Did they leave or not? A critical perspective on the beginnings of the La Tène period in Bohemia

Odešli nebo ne? Kritický pohled na počátky doby laténské v Čechách

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One of the key unresolved questions regarding the archaeology of La Tène Europe concerns the continuity of settlement around 400 BC. Archaeological evidence of settlement in the countries north of the Alps, including the Czech Republic, declines during this period – a decline which for decades has generally been attributed to population migration. Demographic growth, climate deterioration, land depletion, disease, and social crisis have all been put forward as reasons for this migration. Our contribution critically reflects on all these alternatives and asks whether there was indeed any significant migration out of Bohemia. We suggest that a reduction in archaeological visibility – the possibility of detecting archaeological traces of human activity – is behind most of the decrease in the number of recorded settlement sites during the transition from LT A to LT B. Some form of social 'revolution' is considered the main cause of the changes recorded in this period.

Hallstatt–La Tène transition – archaeological visibility – migration – climate change – social revolution – settlement – Bohemia – EDE interpolation

Jedna z nevyřešených klíčových otázek archeologie laténské Evropy se týká kontinuity osídlení kolem roku 400 př. Kr. Archeologická evidence osídlení severně Alp včetně území České republiky v tomto období slábne a tento pokles se již dlouho připisuje migraci obyvatelstva. Za důvody této migrace se považuje demografický nárůst, zhoršení klimatu, vyčerpání půdy, nemoci a sociální krize. Náš článek kriticky hodnotí všechny tyto alternativy a táže se, jestli skutečně došlo k významnému vystěhování z Čech. Zastáváme názor, že pokles počtu evidovaných sídlišť kolem přelomu LT A a LT B lze z velké části vysvětlit jejich sníženou archeologickou viditelností, resp. možností zjistit stopy tehdejší lidské aktivity. Za hlavní příčinu změn v tomto období považujeme nějakou formu sociální „revoluce".

doba halštatská – doba laténská – archeologická viditelnost – migrace – klimatická změna – sociální revoluce – osídlení – Čechy – EDE interpolace

Introduction: Historical and archaeological background

Settlement continuity from the late Hallstatt to the early La Tène period (Ha D2/3 to LT A) and the beginnings of the later La Tène period (LT B) is still an unresolved question with respect to Iron Age archaeology in Bohemia and indeed the whole of La Tène Europe. Researchers agree on the existence of a profound cultural change in transalpine Europe around 400 BC according to European chronology (*Venclová ed. 2013b*, 23–24). In LT B, this change can be seen in the (apparent?) discontinuity in various areas of human activity, such as a transition from centralised to decentralised settlement (the end of the hillforts), changes in burial rites (the beginnings of flat inhumation graves), a reorganisation of production and trade (new technologies, the development of specialised and serial production

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and of industrial zones and distribution centres), and a standardisation of artefactual products and changes in ornamental styles (for example, plainer, less decorated pottery). Not all of these changes commenced at the beginning of LT B: some set in earlier; others started only from LT B2 onwards, if not later. Slabina's (at the time) ground-breaking suggestion of a regression in development could then apply only to the earliest phase of LT B (*Slabina 1992*).

It is only the period between LT A and LT B for which a partial depopulation of transalpine Europe (or a migration southwards) has been considered, as reflected in the record of Livy (*Livius V*, 34–35), who states that because of overpopulation, Ambigates, king of the Bituriges, settled in central France, sent a group of people under the leadership of his nephews to the Hercynian Forest (Segovesus) and to Italy (Belovesus). *Polybios* (*II*, 17.7; 2nd century BC) describes the invasion of the Boii and other Celtic tribes into northern Italy. This report allows for various interpretations, including the geographical and chronological setting of the events (*Tomaschitz 2002*; *Kysela 2019*, 21). The starting point of the migrants might not have been France only, but also elsewhere in 'Celtic' Europe north of the Alps (*Tomaschitz 2002*, 49–50). It can be deduced from the historical records that these migrations took place at the beginning of the 4th century BC; an important moment was the conquest of Rome by the Celts in 386 BC, the only historical date connected with the Celtic settlement of Italy (*Bouzek 2015*; *Kruta 2015*, 106–108: 'great transalpine invasion'). Archaeological evidence is interpreted as suggesting the abandonment of various sites in transalpine Europe, including some cases of planned departure (Bourges: *Fernández-Götz 2017*). It should be recalled, however, that Celtic-speaking groups from the north had already been integrated into Etruscan society (*Tomaschitz 2002*, 48; *Buchsenschutz – Gruel – Lejars 2012*, 313–314). In the 4th century BC, a gradual infiltration of 'Celtic' groups in northern Italy can perhaps be considered, based not only on the presence of typical artefacts, such as weapons, but also on changes in the settlement pattern: one exogenous phenomenon of this time was the obvious absence of urban centres, which had characterised Etruscan society before (*Vitali 2004*).

The so-called migration of the 4th century BC cannot be specified, and we can imagine various forms of movement or transfer. According to *Danielisová et al.* (*2019*, 80), it could have been a mass migration overlaying or replacing the original population, the arrival of elites who took control of local populations, or numerous smaller migrations accompanying the spread of the cultural and social La Tène model; the authors tend to consider this last alternative as the most acceptable. A similar view is held by *Kysela* (*2020*, 304–305), who adds that attractive ideologies travelled alongside the people. The causes of the migrations at that time are frequently discussed with respect to the interpretations of ancient authors, according to whom demographic growth, natural catastrophes, soil depletion, and disease were the prime movers (*Steinacher 2015*).

For the period between LT A and LT B, the rather vaguely described social changes ('changed social situation': *Neustupný – Neustupný 1960*, 186; 'democratic revolution': *Bouzek 2015*) are nonetheless described as significant phenomena for the changes at that time. In 1984, Slabina supposed 'unbearable' conditions for the lower social strata and the 'pressure of social forces' (published later: *Slabina 1992*) as the probable cause of the changes at the beginning of LT B. Another explanation was seen in a sudden climatic change, or a decline in solar activity (which peaked around 400 BC; *Maise 1998*) and all its associated consequences.

In general, demographic growth and a subsequent decline are considered, which could have been caused by some kind of social or climatic crisis (or both) around 400 BC. It is not, however, entirely clear whether the number of inhabitants did indeed decrease, and if so by what extent. Using Bohemia as our example, we attempted to critically review the following alternatives regarding the supposed change in population density: in the period between LT A and LT B, the density did not change significantly but is less archaeologically visible for various reasons; in the period between LT A and LT B, the settlement density did change (there was a decrease in population) for various reasons. The two alternatives are discussed in the second part of this paper.

The beginnings of LT B in Bohemia and the question of the visibility of settlements in the archaeological record

Chronological support for the study of the beginnings of LT B in the 4th century BC is mainly provided by finds from graves. Burial rites changed around this time, with flat inhumation graves replacing the hitherto ubiquitous burial mounds (*Chytráček ed. 2021*, 271). The change to flat inhumation cemeteries took place as the ruling elite imposed new models of social structure, ideology and material culture on the local population (*Chytráček et al. 2021*, 597).

It has even been suggested that the group that transformed into the new social elite, as expressed in flat inhumation graves from the LT B1 stage, is represented by LT A graves with swords (*Chytráček – Sankot 2019*, 104). According to archaeological classification, flat cemeteries began in LT B1a, that is, in the first quarter of the 4th century BC. Until now, this horizon has been recognised in a few cases in some regions only (*Holodňák – Waldhauser 1984*; *Waldhauser et al. 1993*, 406, Abb. 191; *Sankot 2017*, 360; for Moravia *Goláňová – Hlava 2020*). These earliest graves can be clearly identified by certain types of personal jewellery, specifically, brooches and bracelets.

Nevertheless, inhumation burials in flat graves in fact appeared as early as LT A (*Venclová ed. 2013a*, 147 and 154; *Chytráček – Sankot 2019*, 106). Some LT A and LT B1a cemeteries obviously coexisted for a short time, as witnessed by typical items found among the grave goods (*Holodňák – Waldhauser 1984*, 40, 42, obr. 6; *Sankot 2013*, 90). Difficulties in distinguishing the late LT A and early LT B finds were suggested in the case of western Bohemia by *Šaldová* (*1971*, 130) and were indicated by grave finds from central and north-western Bohemia (Dneboh-Hrada sunken hut 273, mass burial: *Waldhauser et al. 1993*, II, 311, Tab. 41/3; Libochovany grave No. 78/1903: *Budinský – Waldhauser 2004*, 147). While the number of identified LT B1a graves is low, the number grows significantly during LT B1b–c. Also in Lower Austria, *Trebsche et al.* (*2020*, 471) observed only a few changes in the 4th century BC and pointed out that some of the cemeteries existed continuously from LT A to LT B, when the number of graves gradually grew. In addition, some types of burial can be detected only with difficulty. For example, in the Eneolithic burial mound at Dušníky in Litoměřice district (unpublished excavation by P. Krištuf and J. Turek from 2021), the mantle contained an inhumation grave without grave goods. Radiocarbon dating pointed to 516–396 BC (CRL 22_0139r, 2379±20, 95.4 % probability, IntCal20).

The only type of settlement in LT B1 was the unfortified flatland settlement. In Bohemia, a smaller number of settlements has been recorded than in earlier times, but there is no complete discontinuity from LT A. Until 1993, a spatial continuity of the settlements on the middle course of the Bílina river in north-western Bohemia was recorded in 50 % of the cases, 30 % were deserted, and 20 % were founded anew (*Waldhauser et al. 1993*, 405). A temporal continuity between LT A and LT B1 is proven, although weakly, in only four settlements in north-western Bohemia (in three cases a small gap has been admitted: *Salač – Kubálek 2015*, 75–79, obr. 41), sporadically in western Bohemia (*Chytráček – Metlička 2004*, 29, 124, Tabelle 1, Graph 2, 7–9, Karte 6, 7), and similarly in central Bohemia (Říčany district: *Dreslerová 1998*, 126–127, pl. 21; *Venclová et al. 2008*, 177; Loděnice region: *Venclová 2001*, 205). A similar situation was observed in Moravia (*Goláňová 2018*, 202). Unfortunately, these results are not up to date, and new and detailed regional research is much needed.

A well-known problem of La Tène archaeology is the difficulty of identifying LT B1 and perhaps also LT B2 settlements. There are only a few examples, such as the small short-term LT B1a settlement at Bílina with a small contemporary graveyard (*Waldhauser – Holodňák 1984*). The main chronological guideline (not only for this phase) in the settlement finds is pottery. Reasons for the difficulty of identifying LT B1 pottery include a scarcity of decoration on the vessels and a lack of variability in form. This phase (including LT B2) has been called the 'horizon of undecorated pottery' (*Salač 1989*, 560–562, obr. 9; *Salač – Kubálek 2015*, 53, 75–76). It is likely that the existence of the LT B1 phase has been detected in so few settlements because of the inconspicuousness of the pottery.

A good example is the settlement pit at Čimelice (unpublished excavation by J. Fröhlich, AMCR: record C-9105376A)[1] with radiocarbon date from a carbonised caryopsis of *Triticum aestivum* 408–364 BC (CRL 18_060, 2314±20, 95.4% probability, Intcal20, here *fig. 6*) which contains some undistinctive and undecorated pieces of pottery (Prácheňské Museum in Písek, inv. No. A14475–14480) generally datable to the La Tène period (LT B–D). Such inconspicuous material usually escapes attention but represents key evidence regarding settlement in the region in LT A–B1.

Given the large number of graves in the following LT B1b–c stages, the number of settlements must already have been considerable at that time. The problem is that typologically nondescript pottery is only in rare cases accompanied by chronologically diagnostic objects. As an example, we present the hitherto unpublished assemblage find from one of the very few settlement features that can safely be dated to LT B1, namely one of the features at Loděnice near Beroun, west of Prague.

Between 1978 and 1984, a rescue excavation at Loděnice (tracts Horka or V hlubokém), carried out during construction of the D5 motorway, uncovered seven LT C1–C2 features and one further feature – feature 20/81 dated to LT B – which is the object of our interest. The settlement was situated at an altitude of 265–270 m ASL on the right-hand side of the Krahulovský brook, a tributary of the Loděnice/Kačák stream (WGS 84: 8449.9984372668026: 14.1657661373742). Feature 20/81 was located at the edge of the excavated area, 2.5 m from the nearest La Tène feature (LT C) identified from previous investigations; the other LT C1–C2 features were found to the east and north-east of this spot (*fig. 1*; *Venclová – Vencl – Čapek 1982*; *Matoušek 1984*; *1987*; AMCR C-9115725A-K02).

Feature 20/81. The sunken hut was rectangular with two postholes in the centre of the shorter walls, with the longer axis oriented SWW-NEE. It measured 388 × 234 cm and was 28 cm deep and filled with black

[1] AMCR: Archaeological map of the Czech Republic. https://amcr.info.aiscr.cz

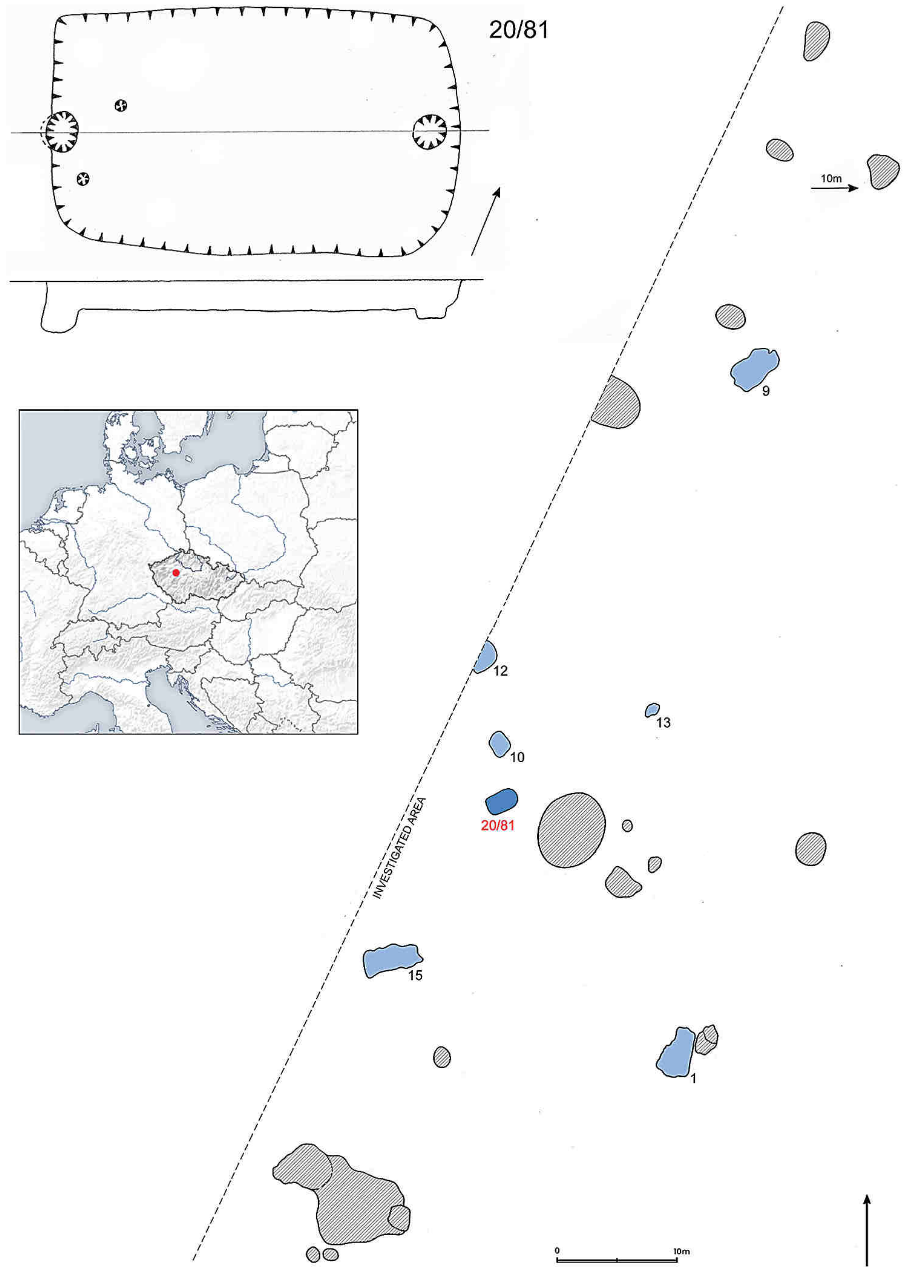

Fig. 1. Loděnice, Beroun district. Excavated area of the settlement, and plan and section of feature 20/81. Features: blue – La Tène period; hatched – Neolithic.

soil (*fig. 1*). The finds included pottery (*figs. 2*, *3*), spindle whorls, a fragment of a bronze bracelet and an iron object, iron slag, grinding stones, burnt clay from a clay 'pan' or a fired block from the fireplace (*fig. 4*), daub, animal bones, and carbonised wood.

Pottery characteristics	pcs	%
Technique		
1 wheel-turned	26	7.0
3 hand-made	345	93.0
Fabric		
1 fine	18	4.8
2 fine grained	38	10.2
4 sandy	0	0.5
5 coarse	274	73.8
7 very coarse	38	10.2
9 graphite	3	0.8
Surface treatment		
1 polished	45	12.1
2 smooth	236	63.6
3 roughly smoothed	41	11.0
4 uneven	11	3.0
6 „marble" type	11	3.0
9 crumb-roughened	26	7.0
11 tooled	1	0.3
Decoration (% from all sherds)		
11 row of impressions	1	0.3
12 row of dimples	1	0.3
18 relief band with dimples	7	1.9
Form (% from formally determined sherds)		
100 storage jar	3	4.6
200 pot	40	61.5
700 bowl	22	33.8

Tab. 1. Loděnice, feature 20/81. Characteristics of pottery. Pottery classification after *Venclová 1998*.

Pottery. Some 374 fragments of La Tène pottery are described and quantified in the find report ref. No. 4915/81 in the archives of the Institute of Archaeology, Prague. The classification corresponds to the Descriptive system of La Tène pottery (*Venclová 1998*, 82–92, 345–348).

Apart from three highly weathered LT C1–C2 sherds, which are considered intrusions from later features in the settlement, the number of 371 ceramic fragments places the sunken hut among other somewhat below-average huts when compared to the other La Tène settlements in central and north-western Bohemia (*Venclová 2001*, 48, tab. 7; *Venclová et al. 2008*, 182, tab. 19; *Venclová – Danielisová 2020*; *Salač 1998*, 48, tab. 2), which is not surprising as only the lowest part of the backfill was preserved. The density of 147.2 sherds/m^3 can nonetheless be considered above average; a representation of 14 % rim fragments is about normal (*Venclová – Danielisová 2020* with refs). Statistics relating to the properties of the pottery are contained in the find report.

The assemblage consists of settlement pottery with a low share (7 %) of fine wheel-made tableware; the hand-made vessels can be interpreted as kitchenware, while large pot-like vessels seem to have been used for storage *(tab. 1*; *fig. 2*, *3*). The strong representation of coarse vessels with an uneven, smoothed or marbled and crumb-roughened surface is characteristic. The vessel forms include pots with straight or slightly profiled sides and bowls with slightly inverted or everted walls. With a few exceptions, the pottery was undecorated. One case of a relief band with cuts, one fragment with a row of dimples, and one with a row of cuts on the shoulders are the only properties linking this assemblage to the LT A or Ha D–LT A stages in Bohemia (*Tappert – Klementová – Sankot 2020*, fig. 6). A comparison with LT A pottery shows that typical properties of this stage – such as wheel-made Braubach bowls and ribbed bowls, tureen and bottle shapes, rounded rims, stamps inside and outside, or late Hallstatt elements (*Venclová ed. 2013a*,

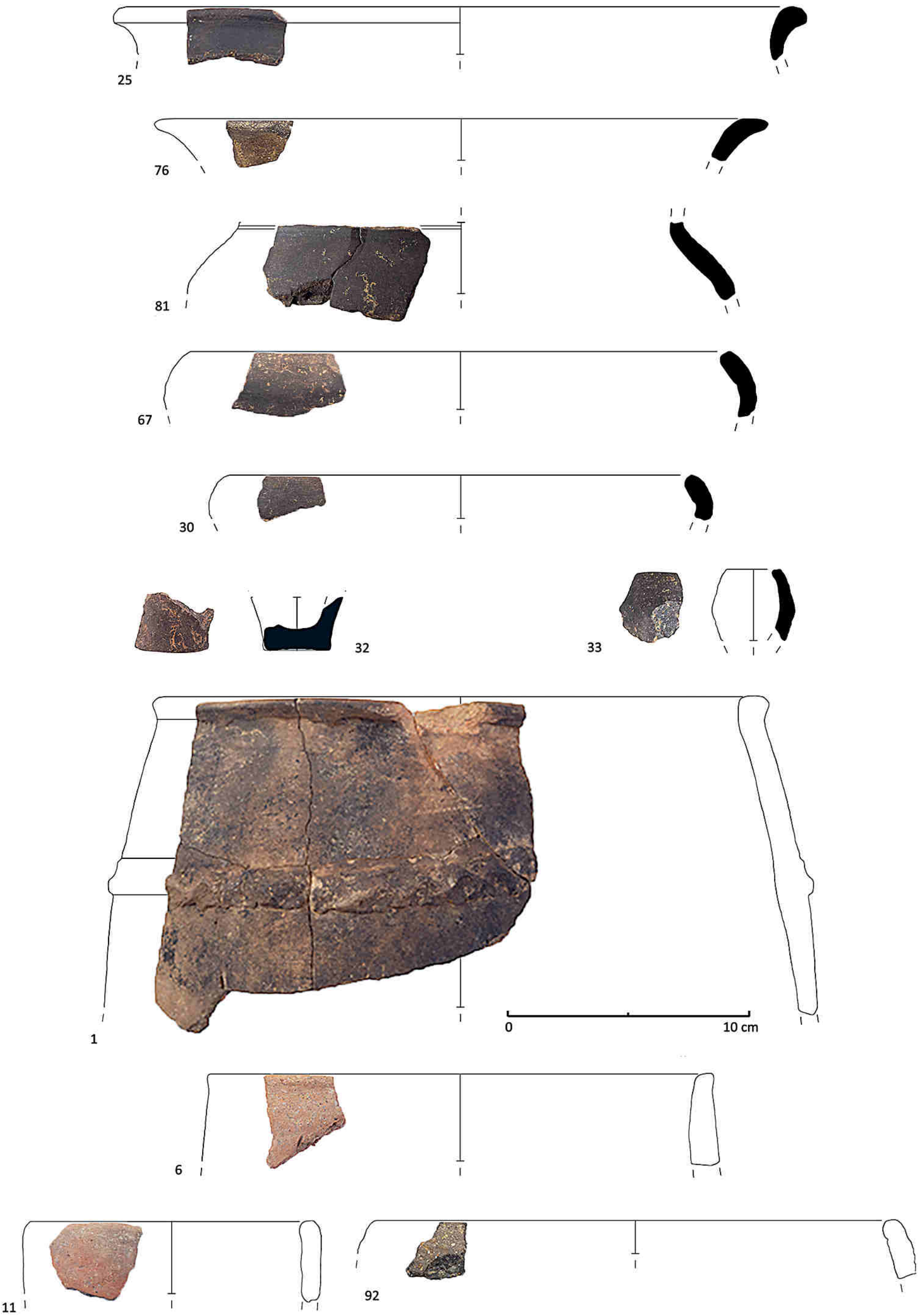

Fig. 2. Loděnice. Feature 20/81. Pottery. Profiles: black – fine wheel-turned vessels; white – coarse hand-made vessels.

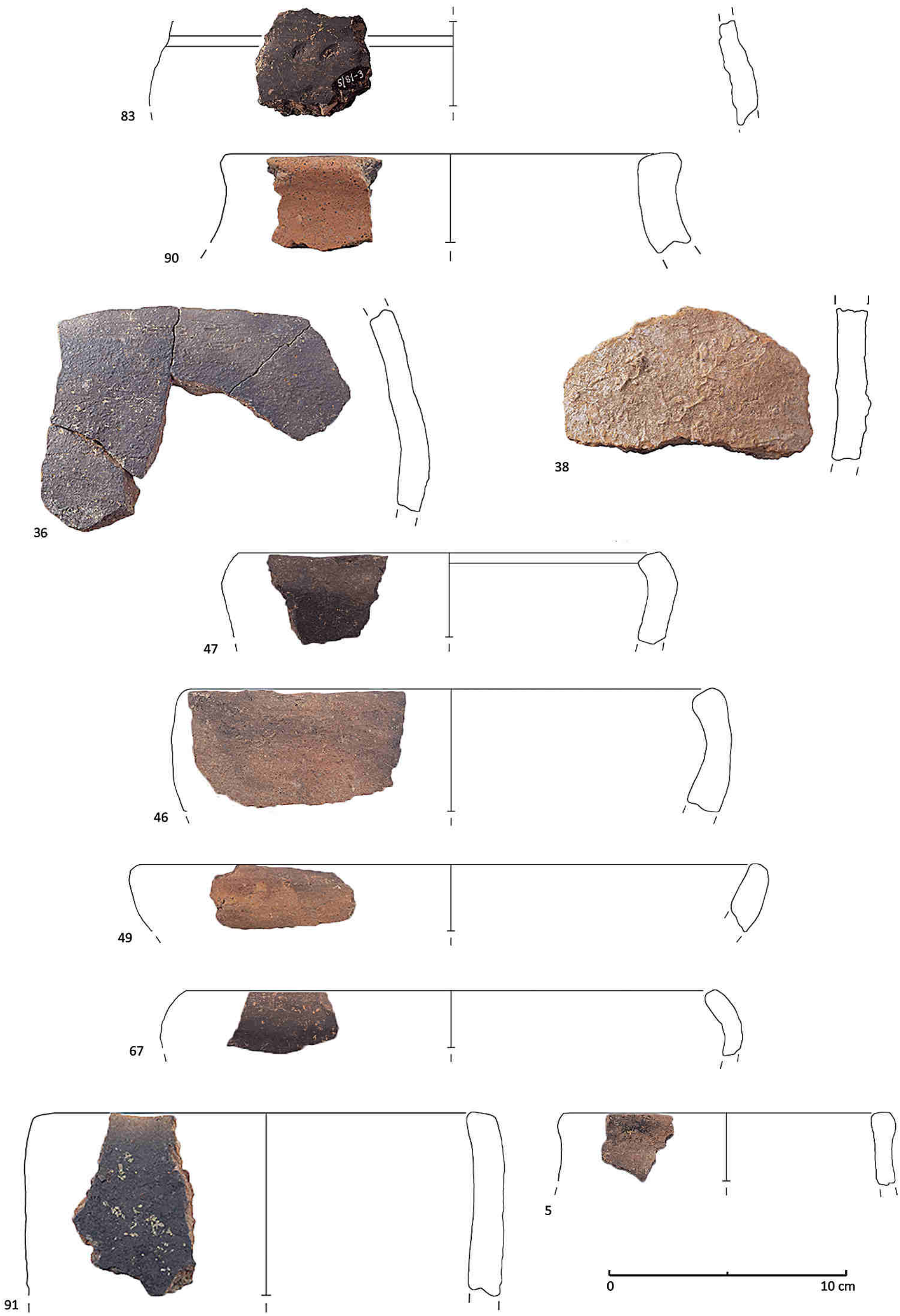

Fig. 3. Loděnice. Feature 20/81. Pottery.

Category	Pottery characteristics	Loděnice 20/81	Rakovník region	Stradonice 1929	Kosoř
		LT B1	LT B2-C1/C2	LT C2-D1	LT D1
Technique	fine wheel-turned vessels	7.0	10.6	34.7	23.2
	wheel-finished and hand-made coarse vessels	93.0	89.3	65.3	76.8
Fabric	4 sandy	0.0	2.3	43.1	68.0
	7 very coarse	10.2	3.8	0.5	0.0
Surface treatment	6 'marble' type	3.0	3.1	0.04	0.0
	7 grated	0.0	0.8	24.7	41.8
	8 grainy	0.0	0.5	2.5	1.4
	9 crumb-roughened	7.0	2.7	0.1	0.0
Decoration	201-203 black coating	0.0	0.5	4.2	9.2
	5 fine combing	0.0	0.05	1.2	1.0
Vessel form	232 shouldered pot with strongly curved neck	0.0	1.3	13.7	20.7
	716 rounded bipartite bowl	0.0	0.0	3.5	15.6

Tab. 2. Comparison of the Loděnice pottery with younger assemblages. Given as % of the total number of sherds; vessel forms: % of the formally determined sherds. After *Venclová et al. 2008*; *Venclová – Valentová 2012*; *Venclová – Danielisová 2020*.

122–125; cf. for Moravia *Goláňová 2018*, 192–199) – are entirely absent from the Loděnice assemblage. Except for the three sherds mentioned above, which we consider a later La Tène intrusion, later properties of the LT C–D stages are missing in the fabric, vessel forms, surface treatment and decoration.

The forms or (mostly missing) decoration of the pottery from Loděnice are similar to LT B1a assemblages, that is, the so-called pre-Duchcov horizon (Bílina: *Waldhauser – Holodňák 1984*; *Holodňák – Waldhauser 1984*; Lužice feature 7: *Salač – Smrž 1989*), but also to LT B1b–c assemblages (Lužice feature 6: *Salač – Smrž 1989*, 559; perhaps also Březno by Chomutov features 9 and 10: *Salač – Neruda – Kubálek 2006*). Currently, stages LT B1a and B1b–c cannot be distinguished in the settlement pottery.

Unfortunately, the pottery of the following LT B2 stage also fails to provide chronologically diagnostic properties. According to Salač, stages LT B1 and B2 both belong to his horizon II with undecorated (or ribbed) pottery, which could be divided into sub-horizons IIa (LT B1) and IIb (LT B2), but the differences between them are negligible, which also holds for the result gained by seriation (*Salač – Smrž 1989*, 560–563, obr. 9; *Salač – Kubálek 2015*, 52–54, obr. 24, tab. ST 11, ST 12). Features 13, 17 and 18 from Počerady, Louny district, also seem to fit into LT B, but cannot be dated more precisely (*Koutecký – Venclová 1979*; see *Salač – Smrž 1989*, 562). If LT B1 and B2 stages differ at all, it is in the occurrence of ribs on wheel-made LT B2 pottery.

There are multiple data for comparison with later La Tène stages. The LT B2–C1/C2, LT C2–D1 and LT D1 assemblages studied using a similar approach from the nearby Rakovník district (Mšecké Žehrovice), Stradonice and Kosoř were available for statistical comparison (*tab. 2*). The assemblage from feature 20/81 at Loděnice differs in the considerably lower representation of wheel-made ware, the lack of sandy fabric and the absence of grated and grainy surfaces. Black coating and fine combing are also missing. Among the vessel forms, there are no bowls with a strongly rounded bipartite profile. Properties characteristic of the later period are present only rarely or are absent.

To sum up, the assemblage of pottery from Loděnice feature 20/81 undoubtedly belongs to stage LT B, and most of the correspondences can be dated to LT B1 (a–c).

Bronze jewellery. The chronologically most sensitive artefact is a wavy bracelet of bronze wire (*fig. 4: 1*). This piece of jewellery is typical of LT B1b–c across a vast area from Moravia to eastern France. The dating is confirmed by a collection of 89 bracelets of this type in the Duchcov hoard (*Kruta 1971*, pls. 38: 6, 39: 1; *Delnef 2003*, 271) and numerous wavy bracelets in the graves. *Delnef* (*2003*, 282–289) dates this

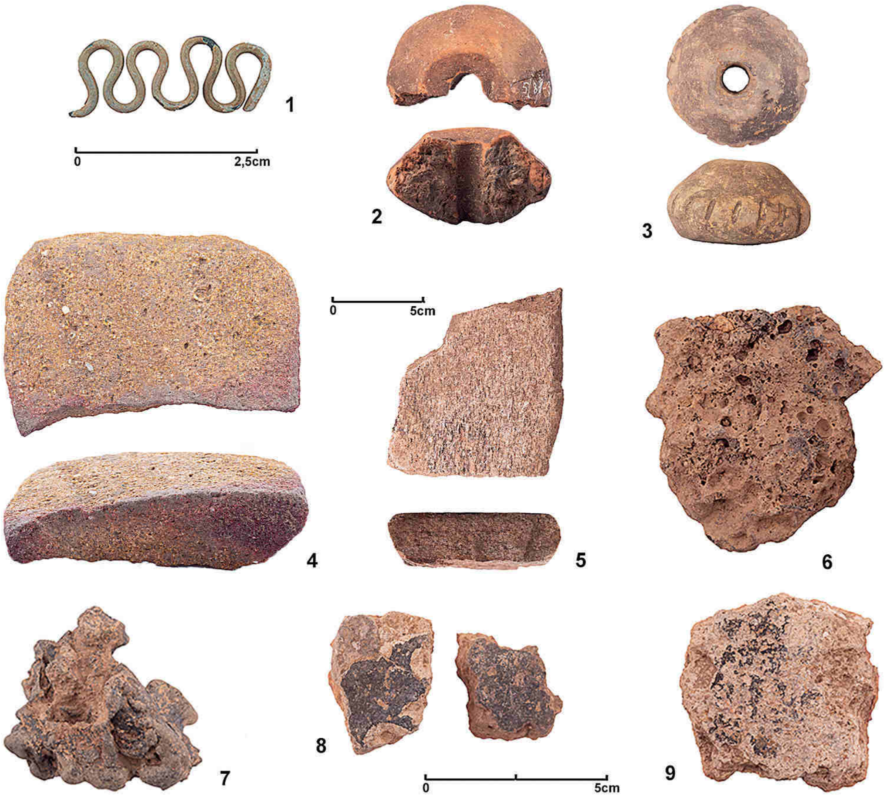

Fig. 4. Loděnice. Feature 20/81. Other finds. 1 bronze; 2–3 clay; 4–5 stone; 6 smithing slag; 7 bloomery slag; 8–9 burnt clay from fireplace. Photo T. Chlup.

type 3 bracelet – that is, a variant with S-shaped loops, to which the bracelet from Loděnice belongs – mainly to LT B1 with single items in LT B2a context. The same was stated at Bohemian cemeteries by Waldhauser (Letky grave 13, Stránce grave 12; *Waldhauser 1987*, Abb. 4, Taf. 12, 30) and by other finds from Bohemia, such as the S-shaped bracelets from the middle Ohře region (LT B1b–c: *Holodňák 1988*, 93, obr. 25, tab. 6), from Prague (LT B1b–c graves: *Hlava 2017*, 92) and from Holohlavy in eastern Bohemia (grave 1/1871, LT B1c–B2a: *Mangel 2009*, 13, 39, tab. 15). Moravian examples include Bučovice grave 20 (*Čižmář 1975*, 422, obr. 3), Marefy grave 20 (*Čižmářová 2013*, 220–221, tab. 37: 10–18) and Čelechovice (*Hlava 2014*, 550, obr. 8). Another comes from Mannersdorf in Austria (*Ramsl 2011*, 117, 205, 211). Although LT B1b–c dating prevails, occurrences in the pre-Duchcov horizon of LT B1a, such as grave 13 at Letky (*Waldhauser 1987*) or grave 305 at Vliněves (*Limburský et al. 2015*, 219–220), have been recorded.

Animal bones. The osteological collection from Loděnice (c. 1.2 kg) contains material with a high level of pre-deposit fragmentation, resulting in a high number of 258 finds (primary data are provided in R. Kyselý's report No. TP-2022-50023 in the archive of the Institute of Archaeology, Prague).

The material was quantified using two different methods, according to the number of bone finds or their fragments (N), and to their mass. This allows for two different views of the taxonomic and anatomical composition. From these two methods, the mass method is not as dependent on fragmentation and possibly better reflects the contribution of meat in diet. The representation of animal species/categories and anatomical elements (*tab. 5*) and the intensity of fragmentation (*tab. 3*) were determined and quantified.

	large mammal – domestic	medium mammal – domestic	large mammal – wild	medium mammal – undetermined	large mammal – undetermined	mammal – undetermined	birds – domestic	∑ (N)
complete/almost complete element	10	12		1				**23**
c. 3/4 of the element	2	2		1			1	**6**
c. 1/2 of the element		1	1	1		1		**4**
c. 1/4 of the element		7	2	4	1			**14**
fragment	7	6	3	12	12	7		**47**
small fragment	2			17	19	126		**164**
∑ (N)	**21**	**28**	**6**	**36**	**32**	**134**	**1**	**258**

Tab. 3. Loděnice, feature 20/81. Quantification of animal bone finds depending on fragmentation and animal size categories using the number of finds (N).

Taxon	Element	Side**	P2P4*	D1D3*	Bp	BFp	Dp*	SD	D*	Bd	BFd	Dd*	BT	GB	GH	LmT	GLm*	SH*	B*
Equus caballus	Talus	d									43.4			53.2	49.5	51			
Equus caballus	Phalanx proximalis	s			48.4	43.7	30.9	30.7	18										
Bos taurus	Talus	d								34							49.8		
Bos taurus	Phalanx proximalis				31.5		34.5	25.3	18.5	29.3		21.3					53.5		
Ovis/Capra (cf. *Capra*)	Mandibula + dentes	d		30.8															
Ovis/Capra	Mandibula + dentes	d	20.3															11.8	7.4
Ovis/Capra	Humerus	d								29.1			28.5						

Tab. 4. Loděnice, feature 20/81. Osteometric data obtained from animal bones. Values given in mm. *D1D3 – alveolar length of the row of deciduous molars; P2P4 – alveolar length of the row of premolars; Dp – max. proximal depth; D – min. depth of diaphysis; Dd – max. distal depth; GLm – max. length of medial/axial half; SH – min. height of diastema; B – min. breadth of diastema; other dimensions according to *von den Driesch 1976*; **s – left (sinistra), d – right (dextra).

		N – number of finds																							
		head					trunk			foreleg					hind leg					other					
		Calva	Mandibula	Dens inferior	Dens superior	Dens	Vertebra lumbalis	Vertebra indet.	Costa	Scapula	Coracoideum	Humerus	Radius	Metacarpus	Tibia	Talus	Calcaneus	Tarsal	Metatarsus	Phalanx I	Phalanx II	Phalanx III	Metapodium	undetermined	∑ (N)
domestic cattle	*Bos taurus*		1	4	2							2	1	1		2	1		3	1					**18**
sheep/goat	*Ovis/Capra*		3	1	5	1						1		3					2						**16**
domestic pig	*Sus domesticus*			1	2									1	2	2					2	1	1		**12**
horse	*Equus caballus*															1				1					**2**
pig undet.	*Sus* indet.					3							1					1					1		**6**
domestic fowl?	cf. *Gallus gallus dom.*										1														**1**
red deer	*Cervus elaphus*			1		4													1						**6**
large mammal		3							1	1		1												26	**32**
medium mammal			2						8						1								1	19	**31**
undet. mammal		2	1			3	2	1					1											124	**134**
∑ (N)		**5**	**7**	**7**	**9**	**11**	**2**	**1**	**9**	**1**	**1**	**4**	**3**	**5**	**3**	**5**	**1**	**1**	**6**	**2**	**2**	**1**	**3**	**169**	**258**

		weight (grams)																							
		head					trunk			foreleg					hind leg					other					
		Calva	Mandibula	Dens inferior	Dens superior	Dens	Vertebra lumbalis	Vertebra indet.	Costa	Scapula	Coracoideum	Humerus	Radius	Metacarpus	Tibia	Talus	Calcaneus	Tarsal	Metatarsus	Phalanx I	Phalanx II	Phalanx III	Metapodium	undetermined	∑ (weight)
domestic cattle	*Bos taurus*		5.8	44.4	8.1							48.1	12.7	2.9		50.7	47.7		48.2	20.7					**289.3**
sheep/goat	*Ovis/Capra*		30.8	4.2	21.3	2.9						9.4		14.8					15.8						**99.2**
domestic pig	*Sus domesticus*			1	4.7									2.7	10	15.3					3.6	2	1.8		**41.1**
horse	*Equus caballus*															49.1				41.7					**90.8**
pig undet.	*Sus* indet.					8.8							9.3					0.5					1.5		**20.1**
domestic fowl?	cf. *Gallus gallus dom.*										0.8														**0.8**
red deer	*Cervus elaphus*			5.8		11.8													15.1						**32.7**
large mammal		30.8							5.7	15		5.1												215.2	**271.8**
medium mammal			7.6						19.1						3.8								2.7	40.1	**73.3**
undet. mammal		4.5	9.2			2.4	35	3.2					7.3											183.6	**245.2**
∑ (weight)		**35.3**	**53.4**	**55.4**	**34.1**	**25.9**	**35**	**3.2**	**24.8**	**15**	**0.8**	**62.6**	**29.3**	**20.4**	**13.8**	**115.1**	**47.7**	**0.5**	**79.1**	**62.4**	**3.6**	**2**	**6**	**439.4**	**1164.8**

Tab. 5. Loděnice, feature 20/81. Taxonomic and anatomical determination and quantification of animal bone finds using two quantification methods.

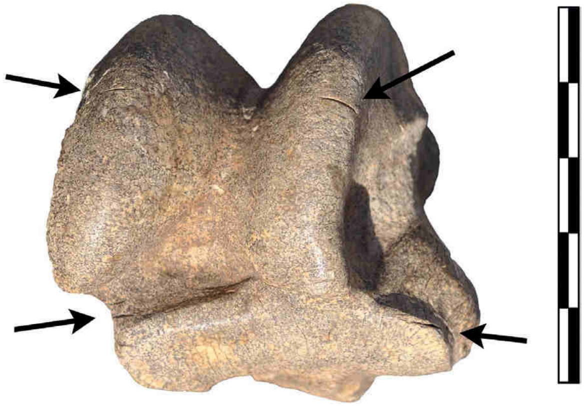

Fig. 5. Loděnice. Feature 20/81. Right ankle bone (*talus*) of a horse (*Equus caballus*) of smaller size, view from proximal aspect. Arrows indicate cuts. Scale: 1 segment = 1 cm.

Small fragments represent c. 64 % of the finds (*tab. 3*), with only the smaller complete elements (some phalanges, tarsal bones and teeth) and no coherent skeleton parts observed. Five bones of cattle extremities and one sheep/goat bone were gnawed (obviously by dog) and 28 small indeterminable fragments were burnt. These taphonomic observations indicate that the assemblage represents neither fresh parts of the bodies nor direct kitchen or butcher's waste. Transverse cuts were made from the front to the horse's talus. They obviously represent portioning of the body in the area of the ankle bone *(fig. 5*), so hypothetically, the consummation of horse meat can be assumed. Further intentional cuts were observed on the distal humerus of sheep/goat and on the rib of a medium-sized mammal.

The quantification points to a strong dominance of domestic animals at Loděnice (cattle, pig, sheep or goat). According to the osteometric data (*tab. 4*), the domestic animals show the usual sizes. Red deer – the only reliably determined representative of wild (hunted) species – is attested by fragments of a tooth and a metatarsus (*tab. 5*). These are elements without meat, but they prove hunting. Two bones from meatless parts of the extremities possibly belong to two fully adult horses of smaller size, somewhat smaller than Przewalski's horse. A single bird bone in the assemblage probably stems from domestic fowl.

The taxonomic composition of the assemblage, including a very low share of fowl and horse, corresponds to the findings from other Bohemian La Tène sites from LT B and later, such as Radovesice (*Peške 1993*), Velké Hostěrádky (*Peške 1984a*), Mšecké Žehrovice (*Beech 1998*), Bílina (*Peške 1984b*) and Hulín, and other Moravian sites (*Čižmář – Čižmářová 2013*). Like the material from Loděnice, the slightly richer assemblage from Bílina (N=383) can be dated to LT B1, also with an obvious dominance of the three main categories of domestic ungulates (cattle, pig, sheep/goat), with a rare occurrence of fowl (and bird bones in general), and, at the same time, the complete absence of horse. According to Peške, the slaughter age of sheep from Bílina was 2–6 years; pigs were slaughtered before their second year. Most of the pig bones from Loděnice also belong to young individuals and only occasionally to adults; the findings of cattle and sheep/goat are not limited to a particular age category.

Comparisons with the preceding period can be made using several analysed assemblages of animal bones from Ha D / LT A studied by *Beech* (*1995*; a total of seven Bohemian sites, with only Tuchoměřice and Jenštejn offering a larger number of bones), and the finds from Horšovský Týn (*Boenke – Pokorný – Kyselý 2006*) and Vladař (*Chytráček et al. 2012*). We cannot draw extensive conclusions from the small number of bones from Loděnice, but we can state that no essential differences between the assemblage from Loděnice and the Ha D / LT A assemblages were observed. Even in this period, game was only complementary, while domestic cattle, pig and sheep/goat were well represented, much less so horse and dog, with exceptional (if any) occurrence of fowl.

Activities of the local community in Loděnice during LT B1 included agriculture and animal husbandry. The grinding of grain is attested by the fragment of a rectangular grinding stone (*fig. 4: 4*), whose regular shape recalls the handstone of a Greek-type quern.

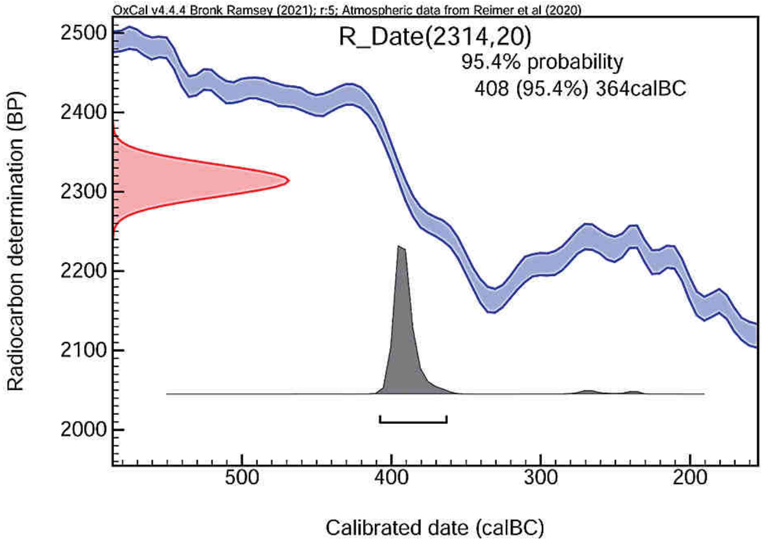

Fig. 6. Čimelice. Results of radiocarbon dating.

This cannot be proven, however, as the fragment does not include the spot where the feed hole would be expected. Evidence of animal husbandry and hunting is present. Specialised production is represented by two sectors. Smithing, attested by fragments of smithing slag (*fig. 4: 6*), is common at La Tène settlements. Three small fragments of bloomery slag (*fig. 4: 7*) are not proof of iron production at the site as, together with the sponge iron, the small amount of slag could have come to the blacksmith's workshop from an iron smelting site elsewhere. The same holds for the later LT C1–C2 settlement with features containing a larger number of pieces of bloomery slag (see excavation report ref. No. 4915/81 in the archive of the Institute of Archaeology, Prague). There is proof of iron smelting in the vicinity: the next attested bloomery was situated at a distance of 1 km southwest at Loděnice / Svatý Jan pod Skalou in the early La Tène and Roman periods (*Venclová 1982*). The conditions for iron production were favourable as Nučice iron ore occurs in the region.

Feature 20/81 is the earliest at the La Tène settlement at Loděnice; the others belong to LT C1–C2. A closer dating of the feature is possible as the S-shaped bronze bracelet, which already occurs in LT B1a, is characteristic of LT B1b–c and is occasionally found at the beginning of LT B2. According to the detailed analysis of the pottery, the assemblage can be dated to the interval of the pre-Duchcov horizon LT B1a and the following LT B1b–c stage, without excluding an overlap to the beginning of LT B2. Continuity of the settlement at Loděnice from LT B1 to LT C2 is probable but cannot be proven (only part of the settlement has been investigated).

A radiocarbon date from the bottom of the sunken hut 20/81 at Loděnice from oak (*Quercus*) charcoal dates the feature to 361–172 BC (CRL 20_473, 2193±21, 95.4% probability, IntCal20).

It can be concluded that without the presence of the chronologically diagnostic metal artefact, the find assemblage from the feature would possibly be classified as datable only

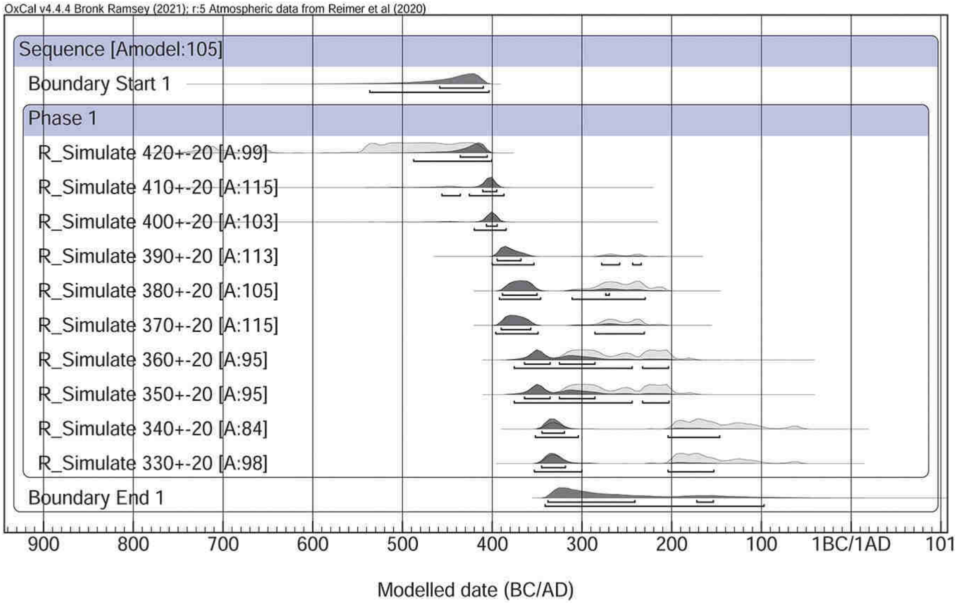

Fig. 7. Sequence model with simulated dates expected from a radiocarbon lab for a sample of a particular date. The beginning, end and span of the whole sequence is calculated. Modelled data are processed using the function R_Simulate in Oxcal (https://c14.arch. ox.ac.uk).

generally into the La Tène period. The single radiocarbon date allows us to shorten the interval to LT B1b – LT C1.

The possibility of identifying the LT A / LT B transition using radiocarbon data

Changes in the activity of atmospheric $^{14}CO_2$ mean the radiocarbon calibration curve fluctuates and is non-linear; the resulting calibrated time intervals differ in duration from decades to centuries. The observed period lies at the interface between the end of the so-called Hallstatt Plateau and the period of the steep part of the curve with the relatively rapid increase in the activity of atmospheric $^{14}CO_2$.

During the Hallstatt Plateau, the dated samples fall into century-long time intervals. When the curve steepens, the sample origin intervals are very short. However, since the steep part of the curve spans only a few decades, the occurrence of samples that happen to fall into the same time interval is rare (*Světlík et al. 2019*; *Kerr – McCormick 2014*).

It is possible to capture the phase of the LT A/B1 transition (see the date from Čimelice, *fig. 6*) but it requires the systematic taking of a large number of samples from all the contexts that could contain finds from this period.

A model (*fig. 7*) simulating the radiocarbon date you might expect to obtain for a sample of this age shows that the critical period of 410–390 BC (LT A/B1a) can be captured with great accuracy. Later and earlier data already fall into sections lasting 150–200 years and can contain a date falling not only into the LT A/B1a transition but also into Ha D2–3 or LT B–C1.

Density of settlement traces and settlement development in the late Hallstatt and La Tène periods

Our study of the development of settlement in the Hallstatt and La Tène periods in the territory of Bohemia is based on data contained in the AMCR database (as of 2020). It contains a total of 1,879 entries from the late Hallstatt and 3,714 entries from the La Tène period, which are unique either for their temporal determination or for the coordinates; with some caution, we can consider this number to be the number of known 'sites', that is, settlements and cemeteries, or other sites such as ritual places. The entries belong to the late Hallstatt period (the stages Ha D2, Ha D3 and LT A) and La Tène (LT B–D for settlements and LT B–C1 for cemeteries, which do not occur in the later La Tène stages). Some 58 % of the entries from LT B–D cannot be determined precisely and are marked as La Tène only. The remaining 42 % contain more exact determinations entered in tens of variations, the choice of which is presented in *tab. 6*. The ambiguous determination reflects many years of attempts to specify the dating of La Tène material and highlights the difficulty of this task. To enable comparison and quantification, we converted the verbal determination into a time interval according to the currently accepted Hallstatt and La Tène phases (*Venclová ed. 2013a*; *2013b*) as shown in *tab. 6*. In the case of the ambiguously determined beginning or end of the period (e.g. LT C1: 260/250 to 190/175 BC), we used the broadest possible dating. The basic set was added to with hitherto unrecorded finds from LT B1.

The distribution of late Hallstatt and early La Tène settlement

The maps in *fig. 8a* and *8b* are based on the data in *tab. 6* and show the distribution of known sites from the late Hallstatt to La Tène periods. The maps exemplify a fairly uniform distribution of Ha D2 – LT A settlement in central, north-western and mainly southern and western Bohemia, with an even dispersion of settlements into the LT A period. Compared to these territories, settlement in eastern Bohemia appears undistinctive. The most significant feature of the transition period is the rapid decline of settlement in western Bohemia (which lasted for almost the whole La Tène period) and a marked thinning in southern Bohemia. Thanks to new LT B1a finds, however, a thinning of settlement can indeed be observed but not a complete depopulation. There is a somewhat surprising increase of the known LT B sites in the northern half of Bohemia, where the invasion of the historical Celts is supposed to have been targeted.

Settlement density expressed by EDE interpolation

Accurate reconstruction of prehistoric settlement is hampered by the very nature of archaeological sources: temporal limitations arise from the range of relative dating of archaeological periods and the usually unknown duration of the settlement or cemetery; spatial limitations include the difficulty of determining the size of a given site and locating its footprints in the terrain, which can vary from a precise geodetic point to an area covering several hectares.

In order to process such ambiguous and barely comparable data statistically, we have used a probabilistic method that produces a spatio-temporal distribution of traces of settle-

Period	Beginning	End	∑
H C – H D3	800	480	14
H C – LT A	800	390	15
H C – LT C	800	175	1
H C2 – H D2	730	500	1
H C2 – LT A	730	390	1
H D1 – H D2	625	500	6
H D1 – H D3	625	480	868
H D1 – LT A	625	390	12
H D2 – H D3	540	480	84
H D2 – LT A	540	390	628
H D3 – LT A	500	390	4
H D3 – LT C	500	110	1
LT A	480	390	244
In total			**1879**
LT A – LT B1	480	320	2
LT A – LT B	480	250	5
LT A – LT C1	480	175	3
LT A – LT C	480	110	3
LT A – LT D	480	40	3
LT B1a	390	370	44
LT B1	390	320	4
* cemeteries ▪ settlement sites			

Period	Beginning	End	∑
LT B1 – LT B2a	390	290	2
LT B	390	250	41
LT B – LT C1	390	175	721*
LT B – LT C	390	110	5
LT B – LT D1	390	80	2
LT B – D	390	40	2137▪
LT B1a – LT B2a	390	290	18
LT B1b – LT C2	370	110	30
LT B2a	330	290	1
LT B2a – LT D1	330	80	8
LT B2a – LT D2a	330	40	2
LT B2b	290	250	6
LT B2b – LT C1	290	175	12
LT C1	260	175	11
LT C	260	110	84
LT C – LT D1	260	80	9
LT C1 – LT D	260	40	7
LT C – LT D	260	40	72
LT C2	190	110	11
LT C2 – LT D1	190	80	9
LT D	130	40	462
In total			**3714**

Tab. 6. Archaeological dating and its equivalent in BC absolute dates. ∑ indicates the number of records of the given period in the AMCR database. Burial sites established as La Tène or LT B–D were included in LT B – LT C1 as burials from the later period are not known.

ment activities and represents the probability of the occurrence of evidence of settlement in a given place and time interval and so provides a more precise view of the extent of the settlement in time and space. The EDE function (Evidence Density Estimation) was developed to process heterogeneous archaeological data and takes into account the spatial and temporal (in)accuracies of the initial data (*Demján – Dreslerová 2016*; *Dreslerová – Demján 2019*). The basic features and mathematical calculation of this function have been described by *Demján – Dreslerová* (*2016*) and *Demján et al.* (*2022*).

The resulting probability of the occurrence of settlement evidence was modelled according to four factors of inaccuracy for each archaeological entry. The first factor is the known time interval of dating (in)accuracy in which the actual date of creation of the recorded artefact lies. The probability of dating to a specific year is therefore lower the longer this interval is. For the modelling of settlement density in LT B1, this probability will be influenced by entries dated to LT B1 (36 %), LT B (18 %) and LT B–D (7 %), which will then be combined (see below). The second factor is the known inaccuracy of the spatial determination, which can vary from a very precise geodetic measurement to indicating the location only on the cadastre of a municipality. The true location of a find therefore lies somewhere on the surface, defined by the recorded coordinates and the radius of inaccuracy. The probability of the occurrence of evidence of settlement on specific coordinates will be lower, the larger this radius is.

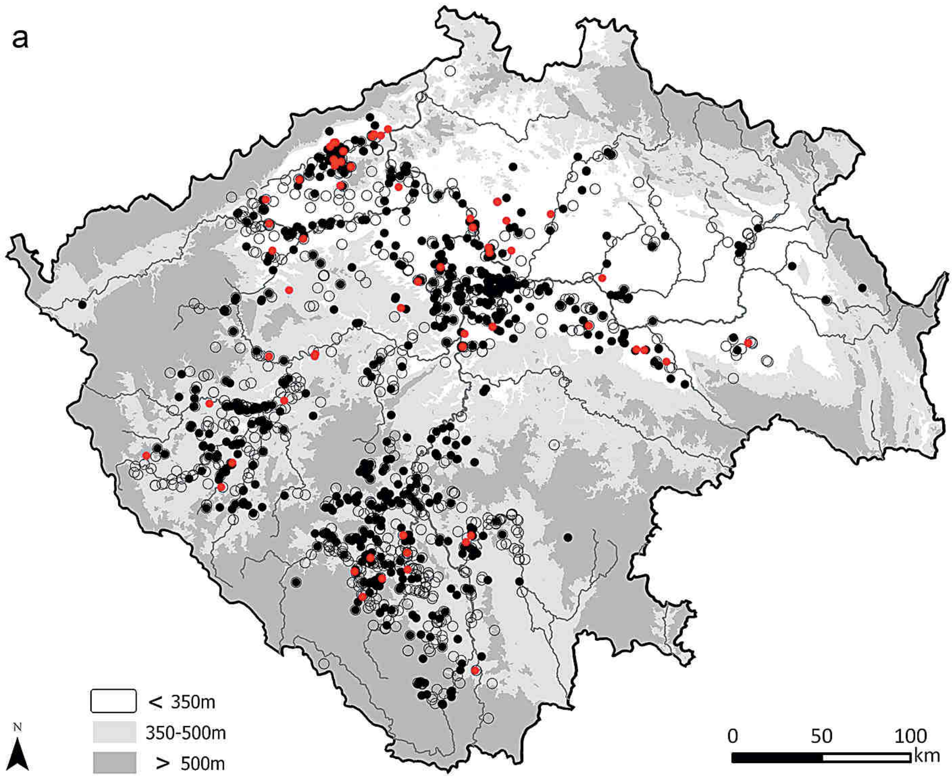

Fig. 8a. Map of Bohemia with sites from LT A (red dots); Ha D2 – LT A (black dots); Ha D1–3 (empty dots).

The third factor presupposes a minimal duration of the settlement on a specific site. We aim to record the presence of human settlement, not of a specific event such as the production of a ceramic artefact. We assume that the settlement where the given artefact was produced must have existed for some time before and/or after production. The longer the assumed period, the lower the probability of the occurrence of a settlement derived from the occurrence of an artefact found in a particular year. The fourth factor is the expected minimum area of a settlement (expressed by the radius) or the residential component that produced most of the artefacts. We are again interested in the location of the settlement itself, or its centre, not in the site of deposition of a specific artefact. In other words, this factor expresses the maximum expected distance from the centre of the settlement to the place the artefact was found. The greater this expected distance, the lower the probability of the centre of a settlement occurring at specific coordinates.

By multiplying the probability values derived from all four factors for each archaeological entry and each spatio-temporal coordinate (i.e., the spatial coordinates of the interpolated raster maps and the time slice) and then combining them, we obtain a series of raster maps which present the probability distribution of evidence of settlement in time and space. For the purposes of this study, we used the data on archaeological dating (expressed as an interval in calendar years) and the radius of the accuracy of the measurements (in metres) for the first and second factor; for the third and fourth factors we used an assumed mini-

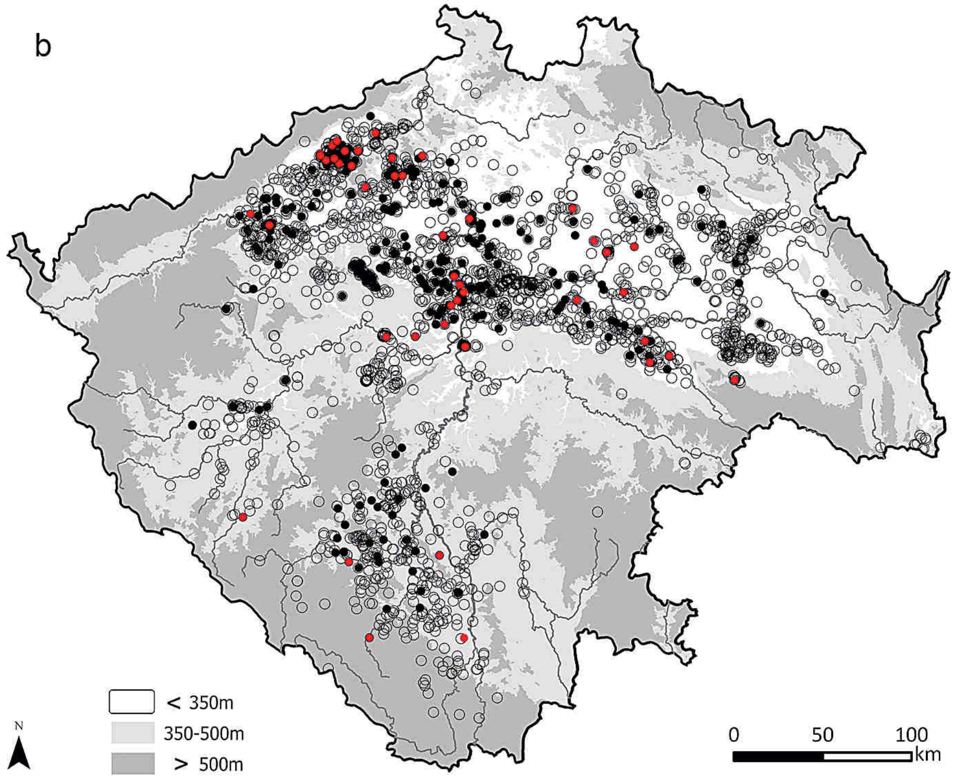

Fig. 8b. Map of Bohemia with sites from LT B1a (red dots); LT B–C1 (black dots); LT B–D (empty dots).

mum duration of the settlement of 50 years and a radius for the residential component of 100 m (an arbitrary decision based on the models in *Dreslerová – Demján 2019*). For the grave finds, we used 250 m as the fourth factor. This represents the maximum assumed distance from the centre of the settlement core, based on an estimated size of a settlement area (*Demján – Dreslerová 2016*). The resulting values were interpolated into a spatial raster with a resolution of 100 × 100 m in temporal steps of 25 years.

The resulting probabilities are presented both by the probability of the occurrence of a site on the map and the TFD (Temporal Frequency Distribution) of the curves, that is, by the summed density of probable occurrences of settlement in a given time slice. The curves were processed separately for each of the main river basins of Bohemia and show important regional differences in the distribution of settlement traces (*fig. 9*).

The picture of settlement development provided by EDE differs from the traditional picture of that development as derived from the known number of sites and their distribution on the map. The EDE results can be interpreted as follows: In the southern and western regions of Bohemia, the decline of settlement started sometime earlier, shortly before c. 500 BC, than it did in the rest of Bohemia, where we can observe depopulation roughly from 450 BC. In the northern half of Bohemia (OLE, UME), the decrease culminated around 420 BC and settlement density began to grow again, with the fluctuation being erased or even overcome within a mere 50 years.

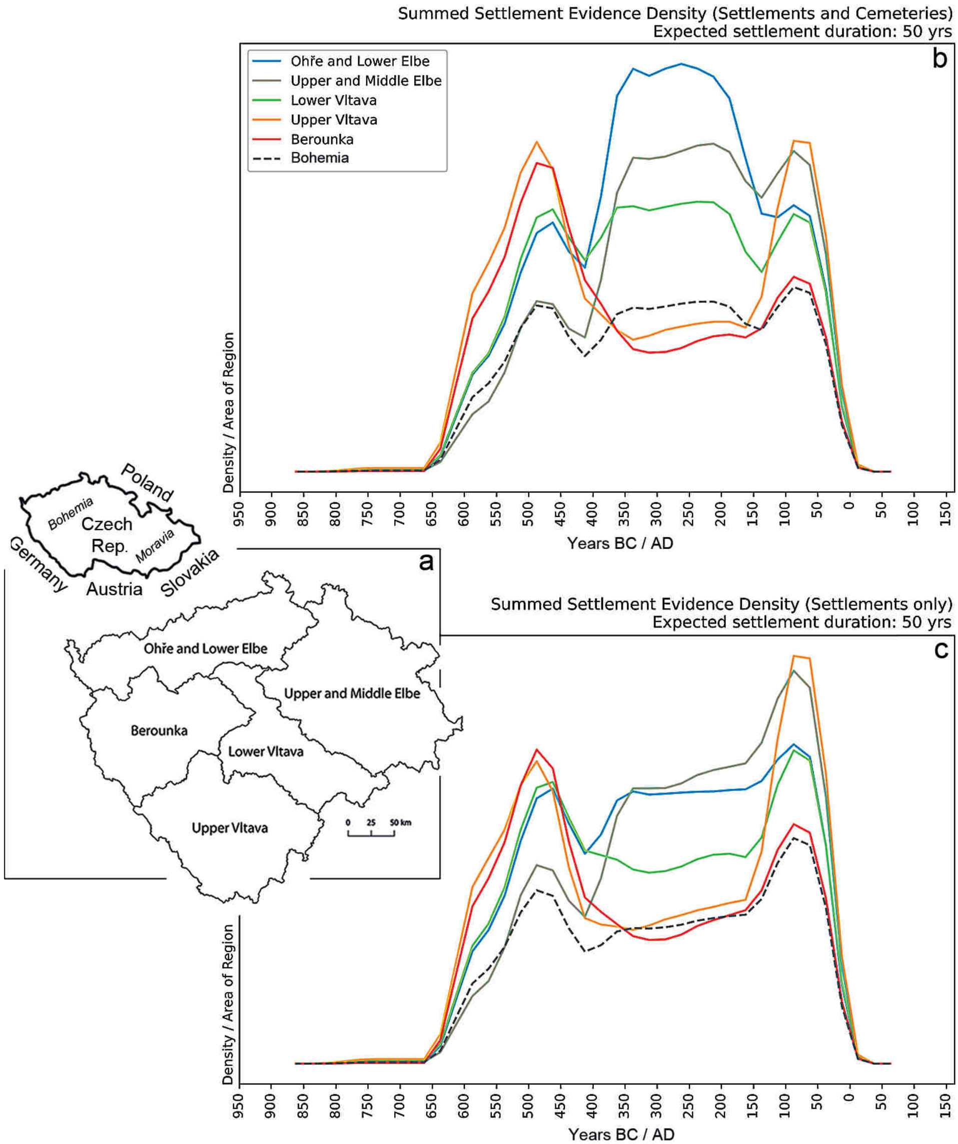

Fig. 9. a – Bohemia and its main river basins. b – TFD curves for particular river basins (settlements and cemeteries). Expected settlement duration 50 years (the beginnings and ends of the curves are affected by the edge effect). c – TFD curves for particular river basins (settlements only). Expected settlement duration 50 years (the beginnings and ends of the curves are affected by the edge effect).

In southern and western Bohemia, as well as in the lower Vltava river basin (UV, BE, LV), the decrease continued with varying intensity until a reversal took place around 350 BC in southern Bohemia and around 300 BC in western Bohemia; the lower Vltava river basin (LV) maintained its low density, which started to increase again only after c. 150 BC. At the same time, the density of settlement started to grow in all catchment areas and the overall peak took place between c. 100 and 50 BC. As expected, the highest density of settlement was recorded in the northern half of Bohemia, mainly throughout the Labe and Ohře river basins. The overall curve of Bohemia for settlement density surprisingly delivers continuous settlement values with a slight decline at the end of the 5th century, followed by steady growth which peaked between 100 and 50 BC, after which came an abrupt end.

Social complexity seen through the spatial structure of the settlement

We created a model of the space-time development of prehistoric settlement based on the combined dataset of destructive and non-destructive findings known from the AMCR database and surface surveys (*Dreslerová – Demján 2019*). The degree of spatial organisation and complexity of the settlement structure in various periods was analysed using the Pair Correlation Function (PCF), which quantifies clustering at various radii. It allows us to observe whether the habitation areas of the settlements formed groups in the immediate mutual vicinity and whether those groups were clustered at increasing distances up to 5 km, which was the maximum extent of our dataset available at the required spatial and temporal resolution. *Fig. 10* depicts the spatial clustering of the Hallstatt and La Tène habitation areas in the landscape. There is no significant spatial clustering of settlements in the early Hallstatt period. In the Ha D – LT A period, we can observe peaks of spatial clustering at radii up to 1.5 km and 2.5–4.0 km, the latter indicating relatively complex micro-regional structures. With the onset of LT B, observable spatial structuring decreases to a radius of 1.0 km, and this is somewhat surprisingly maintained throughout the La Tène period. In our opinion, a greater degree of spatial structuring of habitation areas could indicate a greater degree of social complexity.

Identifying demographic changes and their causes

Demographic crises or fluctuations in the period in question are usually considered to be a result of social and/or climatic changes that result in famines, epidemics, wars, migration, or changes in subsistence strategies. Causal relations could exist between some or all of these phenomena.

Climate

One cause considered for the (apparent) decrease in or replacement of the population and the change of the whole system between LT A and LT B or within LT B was climate change, particularly the onset of colder and wetter weather (*Maise 1997*; *1998*; *van Geel et al. 2004*). Low $\Delta^{14}C$ concentrations, which should derive from an increase in solar activity, are connected with warm and dry conditions; high concentrations are associated with cold and wet conditions. We can assume that the archaeological finds are more frequent at times of a low or medium $\Delta^{14}C$ values and less frequent when $\Delta^{14}C$ values are higher (e.g. *Maise 1997*; *1998*; *Magny 1993*; *Tinner et al. 2003*; *Schibler 2006*; *Schibler – Jacomet 2010*).

The climatic fluctuation suggested for the LT A / LT B transition could have been caused by a change in solar activity, with a peak between 400 and 300 BC. This was when

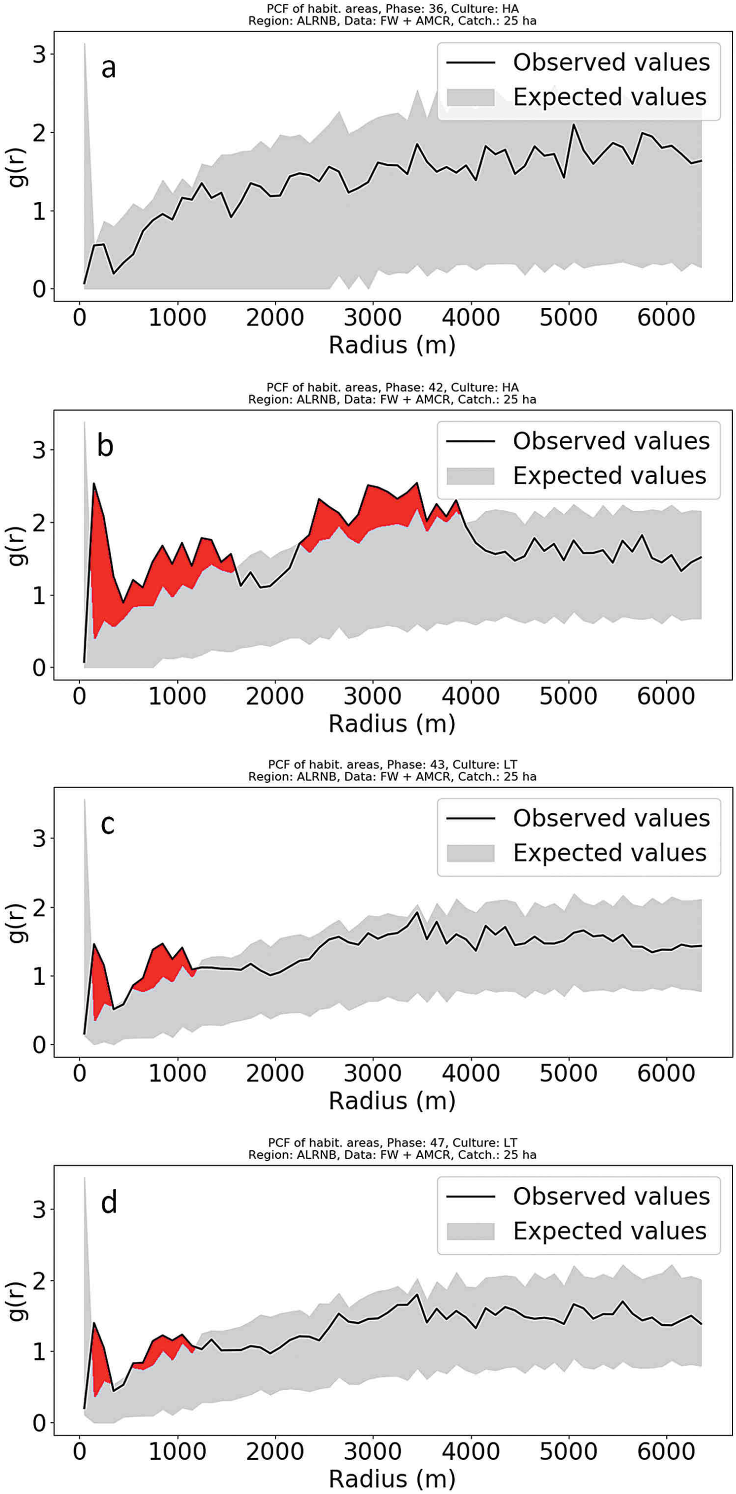

Fig. 10. Spatial clustering of habitation areas from the beginning of (a) Ha, (b) Ha D2 – LT A, (c) early LT, (d) late LT periods. The clustering is expressed by the Pair Correlation Function (PCF) at different distances in km. The expected values (grey) were generated by randomising the spatial distribution of the settlement evidence. Red colour under the PCF curve indicates a statistically significant increase of spatial clustering of habitation areas.

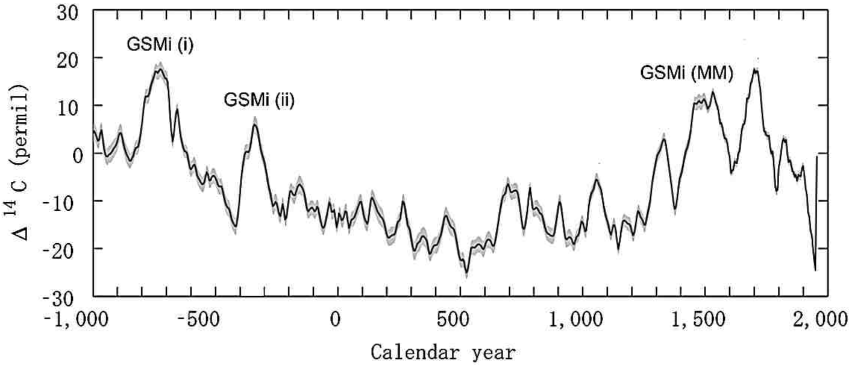

Fig. 11. Decadal carbon-14 record (IntCal09) of the last 3,000 years. The grey area represents one-sigma standard deviation; upper peaks correspond to the seven grand solar minima (carbon-14 maxima). Adapted from *Reimer et al. 2009* and *Nagaya et al. 2012*.

one of the so-called Grand Solar Minima (GSMi) occurred, that is, an extreme lowering of solar activity and of the number of observed sunspots from the usual 20–50 to significantly below this level (*Wu et al. 2018*). A GSMi is reflected in the curves of the ^{14}C and ^{10}Be isotopes as stressed peaks (*Usoskin et al. 2016*, fig. 5). The opposite fluctuations in solar activity are called Grand Solar Maxima (GSMa). The causes of these fluctuations are usually described as being a result of a special mode (function) of the solar dynamo (*Wu et al. 2018*). Apart from the fact that the sun is the prime mover of the earth's climate, it has proven difficult to create a convincing connection between solar variability and climate change (*Dergachev et al. 2007*).

At the end of the middle and late Holocene, some marked GSMi have been recorded, three of which will be mentioned here: (i) at the beginning of the so-called Hallstatt Plateau, (ii) at the end of the same plateau and (iii) during the Maunder Minimum (1645–1715; *fig. 11*). The dating and estimated duration differ slightly from researcher to researcher (*tab. 7*).

GSMi (MM). The Maunder Minimum will be used for a comparison with the GSMi of the Iron Age. The MM was the coldest period of the so-called Little Ice Age. In the MM, total solar irradiance dropped by 0.22 % (*Zharkova 2020*) and sunspots almost vanished from the sun's surface (*Usoskin 2017*). The average terrestrial temperature in the northern hemisphere is thought to have dropped by 1.0–1.5°C; the surface temperature is thought to have fallen worldwide. This seemingly small change in average temperature would have caused the freezing of rivers, and long cold winters and cold summers, especially in the northern hemisphere (*Zharkova 2020*). In general, the MM is characterised as a period of lower atmospheric temperatures (mostly with a longer duration of the winter season) and higher precipitation, which led to social crises in the shape of an increase in food costs following bad harvests (*Špinarová 2021*).

GSMi (i). Almost all of the proxy data agree on a cold event around 2800 cal BP. *Van Geel et al.* (*2004*) link this sudden climatic transition towards higher humidity to lower solar activity in Eurasia and consider it a global event as it was recorded in both the northern and the southern hemisphere. The dendrological reconstruction curve of the summer temperatures points to a permanently cold summer for Tasmania between 850 and 750 BC

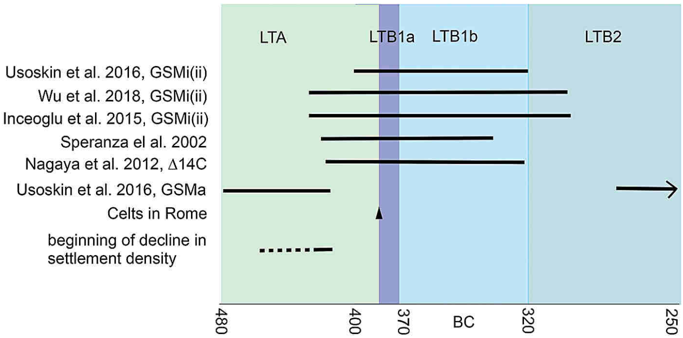

Fig. 12. Correlation of solar minima (GSMi), maxima (GSMa) and other climatic proxy with archaeological periodisation of LT A and LT B in Bohemia. Decline in settlement density according to EDE interpolation.

(*Briffa 2000*, 91). At the same time (2800 cal BP), a climatic change is documented in turf sections in South America (*Chambers et al. 2007*), and another can be seen in the eastern Mediterranean (although with different effects from those in central and north-western Europe; *Finné et al. 2011*).

As a consequence of the cold and wet conditions, human activity should be reduced in the Harz mountains (record from Jues lake, Germany: *Voigt 2006*), in the western part of central Europe, and south of the Alps (*Tinner et al. 2003*; *Magny 2004*). *Van Geel et al.* (*2004*) link this climatic change to the expansion of the Scythian culture.

In Bohemia, a climatic fluctuation is exceptionally recorded in the bog sediment at Pančavská louka (meadow) in the Krkonoše mountains. Botanic macroremains and pollen analysis both show a noticeable change in the vegetation which reflects climatic deterioration towards wetter and colder conditions around 850 cal BC. Vegetation returned to its pre-change state around 697 cal BC (*Speranza et al. 2002*).

GSMi (ii). Although the ^{14}C and ^{10}Be curves show almost the same marked decline in solar energy (*Wu et al. 2018*) as in GSMi (i) and GSMi (MM), the literature has paid less attention to GSMi (ii) than to preceding events, perhaps because it is less obvious in the data. Some works treat GSMi (i) and (ii) together as a climatic deterioration at the beginning of the Iron Age (*Magny et al. 2009*) or as a 'cold period of the Iron Age' (*Moffa-Sánchez – Hall 2017*). *Büntgen et al.* (*2011*, fig. 4) link two depressions in summer temperatures (JJA) to the 'Celtic expansion' c. 350 BC and the Roman invasion c. 50 BC. The period c. 650 BC shows a decrease in cemeteries in the Champagne region in Ha D – LT B1 and in the Seine and Yonne basins in LT B2 (*Maise 1998*). In southern France, a short but intense decline in settlement between 650 and 550 BC has been recorded but the population had already started to grow again by around 500 BC (*Berger et al. 2019*). In the Greek Peloponnese, no response to the climatic change was observed in either period in question (i.e. GSMi (i) and GSMi (ii)), partly because humidification is welcomed there, and partly because of the high level of organisation of production and advanced technologies (*Weiberg et al. 2021*). *Dark* (*2006*) analysed the impacts of climate deterioration in the first millennium BC in the territory of Great Britain. Although some deterioration seems to be proven, it did not cause any vast desertion of the settlements or long-term land-use change, even where conditions for agricultural cultivation were marginal. On the contrary, many places show growth rather than a decline in agricultural activities and deforestation at that time. There is no proof of a general transition from arable to pastoral farming, which is generally considered to be a reaction to climate change. Some areas could have practised

Source	GSMi (i)	GSMi (ii)	GSMi Maunder (MM)
Usoskin et al. 2016	centre 750 BC (duration 120)	centre 360 BC (duration 80)	
Usoskin 2017			1645–1715 AD (duration 70)
Wu et al. 2018	centre 750 BC (duration 70)	centre 360 BC (duration 120)	
Inceoglu et al. 2015		centre 348 BC (duration 107)	
Zharkova 2020			1645–1710 AD (duration 65)
	GSMa	**GSma**	
Usoskin et al. 2016	centre 435 BC (duration 50)	centre 245 BC (duration 70)	

Tab. 7. Selected solar minima and maxima between 750 BC and AD 1715 (the duration of the period is given in parentheses).

extensive agriculture, requiring further deforestation. Growth in deforestation is understood as a consequence of increased human activity prompted by climatic deterioration rather than by a favourable climate and an increase in population.

In Bohemia, the change that took place in the GSMi (ii) period is again recorded in the sedimentary record from Pančavská louka as a second but less significant deterioration. It occurs around 414 cal BC, peaks around 376 cal BC, and persists until about 334 cal BC (*Speranza et al. 2002*).

If we view the periods of solar minima as times of climatic deterioration (in Bohemia meaning a decrease in temperature and an increase in precipitation), the LT B1 period provides the closest correlation (*fig. 12*); during LT B2, the effects of the change should fade away or disappear. According to *Usoskin et al.* (*2016*), the solar maximum should have lasted until 400 BC, that is, for the whole of LT A, but according to *Speranza et al.* (*2002*) and *Nagaya et al.* (*2012*), a worsening might have occurred as early as 415 BC. It should be noted that the findings for the key period at the end of LT A are contradictory.

In terms of the strength of the event and its consequences for society, the climate changes around 400 BC could correspond to the modern Maunder Minimum. Unfortunately, however, MM coincides with the period immediately after the end of the Thirty Years' War, when the population of the Czech lands was reduced by a third (*Fialová et al. 1996*). Even 40 years after the war, 20 % of the cultivable land remained abandoned. Despite this, the volume of agricultural production had re-attained pre-war levels by the end of the 17th century (*Agnew 2008*).

In general, we assume that climatic fluctuations and changes in the weather influenced agricultural production and the health of the population and led to dangerous conflicts. In historical times, a reduction in the harvest meant famine, a refusal to pay taxes, and a weakening of the state's authority; deficiencies in subsistence resources worsened with the growth of population at times of favourable climate (*Lee – Zhang 2015*). The reaction to climate deterioration was war, epidemics, and migration. However, estimating the extent to which a climatic fluctuation could influence a population in prehistory is problematic because we lack basic knowledge for such considerations, including exact population figures and evidence of people's ability to help each other. In addition, some climatic changes might have brought prosperity to some regions but not to others. For example, *M. Kohler-Schneider* (*2020*, 45–46) suggests that in the northern foothills of the Alps (Lower Austria) in the La Tène period, lower temperatures and higher precipitation could have been simply 'less favourable' for agriculture rather than disastrous.

The comparison between the EDE interpolation and the climatic scenarios shows that a decline in the settlement of southern and western Bohemia, and later across the whole of Bohemia, apparently preceded the beginning of the climatic deterioration and continued to take place during the solar maximum (*fig. 12*; *Usoskin et al. 2016*). At the same time, however, the abandonment of agriculturally less favourable areas suggests the idea of a response to climate deterioration.

Subsistence strategies

One of the signs that accompanies the discontinuous settlement development brought about by migration, social change, a lack of food, and so on, could be changes to or innovations in subsistence strategies (new crops, a greater or lesser representation of game, etc.). Such changes are not, however, visible in LT B1. On the contrary, there is evidence of the continuity of some important innovations that originated in LT A, such as the short scythe (probably used to cut grass), the iron ploughshare (which enabled cultivation of heavier soils in less fertile areas), the Greek-type quern (raising the productivity of grinding grain), and a greater variety of cultivated crops (*Kočár – Dreslerová 2010*). We could also mention the continued and intensive use of fertilisers (from the Neolithic onwards), which mitigated against exhaustion of the soil (*Dreslerová et al. 2021*). No differences in animal husbandry – an important part of the subsistence strategy – are observed between the Ha D / LT A and LT B or later periods. Little data is available to evaluate such significant phenomena as the genetic continuity or discontinuity of herds (*Waldhauser et al. 1993*, 405–406).

Famine, epidemics, and war

Morgan (*2013*) posed the question of whether it is possible to identify famine in the archaeological record and concluded that it is practically impossible. Theoretically, hunger could be documented by changes in diet (eating bark, twigs, wild-growing fruits, etc.), but such changes are not visible in the macroremains, and finds from latrines and coprolites do not exist from the period in question. The small number of graves (at the beginning of LT B) does not allow us to evaluate mortality and to create a curve, which would show the age structure of the deceased. The bones show no consequences of short-term starvation, nor can changes be seen in the composition of the nutrition using isotopes. Fertility usually drops during a famine and regenerates after one year: spermatogenesis, menstruation, and the ability to carry a child to full term are renewed and the population begins to grow again.

Epidemics have similar effects and often occurred alongside famine and war. The graph of the natural development of the population between 1645 and 1799 in the Czech lands (*Fialová et al. 1996*, 122) shows the effect of pests, crop failure, and war (War of the Austrian Succession and the Seven Years' War), but the consequences were overcome in two to three years, which we are not able to detect in the archaeological record despite improved dating techniques.

Only an event such as the Thirty Years' War, when the population of the Czech lands decreased by about 30 %, could have, theoretically at least, had an impact on the archaeological record. According to some estimates, the results of depopulation were overcome only after 50 years of continuous population growth (*Fialová et al. 1996*, 105). Remarkably, roughly the same 50-year interval can be seen in the graphs of settlement curves from that period in the Ohře and Lower, Middle and Upper Elbe river basins. In the other river basins, the recession in settlement lasted for a longer period, and it is unlikely that a long-term military conflict could have been the cause.

Migrations

Population changes resulting from migration can be detected in the archaeological record. The causes of that migration cannot, however, be safely determined by archaeology.

Causes could include the need for further or different resources, overcrowding, social disturbances or inequality, and the subsequent search for a 'Promised Land'. In the Middle Ages and modern times, overcrowding has sometimes been solved by the colonisation of new territories. The population density graphs show that in the late Hallstatt period, the population reached one of its peaks and, at the same time, territories in the northern parts of southern Bohemia were colonised (*Dreslerová 2004*), as were the foothills and montane areas of southern and western Bohemia (*Dreslerová et al. 2020*).

A comparison of regional curves for the density of traces of settlement activity points to a redistribution of the population, perhaps from the southern half of the country to the north, rather than to a migration outside the Czech basin, as after a short slump the overall traces of settlement remain stable. Such a redistribution could be explained as a consequence of climatic deterioration, but only to the extent that southern and western Bohemia would comply with the requirements for reasonable sustainability for a smaller number of inhabitants. Such a migration would have prompted resistance from the local population (if it was not too depleted), but there is no support for such conclusions in the archaeological record.

Conclusions

The changes that took place during the transition from LT A to LT B can be summarised as follows. Signs of the social inequality that must have existed in Ha D2 – LT A disappear. The settlement structure changes from centralised to decentralised and becomes less complex. Instead of the earlier diversity of burial rites with respect to arrangement, size, and inventory of graves, LT B sees the appearance of uniform flat graves with more or less standardised equipment. The artefactual features of the culture change and show standardised dwellings and products that develop from individual creations to serial production. Symbolism undergoes small changes, such as on the pottery, but it follows the so-called La Tène style (early Celtic art) of LT A with specific further development. Initially, social differences disappear.

If we understand revolution as a rapid and significant social and political change that disrupts the mores of the previous system (*Scruton 1989*), could such a social crisis be expressed in the archaeological record? Revolutions usually involve a change of the elite, of ideology and symbolism, as well as changes in the economy. Before the incoming elite is able to make new contacts, trade relations are suppressed or interrupted, and this has economic consequences.

Although it is inappropriate to draw parallels between the present and the prehistoric past, we cannot avoid making a comparison with modern society after the westward expansion of communism in the wake of the Second World War. *H. L. Agnew* (*2008*) describes the situation in Czechoslovakia after the communist coup of 1948, when the region went into economic decline, many goods became scarce, and the quality of those that could be obtained fell. Food consumption per person did not recover to pre-war levels until the mid-1960s. Agnew concludes that it often takes some decades before society returns to its 'original' state and begins to develop a new and progressive economy and society. Changes in symbolism linked to the new ideology also appeared: the Czech lion now bore a five-pointed star instead of a crown. There was significant emigration, mainly of the elite. According to figures from the State Security (StB), approximately 25,000 people (or more) left the republic between 1948 and 1951 (*Marès 1994*). This would, theoretically, correspond to the assumption that groups of the La Tène military elite left Bohemia.

We should stress again that we are fully aware of the difficulty (or even impossibility) of projecting examples from modern society onto prehistory. Nevertheless, although the external social, political and technological circumstances are entirely different, archaeological finds (and ancient authors) repeatedly assure us that human thinking and behavioural patterns change little over time. Is it therefore completely improbable that events with similar consequences could have taken place in Bohemia at the beginning of the 4^{th} century BC, that is, in LT B1?

We must return to the alternatives we posed at the beginning of this contribution: during the transition from LT A to LT B, settlement did not change significantly, but for some reason, it is less visible in the archaeological record; or, at the transition between LT A and LT B, settlement did change (in the sense of a decline of the population) for various reasons.

The reduction in the archaeological settlement record is not a consequence of changes in subsistence strategies, epidemics, famine, or long-term military conflict. Climate deterioration is a possible reason for a lower density of settlement in southern and western Bohemia, but the more clement and fertile parts of the country also show a short-term decline in settlement that lasted 50 years or so, followed by continuous growth, even though the climatic conditions were no better than they were at the beginning of the crisis. Regarding migration, it is still unclear whether sections of the population moved, for example, from southern and western Bohemia to central Bohemia, which would seem a logical response to a 'climate crisis'.

Our favoured hypothesis, currently, is that some kind of 'revolution' caused the events that archaeologists describe as the transition from LT A to LT B. The consequence of these events was a decline in the archaeological visibility of settlement traces. Future research should focus on this subject. In addition to wider collaboration with sociologists and anthropologists, a suitable approach would be systematic sampling and radiocarbon dating of archaeological finds from the broader interval of Ha D2/3 to LT B. We are convinced that the 'nondescript' archaeological material from the La Tène period holds the potential to solve many outstanding questions if we give it the necessary attention. The same approach could also be used for other prehistoric periods for which settlement traces have hitherto proven elusive.

English by *Tomáš Mařík*

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