: Agentura ochrany přírody a krajiny ČR.
- ČERNÝ, E., 1973. *Metodika průzkumu zaniklých středověkých osad a plůžin na Dražanské vrchovině*. Zprávy Československé společnosti archeologické při ČSAV, 15, Praha, Nitra, Brno: Československá akademie věd.
- ČERNÝ, E., 1979. *Zaniklé středověké osady a jejich plůžiny. Metodika historickogeografického výzkumu v oblasti Dražanské vrchoviny*. Praha: Academia.
- DENECKE, D., 1979. Zur Terminologie ur- und frühgeschichtlicher Flurparzellierungen und Flurbegrenzungen sowie im Gelände ausgeprägter Flurrelikte, Grundzüge eines terminologischen Schemas, In: *Untersuchungen zur eisenzeitlichen und frühmittelalterlichen Flur in Mitteleuropa und ihrer Nutzung I*, Göttingen: Akademie der Wissenschaften Göttingen, pp. 410–440.
- DOHNAL, M., 2003. *Historická kulturní krajina v novověku. Vývoj vsí a plůžiny v Borovanech u Bechyně*. Praha: ÚAPPSC.
- DUDOVÁ, L., HÁJEK, M., PETR, L. and JANKOVSKÁ, V., 2018. Holocene vegetation history of the Jeseníky Mts: Deepening elevational contrast in pollen assemblages since late prehistory. *Journal of Vegetation Science*, 29(3), 371–381. DOI: 10.1111/jvs.12612
- EMANUELSSON, M., SEGERSTRÖM, U., 2003. Medieval Slash-and-Burn Cultivation: Strategic or Adapted Land Use in the Swedish Mining District? *Environment and History*, 8, 173–196.
- EVANS, R., COLLINS, A.L., ZHANG, Y., FOSTER, I.D.L., BOARDMAN, J., SINT, H., LEE, M.R.F., GRIFFITH, B.A., 2017. A comparison of conventional and 137Cs-based estimates of soil erosion rates on arable and grassland across lowland England and Wales. *Earth-Science Reviews*, 173, 49–64.
- FANTA, V., ZOUHAR, J., BENEŠ, J., BUMERL, J., SKLENIČKA, P., 2020. How old are the towns and villages in Central Europe? Archaeological data reveal the size of bias in dating obtained from traditional historical sources. *Journal of Archaeological Science*, 113. DOI: 10.1016/j.jas.2019.105044
- FORMAN, R.T.T., GODRON, M., 1986. *Landscape Ecology*. New York: John Wiley & Sons.
- FUKAMACHI, K., 2017. Sustainability of terraced paddy fields in traditional satoyama landscapes of Japan, *Journal of Environmental Management*, 202, 543–549.
- GASPAR, L., NAVAS, A., MACHÍN, J., WALLING, D.E., 2013. Using 210Pb measurements to quantify soil redistribution along two complex toposequences in Mediterranean agroecosystems, northern Spain. *Soil and Tillage Research*, 130, 81–90.
- GOJDA, M., 2000. *Archeologie krajiny – vývoj archetypů kulturní krajiny*. Praha: Academia.
- GOJDA, M., JOHN, J., STARKOVÁ, L., 2011. Archeologický průzkum krajiny pomocí leteckého laserového skenování. Dosavadní průběh a výsledky prvního českého projektu. *Archeologické rozhledy*, 63, 680–698.
- GOJDA, M., JOHN, J., eds., 2013. *Archeologie a letecké laserové skenování krajiny*. Plzeň: Katedra archeologie. Západočeská univerzita v Plzni.
- GOODMAN-ELGAR, M., 2008. Evaluating soil resilience in long-term cultivation: a study of pre-Columbian terraces from the Paca Valley, Peru. *Journal of Archaeological Science*, 35, 3072–3086.
- HEJCMAN, M., KARLÍK, P., ONDRÁČEK, J., KLÍR, T., 2013a. Short-Term Medieval Settlement Activities Irreversibly Changed Forest Soils and Vegetation in Central Europe. *Ecosystems*, 16, 652–663.
- HEJCMAN, M., HEJCMANOVÁ, P., HLÁSNÁ-ČEPKOVÁ, P., HORÁK, J., KARLÍK, P., PAVLŮ, V., ROSENBERG, R., SOUČKOVÁ, K., STAŇKOVÁ, P., STEJSKALOVÁ, M., 2013b. Environmental Archaeology at the University of Life Sciences Prague – An Application of New Methods for Interdisciplinary Research. *Interdisciplinaria Archaeologica, Natural Sciences in Archaeology*, 4(2), 223–231. DOI: 10.24916/iansa.2013.2.8
- HISTORICKÝ LEXIKON OBCÍ ČESKÉ REPUBLIKY 1869–2005, 2006. Praha: Český statistický úřad.
- HOLATA, L., PLZÁK, J., SVĚTLÍK, R., FONTE, J., 2018. Integration of low-resolution ALS and ground-based SfM photogrammetry data. A cost-effective approach providing an “Enhanced 3D Model” of the Hound Tor archaeological landscapes (Dartmoor, South-West England), *Remote Sensing*, 10(9), 1357.
- HORÁK, J., KLÍR, T., 2017. Pedogenesis, Padochemistry and the Functional Structure of the Waldhufendorf Field System of the Deserted Medieval Village Spindelbach, the Czech Republic. *Interdisciplinaria Archaeologica, Natural Sciences in Archaeology*, 8(1), 43–57. DOI: 10.24916/iansa.2017.1.4
- HORÁK, J., JANOVSKÝ, M., HEJCMAN, M., ŠMEJDA, L., KLÍR, T., 2018. Soil geochemistry of medieval arable fields in Lovětín near Třešť, Czech Republic. *Catena*, 162, 14–22.
- HOSÁK, L., 2004. *Historický mistopis země Moravsko/Slezské*, reprint prvního vydání z r. 1938. Praha: Společnost přátel starožitností.
- HOUFKOVÁ, P., BUMERL, J., POSPÍŠIL, L., KARLÍK, P., BENEŠ, J., BERNARDOVÁ, A., HRABALÍKOVÁ, M., JANEČKOVÁ MOLNÁROVÁ, K., HEJCMAN, M., 2015. Origin and development of long-strip field patterns: A case study of an abandoned medieval village in the Czech Republic. *Catena*, 135, 83–91.
- HOUFKOVÁ, P., HORÁK, J., POKORNÁ, A., BEŠTA, T., PRAVCOVÁ, I., NOVÁK, J., KLÍR, T., 2019. The dynamics of a non-forested stand in the Krušné Mts.: the effect of a short-lived medieval village on the local environment. *Vegetation History and Archaeobotany*, 28(6), 607–621.
- HUISMAN, H., DE KORT, J., KETTERER, M.E., REIMANN, T., SCHOORL, J.M., VAN DER HEIDEN, M., VAN SOEST, M., VAN EGMOND, F., 2019. Erosion of archaeological sites: Quantifying the threat using optically stimulated luminescence and fallout isotopes. *Geoarchaeology*, 34(4), 478–494. DOI: 10.1002/gea.21716
- IYAMA, N., KAMADA, M., NAKAGOSHI, N., 2005. Ecological and social evaluation of landscape in a rural area with terraced paddies in southwestern Japan. *Landscape and Urban Planning*, 70, 301–313.
- JANOVSKÝ, M., HORÁK, J., 2018. Large Scale Geochemical Signatures Enable to Determine Landscape Use in the Deserted Medieval Villages. *Interdisciplinaria Archaeologica, Natural Sciences in Archaeology*, 9(1), 71–80. DOI: 10.24916/iansa.2018.1.5
- JONES, R., 2004. Signatures in the Soil: The Use of Pottery in Manure Scatters in the Identification of Medieval Arable Farming Regimes. *Archaeological Journal*, 161(1), 159–188. DOI: 10.1080/00665983.2004.11020574

- JOSEFSKÝ KATASTR (1723) 1785–1792 (1855), Úřední kniha, Kraj opavský, dříve Krnovský. Č. pomůcky 1518, č. listu NAD: 11 Zemský archiv v Opavě (Parcelní protokol pro katastrální obec Velký Valštejn, Závěrečný protokol, Popis obecních hranic (1 kus pro Velký Valštejn a 1 kus společný pro Velký a Malý Valštejn, – Grenze Beschreibung die Gemeinde Grosswallstein).
- KAT. JOSEFSKÝ – NAD 11 – Sumární přiznací protokoly (1786–1789), č. pomůcky 1518, sign. 1/190, i. č. 385 (Summarischer Fassionsbogen der Gemeinde Grosswallstein – Fassions Protokoll mit der untertheilen Dorfsgeometrie).
- KIM, J., WRIGHT, D.K., HWANG, J., KIM, J., OH, Y., 2019. The old wood effect revisited: a comparison of radiocarbon dates of wood charcoal and short-lived taxa from Korea. *Archaeological and Anthropological Sciences*, 11(7), 3435–3448.
- KLÁPŠTĚ, J., 1978. Středověké osídlení Černokostelecka. *Památky archeologické*, 69, 423–475.
- KLÁPŠTĚ, J., 2005. *Proměna českých zemí ve středověku*. Praha: Nakladatelství Lidové noviny.
- KLÁPŠTĚ, J., 2012. *The Czech Lands in Medieval Transformation*. Leiden: BRILL.
- KLÁPŠTĚ, J., SMETÁNKÁ, Z., 1979. Geodeticko-topografický průzkum zaniklých středověkých osad. *Archeologické rozhledy*, 31, 614–639.
- KLÍR, T., 2003. Plužiny pozdní středověkých sídel na příkladě severovýchodního Nymburska. *Mediaevalia Historica Bohemica*, 9, 245–292.
- KOŘÍNEK, R. 2016. *Plužiny a agrární prvky*. On-line: <http://www.valstejn.cz/2016/10/05/pluziny-a-agrarni-prvky/>. Accessed: 5.3.2020.
- KOŘÍNEK, R., 2018. *Nejstarší dokumenty o vzniku Valštejna a Ztracené Vody*. On-line: <http://www.valstejn.cz/2018/01/28/nejstarsi-dokumenty-o-vzniku-valstejna-a-ztracene-vody/>. Accessed: 5.3.2020.
- KOZÁKOVÁ, R., ŠAMONIL, P., KUNEŠ, P., NOVÁK, J., KOČÁR, P., KOČÁROVÁ, R., 2011. Contrasting local and regional Holocene histories of *Abies alba* in the Czech Republic in relation to human impact: Evidence from forestry, pollen and anthracological data. *The Holocene*, 21(3), 431–444.
- KRÜGER, R., 1967. Typologie des Waldhufendorfes nach Einzelformen und deren Verbreitungsmustern. *Göttinger geographische Abhandlungen*, 42, Göttingen.
- KUČA, K., 2014. Oblasti dochovaných strukturálně výrazných plužin v České republice. *Zprávy památkové péče*, 1(74), 34–49.
- KUNA, M., BENEŠ, J., DRESLEROVÁ, D., KŘIVÁNEK, R., MAJER, A., PRACH, K., TOMÁŠEK, M., 2004. *Nedestruktivní archeologie*. Praha: Academia.
- LÖW, J., MÍCHAL, I., 2003. *Krajinný ráz*. Kostelec nad Černými lesy: Lesnická práce.
- MARSHALL, E.J.P., MOONEN, A.C., 2002. Field margins in northern Europe: their functions and interactions with agriculture. *Agriculture, Ecosystems & Environment*, 89(1–2), 5–21.
- MOLNÁROVÁ, K., ŠÍMOVÁ, P., KOTAŠKA, J., EŠNEROVÁ, J., ŠKVÁROVÁ, Š., 2008. Hedgerow-defined medieval field patterns in the Czech Republic: a case study of the dendrological and dendrochronological structure of hedgerows of varying ages in Northern Moravia. *Journal of Landscape Studies*, 1, 145–158.
- MÉROT, P., 1999. The influence of hedgerow systems on the hydrology of agricultural catchments in a temperate climate. *Agronomie*, 19, 655–669.
- NEKUDA, V., 1975. *Pfaffenschlag – zaniklá středověká ves u Slavonic: příspěvek k dějinám středověké vesnice*. Brno: Moravské muzeum.
- NEUHÄUSLOVÁ, Z., BLAŽKOVÁ, D., GRULICH, V., HUSOVÁ, M., CHYTRÝ, M., JENÍK, J., JIRÁSEK, J., KOLBEK, J., KROPÁČ, Z., LOŽEK, V., MORAVEC, J., PRACH, K., RYBNÍČEK, K., RYBNÍČKOVÁ, E., SÁDLO, J., 2001. *Mapa potenciální přirozené vegetace České republiky*. Praha: Academia.
- OWENS, P.N., WALLING, D.E., HE, Q., SHANAHAN, J., FOSTER, I.D.L., 1997. The use of caesium-137 measurements to establish a sediment budget for the start catchment, Devon, UK. *Hydrological Sciences Journal*, 42(3), 405–423. DOI: 10.1080/02626669709492037
- POHL, J., 1934–1935. Typy vesnických sídel v Čechách, *Národopisný věstník Československý*, 27–28, 5–55.
- POLLARD, E., HOOPER, M.D., MOORE, N.W., 1974. *Hedges*. London: Collins.
- RACKHAM, O., 1986. *The History of the Countryside*. London: J.M. Dent.
- REIMER, P., BARD, E., BAYLISS, A., BECK, J., BLACKWELL, P., BRONK RAMSEY, C., BUCK, C., CHENG, H., EDWARDS, R., FRIEDRICH, M., GROOTES, P., GUILDERSON, T., HAJDAS, I., HATTE, C., HEATON, T., HOFFMANN, M., HOGG, A., HUGHEN, K., KAISER, K., KROMER, B., MANNING, S., NIU, M., REIMER, R., RICHARDS, D., SCOTT, E., SOUTHON, J., STAFF, R., TURNER, C., VAN DER PLICHT, J., 2013. INTCAL13 and MARINE13 radiocarbon age calibration curves, 0–50,000 years cal. BP. *Radiocarbon*, 55, 1869–1887. DOI: 10.2458/azu_js_rc.55.16947.
- RÖSCH, M., 2013. Land use and food production in central Europe from the Neolithic to the Medieval period: change of landscape, soils and agricultural systems according to archaeobotanical data. In: T. Kerig, A. Zimmermann, eds. *Economic archaeology: from structure to performance in European archaeology*. Bonn: Dr. Rudolf Habelt GmbH, pp. 109–127.
- SKLENIČKA, P., MOLNÁROVÁ, K., BRABEC, E., KUMBLE, P., PITTNEROVÁ, B., PIXOVÁ, K., ŠÁLEK, M., 2009. Remnants of medieval field patterns in the Czech Republic: Analysis of driving forces behind their disappearance with special attention on the role of hedgerows. *Agriculture, Ecosystems and Environment*, 129, 465–473.
- SCHIFFER, M.B., 1986. Radiocarbon dating and the “Old Wood” Problem: The case of the Hohokam chronology. *Journal of Archaeological Science*, 13, 13–30.
- SCHWEINGRUBER, F.H., 1990. *Microscopic Wood Anatomy*. 3rd ed. Birmensdorf: Eidegenössische Forschungsanstalt für Wald, Schnee und Landschaft.
- SMETÁNKÁ, Z., KLÁPŠTĚ, J., 1981. Geodeticko-topografický průzkum zaniklých středověkých vsí v Československu. *Památky archeologické*, 72, 416–458.
- SPERLING, W. 1982. *Formen, Typen und Genese des Platzdorfes in den böhmischen Ländern: Beiträge zur Siedlungsgeographie Ostmitteleuropas*. Wiesbaden: F. Steiner.
- TAROLLI, P., PRETI, F., ROMANO, N., 2014. Terraced landscapes: From an old best practice to a potential hazard for soil degradation due to land abandonment. *Anthropocene*, 6, 10–25.
- TAROLLI, P., RIZZO, D., BRANCUCCI, G., 2019. Terraced Landscapes: Land Abandonment, Soil Degradation, and Suitable Management. In: M. Varotto et al., eds. *World Terraced Landscapes: History, Environment, Quality of Life*. Cham: Springer International Publishing, pp. 195–211.
- THINON, M., 1992. *L'analyse pédoanthracologique. Aspects méthodologiques et applications*. Thesis. Univ. Aix-Marseille III.
- UCAR, T., HALL, F.R., 2001. Windbreaks as a pesticide drift mitigation strategy: a review. *Pest Management Science: formerly Pesticide Science*, 57(8), 663–675.
- VAROTTO, M., BONARDI, L., TAROLLI, P., eds., 2019. *World Terraced Landscapes: History, Environment, Quality of Life*. Environmental History, 9, Cham: Springer International Publishing.
- VAREKA, P., 2018. Badania archeologiczne zanikłych osad z okresu średniowiecza i nowożytności na terenie kraju pilzneńskiego (Czechy). In: P. Nocuń, A. Przybyła-Dumin, K. Fokt, eds. *Wieś minioną, lecz obecną. Ślady dawnych wsi i ich badania*. Chorzów: Muzeum „Górnośląski Park Etnograficzny w Chorzowie”, pp. 13–54.
- WILLIAMSON, T., 2018. Open fields in England: an overview. In: Ch. Dyer, E. Thoen, T. Williamson, eds. *Peasants and their fields. The rationale of open-field agriculture*. Turnhout: Brepols Publishers, pp. 5–28.
- WILSON, E.O., FORMAN, R.T.T., 1995. *Land mosaics: the ecology of landscape and regions*. Cambridge: Cambridge University Press.
- WINTLE, A.G., 2007. Introduction: History of Dating Methods. In: S.A. Elias, ed. *Encyclopedia of Quaternary Science*. Amsterdam, Boston, Heidelberg, London, New York, Oxford, Paris, San Diego, San Francisco, Singapore, Sydney, Tokyo: Elsevier, pp. 18–27.
- ZILHÃO, J., 2001. Radiocarbon evidence for maritime pioneer colonization at the origins of farming in west Mediterranean Europe. *Proceedings of the National Academy of Sciences of the United States of America*, 98(24), 14180–14185. DOI: 10.1073/pnas.241522898
- ZLATNÍK, A., 1956. Nástin lesnické typologie na biogeocenologickém základě a rozlišení československých lesů podle skupin lesních typů. *Pěstění lesů*, 3, 317–401.
- ZLATNÍK, A., 1976. Přehled skupin typů geobiocenů původně lesních až křovinných. *Zprávy geografického ústavu ČSAV v Brně*, 13(3–4), 55–64.

- ŽEMLIČKA, J., 1997. *Čechy v době knížecí (1034–1198)*. Praha: Nakladatelství Lidové noviny.
- ŽEMLIČKA, J., 2014. *Království v pohybu. Kolonizace, města a stříbro v závěru Přemyslovské epochy*. Praha: Nakladatelství Lidové noviny.