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CHRONOLOGY OF THE UPPER PALAEOLITHIC SEQUENCE IN THE KŮLNA CAVE (OKR. BLANSKO/CZ)

In memory of Karel Valoch (April 16, 1920-February 16, 2013)

In the Moravian region, the development of Upper Palaeolithic cultures is represented mainly by monocultural sites that do not comprise complex stratigraphic sequences like those known to us e. g. from Germany or Austria (Willendorf II, Bez. Krems-Land/A; Krems-Hundsteig/A; Sesselfelsgrotte, Lkr. Kelheim/D etc.). Moreover, the localities belonging to the Last Glacial Maximum are often badly preserved due to the stratigraphic position of geological layers just below the surface, as is exemplified by the Czech sites Brno-Štýřice (Valoch 1975; Nerudová et al. 2012), Loštice I – Kozí vrch (okr. Šumperk; Nerudová et al. 2012; Neruda/Nerudová/Čulíková 2009) or Mokrá (okr. Brno-venkov; Škrdla/Kos 1997-1998). Nevertheless, the settlement strategies in the distinct periods of the Upper Palaeolithic greatly differed from one another, and the large quantity of proofs available to us is related to this as well. At the beginning of the Upper Palaeolithic, the settlement of caves in Moravia was rather episodic (Oliva 1995; 1991), combined with hunting expeditions, and the utilisation of caves was similarly marginal in the Gravettian period (Oliva 2007). By contrast, for the Magdalenian hunters the Moravian Karst was very appealing as is proven by the large number of sites of diverse functions (Valoch 2001; Svoboda 2000). There is indication that the Late Palaeolithic occupation was sporadic, nevertheless this may be affected by considerable sub-recent and recent destruction of cave sediments. At least, because of the above-mentioned reasons the quality of the available information is rather heterogeneous. Nevertheless, compared to the preceding Middle Palaeolithic period, we have many more sets of radiocarbon dates with relatively small standard deviations available from the different localities, and this enables us to determine quite reliably the mutual chronological relations of each archaeological assemblage. Hard animal tissues that are found well-preserved in the cave environment are important materials suitable for the radiocarbon method and we are capable of checking their direct relation to human activities.

In this respect the Kůlna Cave in the Moravian Karst is a unique site (okr. Blansko/CZ; Valoch et al. 2011; Valoch 1988); a large quantity of both lithics and animal osteological material deposited by humans was preserved in the cave in a rather complete stratigraphic situation. The Kůlna Cave is located around 45 km from Brno, on the northern edge of the Moravian Karst. It belongs to the nearby Sloup-Šošůvka cave system, in which the Sloupský stream that drains off the area currently disappears. Kůlna is a tunnel-shaped cavern with two entrances, a smaller northern and a big SSW oriented portal entrance (**fig. 1c. e**). The cave is 91 m long, the maximum width is 25 m and the height 8 m. The shape of the cavern is reminiscent of a double-wave line. It is possible to separate it into several parts. The main section is the southern entrance part of the cave (**fig. 1e**), where all the differentiated layers could be observed in a clear superposition (layers 14-1; **fig. 1d**). On the right side of the main entrance, Holocene and Upper Pleistocene sediments were best preserved (**fig. 2**). The inner part of the cavern yielded sedimentary record from layer 7c or 7a (deposited on the bed rock) to layer 5. The more recent horizons (layers 4-1) have been destroyed there during the Second World War (Neruda 2013). Archaeological relics were mainly discovered in the southern entrance (sectors A-D2, L and K) and the central part of the cave (sectors E-G3), whereas the part adjacent to the northern entrance (sectors H1-3) is archaeologically rather sterile and was also greatly damaged in

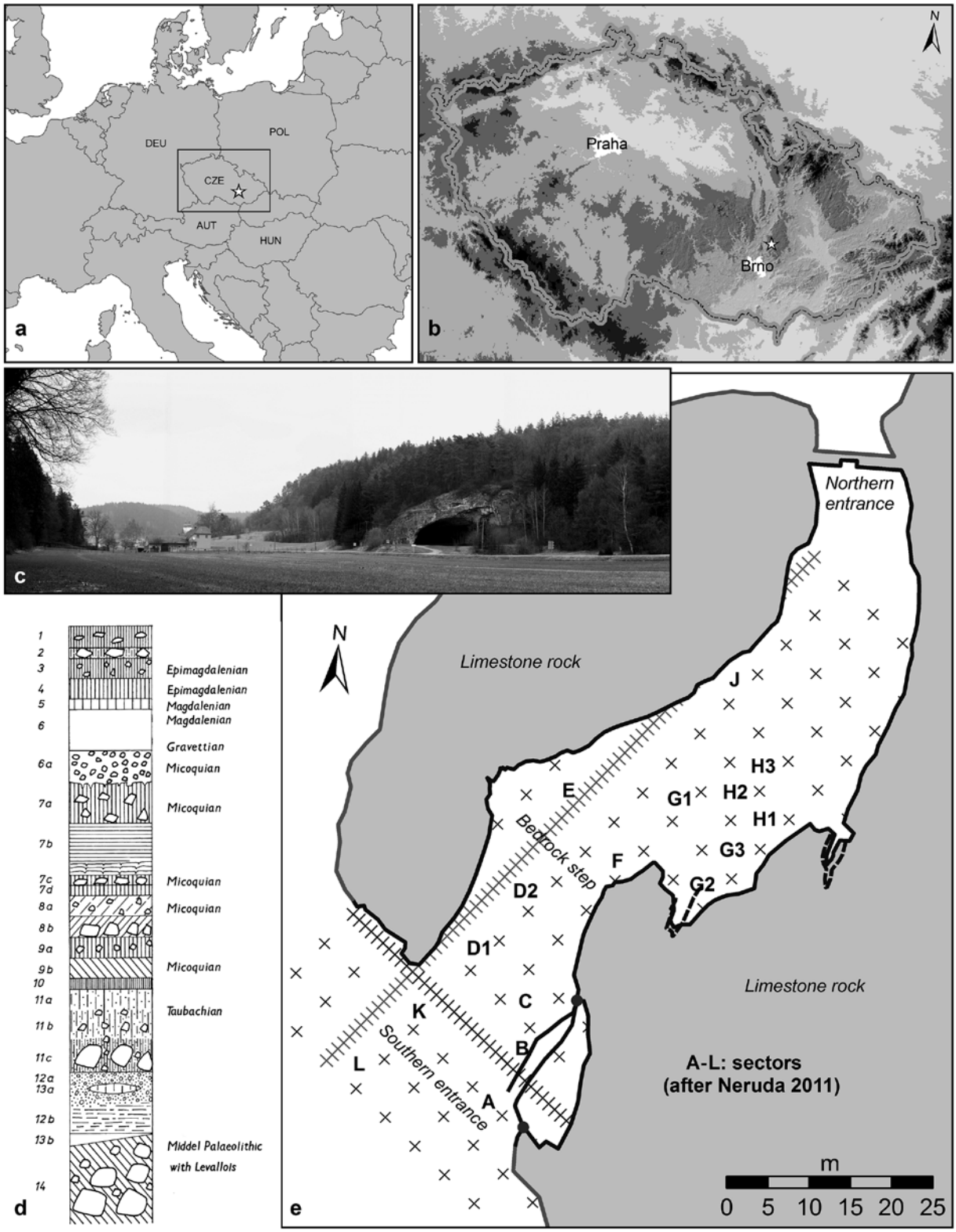

Fig. 1 The Kůlna Cave (okr. Blansko/CZ). – **a-b** location of the cave. – **c** southern entrance of the cave. – **d** schematic stratigraphy of the Palaeolithic sequence (modified after Valoch 1989, fig. 1). – **e** ground plan of the cave with indications of sectors. – (Illustration P. Neruda).

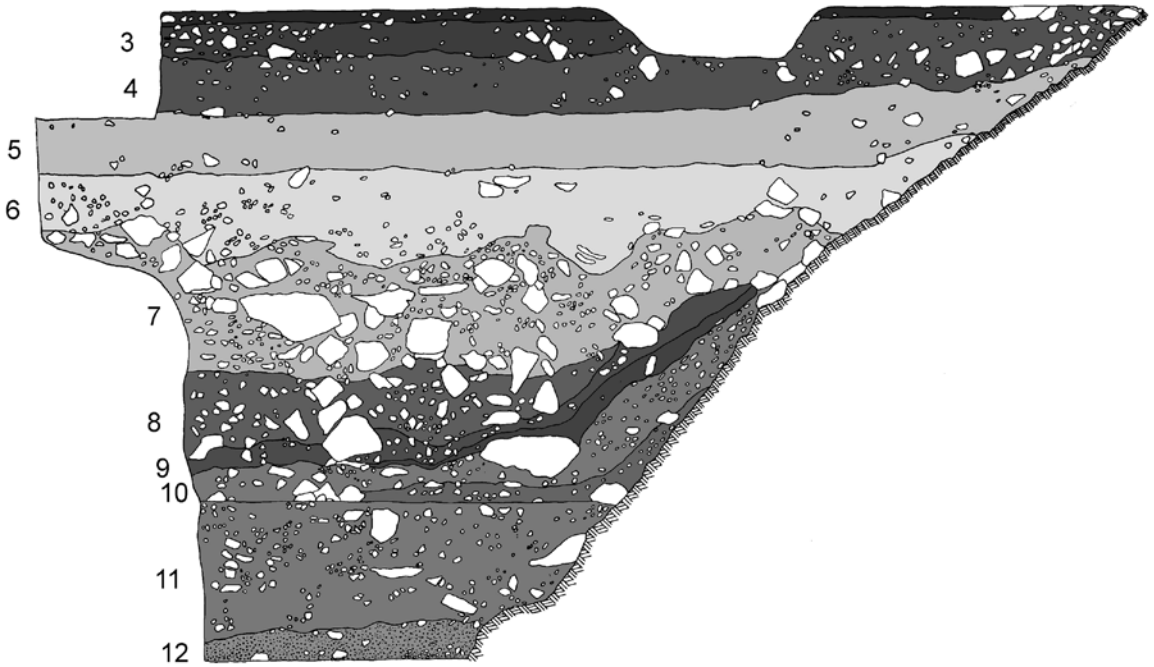

Fig. 2 The Kůlna Cave (okr. Blansko/CZ). Stratigraphy in the main entrance part of the cave, sector C. – (Modified after Valoch 1988, fig. 63).

the period preceding the excavations between 1961 and 1976, when K. Valoch explored the greater part of the cavern (Valoch 1988).

The original shape of the cave and of the surface of the cave filling underwent the greatest changes during the Second World War (Břečka 2011), when the terrain inside the cave was levelled out to form three treads of c. 80 cm difference in height. In some places this has totally removed the horizons of the Holocene and the Late Glacial Termination (LGT)-Last Glacial Maximum (LGM), although the original Middle Palaeolithic layers were fortunately affected only sporadically, and more likely by the older excavation works by J. Wankel (1882), M. Kříž (1903; 1889) and J. Knies (e. g. 1910; 1914).

Above the most recent Middle Palaeolithic horizon 6a loess-like sediments of the younger Weichselian were captured in the entire cave (**figs 2-3**). The presence of the Gravettian hunters was evidenced by archaeological finds (lithic chipped industry, artefacts made of hard animal materials etc.) in the rear part of the cavern (sectors J and G1), but only bones, from which we acquired data of the corresponding age, were discovered in the front part. In the overlying sedimentological sequence two layers of the Magdalenian were distinguished (layers 6 and 5), and in the darker loams related to Holocene pedogenetic processes K. Valoch differentiated two layers 4 and 3 (**fig. 2**), on the basis of which he distinguished the hitherto unknown Epimagdalenian culture (Valoch 1988). From the collection of the most recent layer 3 he separated also an assemblage of artefacts that he linked with a possible Mesolithic occupation (Valoch 2011b, 76).

The first attempts at absolute dating of the Upper Palaeolithic layers were performed in relation to the monographic elaboration of the excavations between 1961 and 1976 (Mook 1988). By means of the ^{14}C method the age of the Gravettian horizon was determined to be in the interval 21,260-22,990 ^{14}C BP, and this relatively precisely fell within the already known chronological framework of this culture in Moravia. Somewhat contradictory outcomes were acquired for the upper part of the sedimentological sequence, because the data for both the Magdalenian and the Epimagdalenian have been interstratified (cf. **fig. 5**). At that time the explanation of contradictions in dating through contamination did not seem probable. The

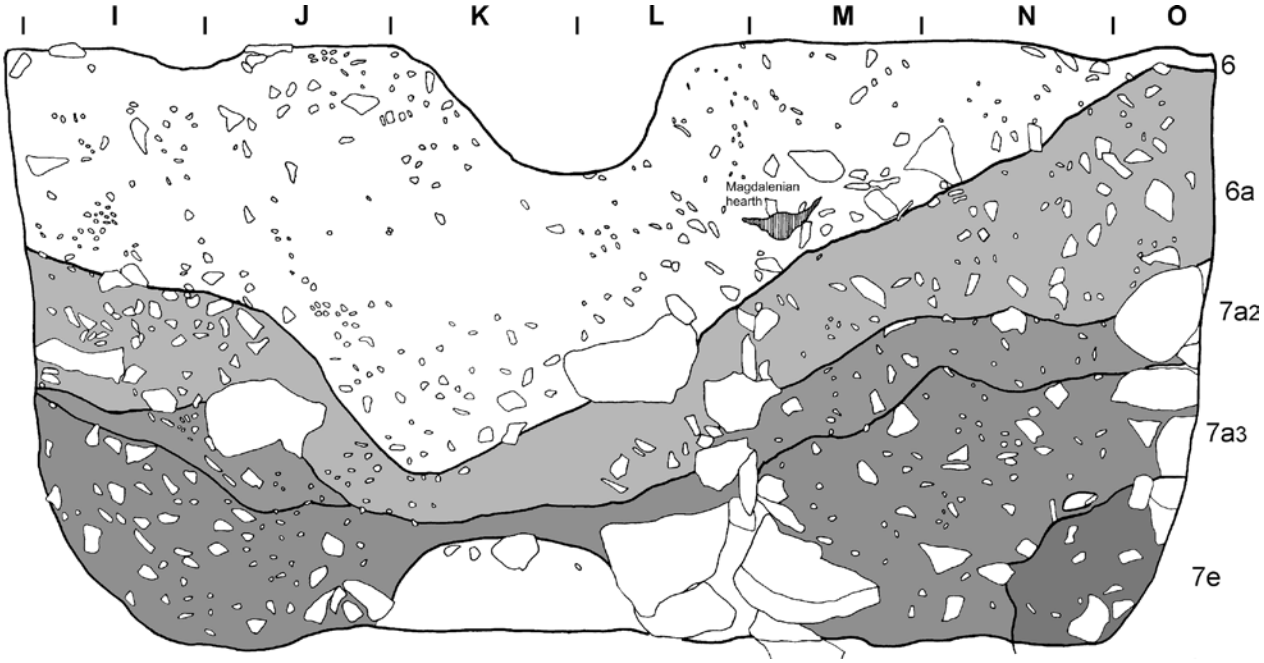

Fig. 3 The Kůlna Cave (okr. Blansko/CZ). Stratigraphy in the central part of the cave, sector G1. – (Modified after Valoch 1988, fig. 75).

probable mixing of finds it should be taken into account within layers 6a, 6 and the Gravettian horizon that were deposited in a macroscopically indistinguishable sediment (Valoch 2011a, 51).

Since that time no one has paid attention to further dating of the Upper Palaeolithic finds. For this reason, we have included also the layers of the LGM/LGT period into the project (P405/11/0406; Chronostratigraphic revision of the unique Palaeolithic site – the Kůlna Cave), the goal of which was to state the chronostratigraphic model of the cave more precisely.

METHODOLOGY

In the selection of samples, we followed several rules. We decided to ascertain the dating of the same material, and opted for hard animal material that was found in all of the studied layers. This secured mutual comparability of the results.

In conformity with our second rule, we preferred samples with a clear relation to human activities. In this respect as well the chosen material appeared to be suitable, since human actions on animal skeletal remains can be easily differentiated. Only in sporadic cases, when adequate quantities of samples meeting our requirements were unavailable, we also made use of pieces of hard animal materials bearing less confirmative use-wears (e. g. sample OxA-25299). We excluded charcoals from our main analysis: at once they were not found in all layers, and isolated pieces of charcoal cannot be unequivocally linked to human activities (they are more likely to provide a date for a geological layer). We have used this material for additional sampling only in the case of the Middle Palaeolithic layer 7a. All obtained data fall into the time range of this report.

Our third important rule was an unambiguous spatial and stratigraphic classification of the items. It was necessary to know the precise position of an artefact for the assessment of possible contaminations, because

stratigraphy changed within the area of the cave. An exception is sample OxA-25282, where it was uncertain, whether it originated from layer 3.
We elected to date the selected samples in the same laboratory in order to eliminate differences that might arise from processing and measuring the samples at various institutions. All samples were processed in the Oxford Radiocarbon Accelerator Unit in Britain.
The material was chosen from the assemblage of hard animal materials selected by K. Valoch on the grounds of anthropic impacts he recognised during his excavations. The collection includes especially bones with cut-marks and traces of fracturing and scraping, but also antlers with marks of transversal dividing or groove technique.
We subjected the individual samples to a critical revision, both from the viewpoint of taxonomical identification and verification of use-wears, and from the angle of checking their spatial locations. Collections for dating were cut out from the selected items in a way that prevented damaging the areas bearing use-wears. The cut-out parts were remoulded using plaster to preserve the information on their state, which was also captured in photos.
The quantities of samples taken for the individual layers differed according to the significance of the layer and the quantity of osteological material available. Some strata, especially the Epimagdalenian, did not contain the required quantities of hard animal materials suitable for the purposes of dating (in terms of size, spatial determination, and a clearly established layer).
The data obtained from the Oxford laboratory (cf. **tab. 1**) were calibrated using the CalPal programme (Weninger/Jöris 2004) and the IntCal09 climatic curve (Reimer et al. 2009). Older dates acquired from the Kůlna Cave were included into the calibration to enable an assessment of a possible shift in the dating. For the evaluation of some stratigraphic issues the data were compared with a view to their respective positions within the cave. Their visualisation was based on a new model of the cavern (Neruda 2013), and the positions of the samples (after K. Valoch´s system) were georeferenced into the S-JTSK/Krovak East North coordinate system.

RESULTS OF DATING

Layer 3 (Epimagdalenian)

Since in the project we primarily focused on the re-evaluation of dating of the Middle Palaeolithic horizons, the number of samples for the Upper Palaeolithic sequence was limited. Because of the methodological requirements only two samples could be taken from layer 3.
The first was a red deer antler with a less reliable stratigraphic classification (layer 3?; OxA-25282). This sample was dated to the Mesolithic period (7380 ± 40 cal BP).
The second sample originating from the radius of a *Bos primigenius* (OxA-25283) clearly belonged to layer 3 according to the differentiation by K. Valoch. From this sample we obtained the date 12,940 ± 110 cal BP.

Layer 4 (Epimagdalenian)

Three data were acquired for layer 4; all of them originate from the right side part of the big entrance area of the cave (sector A), where the Epimagdalenian horizon was relatively well-preserved and differentiated (**fig. 2**).

lab code	^{13}C	^{14}C age ± STD (BP)	date cal BP (2σ)	date cal BP (1σ)	culture	original layer
GrN-6120	0	10070 ± 85	12060-11220	11640 ± 210	Epimagdalenian	3
GrN-6799	0	5510 ± 40	6420-6220	6320 ± 50	Epimagdalenian	3
GrN-6102	0	11470 ± 105	13530-13130	13330 ± 100	Magdalenian	4
GrN-11051	0	2135 ± 45	2350-1950	2150 ± 100	Magdalenian	4
GrN-6103		17480 ± 155	21430-20230	20830 ± 300	Magdalenian	5
GrN-5097	0	11590 ± 80	13660-13260	13460 ± 100	Magdalenian	6
GrN-11053	0	11450 ± 90	13470-13150	13310 ± 80	Magdalenian	6
GrN-11052	0	7550 ± 110	8560-8120	8340 ± 110	Magdalenian	6
GrN-6853	0	22990 ± 170	28300-27140	27720 ± 290	Gravettian	6b
GrN-6800	0	21630 ± 150	26420-25300	25860 ± 280	Gravettian	6b
GrN-5773	0	21750 ± 140	26680-25520	26100 ± 290	Gravettian	6
GrN-5774	0	21260 ± 140	25990-24870	25430 ± 280	Gravettian	6a
OxA-25282	-21.7	6462 ± 34	7460-7300	7380 ± 40	Epimagdalenian	3?
OxA-25283	-20.64	11045 ± 50	13160-12720	12940 ± 110	Epimagdalenian	3
OxA-25284	-21.15	11820 ± 50	13840-13480	13660 ± 90	Epimagdalenian	4
OxA-25285	-20.68	11770 ± 55	13810-13410	13610 ± 100	Epimagdalenian	4
OxA-25286	-19.92	11070 ± 50	13140-12780	12960 ± 90	Epimagdalenian	4
OxA-25287	-20.1	11010 ± 50	13120-12680	12900 ± 110	Magdalenian	5
OxA-25288	-20.43	12600 ± 60	15230-14430	14830 ± 200	Magdalenian	5
P-29793	0	withdraw	no	no	Magdalenian	5
P-29794	0	withdraw	no	no	Magdalenian	5
OxA-25289	-20.76	12575 ± 60	15210-14370	14790 ± 210	Magdalenian	6
OxA-25290	-20.89	12555 ± 60	15190-14310	14750 ± 220	Magdalenian	6
OxA-25291	-19.44	12620 ± 60	15240-14480	14860 ± 190	Magdalenian	6
OxA-25292	-20.73	11185 ± 50	13250-12890	13070 ± 90	Gravettian	6x
OxA-25293	-21.49	11340 ± 55	13340-13100	13220 ± 60	Gravettian	6x
OxA-25294	-19.93	12620 ± 55	15250-14490	14870 ± 190	Gravettian	6x
OxA-25295	-19.9	12455 ± 55	15080-14040	14560 ± 260	Gravettian	6x
OxA-25296	-20.75	24510 ± 190	29770-28730	29250 ± 260	Micoquian	6a
OxA-25297	-18.69	34350 ± 600	40920-37920	39420 ± 750	Micoquian	6b
OxA-25299	-20.38	24900 ± 200	30390-29270	29830 ± 280	Micoquian	6a
OxA-25300	-20.36	>47600	no	no	Micoquian	6a
OxA-25301	-19.81	>50000	no	no	Micoquian	6b
OxA-25302	-19.47	12585 ± 55	15210-14410	14810 ± 200	Micoquian	6a
OxA-25719	-23.29	4001 ± 28	4550-4390	4470 ± 40	Micoquian	7a
OxA-25720	-25.02	149 ± 23		150 ± 100	Micoquian	7a
OxA-25721	-24.72	8832 ± 37	10240-9640	9940 ± 150	Micoquian	7a
OxA-25722	-25.38	8940 ± 40	10290-9850	10070 ± 110	Micoquian	7a

Tab. 1 The list of ^{14}C data for the Upper Palaeolithic sequence of the Kůlna Cave (okr. Blansko/CZ).

layer after dating	sector	unit	ID	material	taxon	anatomical part	reference
3?	K	III/C-G	no	bone		no	Mook 1988
Neolithic	B	9-11/O-S	no	charcoals		no	Mook 1988
4	K	III-IV/F	no	bone		no	Mook 1988
?	B/C	I-II/L,M,P,R	no	charcoals		no	Mook 1988
?	C	I-III/K-L		bone			Mook 1988
?	G1	37-38/M,O	no	charcoals		no	Mook 1988
4	D2/C	13-14/I-L	no	charcoals		no	Mook 1988
Mesolithic	D2/C	13-14/I-L	no	charcoals		no	Mook 1988
Gravettian	J	40-42/a,b	no	residuum		no	Mook 1988
Gravettian	J	40-42/a,b	no	extrakt		no	Mook 1988
Gravettian	K	I-III/A-D	no	bone		no	Mook 1988
Gravettian	K	III-IV/C-F	no	bone		no	Mook 1988
Mesolithic?	A	8a=T/VI	K-131/61	antler	*Cervus elaphus*	fragment	
3	A	7= GXIV	K-12676/75	bone	*Bos primigenius*	radius	
4	A	7f=P/VII	K-215/61	bone	*Alces alces*	metatarsus	
4	A	1a=T/XIII	K-130/61	bone	*Alces alces*	metatarsus	
3	A	6f=P/VIII	K-372/61	bone	*Equus* sp.	tibia	
3	C	I/L.M	no	bone	undetermined	undetermined	
6	C	I-III/K,L	no	bone	undetermined	undetermined	
	A	8e=R/VI	K-367/61	bone	*Equus* sp.	tibia	
	L	31=CXII	K-12909/76	bone	*Equus*-sized animal	long bone frg.	
6	G1	37-38/M	K-4423/66	bone	*Equus* sp.	pelvis	
6	G1	36-37/N	K-4577/66	bone	*Equus* sp.	tibia	
6	G1	38/L	K-4777/66	bone	*Rangifer tarandus*	humerus	
?	J	40-43/ab	K-10720/70	bone	*Bos primigenius*	metacarpus	
4?	J	40-43/ab	K-10717/70	bone	*Bos primigenius*	humerus	
6	J	46/B	K-10713/70	bone	*Equus*/*Bos*-sized animal	long bone frg.	
6	J	46/B	K-10713/70	bone	*Equus*/*Bos*-sized animal	long bone frg.	
Gravettian	L	32=LXI	no	bone	*Mammuthus primigenius*	fragment	
EUP	H1	52-54/R	no	bone	*Rangifer tarandus*	humerus	
Gravettian	D1	9/H	no	bone	*Mammuthus primigenius*	bone	
	C	I-II/M-N	no	bone	*Equus*/*Bos*-sized animal	bone	
	G1	31/O	no	bone	*Equus*/*Bos*-sized animal	long bone frg.	
6	D1	7-8/G-H	no	bone	*Rangifer tarandus*	tibia	
Neolithic	D1	2-5/B-C	no	charcoal	*Fraxinus*		
Subrecent	D1	2-5/B-C	no	charcoal	*Pinus*		
Mesolithic	D2	11/I	no	charcoal	*Pinus*		
Mesolithic	D2	11/I	no	charcoal	*Quercus*		

One date (OxA-25286) comes close to the second sample from layer 3 (12,960 ± 90 cal BP; cf. above), other two data (OxA-25284 and OxA-25285) are c. 700 years older (13,660 ± 90 cal BP and 13,610 ± 100 cal BP respectively).

Layer 5 (Magdalenian)

From layer 5 four samples were taken from the southern entrance into the cave; in this area the layer was relatively reliably differentiated (fig. 2). In two samples of bones of an animal of the size of a horse taken from sectors A (P-29793) and L (P-29794) the dating failed. Another two (of undetermined taxon) originated from sector C. One date (OxA-25287) corresponds to the Epimagdalenian position (12,900 ± 110 cal BP), the other relatively precisely matches with the dataset from layer 6 (14,830 ± 200 cal BP).

Layer 6 (Magdalenian)

We acquired the most coherent dataset from the samples of the Magdalenian layer 6. All of the three samples originate from sector G1, in which the sediment of layer 6 clearly differs from layer 6a (fig. 3). Two data are from the pelvis (OxA-25289) and tibia of a horse (OxA-25290). The third sample comes from the humerus of a reindeer (OxA-25291). These data allow us to classify the finds from layer 6 (14,750-14,790 cal BP) into the period of the end of the LGT.

Gravettian

We tried to revise the age of the Gravettian occupation using four samples (OxA-25292-25295), which were taken from the bones of an *Equus*/*Bos*-sized animal (two data from one bone) and a *Bos primigenius*, unearthed in sector J, where K. Valoch differentiated Gravettian lithic artefacts (Valoch 1988). The chronological positions of two data (OxA-25292 and OxA-25293) generally correspond to the Epimagdalenian, the other two (OxA-25294 and OxA-25295) very precisely correlate with the data acquired for the Magdalenian layer 6 (14,870 ± 190 and 14,560 ± 260 cal BP).
However, another two data, acquired from the samples of bones K. Valoch linked with the most recent Micoquian layer 6a, correspond to the chronological position of the Gravettian. Both samples (OxA-25296 and OxA-25299) originate from the main entrance part of the cave, where artefacts belonging to the Magdalenian (layer 6) and the Micoquian (layer 6a) were found lying in one and the same sediment (Neruda/Nerudová 2014).

Early Upper Palaeolithic complex

Only one date, 34,350 ± 600 ^{14}C BP (39,420 ± 750 cal BP) acquired from the youngest Micoquian layer 6b (equivalent to layer 6a inside of the cave) comes under the beginning of the Upper Palaeolithic period. The sample (OxA-25297) was collected in sector H, where the younger Weichselian sediments were destroyed during the Second World War. It is a fragment of a reindeer humerus, but it bears no signs of anthropic impact.

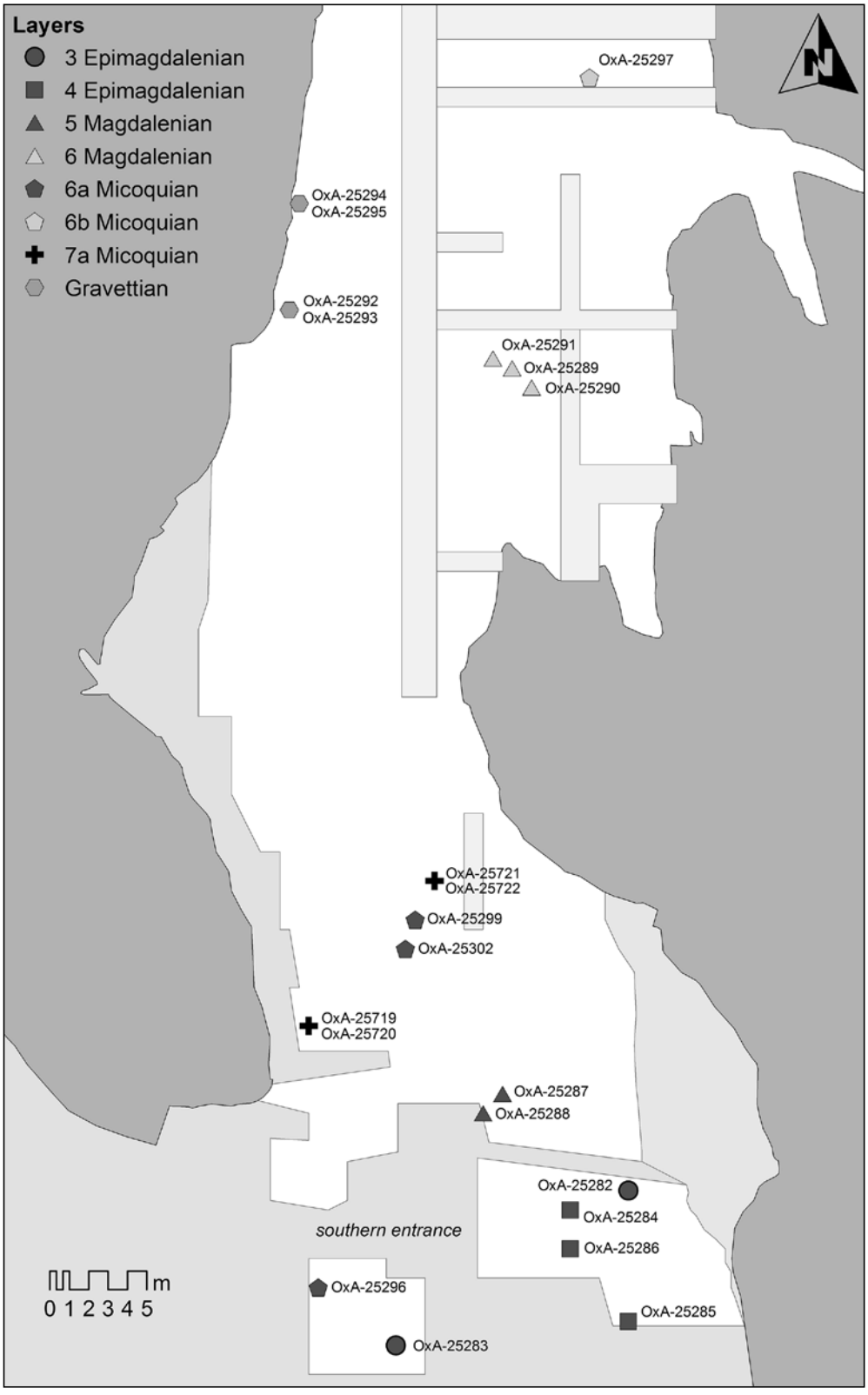

Fig. 4 The Kůlna Cave (okr. Blansko/CZ). Positions of new samples in the cave. – (Illustration P. Neruda).

DISCUSSION

Although the dating of the Upper Palaeolithic sequence in the Kůlna Cave was performed with a relatively small number of samples, the outcomes are much more consistent and confirmative than those for the Middle Palaeolithic sequence (Neruda/Nerudová 2014). In spite of this, some of the obtained results do not correlate with the assumed age of the layer. Therefore, an important question is, whether an incorrect stratigraphic classification of the finds could have occurred during the excavations, or whether this is due to natural redepositions.

Epimagdalenian (layers 3 and 4)

Regarding the collections from layer 3, sample OxA-25282 falling within the Mesolithic period is problematic. Since the finds from layer 3 were discovered lying in the dark Holocene soil that was difficult to differentiate from the overlying layer 2 (Neolithic) (Valoch 2011a, 50), it could have contained more recent artefacts as well. This is corroborated indirectly by the radiocarbon date previously acquired from a piece of charcoal (GrN-6799), which corresponds to the Lower Neolithic (Mook 1988). In terms of stratigraphy, possible finds from the Mesolithic period would be part of the sediment of layer 3 as well. Although an independent Mesolithic layer was not differentiated during the excavations, in the processing of the material at a later date K. Valoch separated out stone artefacts the character of which corresponds to the Early Mesolithic (Valoch 2011b, fig. 1). The temporal position of the Mesolithic occupation of the cave could be determined to the date 7380 ± 40 cal BP that we can deem reliable because of use-wears on the surface of a red deer antler. Other two data from isolated charcoals (OxA-25721 and OxA-25722) fall within the older phase of the Mesolithic (Preboreal) and they represent an evident contamination (Neruda/Nerudová 2014). Sample OxA-25283 (12,940 ± 110 cal BP) would provide the best chronological delimitation of the Epimagdalenian from layer 3.

We noted a significant shift in the chronological interpretation of the Upper Palaeolithic sequence in the Kůlna Cave for layer 4; according to the original data layers 4 and 6 chronologically overlapped each other. At present it is newly clearly delimited by the dates in the interval 13,660-12,960 cal BP. Out of this two samples (OxA-25284 and OxA-25285) come very close to each other, and are generally 700 years older that the values for layer 3. Since layer 4 is clearly delimited in the main entrance part of the cave also geologically (Valoch 2011a, 50), we can consider layer 4 to be a kind of a first chronostratigraphic marker of the upper part of the cave filling.

In any case, the mixed character of layer 3 evokes the question, whether the independent term Epimagdalenian was separated off and the Mesolithic and Late Palaeolithic industries in the Kůlna Cave were differentiated with reason. Since the layers that yielded the assemblages in question are not available for detailed revision excavations, we can only rely on the published information and the preserved industry. The main question is, whether dividing out of the Mesolithic within layer 3 is not artificial; in fact, it might be some specific facies of the Late Palaeolithic. The preserved sequence of layers 6-3 is important in this respect; in them we notice a gradual development of the Magdalenian into industries that K. Valoch denoted as Epimagdalenian on the grounds of resemblances. Since the layer 5 we observe the arrival of small flake-type endscrapers that are characteristic of the Epimagdalenian from both younger layers 3 and 4. We can also state resemblances in the presence of a large quantity of backed bladelets, many times with truncated retouches constituting the shape of a rectangle. Such form appeared first time in layer 5. A significant element suggesting a genetic relevance to the Magdalenian is also the presence of borers and mainly edged

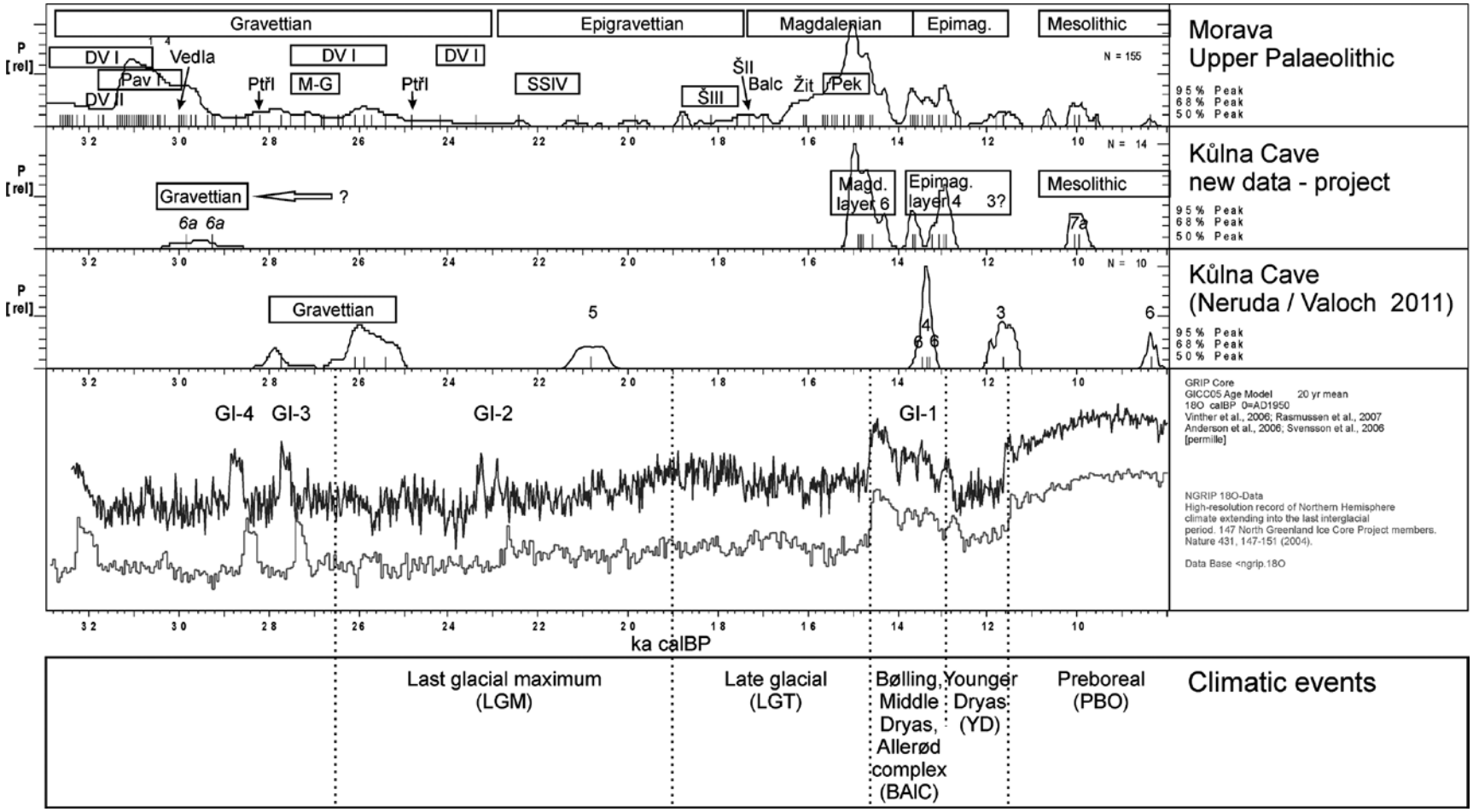

Fig. 5 Calibrated radiocarbon data from the Kůlna Cave (okr. Blansko/CZ) and their comparison with Upper Palaeolithic data from Moravia. – Abbreviations: Balc: Balcarka Cave; DV I: Dolní Věstonice I; M-G: Milovice (Gravettian); Pav I: Pavlov I; Pek: Pekárna; Ptřl: Petřkovice I; SSIV: Stránská skála IV; ŠII: Brno-Štýřice (Kamenná Street); ŠIII: Brno-Štýřice III (Vídeňská Street); Žit: Žitného Cave. – Geochronological scheme based on Yokoyama et al. 2000; Litt et al. 2001; Svensson et al. 2006; Vinther et al. 2006; Markova et al. 2013; Andersen et al. 2006; Clark et al. 2009). – Denomination of layers in italics (*6a* and *7a*): younger intrusion in the layer. – (Illustration P. Neruda).

and backed burins in layers 3 and 4. Their proportion is roughly the same as in the Magdalenian, the quantity of borers is somewhat smaller. Analogies can also be stated in the group of finds of hard animal materials. A characteristic example can be a fragment of an antler point in layer 3, which is virtually identical to the artefacts from the Magdalenian sequence. Epimagdalenian assemblages from the Kůlna Cave indicate a similar strategy in the use of stone raw materials with an important proportion of long-distance imports that are typical exactly of the Moravian Magdalenian. It is also important that the geometrical microliths characteristic of the Mesolithic, quite numerous e. g. in the Mesolithic settlement in Smolín (okr. Brno-venkov/CZ; Valoch 1978), appeared in significant amount in layer 3 (Valoch 1978, fig. 1, 1-12) and only sporadically in the underlying layer 4 (Valoch 1988, fig. 5, 11-12). Obviously we cannot foreclose that some less culturally confirmative artefacts (short endscrapers, cores etc.) cannot be unequivocally differentiated.
For all these reasons we consider the separation of the Epimagdalenian substantiated. With utmost probability the Mesolithic types from layer 3 represent an independent constituent of industry that corroborates a sporadic use of the caves in the Moravian Karst during the Mesolithic.

Magdalenian (layers 5 and 6)

We acquired somewhat problematic results for layer 5. The difference between both of the new dates is 1600 years. The more recent date (12,900 cal BP) is very close to layer 3 (cf. 12,940 cal BP; OxA-25283), the second matches with the Magdalenian of layer 6. From the stratigraphic point of view, in the case of the younger date we have to do with an overt contamination (mixing), although it is unclear, how this contamination between layers 3 and 5 could occur, since the position of the bone from which the sample has been taken was indubitable. Two explanations can be taken into consideration as regards the second date (OxA-25288): either the two horizons 5 and 6 are temporally so close to each other that the data become overlapped, or the layers that yielded the finds were not very well differentiated. The previously acquired date (GrN-6103, bone; Mook 1988) 17,480 ± 155 ^{14}C BP (20,830 ± 300 cal BP) most probably has nothing to do with the real chronological position of layer 5, because it is markedly older than the data from the underlying layer 6.
We can consider layer 6 to be the second chronostratigraphic marker of the Upper Palaeolithic sequence. A coherent set of data provided through new dating shifts the age of the Magdalenian of layer 6 from Allerød to the period of the end of the LGT. In our opinion the date for layer 5, the data acquired from sector J (OxA-25294 and OxA-25295), and primarily sample OxA-25302 from a reindeer tibia dated at 14,810 ± 200 cal BP and originating from layer 6a belong to this dataset as well (Neruda/Nerudová 2014).
In this respect, the previously acquired data for layer 6 cannot be considered reliable. Interstratification of the dates between layers 6 and 4 is striking. The data were mostly obtained from charcoals gathered in an area of c. 8 m^2, while sample GrN-11592 was contaminated with Holocene material, and the second sample GrN-11953 yielded a date roughly corresponding to the Epimagdalenian of layer 4. A similar date was given for a place with charcoals in square 37-38/M-O (GrN-5097); according to the then knowledge the hearth should have been located in the Magdalenian layer, and consequently a contamination did not seem probable (Neruda/Valoch 2011, 69). During taking of samples for microtephra identification (project RESET, D. White/R. Housley) it turned out that the thick layer of loess sediments with tiny limestone clasts designated as layer 6 by K. Valoch (1988, fig. 75) can be further divided into at least two horizons, based on the contents of limestone debris. From the profile in the northern part of sector G1 it is evident that there was a marked post-deposition subsidence of sediments, which is related with the existence of a hole, captured in the bottom of the trench and connecting the Kůlna Cave with an underground system of the Křížovy

Caves (Valoch 2011a, 50). Therefore, we can exclude neither post-deposition shifts of items inclusive of bones, nor incorrect stratigraphic differentiation of the finds.

Gravettian (a layer without designation)

The existence of the Gravettian in the Kůlna Cave is an interesting issue[1]. During the excavations an independent Gravettian layer has not been recognised in the cavern. Later on its existence it has been determined on the grounds of typological processing of the finds from sectors G and J and the radiocarbon data GrN-5773, GrN-5774, GrN-6800 and GrN-6853 (Mook 1988). However, the outcomes of a new dating of samples from sector J do not correspond to the established position, since they fit with the positions of the Epimagdalenian (OxA-25292 and OxA-25293) and the Magdalenian (cf. layer 6; OxA-25294 and OxA-25295). Sector J was chosen for sampling, because at the time of K. Valoch's digs this was the only place with a preserved deposition of Gravettian artefacts. Yet it was necessary to take into account that K. Valoch has already stated the complicated stratigraphic situation in this part of the cave, while it was impossible to decide whether this was an intact deposition or a post-deposition accumulation (Valoch 2011b, 91). At this location the sediments slopped from east to west (pers. comm. K. Valoch), and the reconstructed orientation of the Holocene sediments matches up with this as well (Neruda 2013). Therefore, it cannot be excluded that more recent fragments of hard animal materials got into the layer containing Gravettian objects. Thus the only data that temporally fall within the Gravettian period paradoxically come from layer 6a from the main entrance into the cave, where Gravettian stone artefacts have not been identified. However, the obtained values (29,250 ± 260 and 29,830 ± 280 cal BP) are markedly older than the previous dates, which were within the range from 25,430 to 27,720 cal BP (Mook 1988). Regretfully, at present we cannot decide whether it is necessary to shift the time of occupation of the Kůlna Cave to the middle phase of the Gravettian, or whether the new dating in confrontation with the older data corroborates the second, older phase of the Gravettian settlement within the cavern.

Early Upper Palaeolithic complex

Another issue of interest is the possible existence of the Weichselian Interpleniglacial sediments in the cave. Geological layers corresponding to those captured in the nearby Pod Hradem Cave were not identified by the research of the filling of the Kůlna Cave (Nejman et al. 2013). In terms of stratigraphy, comparable sediments should be found between layers 6a and 6; in the big entrance part of the cave these only differed by the proportion of limestone clasts, otherwise the sediment was macroscopically uniform. It contained both Micoquian and Magdalenian artefacts and bones, from which we acquired also the data capable of a correlation with the Gravettian (GrN-6853, GrN-6800, OxA-25269 and OxA-25299). No obvious proof of an erosion event was identified in the sediment; such an event would explain the absence of Interpleniglacial soil, in which Early Upper Palaeolithic (EUP) industries occur in Moravia. It seems that sedimentation in the southern entrance to the cave has been very limited in the period since the end of the Middle Palaeolithic to the LGM, and for a long time the morphology of this part of the cavern has remained basically unchanged. A distinct separation of the Lower Weichselian Glacial and the LGM sediments is only visible in the central part of the cave (sectors G1-H); however, neither a separate Gravettian, nor a Weichselian Interpleniglacial layer has been differentiated here.

Neither does the archaeological inventory from the Kůlna Cave contain objects that we could unambiguously link to the cultures of the EUP complex. In our opinion, the original radiocarbon dates for layer 7a

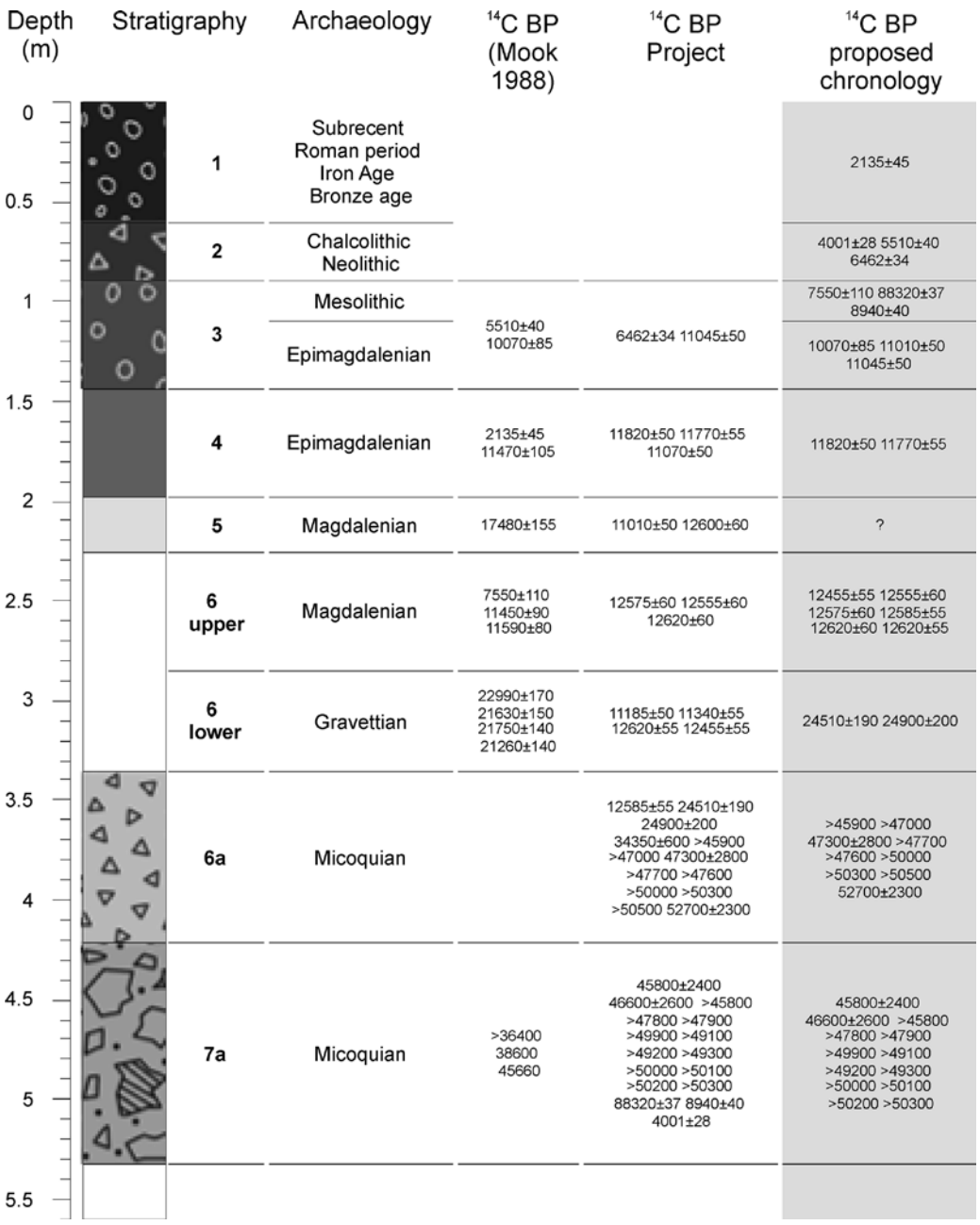

Fig. 6 Chronostratigraphy of the Kůlna Cave (okr. Blansko/CZ). A new chronological position of archaeological layers is proposed in the grey column. – (Illustration P. Neruda).

(GrN-6024 or GrN-10347; Mook 1988; Neruda/Valoch 2011), which come under the EUP period, are more likely related to the quality of preparation of the samples (e. g. Talamo/Richards 2011; Higham 2011). That is to say the analyses have shown that the new dataset for layer 7a is markedly older, and it does not contain contaminations from the Upper Palaeolithic layers (Neruda/Nerudová 2014). Although we obtained one date from layer 6a, which falls within the EUP period (34,350 ± 600 ^{14}C BP; i. e. 39,420 ± 750 cal BP), the dated bone originates from the northern part of the excavated area (sector H3; cf. **fig. 1**), where even the Middle Palaeolithic sediments have been damaged, and there are no proofs of anthropic impact on its

surface. Apparently, this was the prey of carnivores with no relation to the occupation of the cave by humans (Neruda/Nerudová 2014). Thus at present there is no proof available to us to indicate the utilisation of the cave at the beginning of the Upper Palaeolithic.

CONCLUSIONS

The outcomes of the project aimed at dating of archaeological layers in the Kůlna Cave have brought important findings that contribute to a more precise determination of the chronological position of the Upper Palaeolithic industries in Moravia. In the first place, we succeeded in making a chronological separation of the Magdalenian and Epimagdalenian horizons. The former interstratification of data (Mook 1988) originating from layers 6 and 4 has not been corroborated; on the contrary, both layers are now quite markedly separated from each other and present the most reliable chronostratigraphic markers in the cavern.
On the grounds of our newly-acquired data and their comparison to the older we can state that the most recent Palaeolithic occupation of the Kůlna Cave, represented by the Epimagdalenian of layer 3, comes under the period around 12.9 kyr cal BP, and the older Epimagdalenian settlement from layer 4 falls within the temporal interval 13-13.6 kyr cal BP. Therefore, generally we can relate the industries from both layers with the climatic development of the Bølling-Middle Dryas-Allerød Complex (BAlC; **fig. 4**).
As regards the Magdalenian, we were unsuccessful in a more precise dating of the finds from layer 5. From the stratigraphic point of view it is clear that this layer has to be older than layer 4. The upper boundary is based on the dating of the underlying Magdalenian horizon 6; on the grounds of the dates (14.8-14.9 kyr cal BP) it falls within the LGT, so that it is generally in correlation with e. g. the finds from the Pekárna Cave in the southern part of the Moravian Karst (Neruda 2010).
The dates for the Gravettian were obtained only indirectly. Temporally, the samples from the corresponding layer belong to the more recent period (Epimagdalenian, Magdalenian). Only two samples taken for the dating of the Micoquian horizon 6a come under the known temporal framework. On their basis we could link the Gravettian settlement of the cave with the time interval 29.3-29.8 kyr cal BP. Until now, the Gravettian occupation of the cave was considered to belong to a more recent period (25.4-27.7 kyr cal BP). At present, we cannot decide whether the different intervals are connected with a recurrent utilisation of the cave in various periods, or whether the problem is hidden at the methodological level (e. g. the preparation of samples, other material for dating etc.).
Within the set of newly-acquired absolute data one can be linked to the Weichselian Interpleniglacial. However, there were no marks of anthropic impact found on the surface of this sample, and bearing in mind that in the archaeological inventory from the Kůlna Cave the EUP industries were not noted either, we assume the reindeer bones got into the cavern in relation to the activities of carnivores. Most probably, in this period hunters did not use the cave.
The obtained data, those from the Middle Palaeolithic horizons included (Neruda/Nerudová 2014), have simultaneously revealed the complexity of the Kůlna stratigraphy (**fig. 6**). The sequence has been modified not only by sub-recent actions (older archaeological excavations, modification of the sediments during the Second World War etc.), but also by a number of post-deposition influences (activities of carnivores, redeposition, subsidence of the sediments, erosion etc.). For these reasons, the ages of some of the samples correspond to another layer that from which they were retrieved. We are capable of providing explanations of the majority of these discrepancies through spatial analysis and our awareness of the stratigraphic situation in the cave. Moreover, this will be made even more precise through a targeted sedimentological analysis that is being performed within the grant project.

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Note

1) With its position in the most recent loess, the Gravettian belongs to the complex of layer 6. At the time of differentiation of the Gravettian settlement, however, the designating number 6 has been reserved for the Magdalenian, and 6a for the youngest Micoquian. As a consequence, in the monograph the Gravettian has been marked layer 6b (Valoch 1988; 1989), although this designation was identical to that in the original documentation of the excavations, in which layer 6b served for the differentiation of the most recent Micoquian inside of the cave (as an equivalent of layer 6a). In the more recent works (Valoch et al. 2011; Neruda 2011) we returned to the original system of designation of the layers that corresponds to the field notebooks; therefore, there is not an independent layer separated out for the Gravettian in this system.

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Zusammenfassung / Abstract / Résumé

Chronologie der jungpaläolithischen Sequenz in der Kůlna-Höhle (okr. Blansko/CZ)

Die Kůlna-Höhle im Mährischen Karst ist ein wichtiger Fundplatz, um Kenntnisse über die Entwicklung der jungpaläolithischen Kulturen in Mitteleuropa zu erlangen. Im Rahmen eines neuen Projekts mit dem Ziel, die Chronologie dieser Höhle neu zu bewerten, haben die Autoren dieses Beitrags auch der Datierung der jungpaläolithischen Sequenz Aufmerksamkeit geschenkt, die gravettien-, magdalénien- (Schicht 6 und 5) und epimagdalénienzeitliche (Schicht 4 und 3) Fundhorizonte beinhaltet. Stichproben wurden aus der osteologischen Sammlung ausgewählt, wobei Knochen mit Anzeichen für eine menschliche Einwirkung und eindeutigen Herkunftskontexten präferiert wurden. Die Datierung aller Stichproben wurde im Oxford Radiocarbon Accelerator Unit durchgeführt. Es war offensichtlich, dass einige Fundhorizonte entweder mit neuerem Material kontaminiert waren oder ihre tatsächliche stratigraphische Lage nicht korrekt erkannt wurde. Durch einen Vergleich aller Daten wurden vor allem die Positionen der epimagdalénienzeitlichen Schicht 4 und der magdalénienzeitlichen Schicht 6 präziser bestimmt. Die Lage des magdalénienzeitlichen Niveaus aus Schicht 5 bleibt vorerst unklar. Die Datierung des gravettienzeitlichen Horizontes basiert lediglich auf zwei Datensätzen, und diese stammen von der jüngsten Micoquien-Schicht 6a. Der Datensatz für diese Kultur ist deutlich älter als das vorher bestimmte Intervall. Es gibt keine Indizien für eine mögliche Existenz früher jungpaläolithischer Industrien in dieser Höhle.

Chronology of the Upper Palaeolithic sequence in the Kůlna Cave (okr. Blansko/CZ)
The Kůlna Cave in the Moravian Karst is an important site for acquiring knowledge on the development of Upper Palaeolithic cultures in Central Europe. Within a new project aimed at the re-evaluation of the chronology of the cave, the authors have also paid attention to the dating of the Upper Palaeolithic sequence that comprises the Gravettian, the Magdalenian (layers 6 and 5) and the Epimagdalenian (layers 4 and 3). Samples were selected from the osteological collection, and items bearing marks of human impact and with clear data on their locations were preferred. The dating of all samples was performed in the Oxford Radiocarbon Accelerator Unit. It was obvious that some of the horizons had either become contaminated with more recent material, or their real stratigraphic position was not recognised correctly. Through a comparison of all data, particularly, the positions of the Epimagdalenian layer 4 and the Magdalenian layer 6 were stated more precisely. For the time being the position of the Magdalenian from layer 5 remains unclear. The dating of the Gravettian is based on two pieces of data only, and these originate from the most recent Micoquian layer 6a. The dataset for this culture is markedly older than the previously determined interval. There were no indicia of a possible existence of Early Upper Palaeolithic industries in this cave.

Chronologie de la séquence du Paléolitihque supérieur de la grotte de Kůlna (okr. Blansko/CZ)
La grotte de Kůlna, située dans les karsts de Moravie est un site important pour acquérir des connaissances sur le développement du Paléolithique supérieur en Europe centrale. Dans le cadre d'un projet visant à réévaluer la chronologie de la grotte, les auteurs se sont attachés à la datation des niveaux du Paléolithique supérieur, séquence qui comprend des niveaux gravettiens, magdaléniens (niveaux 5 et 6) et épi-magdaléniens (niveaux 4 et 3). Des échantillons ont été sélectionnés dans les collections ostéologiques, en préférant les os clairement marqués par une action anthropique en provenance de contextes clairement identifiés. Tous ces échantillons ont ensuite été datés par le Oxford Radiocarbon Accelerator Unit. Il était évident que certains horizons ont été contaminés avec du mobilier plus récente, ou que leur position stratigraphique originelle avait mal été reconnue. La comparaison de toutes les données, particulièrement celle du niveau épi-magdalénien 4 et magdalénien 6 ont ainsi pu être précisées. La datation du niveau gravettien ne repose que sur deux pièces, et elles proviennent d'un niveau plus récent, micoquien (6a). Les données de cette culture sont clairement plus anciennes que l'intervalle déterminé précédemment. Il n'y avait aucun indice d'une possible existence d'industries du Paléolithique supérieur ancien dans la grotte. Traduction: L. Bernard

Schlüsselwörter / Keywords / Mots clés

Tschechische Republik / Mähren / Jungpaläolithikum / Gravettien / Magdalénien / Epimagdalénien / ^{14}C Datierung
Czech Republic / Moravia / Upper Palaeolithic / Gravettian / Magdalenian / Epimagdalenian / ^{14}C dating
République tchèque / Moravie / Paléolithique supérieur / Gravettien / Magdalénien / Epi-magdalénien / datation ^{14}C

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