How do they fit together? A case study of Neolithic pottery typology and radiocarbon chronology

Jak to do sebe zapadá? Případová studie keramické typologie neolitu a radiokarbonového datování

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The object of the paper is to update the current concept of the chronology of the Neolithic (*c. 5400–3300 BC*) *of the Czech Republic and northern Lower Austria by comparing the typo-chronological development of pottery and modelling the corresponding radiocarbon dates. Up until now, pottery and its style have often been perceived in Central Europe as "basic indicators" of archaeological cultures or pottery traditions, which are then further divided into chronological stages and phases. And yet, an analysis of the relationships of all three levels of these entities in the context of four types of models of radiocarbon dates indicates that changes in the original material culture do not necessarily occur on a time axis. While it is true that archaeological cultures have proven to be the robust materialisation of primarily chronological trends valid in larger geographic areas, at the level of general and more detailed pottery groups, development can be manifested in other ways* (*regionally, socially or in a way that is difficult to interpret*).

Central Europe – Neolithic – pottery typo-chronology – archaeological culture – radiocarbon dating

Cílem práce je revidovat současnou koncepci chronologie neolitu v České republice a na severu Dolního Rakouska (*ca 5400–3300 BC*)*, a to na základě konfrontace typo-chronologického vývoje keramiky a modelace odpovídajících radiokarbonových dat. Ve střední Evropě jsou dosud keramika a její styl často vnímány jako základní indikátory archeologických kultur, které jsou dále členěny na chronologické stupně a fáze. Analýzou vztahů všech tří úrovní těchto entit v kontextu čtyř druhů modelů* ^{14}C *dat však vychází najevo, že proměny původní hmotné kultury neprobíhají nutně jen na časové ose. Je pravdou, že archeologické kultury se ukazují být robustní materializací primárně chronologických trendů platných v širokém geografickém prostoru. Avšak v rovině obecných, a tím spíše detailních keramických stupňů a fází se vývoj může projevovat i jinak* (*regionálně, sociálně či způsobem, který je obtížné interpretovat*).

střední Evropa – neolit – typochronologie keramiky – archeologická kultura – radiokarbonové datování

1. Introduction

Archaeological cultures are regarded as the foundation of the material reflection of past societies. And yet, the connection between material culture deformed into archaeological sources and specific forms of social identity is more than uncertain. In other words, while we know that archaeological cultures are highly capable of methodologically partitioning space and time, we don't know what this means for interpreting the original living culture. It is not possible to work with an archaeological culture as a direct proxy of social relationships (*Shennan 1989*; *Květina 2010*), and the same can be said of the term "culture" in the context of anthropology, which has also been unable to find a universal context suitable

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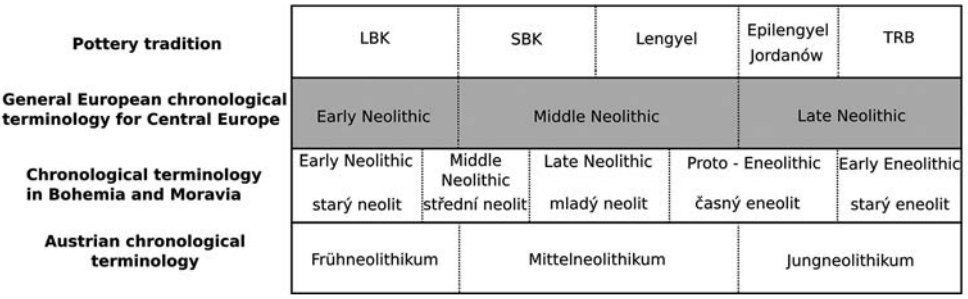

Fig. 1. Overview of chronological terminology in the given part of Central Europe.
Obr. 1. Přehled chronologické terminologie v předmětné části střední Evropy.

for explaining social phenomena (for example, *Geertz 1975*; *Wolf 1984*; *Clifford – Marcus 1986*; *Paleček 2017*).

Moreover, archaeology itself does not work with archaeological cultures as with "prime numbers", but has a tendency to divide them further. Interestingly, researchers focus this multiple division primarily on the temporal dimension of archaeological cultures, much less on their geographical distribution. This is very apparent in the Neolithic archaeology of Central Europe, where each archaeological culture is principally divided into chronological sections (stages) and further into sub-sections (phases). Moreover, it is precisely for the Neolithic that individual archaeological cultures are differentiated primarily on the basis of a different style of pottery inventory and thus involves a pottery tradition rather than a fundamentally different whole of divergent categories of material culture.

Several problems crystallise from the defined foundation. They are connected with questions about the actual meaning of changes in the pottery tradition in the original living culture, with answers likely including terms such as "social identity" (for example, *Díaz-Andreu et al. 2005*), "technological systems" (see *Gosselain 1992*) and "style". The material representation of social identity is formed particularly by style. However, does a uniform concept of style actually exist? Surely, it existed at the outset of its study, when the basic concept seemed clear and promising: for W. Davis, style was a certain "formal statement of the particular ways in which different artefacts are similar to each other" (cited after *Conkey – Hastorf 1990*, 2). Three assumed dimensions of style were described: 1. form elements, motifs; 2. form relationship; 3. qualities (*Conkey – Hastorf 1990,* 2). Of these three dimensions, only the first refers directly to the physical (material) world and can be used to study material culture. The other two dimensions are derived from the cultural context and their meaning cannot be determined outside of it.

After further research, the definition and essence of style was blurred in the 1970s and 1980s. It was shown that the original concept is not valid and that each researcher involved in the study of style perceived it in a different way. *Martin Wobst* (*1977*, 321) describes style as part of the formal variability of material culture, which can be put into context with the participation of artefacts in the process of exchanging information. *Polly Wiessner* (*1983*, 256) conceived style in a similar manner, defining it as the formal variability of material culture providing information on the social identity of individuals and society. *James Sackett* (*1977*, 370) defines style "as a highly specific and characteristic method of performing something … always typical for a certain time and space … a supplement to

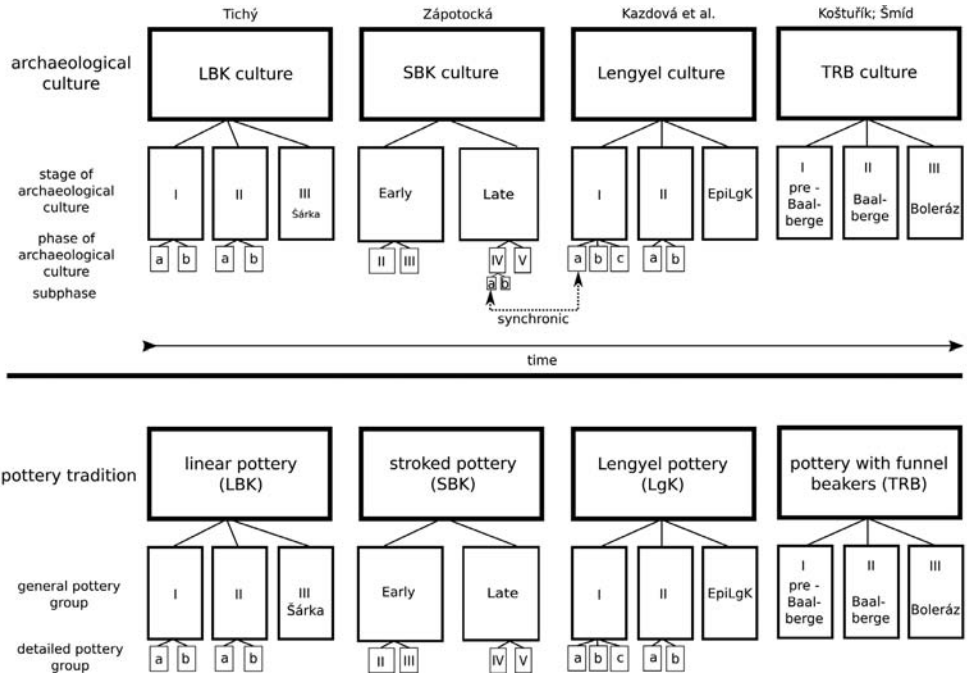

Fig. 2. Above – the traditional concept of chronology based on Neolithic archaeological cultures and their subdivision in Moravia. After *Tichý 1962*; *Zápotocká 1970*; *Kazdová et al. 1994*; *Koštuřík 1997*; *Šmíd 2017*. Below – the categorisation concept of Neolithic pottery in Moravia on which this study is based.
Obr. 2. Nahoře – tradiční pojetí chronologie na základě neolitických archeologických kultur a jejich dílčího členění na Moravě. Podle *Tichý 1962*; *Zápotocká 1970*; *Kazdová et al. 1994*; *Koštuřík 1997*; *Šmíd 2017*. Dole – pojetí kategorizace neolitické keramiky na Moravě, ze kterého vychází tato studie.

function … style and function jointly exhaust the potential of this formal variability with the exception … of the role of post-depositional processes, which could lead to changes in the form of artefact".

While style became difficult to express, hidden and vague in the late 1980s and early 1990s, a certain theoretical crystallisation nevertheless occurred. Two research currents emerged, with the first attributing significant potential to style in transmitting social information (e.g., identity, integration, gender, status, etc.). The second current more or less sceptically acknowledged that the stylistic level of artefacts has a highly symbolic dimension, that it was part of a cultural tradition that was essentially passive and that the decoding of "transferred information" is extremely complicated (*Conkey 1990*). *Ian Hodder* (*1990*, 45) noted that style involves the relational referral of an individual event to a general way of doing. Hence, a uniform concept of style does not exist today.

For the purposes of this text, we shall set aside the given group of questions and focus on a second area of concern, one that touches on the first but is more general in nature: the actual concept of Neolithic chronology materialised in the typological development of artefacts (*fig. 1* and *2*). If we want to touch on a solution to the question we've just defined, it means first and foremost validating the existing relative-chronological systems, for which we will use external evidence in the form of radiocarbon dating. Making such an analysis

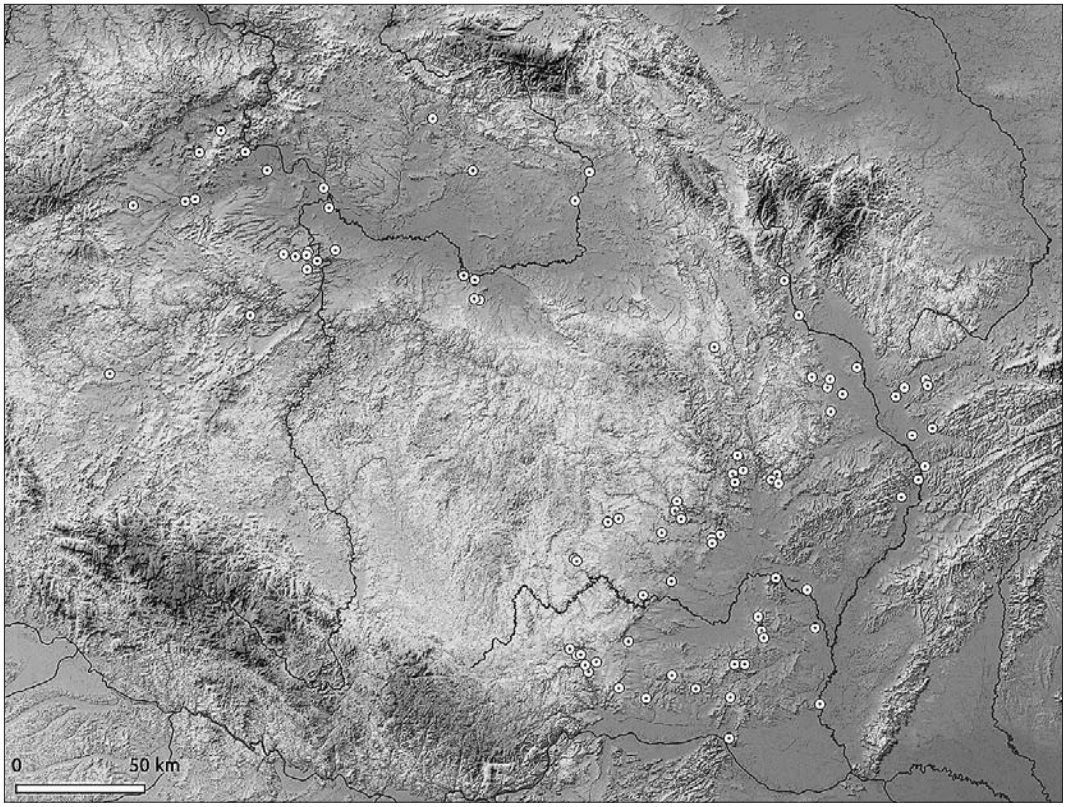

Fig. 3. The area of interest is formed in the west by Bohemia and in the east by the Morava River Basin connected with Lower Austria above the Danube River. Marked points represent sites with C14 dates related to Neolithic ceramics.
Obr. 3. Zájmové území tvořené na západě Čechami a na východě povodím řeky Moravy spojeným s naddunajským Dolním Rakouskem. Vyznačené body reprezentují lokality se ^{14}C daty vztaženými k neolitické keramice.

possible is the sufficient quantity of absolute dates that have been collected over the past twenty years in the studied territory (*fig. 3*) – Bohemia (as one region) and Moravia and the part of Lower Austria north of the Danube (as the second region). We will ask to what extent contemporary relative-chronology systems are "strong" and what are the relationships (geographic, temporal, etc.) between individual pottery traditions and their more detailed divisors.

It should be said that the use of absolute dating for validating the relative chronology is not a new approach. And yet, it is interesting that with the application of large series of absolute dates, this does not produce results in accordance with the existing ideas on the sequence of defined typological groups, specifically in the case of the Neolithic of the eastern part of the Carpathian Basin (*Hertelendi et al. 1995*; *Yerkes – Gyucha – Parkinson 2009*; *Oross – Siklósi 2012*) and in central Germany (e.g., *Müller 2004*). Clarity demands that the existing chronological and typological framework used for the Neolithic period in the studied territory be presented. The synchronisation table in *fig. 1* is the foundation.

The study addresses the period between c. 5400 BC up to c. 3300 BC. The earliest pottery tradition is Linearbandkeramik (hereinafter LBK), which, outside the area of interest, spread in a wide band between the Paris Basin and eastern Moldova. Around 4900 BC, the complex of this ceramic style breaks down into more regionally-distinct ceramic styles. Stichbandkeramik (Stroked Pottery, hereinafter SBK) occupies the eastern half of Germany, west Poland, Bohemia and to a certain extent Moravia and Lower Austria. Lengyel Pottery (LgK) is found in western Hungary, southwest Slovakia, Burgenland, Lower and Upper Austria and Moravia before later spreading to Bohemia and Poland as well. The subsequent Epi-Lengyel (also Jordanów in Bohemia and Poland or Bisamberg-Oberpullendorf in Austria) remains thus far difficult to classify typologically and geographically. Funnel Beaker culture (Trichterbecherkultur, hereinafter TRB) are spread about a large territory, from southern Scandinavia to northern Austria and from Denmark to western Ukraine (for geographical distribution of the aforementioned cultures, see *Buchvaldek et al. 2007*). Hence, archaeological cultures are the basic methodological manifestations of remains of material culture. Because, as was previously mentioned, these cultures are primarily distinguishable in the Neolithic on the basis of differences in pottery assemblages, we shall understand them in this study as pottery traditions.

The term "stage" (German "Stufe", Czech "stupeň") is typically employed for the further classification of these pottery traditions (cultures). Since "stage" is not understood here as a time indicator but as a set of general specific pottery production characteristics, we will replace it with the term "general pottery group". Henceforth, the established abbreviations such as LBK I, LBK II, etc., are used to name these groups. As with "stage", the term "phase" (German "Phase", Czech "fáze") is also understood as a "detailed pottery group". In this work, this unit represents the final degree of pottery classification (*fig. 2*). To summarize the intent of this article, we ask whether transformations of the original material culture necessarily occur only on a time axis, as has been assumed thus far, or whether development can be manifested in parallel on the geographical or another level (which we shall leave unlabelled for now).

2. Dataset

The LBK dataset comes only from the Moravia–Lower Austrian area. Why not from Bohemia? The LBK ceramic chronologies of Bohemia and Moravia differ significantly and are difficult to compare. Moreover, radiocarbon dating collection for the Early Neolithic of Bohemia is not currently available in terms of an appropriate structure for the needs of our study. For this reason, we decided not to include this dataset from Bohemia in the analysis. In Lower Austria, chronological systems have been modelled thus far by *E. Lenneis* and *P. Stadler* (*1995*), who developed an absolute chronology for the LBK, while a team of authors (*Stadler – Ruttkay 2007*) produced an absolute chronology for Lengyel Pottery. A synthesis has been compiled for Moravia (*Kuča – Kovář et al. 2012*) comparing the typological groups of pottery with calibrated dates. In Bohemia, the modelling of C14 dates related to pottery typology has been dealt with only to a limited extent by *Dobeš et al.* (*2016*) in the context of the Proto-Eneolithic. However, more attention has been paid to the question of the chronology of the fill of rondel ditches associated with the SBK (*Řídký et al. 2018*). The absolute dates used in the modelling come mainly from samples

Site	n. of C14 dates	pottery tradition	region	ref. to C14 data (eventual ref. to typology)
Asparn an der Zaya (Schletz, Am Wald)	4	LBK	LA	*Lenneis – Stadler 1995*; *Lenneis et al. 1996*
Baierdorf	1	TRB	LA	*de Capitani 2002*
Bděněves (Za školou)	2	Jordanów	B	*Dobeš – Metlička 2014*
Bernhardsthal	2	Lengyel	LA	*Stadler – Ruttkay 2007*
Bisamberg (Parkring)	1	Lengyel	LA	*Stadler – Ruttkay 2007*
Brno – Bystrc (Zadní dlouhé)	1	Lengyel	M	*Rakovský 1985*
Brno – Ivanovice (Pod Habřím)	1	LBK	M	*Mateiciucová 2008*
Brno – Líšeň (Čihadlo)	2	TRB	M	*Furholt 2013*
Brozany nad Ohří	7	TRB	B	*Dobeš – Zápotocký 2013*
Březník (Zadní hon)	1	Lengyel	M	*Kuča – Nývltová Fišáková et al. 2012*
Březno u Loun	1	Michelsberg/TRB	B	*Pleinerová 1980*
Březolupy (Čertoryje)	1	Lengyel	M	*Kuča et al. 2010*
Bylany u Kutné Hory	1	SBK	B	*Pavlů – Zápotocká 1979*
Bylany u Kutné Hory	2	Lengyel	B	*Burleigh et al. 1977*
Bylany u Kutné Hory	3	Schussenried	B	*Pavlů – Zápotocká 1979*
Bylany u Kutné Hory	1	TRB	B	*Müller 2001*
Čechůvky (Kopaniny)	3	TRB	M	*Šmíd 2017*
Černý Vůl	2	SBK	B	*Řídký et al. 2018*
Dluhonice (Dolní újezd)	2	Lengyel	M	*Kuča et al. 2011*
Držovice na Hané	1	TRB	M	*Šmíd 2017*
Falkenstein (Schanzboden)	6	Lengyel	LA	*Neugebauer – Neugebauer 1983–1984*
Frauenhofen	2	SBK	LA	*Zápotocká 1970*
Friebritz (Süd)	4	Lengyel	LA	*Stadler – Ruttkay 2007*
Glaubendorf	5	Lengyel	LA	*Stadler – Ruttkay 2007* (*Řídký 2011*)
Grub an der March	3	TRB	LA	*de Capitani 2002*
Guttenbrunn	1	LBK	LA	*Lenneis – Stadler 1995*
Hejčín	1	TRB	M	*Šmíd 2017*
Hlinsko (Podhůra)	9	TRB	M	*Pavelčík 1992*; *Furholt 2013*
Hollabrunn	4	Lengyel	M	*Stadler – Ruttkay 2007*
Horákov (Čtvrtky)	1	Lengyel	M	*Kuča – Kovář et al. 2012*
Horoměřice	1	SBK	B	*Řídký et al. 2018* (*Řídký 2011*)
Hradec nad Svitavou	1	LBK	M	*Janák et al. 2018*
Hrobčice	2	SBK	B	*Řídký et al. 2018* (*Rauerová 2013*)
Hulín (Pravčice)	1	Lengyel	M	*Peška 2011*
Chyjice (V lohovicích)	1	TRB	B	*Novák et al. 2017*
Jaroměř	5	SBK	B	*Burgert 2019*
Jezeřany – Maršovice (Na kocourkách)	5	Lengyel	M	*Koštuřík et al. 1984*; *Rakovský 1985*; *Kuča et al. 2013*
Kamegg	15	Lengyel	LA	*Stadler – Ruttkay 2007*
Kladeruby (Na vlčinském)	1	Lengyel	M	*Vokáč 2011*
Kladníky (Záhumenky)	2	LBK	M	*Kuča – Kovář et al. 2012*
Kleinhadersdorf (Marchleiten)	11	LBK	LA	*Stadler 2013*
Kolín 1	32	SBK	B	*Řídký et al. 2018* (*Končelová 2013*; *Končelová – Květina 2015*)
Kolín 2	10	SBK	B	*Řídký et al. 2018*
Kolín 3	7	SBK	B	*Řídký et al. 2018*
Kolín 8	3	SBK	B	*Dufek 2014*
Kostelec na Hané (Kozí brada)	5	TRB	M	*Šmíd 2017*
Kuřim (U kopečku, Záhoří do klínů)	3	LBK	M	*Mateiciucová 2008*
Kvítkovice u Otrokovic (Chmelín)	1	LBK	M	*Kuča – Kovář et al. 2012*
Lhánice (Kolonie)	2	Lengyel	M	*Holub et al. 2017*
Makotřasy	4	TRB	B	*Breuning 1987*
Mašovice (Pšeničné)	1	Lengyel	M	*Dočkalová – Čižmář 2008*
Michelstetten (Sand)	20	Lengyel	LA	*Stadler – Ruttkay 2007*
Miskovice (Velký Patera)	3	SBK	B	*Zápotocká 1998*
Mladoňovice (Záhumenice ke Slavíkovicím)	1	Lengyel	M	*Vokáč 2012*
Mohelnice (Štěrkovna)	5	LBK	M	*Kohl – Quitta 1964*; *Neustupný – Veselý 1977*
Mohelno (Na boleniskách)	2	Lengyel	M	*Kuča – Kovář et al. 2012*

Mokrá (Spálená seč)	2	Lengyel	M	*Šebela – Kuča 2004*; *Kuča 2008*
Mold	5	LBK	LA	*Stadler et al. 2000*
Moravský Krumlov (Krumlovský les)	1	Lengyel	M	*Oliva 2010*
Mostkovice	1	epilengyel	M	*Šmíd 2017*
Obříství	2	SBK	B	*Řídký et al. 2018* (*Davidová – Fleková 2014*)
Olgersdorf (Am Wald)	1	TRB	LA	*Ruttkay 1985*
Olomouc – Slavonín (Horní lán)	5	SBK	M	*Peška 2011*
Olomouc – Slavonín (Horní lán)	1	Lengyel	M	*Kalábek et al. 2010*
Pavlov (Horní pole)	2	Lengyel	M	*Peška 2011*; *Kuča et al. 2011*
Plotiště nad Labem	29	SBK	B	*Zápotocká 1998*; *Kovárník 2016*; *Burgert 2019*
Podivín (Rybáře)	1	LBK IIb	M	Unpub.; Poz-69768; 6190, 40; animal bone; feat. 514 (*Trampota 2016*)
Podolí (V hlavách)	1	TRB	M	*Kos – Šmíd 2013*
Poigen	1	LBK	LA	*Lenneis et al. 1996*
Postoloprty	1	TRB	B	*Kohl – Quitta 1970* (*Zápotocký 2013*)
Postřelmov (U Františka)	10	LBK	M	*Davidová 2007*
Praha – Ďáblice (Legionářů)	2	Jordanów	B	*Krištuf 2012*
Praha – Ďáblice (Legionářů)	1	Schussenried	B	*Krištuf 2012*
Praha – Dejvice (Baba)	1	TRB	B	*Breunig 1987*
Praha – Dolní Liboc (Šestákův statek)	1	Schussenried	B	*Krištuf 2012*
Prosenice	2	LBK	M	*Kuča – Kovář et al. 2012*
Přemyslovice	1	TRB	M	*Šmíd 2017*
Příšovice	13	SBK	B	*Brestovanský 2009*
Pulkau (Neubruch)	1	LBK	LA	*Trnka 1980*
Rosenburg (Hofmühle)	26	LBK	LA	*Lenneis et al. 2009*
Rouchovany	1	SBK	M	*Kaiser 2012*
Rozdrojovice (U kříže)	2	Lengyel	M	*Kuča – Kovář et al. 2012*
Slatinky	1	epilengyel	M	*Šmíd 2017*
Slatinky	1	TRB	M	*Šmíd 2017*
Slavíkovice	1	Lengyel	M	*Kuča – Kovář et al. 2012*
Spytihněv (Na vrších)	1	LBK	M	*Schenk et al. 2008*
Steinabrunn	1	TRB	LA	*Breunig 1987* (*Stadler 1995*)
Strögen	7	LBK	LA	*Lenneis et al. 1996*; *Lenneis – Stadler 2002*
Šebkovice (Hekrle)	1	Lengyel	M	*Kuča – Kovář et al. 2012*
Štěpánovice (Niva)	2	Lengyel	M	*Vokáč 2010*
Štítary u Kolína (V šornici)	6	TRB	B	*Zápotocký et al. 2019*
Těšetice – Kyjovice (Sutny)	8	LBK	M	*Mateiciucová 2008*; *Kuča et al. 2009*; *Vostrovská 2018*
Těšetice – Kyjovice (Sutny)	4	SBK	M	*Kuča et al. 2009* (*Kazdová 2008*)
Těšetice – Kyjovice (Sutny)	8	Lengyel	M	*Podborský 1975–1976*; *Šabatová et al. 2012*; *Kuča et al. 2010*; *Válek et al. 2016*
Trubín	2	Jordanów, Schussennried	B	*Dobeš et al. 2018*
Tučapy (Nad horkami)	1	Lengyel	M	*Kuča et al. 2010*
Tuchoměřice (Kněžívka)	1	Jordanów	B	*Krištuf 2012*
Tuchoměřice (Za špýcharem)	1	Jordanów	B	*Sankot – Zápotocký 2011*
Tuněchody	1	Lengyel	B	*Kovárník – Tichý 2011*
Určice (Větřák)	1	Lengyel	M	*Šmíd 2017*
Vedrovice (Široká u lesa, Za dvorem)	22	LBK	M	*Dočkalová 2008*; *Pettit – Hedges 2008* (*Podborský 2002*)
Velatice (Velatický široký)	1	LBK	M	*Kuča – Kovář et al. 2012*
Velehrad (Na Nivách)	1	LBK	M	*Bartík – Malíšková 2018*
Vchynice	12	SBK	B	*Řídký 2016*
Vikletice	1	TRB	B	*Baldia et al. 2008*
Vliněves	3	Jordanów, Michelsberg	B	*Dobeš et al. 2016*; *Dobeš et al. 2018*
Wetzleinsdorf	1	Lengyel	LA	*Stadler – Ruttkay 2007*
Žalany	1	SBK	B	*Kohl – Quitta 1966* (*Mašek et al. 1969*)
Žopy (Hrabí cihelna)	1	LBK	M	*Felber – Ruttkay 1983*

Tab. 1. A list of sites and sources of radiocarbon dates. B: Bohemia, LA: Lower Austria, M: Moravia.
Tab. 1. Seznam lokalit a zdrojů použitých radiokarbonových dat: B: Čechy, LA: Dolní Rakousko, M: Morava.

	Moravia + Northern Lower Austria		Bohemia	
	samples	sites	samples	sites
LBK I	56	9	x	x
LBK II	55	16	x	x
LBK III (Šárka)	21	6	x	x
SBK Early	11	4	20	8
SBK Late	2	1	102	11
LgK I	57	16	0	0
LgK II	38	14	3	2
EpiLgK/Proto-Eneolithic	2	2	11	6
TRB I (pre-Baalberge)	6	3	1	1
TRB II (Baalberge)	4	4	15	7
TRB III (Boleráz)	16	5	0	0
TRB III (Salzmünde)	0	0	7	1

Tab. 2. The table shows the number of C14 measurements and the number of measured sites in relation to general pottery groups.
Tab. 2. Tabulka vyjadřuje počet ^{14}C měření a počet měřených lokalit ve vztahu ke keramickým skupinám.

other than pottery itself, i.e., this involves the dating of the archaeological context in which the pottery was found. The dating samples that are used come primarily from human or animal bones and from charred wood or charred short-lived plants.

Possible problems with finds from unclosed contexts and the old wood effect could be reflected for individual samples. We do not expect this assumption for a larger data set, especially if the nature of material used to measure the carbon isotope is heterogeneous. In the case of the old wood effect, *Manning et al.* (*2014*, 1071) pointed out that the effect of old wood is not manifested even in large datasets with a significant proportion of measured wooden charcoals and, conversely, the whole duration of the observed phenomenon often shifts to a later period, usually contrary to conventional expectations.

The variability of used dating samples and laboratories employing different measurement techniques eliminates a possible time bias in favour of one laboratory methodology (for differences in laboratory measurements, see, e.g., *Lenneis – Stadler 1995*; *Bayliss et al. 2007*) and a time bias with respect to the use of specific dating material (*Bánffy et al. 2018*, tab. 1). After eliminating absolute dates standing completely outside the cluster of other dates associated with the relevant type of pottery, a total of 426 absolute dates were collected in *tab. 1* and *tab. 2*. The dates are not evenly distributed in time or space. Tab. 3 express the distribution of the number of dates in relation to the number of sites and typological groups of pottery.

The OxCal program (*Bronk Ramsey 2009*) was used for modelling absolute dates with the IntCal 13 atmospheric calibration curve (*Reimer et al. 2013*). Four different mathematical models are used to express the temporal relationship of the pottery typology. These are the summation (hereinafter SUM) of the calibrated dates and kernel density estimation (hereinafter KDE), which model the course of the studied phenomena (*Bronk Ramsey 2017*). The KDE model, which works with the Gaussian distribution, has the advantage over SUM distributions in that it is able to filter out calibration noise.

Unlike the preceding models, the Uniform and Trapezium models model the beginnings and ends of the given phenomena based on different assumptions (*Lee – Bronk Ramsey*

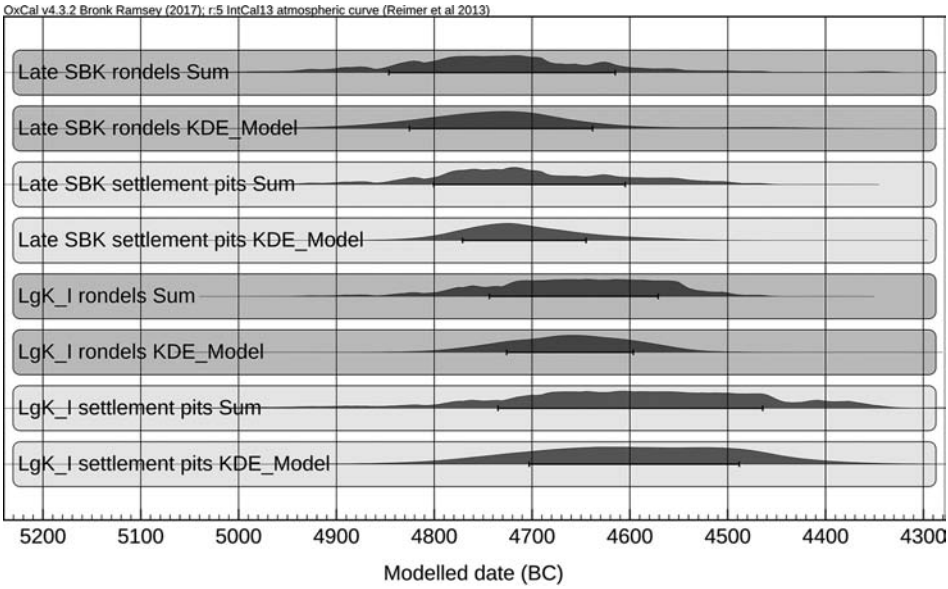

Fig. 4. Comparison of the chronology of fills of rondel ditches and settlement pits in ceramic groups of the Late SBK and LgK I.
Obr. 4. Srovnání chronologie výplní rondelových příkopů a sídelních jam u keramických skupin mladší SBK a LgK I.

2012). The Trapezium model is based on the Gaussian distribution's assumption of social phenomena that have an initial phase of growth and a final phase of decline, with the main development of the studied phenomenon occurring in between. In contrast, the Uniform model works with a simple beginning and end. The use of these models is not typically relevant for small datasets. If multiple measurements are made from a single sample, these dates are combined using the Combine function.

The character of the dataset is heterogeneous; for individual general pottery groups, the amounts of C14 data range from 102 samples to one sample (average 22 samples, median 11 samples). At present, it is not realistic to present a statistically valid dataset. For pottery groups with a smaller number of related C14 data, it is more a matter of defining a vector that determines the direction in research of the Neolithic chronology. In terms of space, the data is most evenly distributed for the LBK, and the SBK is significantly loaded with large datasets from Kolín and its surroundings. Data from the LgK I are spatially limited to south Moravia and Lower Austria, which corresponds to the occurrence of this pottery group. The Late Lengyel is relatively homogeneous in the area of Moravia and Lower Austria, unlike in Bohemia with a sample of three data. In Moravia, the Epi-Lengyel is represented by only two data from central Moravia; in Bohemia, the Proto-Eneolithic, on the other hand, is represented by data only in the western part of the territory. TRB datasets are quite regularly distributed in both regions.

In order to find the possible influence of the data structure by taphonomic processes, we compared larger datasets of samples from the Late SBK, which came from settlement pits (33 samples) and from rondel ditches (59 samples). We used SUM and KDE models for comparison. Based on the results (*fig. 4*), we can state that taphonomy in this case has a relatively significant effect on the formation of fills and the associated pottery groups. While the beginnings of the dataset associated with the Late SBK originating from the rondels are based 20–50 years earlier than in the case of the dataset originating from settlement pits, the ends of the two datasets are practically identical.

This conclusion is important for modelling chronology and for rondel issues. The rondel ditches began to be filled earlier than the Late SBK settlement pits. It is therefore probable that the beginning of the occurrence of rondels in Bohemia is not related to the change in the pottery style from the Early SBK to the Late SBK, and the filling itself probably began before the establishment of the Late SBK style. The time overlap of the Early and Late SBK will probably be less significant than the employed models show (*fig. 7, 14*; *tab. 3*) and we can expect a lower deviation within 50 years at the beginning of the Late SBK.

We performed the same comparison for data from rondel fills (23 samples) and from settlement pits (27 samples) for the practically contemporary pottery group LgK I in Moravia and Lower Austria. Here, however, we did not observe a significantly different occurrence in the chronology of filling the ditches of rondels and settlement pits. The shorter interval of KDE models is more of an expression of their mathematical nature. The fills of rondel ditches in Moravia and Lower Austria have a shorter duration than the pottery group LgK I itself. In terms of the chronology of the occurrence of rondels, this analysis clearly points to the fact that rondels in Bohemia are either older or had a shorter duration and began to be filled earlier. However, with regard to the comparison of the age of individual rondels performed by *J. Řídký et al.* (*2018*, 120), the already published premise confirms that rondels in Bohemia and Germany are older than those in the Middle Danube region.

3. Modelling results

The results of the modelled temporal occurrence of individual pottery groups are expressed graphically (*figs. 5–16*) and in the form of contingency tables, including statistical indexes (*tab. 3* and *4*), A_{model} expresses the consistency of the model in the context of four assumptions used for modelling dates. This value expresses the compatibility of the time span for a given pottery group within individual models. It can be assumed that the consistency of the model will decline with the number of applied assumptions. Obtained models include numerous inconsistent models (less than 60 %). The inconsistency of some (LBK Ib, Early SBK, Late SBK, SBK IV) is heavily influenced by the uniform prior probability distribution in which the end interval is typically different than probabilities of other prior models and conventional expectations. The convergence of integral indicates whether the distribution of data is appropriate for the use of individual prior models. If the value is lower than 95 %, the results are no longer used.

The results of SUM and KDE models are expressed in a range with a probability of 68 %. Using a 95% probability, the extent of some of the resulting intervals would clearly be in conflict with external archaeological evidence. On the other hand, it should be noted that the 68% probability may shorten the time span of pottery groups.

The Linearbandkeramik in Moravia and the northern part of Lower Austria

The question of the duration of the LBK is linked to the fundamental cultural turning point represented by the neolithisation of Central Europe. The modelled data show that the first agricultural culture was present in the area from the horizon of 5400 BC. Although the beginning of the LBK in Lower Austria is also associated with this date (*Lenneis 2017a,* 203), for Moravia an interval of 5600–5500 BC (*Čižmář 2008*, 34) or the date of 5500 BC (*Kuča – Kovář et al. 2012*) or even 5700 BC (*Podborský 1993*, 73; *Mateiciucová 2008,* 20) is assumed. On the other hand, the modelling results are fully in line with assumptions on the beginning of the LBK from the perspective of the Neolithic settlement of the whole of Europe (*Manning et al. 2014*). In addition, the oldest formative phase of the LBK, repre-

Moravia + Northern Lower Austria						Bohemia					
pottery group	model	from	to	A_{model}	convergence integral	pottery group	model	from	to	A_{model}	convergence integral
LBK I	sum	5412	5108	54	100	not modelled					
	kde	5381	5149		100						
	uniform	5396	5153		99/98						
	trapezium	5406	5093		100/99						
LBK II	sum	5232	4992	56	100						
	kde	5190	5018		100						
	uniform	5272	4950		99/99						
	trapezium	5257	4965		100/100						
LBK III Šárka	sum	5197	4921	70	100						
	kde				66						
	uniform				71/70						
	trapezium				5/14						
SBK Early	sum	4970	4712	49	100	SBK Early	sum	4970	4712	49	100
	kde	4917	4761		100		kde	4917	4761		100
	uniform	4968	4731		98/99		uniform	4968	4731		98/99
	trapezium	4915	4750		99/99		trapezium	4915	4750		99/99
SBK Late	sum	4841	4603	43	100	SBK Late	sum	4841	4603	43	100
	kde	4819	4627		100		kde	4819	4627		100
	uniform	4862	4506		99/98		uniform	4862	4506		99/98
	trapezium	4846	4582		100/100		trapezium	4846	4582		100/100
LgK I	sum	4775	4499	49	100	not present					
	kde	4756	4528		100						
	uniform	4784	4426		97/96						
	trapezium	4777	4461		99/99						
LgK II	sum	4546	4326	47	100	LgK II	sum	4652	4458	96	100
	kde	4517	4357		100		kde	4651	4451		100
	uniform	4568	4303		99/99		uniform	4643	4459		98/99
	trapezium	4548	4316		99/100		trapezium				10/9
EpiLgK	sum	4228	4116	90	100	Jordanów	sum	4253	3933	56	100
	kde				18		kde	4203	4005		100
	uniform	4213	4086		100/100		uniform	4268	3946		98/98
	trapezium				87/86		trapezium	4249	3957		99/99
not present						Schussen-ried	sum	4241	3929	88	100
							kde	4229	3935		100
							uniform	4321	3852		97/98
							trapezium	4307	3867		99/99
not present						Michels-berg	sum	4216	3934	92	100
							kde	4220	3920		100
							uniform	4267	3828		95/96
							trapezium	4276	3832		98/97
TRB I pre-Baal-berge	sum	3899	3641	150	100	TRB I – Early	sum	3926	3812		100
	kde	3861	3651		100		kde				
	uniform	3796	3738		97/98		uniform				
	trapezium	3796	3744		97/98		trapezium				
TRB II Baalberge	sum	3808	3644	106	100	TRB II Baalberge	sum	3820	3626	107	100
	kde	3800	3632		100		kde	3752	3510		100
	uniform	3790	3630		100/100		uniform	3768	3466		97/96
	trapezium				88/83		trapezium	3762	3472		99/99
TRB III Boleráz	sum	3600	3370	90	100	TRB III Salzmünde	sum	3619	3229	79	100
	kde	3492	3356		95		kde	3538	3342		100
	uniform	3563	3394		100/100		uniform	3520	3322		99/98
	trapezium	3546	3402		100/100		trapezium	3516	3336		99/99

Tab. 3. The table shows the values for the individual modelling of general pottery groups. The SUM and KDE models are expressed by values with a 68 % dispersion probability. The Uniform model is expressed using the Start Boundary and End Boundary medians, while the Trapezium model is expressed by the MidStart and MidEnd medians. The dates for SBK were modelled jointly for the studied regions. A_{model} is an index showing the consistency of a given model, with a model above 60 % being considered consistent. The convergence integral expresses whether the representative distribution of data used has been found for a parameter. The representative distribution should be over 95 %.

Tab. 3. Tabulka zobrazuje hodnoty pro jednotlivé modelace obecných keramických skupin. SUM a KDE modely jsou vyjádřeny hodnotami s 68% pravděpodobností rozptylu, uniformní model je vyjádřen mediány Start Boundary a End Boundary a trapézovitý model je vyjádřen mediány MidStart a MidEnd. Data pro vypíchanou keramiku byla modelována pro sledované regiony společně. A_{model} je index zobrazující konzistenci daných modelů, model nad 60 % je považovaný za konzistentní. Konvergentní integrál vyjadřuje, zda je rozložení dat pro daný parametr reprezentativní. Reprezentativní rozložení by mělo být přes 95 %.

Moravia + Northern Lower Austria											
pottery group	model	from	to	A_{model}	convergence integral	pottery group	model	from	to	A_{model}	convergence integral
LBK Ia	sum	5424	5254	86	100	LgK Ia0 Lužianky-Unterwölbling	sum	4776	4678	116	100
	kde	5367	5295		100		kde	4778	4682		100
	uniform	5374	5296		98/99		uniform	4777	4689		100/100
	trapezium				24/8		trapezium				76/70
LBK Ib	sum	5395	5089	58	100	LgK Ia	sum	4773	4605	79	100
	kde	5374	5122		100		kde	4754	4630		100
	uniform	5421	4969		98/96		uniform	4798	4549		98/98
	trapezium	5402	5049		99/99		trapezium	4796	4562		99/99
LBK IIa	sum	5240	4994	82	100	LgK Ib	sum	4747	4505	54	100
	kde	5219	5009		100		kde	4701	4555		100
	uniform	5292	4962		99/99		uniform	4750	4513		97/97
	trapezium	5272	4975		100/100		trapezium	4735	4527		99/98
LBK IIb	sum	5226	5006	80	100	LgK Ic	sum	4620	4332	82	100
	kde				94		kde	4602	4350		100
	uniform	5252	4995		100/100		uniform	4645	4224		97/97
	trapezium	5236	5010		100/100		trapezium	4638	4258		99/98
SBK II	sum	4917	4731	100	100	LgK IIa	sum	4547	4361	54	100
	kde	4883	4751		100		kde	4516	4394		100
	uniform	4953	4681		99/100		uniform	4562	4367		97/98
	trapezium				5/11		trapezium	4550	4367		100/100
SBK III	sum	4953	4733	72	100	LgK IIb	sum	4497	4261	87	100
	kde	4903	4771		100		kde	4477	4275		100
	uniform				83/83		uniform	4503	4204		97/96
	trapezium				0/2		trapezium	4499	4219		99/98
SBK IV	sum	4840	4606	30	100						
	kde	4829	4621		100						
	uniform	4873	4494		96/97						
	trapezium	4856	4582		100/98						
SBK V	sum	4765	4535	98	100						
	kde	4749	4539		100						
	uniform	4787	4493		100/100						
	trapezium				53/52						

Tab. 4. Moravia and the northern part of Lower Austria. The table shows the values for the individual modelling of detailed pottery groups. The SUM and KDE models are expressed by values with a 68 % dispersion probability. The Uniform model is expressed using the Start Boundary and End Boundary medians, while the Trapezium model is expressed by the MidStart and MidEnd medians. A_{model} is an index showing the consistency of a given model, with a model above 60 % being considered consistent. The convergence integral expresses whether the representative distribution of data used has been found for a parameter. The representative distribution should be over 95 %.

Tab. 4. Morava a severní část Dolního Rakouska. Tabulka zobrazuje hodnoty pro jednotlivé modelace detailních keramických skupin. SUM a KDE modely jsou vyjádřeny hodnotami s 68% pravděpodobností rozptylu, uniformní model je vyjádřen mediány Start Boundary a End Boundary a trapézovitý model je vyjádřen mediány MidStart a MidEnd. Data pro vypíchanou keramiku byla modelována pro sledované regiony společně. A_{model} je index zobrazující konzistenci daných modelů, model nad 60 % je považovaný za konzistentní. Konvergentní integrál vyjadřuje, zda je rozložení dat pro daný parametr reprezentativní. Reprezentativní rozložení by mělo být přes 95 %.

sented by the Brunn am Gebirge – Wolfholz site located south of the Danube i.e., outside the area of interest of this study (*Lenneis – Stadler – Windl 1996*; *Stadler et al. 2000*). Radiocarbon dates from this site are clearly older than the beginning of the Neolithic in the studied territory.

Based on the SUM model, the end of the LBK, which is represented by Šárka pottery (LBK III), is around 4920 BC. This is both confirmed and in contradiction to other expectations of the end of the LBK around the year 5000 BC (*Čižmář 2008*, 38), 5000–4900 BC (*Podborský 1993*, 73), while *I. Mateiciucová* (*2008*, 41) established the interval for the end as 4850–4700 BC. Based on the modelled data, *E. Lenneis* (*2017a*, 203–204) dates the end of the LBK to 4900–4800 BC, *Kuča – Kovář et al.* (*2012*, 54) to around 4950 BC.

According to *Manning et al.* (*2014*), the LBK ends after 4800 BC, which is consistent with the beginning of the occurrence of Lengyel Pottery. The result of the presented analysis may be partially distorted by the fact that 10 out of 21 dates come from the Postřelmov – U Františka site (*Davidová 2007*), whose values correspond to a plateau between 5200 and 5050 BC, which deflects the entire assemblage in favour of an early end to the LBK. The smaller number of dates from graves in Kleinhadersdorf (*Stadler 2013*) point to the possible later end of this pottery group. Moreover, the character of the dataset related to LBK III prevents any relevant modelling other than calculation of the summation curve. Nevertheless, it is possible to observe a trend similar to southwest Slovakia (*Furholt et al. 2020*, 3–4), where, during the Late LBK, the parallel Želiezovce Pottery style occurs. Despite its formal difference, this style has approximately the same time frame as Šárka Pottery. Although Želiezovce decorative elements occur in the eastern half of Moravia in the context of the Late LBK, unfortunately no radiocarbon dates are linked to them yet.

When dividing the LBK into three general pottery groups, it is evident from all four models that they are not successive chronological stages, but that they partially overlap (*fig. 5*; *tab. 3*), which is also reflected in the fact that these pottery groups are often found in joint archaeological contexts. The same is true with detailed pottery groups (*fig. 6*; *tab. 4*). The apparently oldest LBK Ia group seems to have a contemporaneous start with the LBK Ib group, which, however, existed considerably longer than LBK Ia. The later LBK IIa and LBK IIb pottery groups are obviously contemporary and there is no significant difference in time between them. Although LBK III (Šárka) is, from a traditional perspective, a stage, it can also be seen as a phase, as it almost never occurs alone without other pottery groups.

The Stichbandkeramik in Bohemia, Moravia and the northern part of Lower Austria

Radiocarbon dates for the SBK are modelled here for Bohemia along with Moravia and part of Lower Austria. The reason for this is that the Moravian-Lower Austrian space forms the periphery of the SBK pottery tradition and thus far has produced only a small number of relevant radiocarbon dates. From the modelled data can be concluded that SBK tradition should start around 4950 BC and end around 4600 BC, which is essentially consistent with earlier opinions. For Bohemia the duration of the SBK is established at 5100–4600 BC (*Pavlů – Zápotocká 2013,* 30). The beginning of SBK in Moravia is expected between 5000/4900 BC (*Podborský 1993,* 73) and the end is anticipated only relatively, earlier than in Bohemia.

According to radiocarbon dating, both basic stages of SBK (*fig. 7*; *tab. 3*) are chronologically significant: the Early SBK truly precedes the Late SBK. However, an important finding is that the existence of these two general pottery groups overlap by one-third up to one-half of their duration, which introduces a significant entropic element into the traditional typology.

A time analysis of the detailed pottery groups (*fig. 8*; *tab. 4*) also revealed a major discrepancy with existing ideas. While groups II and III are traditionally regarded as consecutive, dating models indicate that they are synchronous and probably regionally-specific phenomena. This fact was also pointed out by M. Zápotocká, who records SBK II in the west of Bohemia and SBK III in the east (*Pavlů – Zápotocká 2013*, 44). In the SBK V group, the SUM and KDE models show a division of the data assigned to this group into

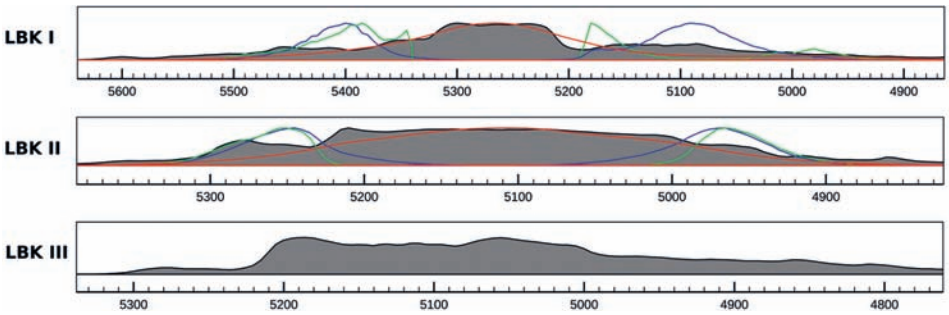

Fig. 5. Modelling curves of general LBK pottery groups. SUM in black, KDE model in red, Uniform model in green, Trapezium model in blue.
Fig. 5. Modelační křivky obecných keramických skupin LBK. Černě sumace, červeně KDE model, zeleně uniformní model, modře trapezoidní model.

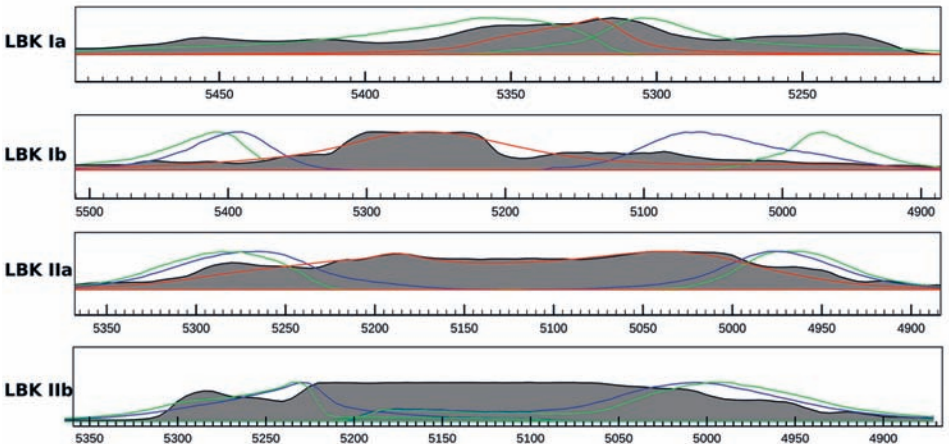

Fig. 6. Modelling curves of detailed LBK pottery groups. SUM in black, KDE model in red, Uniform model in green, Trapezium model in blue.
Obr. 6. Modelační křivky detailních keramických skupin LBK. Černě sumace, červeně KDE model, zeleně uniformní model, modře trapezoidní model.

two time groups, with the younger cluster occurring after 4600 BC. It is therefore a question as to what (if anything) the existence of this group refers to.

Lengyel Pottery and the Proto-Eneolithic period

Based on the depicted models, the beginning of the occurrence of Lengyel Pottery is around 4770 BC, which is essentially consistent with earlier studies (*Lenneis 2017b*, 396; *Čižmář et al. 2008*, 76). Deviating the most is the beginning given in *Manning et al.* (*2014*, 1077), which is modelled by the authors at 4861 BC, which in this case can be influenced by early dates from Hungary. According to the modelling, the end of the Lengyel, which does not include Epi-Lengyel/Jordanów/Bisamberg-Oberpullendorf Pottery, falls in the interval of 4350–4300 BC. Based on radiocarbon dates, *E. Lenneis* (*2017b*, 397) puts the

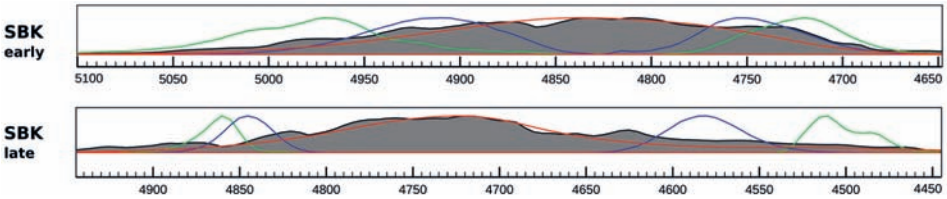

Fig. 7. Modelling curves of general SBK pottery groups. SUM in black, KDE model in red, Uniform model in green, Trapezium model in blue.
Obr. 7. Modelační křivky obecných keramických skupin SBK. Černě sumace, červeně KDE model, zeleně uniformní model, modře trapezoidní model.

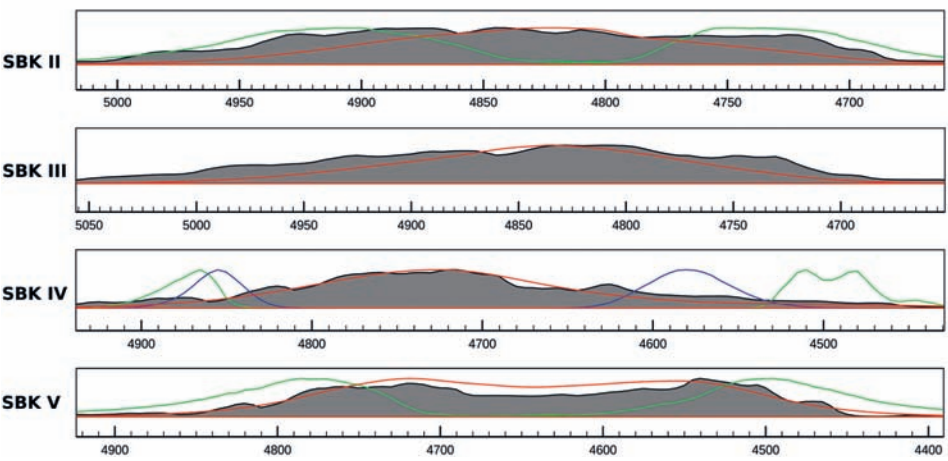

Fig. 8. Modelling curves of detailed SBK pottery groups. SUM in black, KDE model in red, Uniform model in green, Trapezium model in blue.
Obr. 8. Modelační křivky detailních keramických skupin SBK. Černě sumace, červeně KDE model, zeleně uniformní model, modře trapezoidní model.

end of the Lengyel at 4115 BC, which is similar to *Manning et al.* (*2014*, 1077), whose modelling dates the end to 4137 BC. The basic division of Lengyel Pottery into two phases and the Epi-Lengyel/Jordanów (*fig. 9*; *tab. 3*) essentially corresponds to the notion of the succession of these general pottery groups. In the modelling for Epi-Lengyel Pottery, however, the occurrence of a hiatus must not be surprising, since only two radiocarbon dates are related to this pottery group, rendering the models irrelevant. The analysis of the time relationships of detailed ceramic groups yielded alarming results. Groups LgK Ia0, LgK Ia, and LgK Ib have essentially an identical time occurrence (*fig. 10*; *tab. 4*). The LgK Ic detailed pottery group does not have distinctive specific characteristics and is mostly defined by the absence of specific features. As such, Lengyel I is a robust time entity whose separate typological division has no chronological significance. This is also supported by the virtual continuity of the LgK IIa pottery group, which overlaps only minimally, albeit relatively significantly, with LgK IIb.

Only three radiocarbon dates from two sites are available for the time differentiation of LgK II in Bohemia, where LgK I is almost non-existent. The modelling points only to

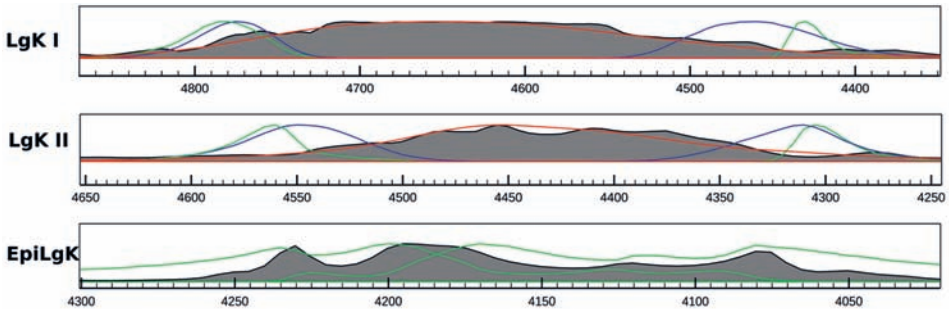

Fig. 9. Modelling curves of general LgK pottery groups in Moravia and the northern part of Lower Austria. SUM in black, KDE model in red, Uniform model in green, Trapezium model in blue.
Obr. 9. Modelační křivky obecných keramických skupin LgK na Moravě a na severu Dolního Rakouska. Černě sumace, červeně, KDE model, zeleně uniformní model, modře trapezoidní model.

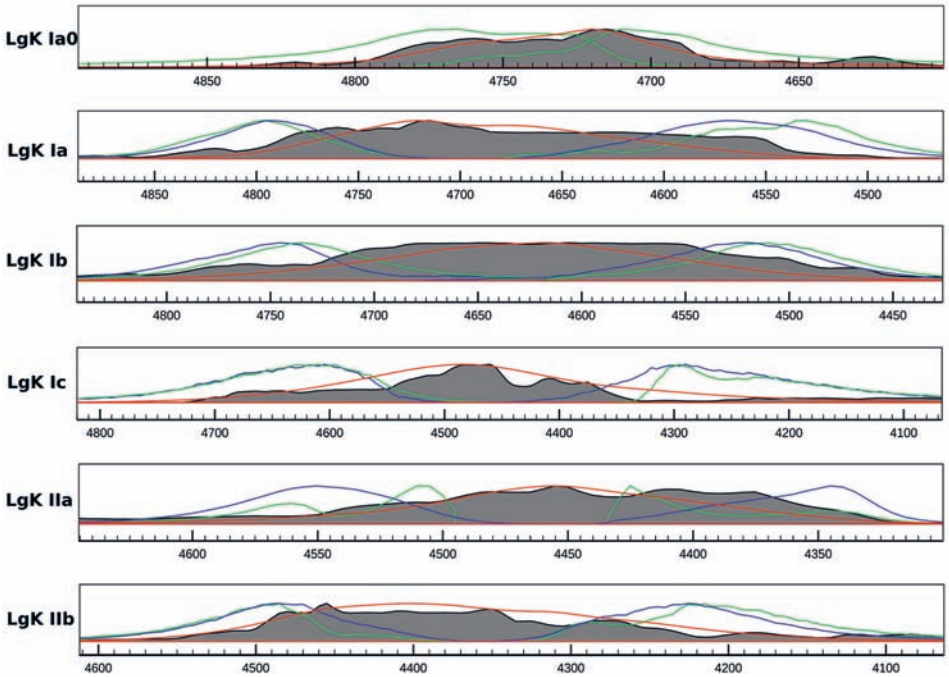

Fig. 10. Modelling curves of detailed LgK pottery groups in Moravia and the northern part of Lower Austria. SUM in black, KDE model in red, Uniform model in green, Trapezium model in blue.
Obr. 10. Modelační křivky detailních keramických skupin LgK na Moravě a na severu Dolního Rakouska. Černě sumace, červeně KDE model, zeleně uniformní model, modře trapezoidní model.

the fact that the occurrence of Lengyel Pottery slightly overlaps with the SBK. The end of Lengyel Pottery in Bohemia cannot be established with the current number of dates.

The following Early Eneolithic period is characterised by the presence of Jordanów and Michelsberg Pottery, which is sometimes supplemented in contexts with Schussenried Pottery; however, Schussenried Pottery does not create its own archaeological contexts.

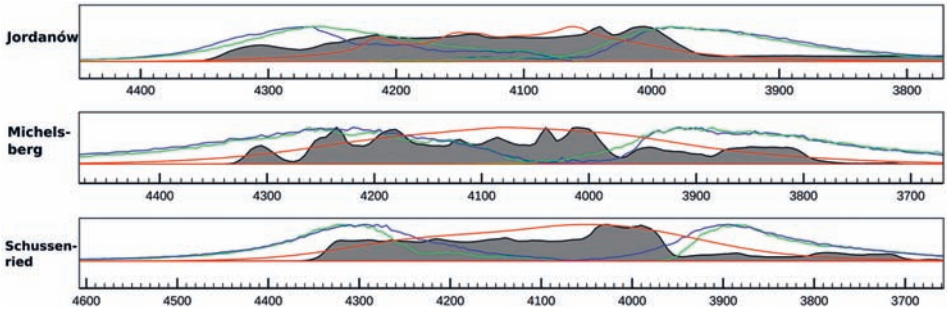

Fig. 11. Modelling curves of general pottery groups in the Early Eneolithic in Bohemia. SUM in black, KDE model in red, Uniform model in green, Trapezium model in blue.
Obr. 11. Modelační křivky obecných keramických skupin v časném eneolitu v Čechách. Černě sumace, červeně KDE model, zeleně uniformní model, modře trapezoidní model.

The issue of the calibration of C14 dates is then characterised in this period by a roughly 200-year-long plateau on the calibration curve in the years 4250–4050 BC. This impacts the modelling of the beginning of this period, regardless of whether this date is actually valid (*fig. 11*; *tab. 3*). The end of the Early Eneolithic then proceeds into a considerable time dispersion of approximately 4000–3850 BC depending on which model is used. With regard to the beginning of the TRB, the probable end of the Early Eneolithic is around 3850 BC, possibly even later. All three represented pottery styles appear to be contemporary, not only on the basis of the modelling of radiocarbon dating, but also with regard to their frequent joint occurrence in archaeological contexts.

The Funnel Beaker culture

The modelling shows the beginning of TRB around 3800 BC, both in Bohemia and in the Moravian-Lower Austrian area (*fig. 12*, *13*; *tab. 3*). It is a considerably later beginning for this pottery tradition than is usually given for Moravia (c. 4100 BC; *Šmíd 2017*, 24), while being consistent with the beginning presented thus far for Bohemia (*Neustupný 2013*, 15). Other modelled data show the general beginning of the TRB in 3913 BC and the end in 2951 BC (*Manning et al. 2014*, 1077). It is obvious, however, that the TRB horizon is a rather heterogeneous pottery complex with various duration lengths in different regions (*Furholt 2014*; *Wencel 2015*, 39). In Moravia and Lower Austria, the end of the TRB (the Boleráz group) is roughly 3370 BC, in Bohemia (the Salzmünde group) also around 3320 BC, albeit based on the dataset from a single site (*Dobeš – Zápotocký 2013*). For general pottery groups in the Moravian–Lower Austrian territory, only a further time division into two basic segments is useful. The first is the pre-Baalberge and Baalberge horizon, the second is the Boleráz horizon. However, it is better to leave the time question of the pre-Baalberge horizon open, since the modelled dataset is small and the end of the Epi-Lengyel is practically unknown.

Only one C14 date is related to the Early TRB I in Bohemia (*Pleinerová 1980*). This horizon is called the Michelsberg-Baalberge (*Dobeš – Beneš 2018*) or just the early TRB (*Neustupný 2013*, 63). This sporadically recorded ceramic horizon is not typical for settlement findings. It is clear from the modelling of the Baalberge and Salzmünde phases

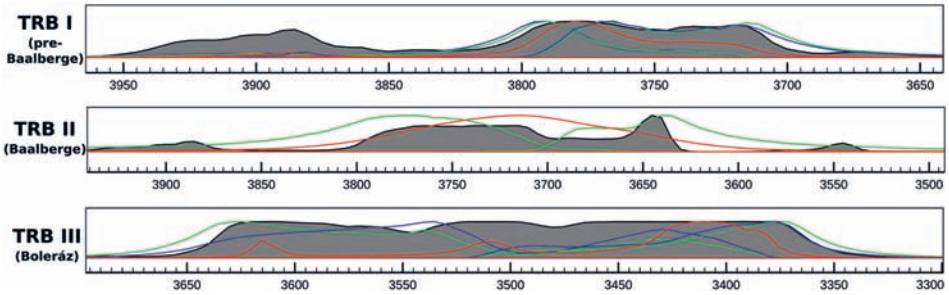

Fig. 12. Modelling curves of general TRB pottery groups in Moravia and Lower Austria. SUM in black, KDE model in red, Uniform model in green, Trapezium model in blue.
Obr. 12. Modelační křivky obecných keramických skupin TRB na Moravě a v Dolním Rakousku. Černě sumace, červeně KDE model, zeleně uniformní model, modře trapezoidní model.

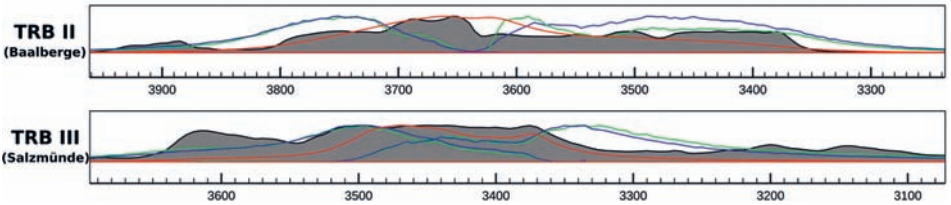

Fig. 13. Modelling curves of general TRB pottery groups in Bohemia. SUM in black, KDE model in red, Uniform model in green, Trapezium model in blue.
Obr. 13. Modelační křivky obecných keramických skupin TRB v Čechách. Černě sumace, červeně KDE model, zeleně uniformní model, modře trapezoidní model.

that the chronological expectations are fulfilled in general: Baalberge Pottery is older than Salzmünde Pottery, without a major overlap between the two. However, it is important to note that there is no longer a chronological place for Siřem Pottery, the occurrence of which is assumed between Baalberge and Salzmünde Pottery. This is probably a pottery type whose interpretation will not have a chronological significance and its temporal occurrence can likely be expected in the Baalberge context, since Siřem Pottery has similar morphological characteristics (*Zápotocký 2013*, 77).

4. Discussion: How does style of pottery fit together with chronology?

What general trends are now apparent? As *figs. 14* and *15* show, the division of pottery traditions into archaeological cultures is linked primarily to chronology. Further classification into general pottery groups (stages) can be evaluated similarly, which essentially means the validity of the basic division of the given pottery tradition into early and late sections. However, these sections need not be exclusively sequential, as the analysis shows their frequent chronological overlap. The frequency of representation of basic pottery traditions and hence more pottery groups changes most on the time axis, but the link to a specific geographic space also simultaneously contributes to the result. Division into detailed pottery groups or phases (*fig. 16*) shows a different interpretation, and these categories

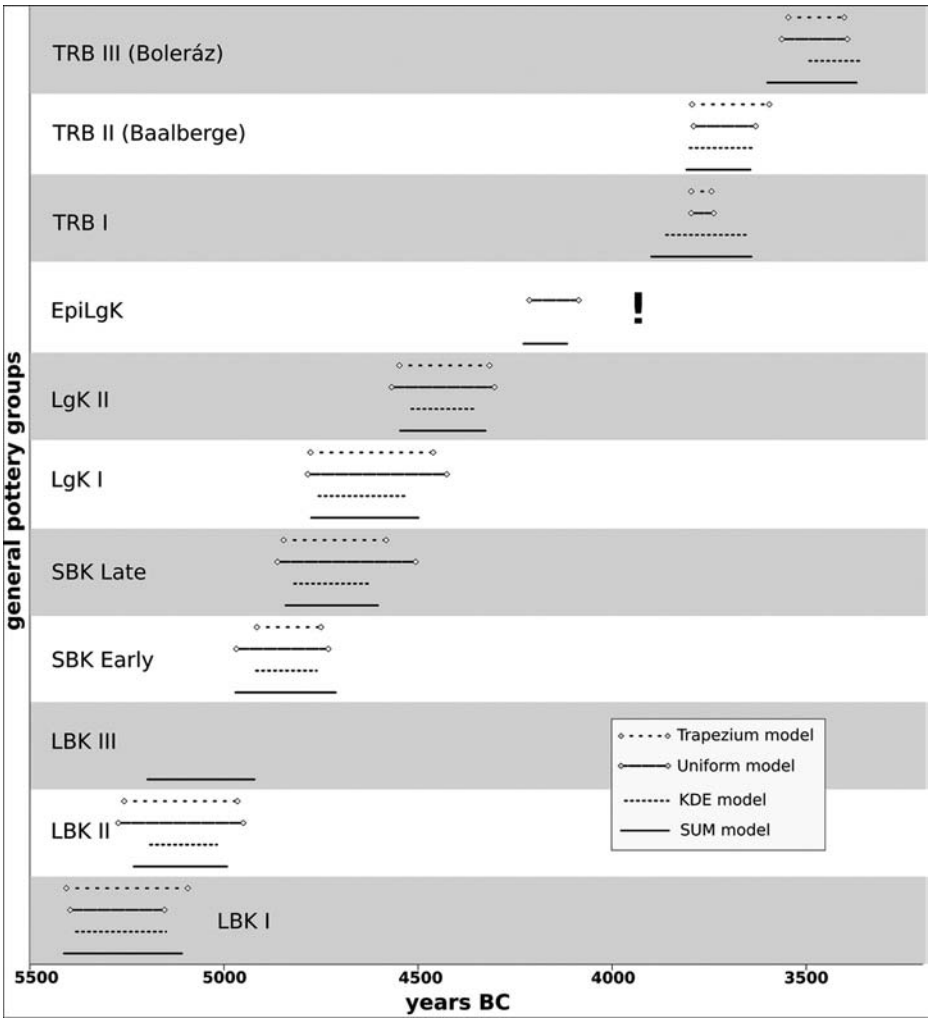

Fig. 14. Moravia and the northern part of Lower Austria: an overview of the time range of general pottery groups. SBK is modelled together with dates from Bohemia. The SUM and KDE models are expressed with a 68% probability, the Uniform model in the values of median start – median end, the Trapezium model in the values median mid-start – median mid-end. Exclamation mark points out irrelevant models calculated based on small dataset.
Obr. 14. Přehled časového rozsahu obecných keramických skupin na základě čtyř použitých modelů na Moravě a na severu Dolního Rakouska. SBK je modelována dohromady s daty z Čech. SUM a KDE modely jsou vyjádřeny s 68% pravděpodobností, Uniform model v hodnotách medián start – medián end, Trapezium model medián mid-start – medián mid-end. Vykřičník upozorňuje na málo relevantní modely vypočítané na základě malého datasetu.

cannot be regarded as a primary and natural chronological indicator in any of the studied cases. It is clear that a principal other than development in time is behind their existence.

Identifying this principle will require addressing the concept of style in material culture. Style is directly or latently involved in any analysis of artefacts. Style is what creates

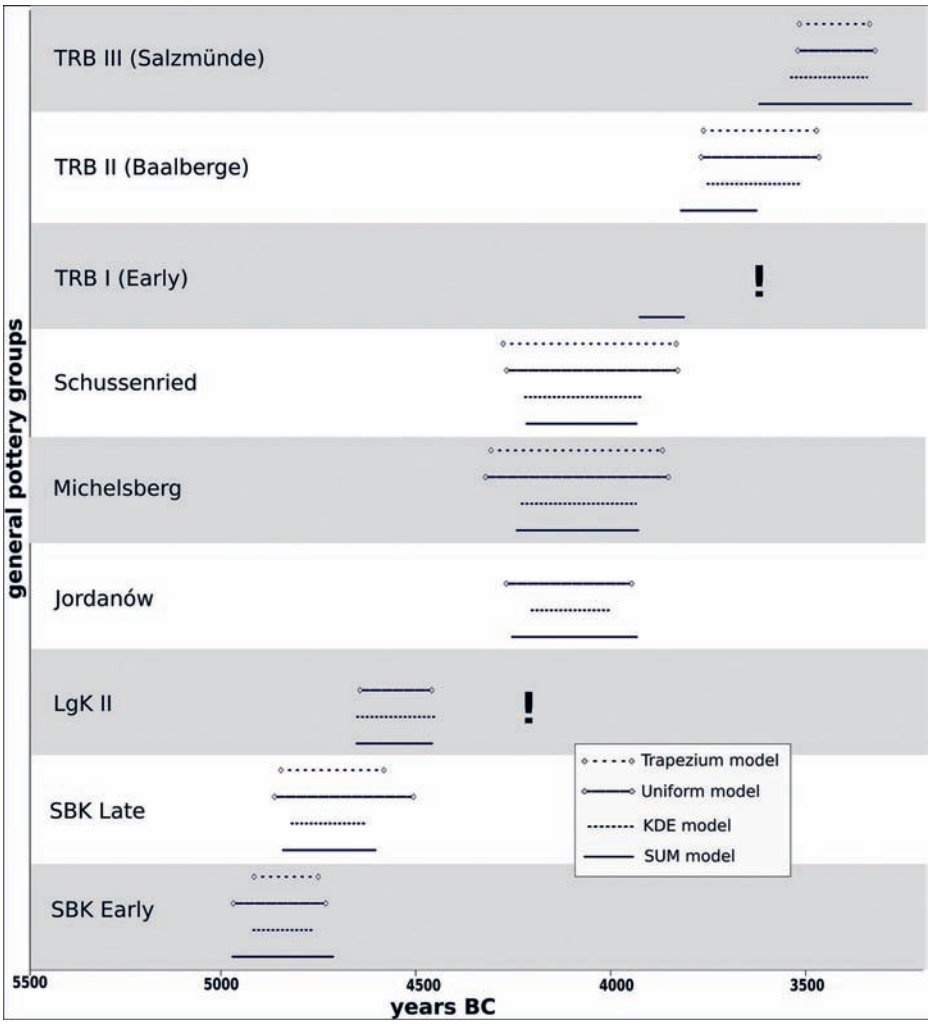

Fig. 15. Bohemia: an overview of the time range of general pottery groups. The SUM and KDE models are expressed with a 68% probability, the Uniform model in the values of median start – median end, the Trapezium model in the values median mid-start – median mid-end. Exclamation mark points out irrelevant models calculated based on small dataset.
Obr. 15. Přehled časového rozsahu obecných keramických skupin na základě čtyř použitých modelů v Čechách. SUM a KDE modely jsou vyjádřeny s 68% pravděpodobností, Uniform model v hodnotách medián start – medián end, Trapezium model medián mid-start – medián mid-end. Vykřičník upozorňuje na málo relevantní modely vypočítané na základě malého datasetu.

and defines cultural differences and types of evolutionary trajectories. Style can be studied on the level of individuals, groups or society. Style is a category of multiple correlations resulting from the culture, given time and space. As with art history, archaeology serves as a key to identifying cultural elements in the sphere beyond the functions of objects (*Conkey – Hastorf 1990*).

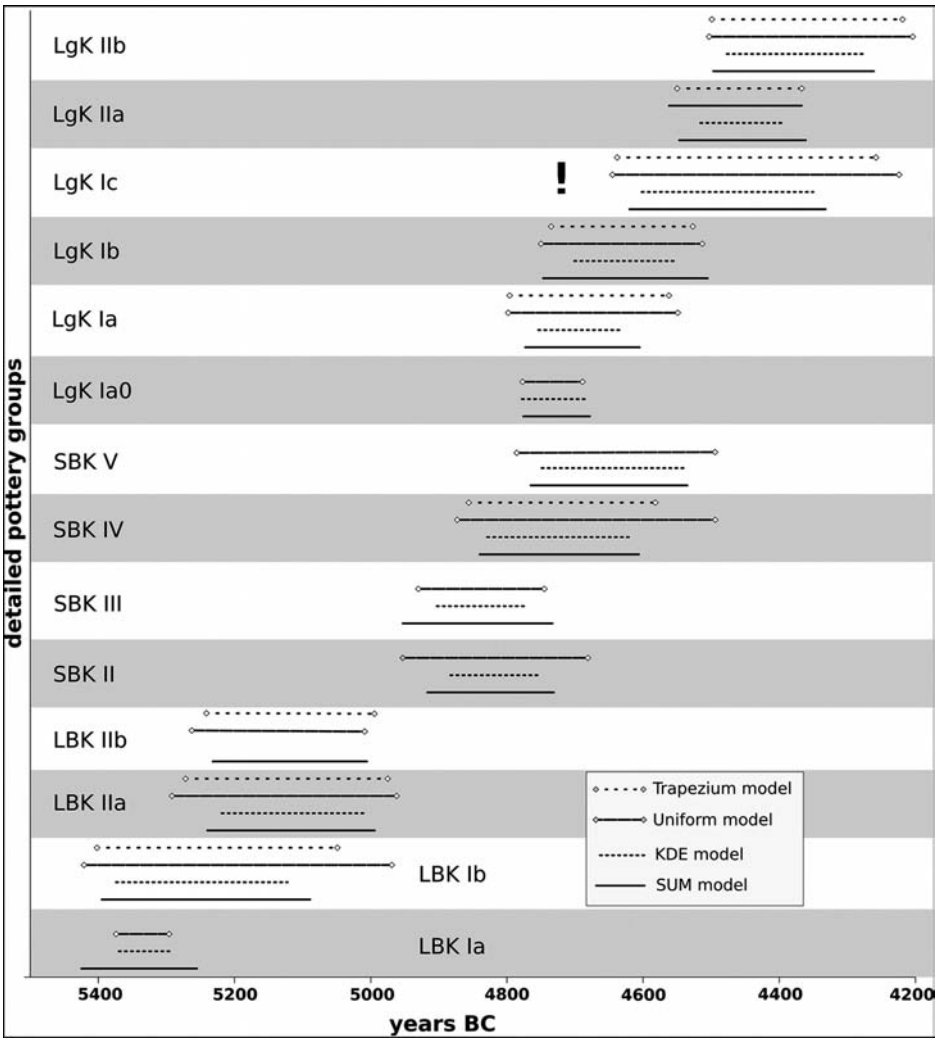

Fig. 16. Moravia and the northern part of Lower Austria: an overview of the time range of detailed pottery groups. The SBK is modelled together with dates from Bohemia, and SBK V occurs only in Bohemia. The SUM and KDE models are expressed with a 68% probability, the Uniform model in the values of median start – median end, the Trapezium model in the values median mid-start – median mid-end. Exclamation mark points out irrelevant models calculated based on small dataset.
Obr. 16. Přehled časového rozsahu detailních keramických skupin na základě čtyř použitých modelů na Moravě a na severu Dolního Rakouska. SBK je modelována dohromady s daty z Čech. SUM a KDE modely jsou vyjádřeny s 68% pravděpodobností, Uniform model v hodnotách medián start – medián end, Trapezium model medián mid-start – medián mid-end. Vykřičník upozorňuje na málo relevantní modely vypočítané na základě malého datasetu.

Types of style shape the spatiotemporal division of the past, i.e. archaeological "cultures" and their sub-sections (stages and phases). By creating types of style and their definitions, we are essentially creating our notion of the past. In fact, style can be described

in a very general way as qualities of artefacts not primarily related to production technology or their utilitarian function in living culture. Two distinct archaeological discourses have focussed on the fact that artefacts have this level of characteristics. The Anglo-Saxon world developed a theory of style based on living material culture, but it has never been tested on archaeological data to any great extent. In turn, large typological systems (prehistoric pottery) were created in Central Europe with a maximum emphasis on chronological development without ambitions to making other possible links to style. To this day, the application of these two approaches does not greatly overlap.

Therefore, what could stylistic ceramic groups represent? The first large issue is based on the concept of ceramic style, which could be considered a symbolic medium that has the potential to carry and transmit information about the social identity of individuals and groups (*Wobst 1977*). But we must keep in mind that when we talk about the ceramic style, in our case we primarily mean decoration. The theory assumes that under a general decorative style (e.g., incised LBK decoration) there are synchronous variants or microstyles that have a social significance and can reflect real past social identity (e.g., clans, ethnicity but also rank and other forms of social parameters). The question is to what extent such a theoretical assumption is based on facts. Has an intentional connection between the decoration of ceramics and people's identities been ethnographically observed between archaic societies?

In answering, we will use two case studies, one of which shows that there is no correlation between pottery decoration and social identity, while the other accepts a possible link, although not without a problem.

The first case is the Luo, who are African hoe agriculturalists, cattle-herders, and fishers whose collective territories comprise some 10,000 km^2 surrounding the northeastern side of Lake Victoria in western Kenya. In the 1980s potting was the work of women, but only a relatively small number of women (only about 1 % of all women are potters). Luo pottery is a specialized craft, but producers are decidedly not full-time specialists. Potters tend to live in homesteads clustered in close proximity to one another around a clay source, usually with several potters in each homestead. This network of interacting potters in such a cluster can be called a "potter community". The pottery of each potter community tends to exhibit characteristic features, a so-called microstyle (*Dietler – Herbich 1989*, 148–150). But the microstyle is by no means indicated solely in decoration: recognition of the potter community microstyles is based on patterned combinations of features including raw materials, the repertoire of pot forms, vessel proportions, and decorative characteristics (*Dietler – Herbich 1989*, 154). In fact, the colour of the fired clay or treated surface, the shape of the rim, the general pot form assigned to a certain function, and the proportions of that form as it is rendered may be more important than the decorative motifs applied (*Dietler – Herbich 1989,* 157). An analysis of the significance of the microstyles showed that it is rather a "silent" formal variability (in the sense of "isochrestic variation" according to *Sackett 1982*). That is, the microstyles transmit some information about the boundaries of communities, but the difference of microstyles is perceived primarily by potters (women) and not by general users of ceramics. Moreover, style defines only the potter community, which has no meaning in terms of the real social identity of non-potters.

The second case is the Shipibo-Conibo. The Shipibo-Conibo are about 20,000 people who live along the Ucayali River in the Amazon rainforest in Peru. Their subsistence traditionally depended on mixed wild (fish, game, turtle eggs, bananas, yuccas) and domestic resources produced by agriculture (corn). Shipibo-Conibo female potters produced distinctive pottery decorated with maze-like red and black geometric patterns. The mode of production was (in 1971) still non-professional and domestic. The designs painted and incised on ceramic vessels are also applied on textiles, carved on canoe paddles, house posts, and gourd and turtle carapace containers and stamped on human skin. Virtually all Shipibo-Conibo artefacts emanate a minimal message, which is: "we are the Shipibo-Conibo; we are not barbaric Remo, Amahuaca, Cashibo, Mestizo, Gringo, or any other tribe" (*DeBoer 1984*, 550).

Is it possible to distinguish microstyles on Shipibo-Conibo ceramics? The answer is not simple. Almost every vessel contains decorative motifs of a very old origin, which can often be traced back to the year 900 AD to the Cumancaya pottery tradition. Particularly stable are cooking vessels, both in terms of form and decoration (*DeBoer 1984*, 557). The main motifs of the intricate design art of the Shipibo-Conibo may well have constituted a graphic device comprising symbolic and semantic units and were employed in a ritual context. But present-day indigenous understanding of the meaning of the designs is fragmentary at best (*Gebhart-Sayer 1985*). Beside the main motifs on the pottery, there are also border designs consisting of circumferential bands, composed of lines and appended elements demarcating the major decorative fields of vessels. One border design type is rim designs which vary according to vessel category. An ethno-archaeological analysis revealed that rim design produced by one potter is highly similar to the designs produced by other potters within her compound. The compound, a residential unit ordinarily composed of a core of matrilineally related females and their families, therefore appears to constitute an agent of design transmission and maintenance (*DeBoer 1984*, 554). So is rim design an indicator of social identity? Probably not.

Rim designs, as a highly limited and redundant code, can hardly be expected to act as group signatures at all levels, from the individual to the region. And there is also a second problem: in viewing designs as messages or signals, the issue is really how the Shipibo-Conibo communicate through their own artefacts and not how the archaeologist decodes a set of rim designs. The Shipibo-Conibo seem much less able to recognize themselves than western researchers can recognize their rim designs (*DeBoer 1984*, 560–562).

The second big point of the conclusion deals with the question: What could have caused the dynamics of a change in decoration style? In a general sense, culture is perceived as a dynamic system striving for relative balance and is composed of interconnected cultural and non-cultural environmental subsystems that help people interact with their environment. In this view, cultural change is associated with a process of natural selection that tends to the most appropriate solution with respect to given conditions. When we add the social interaction that leads to acculturation, we have two main factors of cultural change: time (people adapt their culture to current conditions, e.g. environmental) and social interaction (people change their culture depending on social impulses). But is this assumption valid if we examine the innovation of only one specific segment of material culture? The problem is compounded even further, as in our case the changes are indicated mainly in the ceramic decoration (*Stanislawski – Stanislawski 1978,* 61–62).

The case study which documented the validity of the last sentence is the emergence of whiteware between Hopi-Tewa indigenous pottery producers. The Hopi and Tewa people belong to a pueblo group that resides in the eastern part of the Hopi Reservation on or near the First Mesa in northeastern Arizona. They were traditionally sedentary horticulturalists whose culture was emphasized in collective rituals and religion. Pottery was produced by women potters and the number of producers did not exceed 2% of the entire population (at the time of ethnographic evidence).

The whiteware is a new style of pottery developed in 1920–1925 by a group of three or four Hopi-Tewa women in Polacca and Hano pueblos. Few followers began to make whiteware in the 1930s and 1940s, but the majority of the Hopi potters did not learn the style until the post-1950 period. This means that it took 30 years to spread the style in essentially one geographically limited area. There are no permanent tribal, village, or lineage-clan limitations for the pottery design, regardless of the "anchor persons" or innovators of the styles. The only reason for spreading the new styles was fashion. In 1971 (when the research was conducted), 41 female potters still produced the whiteware, while also producing other ceramic designs. And one more thing: behind the stream of innovations in Hopi ceramics, there was actually a single woman. Her name was Nampeyo (c. 1860–1942), and she became renowned for the revival and innovation of the design of native pottery (*Kramer 1996*). When Nampeyo first began making her pots, Hopi motifs had been diluted by the influence of Spanish, or Zuni designs. Even the clay used by the Hopi potters was inferior. Nampeyo's brilliance was not only her superior natural gifts as an artist, but her ability to recognize the importance of reclaiming the long-lost Hopi symbols. She revived an old traditional Hopi style by copying potsherds from nearby sites, a long important Hopi, Zuni and Acoma learning technique. At the same time, she went beyond imitation and became an inspiration for continuing generations of Hopi potters.[1]

[1] https://www.encyclopedia.com/women/encyclopedias-almanacs-transcripts-and-maps/nampeyo-c-1860-1942 22.5.2020

The ethnographic excursion was to show that the theoretical assumptions associated with decorative microstyles on ceramics (i.e. internal variability within a more general style of decoration) are likely false. The microstyle as such, and even more so its decorative segment, probably does not represent a direct indicator of social identity, at least not identities of the type that archaeologists and anthropologists would like (e.g. lineages, clans, tribes, etc.). But leaving aside the interpretations associated with specific social parameters, the microstyle can be an indicator of regional variability and chronological diversity (with limited spatial spread).

Regarding decorative innovation and style change, it is clear that the process of evolution of morphological and design typology cannot be represented by a single vector. The whole process involves both selection, which can be modelled and estimated to some extent, and drift, which is completely random and unpredictable (the potter Nampeyo in our Hopi case). *Shennan* and *Wilkinson* (*2001*, 592) have already stated this for LBK decoration: "It is clear that both drift and selection are operating and it seems likely to us that there is a broad spectrum of possibilities between pure drift on the one hand and almost pure selection on the other."

Returning now to the question of what other than chronological variability could be hidden by detailed microstyles (i.e. detailed groups or phases) of Neolithic pottery, the answer is that we simply do not know. Based on ethnoarchaeological data, it must be admitted that instead of a reflection of variability given by social parameters, it may be the result of a local tradition of producers. The chronological validity of microstyles is very likely to be narrowly regionally limited. Development trends and microstyle innovations may not be entirely subject to the general directions of style evolution, as drift contributes significantly to them. Finally, some microstyles could easily be an illusory category existing only in the minds of archaeologists.

5. Conclusions

The presented study analysed 426 radiocarbon dates within the period of 5400–3300 BC in Bohemia, Moravia and Lower Austria to the north of the Danube with the aim of investigating the chronological relationships between the pottery styles of the Neolithic cultures LBK, SBK, Lengyel and TRB on several levels. Although the results presented here are inevitably heterogeneous in nature, they make it possible to revise certain assumptions based thus far on the linear development of typo-chronological schemes.

The comparison of the pottery typology with C14 dates indicate that the forms and decoration of pottery can be so different within a single chronological horizon of an archaeological culture that they have been considered evolutionarily non-contemporaneous up until now. However, this seems to be the result of regional or local diversification, which is due to a wide range of potential interpretative schemes. This gives the studied Neolithic pottery traditions an entirely different dimension. If a direct chronological continuity is indeed demonstrated from the LBK to the Lengyel (*Lenneis 2017b*, 396), the SBK in the Moravian-Lower Austrian region will have to be understood as a parallel and highly distinct pottery entity. A completely different interpretation will also have to be found in the Lengyel pottery categories hitherto referred to as the LgK Ia and LgK Ib chronological stages. It appears that they did in fact coexist and their diversity is not purely chronological.

A similar explanation will probably be sought in the case of the diversity of pottery in the Early Eneolithic in Bohemia and in the context of the TRB.

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Jak to do sebe zapadá?
Případová studie keramické typologie neolitu a radiokarbonového datování

Cílem článku je revidovat současnou koncepci chronologie neolitu (ca 5400–3300 př. Kr.) v Čechách, na Moravě a v části Dolního Rakouska, která se materializuje do typologického vývoje artefaktů. Ptáme se, zda proměny původní hmotné kultury probíhají nutně jen na časové ose, jak se předpokládalo dosud, nebo zda se její vývoj může projevovat i paralelně v geografické či ještě jiné rovině. Výchozí rámec kategorizace představuje synchronizační tabulka na *obr. 1*. Protože v neolitu jsou archeologické kultury primárně odlišitelné na základě rozdílů keramických souborů, budeme je v této studii chápat jako keramické tradice. Podobně modifikujeme i význam podrozdělujících termínů stupeň (který chápeme jako obecné keramické skupiny) a fáze (který nahrazujeme pojmem podrobné keramické skupiny). Důvodem je odstranit implicitně chronologický význam daných pojmů (*obr. 2*).

Pokud se chceme dotknout řešení definované otázky chronologie neolitu, znamená to v první řadě přistoupit k validaci existujících relativně-chronologických systémů. K tomu jsme využili externí evidenci v podobě radiokarbonového datování. Těchto absolutních dat bylo v zájmovém prostoru, který čítá Čechy (coby jeden region) a Moravu a naddunajskou část Dolního Rakouska (coby druhý region) za posledních dvacet nashromážděno dostatečné množství, aby byla taková analýzy možná (*obr. 3*). Celkem bylo do analýzy zařazeno 426 absolutních dat, která jsou uvedena v *tabulkách 1* a *2*.

Pro modelaci absolutních dat byl použit program OxCal (*Bronk Ramsey 2009*), s využitím atmosférické kalibrační křivky IntCal 13. Pro vyjádření časového vztahu keramické typologie jsou použity čtyři různé matematické modely. Jedná se o sumaci (dále SUM) kalibrovaných dat a odhad jádrové hustoty (dále KDE), které modelují průběh sledovaných jevů. KDE model, který pracuje s gaussouvskou distribucí, má výhodu v možnosti odfiltrování kalibračního šumu oproti SUM distribucím. Další dva modely, uniformní a trapézovitý, vypočítávají fáze začátku a konce daného jevu. Uniformní model pracuje s předpokladem prostého začátku a konce, zatímco lichoběžníkový model předpokládá iniciační fázi nárůstu a koncovou fázi úpadku. Výsledky modelovaného časového výskytu jednotlivých keramických skupin jsou vyjádřeny graficky (*obr. 4–16*) a formou kontingenčních tabulek, včetně statistických indexů (*tab. 4* a *5*).

Analýza ukázala, že následnost keramických tradic (archeologických kultur) je časově ukotvena přibližně podle dosavadních představ. Čím více se však keramická typologie rozpadá do dílčích chronologických úseků, tím méně robustní se pak tyto intervaly jeví v konfrontaci s ^{14}C daty. Také se ukazuje, že tvary a výzdoba keramiky mohou být v rámci jednoho chronologického horizontu archeologické kultury natolik odlišné, že byly dosud považovány za evolučně nesoučasné. Ve skutečnosti však jde o projev regionální či přímo lokální diverzifikace, za kterou stojí široká škála potenciálních interpretačních schémat. Tato skutečnost dává studovaným neolitickým keramickým tradicím zcela jiný rozměr.

I když získané výsledky mají nevyhnutelně heterogenní charakter, umožňují revidovat některé předpoklady dosud založené na lineárním vývoji typo-chronologických schémat. Jak ukazují *obr. 13* a *14*, rozdělení keramických tradic do archeologických kultur je vázáno převážně na chronologii. Stejně lze hodnotit i další členění na obecné keramické skupiny (stupně), což fakticky znamená platnost základního rozdělení dané keramické tradice na starší a mladší úsek. Tyto úseky však nemusí být výlučně následné, protože z analýzy vyplývá jejich časté chronologické prolínání. Frekvence zastoupení základních keramických tradic a tím více keramických skupin se nejvíce mění na časové ose, ale paralelně s tím se na výsledku podílí i vazba na určitý geografický prostor. Odlišnou interpretaci ukazuje členění na detailní keramické skupiny (fáze; *obr. 14*). Tyto kategorie již nelze považovat za primární a přirozený chronologický indikátor v žádném ze sledovaných případů. A ptáme-li se, jakou jinou než chronologickou variabilitu mohou skrývat detailní keramické skupiny či fáze neolitické keramiky, pak musíme odpovědět, že odpověď neznáme. Mohou být stejně dobře odrazem lokální variability danou sociálními parametry jako iluzorní kategorií existující pouze v mysli archeologů.

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