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^{14}C DATING OF THE UPPER PALEOLITHIC SITE AT KREMS-WACHTBERG, AUSTRIA

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ABSTRACT. In the course of new excavations at the Upper Paleolithic site at Krems-Wachtberg in the loess region near Krems, Lower Austria, a double burial of newborns was discovered in 2005. One year later, a single grave of an infant was excavated nearby. Both graves are associated with the well-preserved living floor of an Upper Paleolithic hunter-gatherer camp with distinct archaeological features and a rich Gravettian find assemblage. Several charcoal samples from different stratigraphic positions were ^{14}C dated with the accelerator mass spectrometry (AMS) method at VERA. The ^{14}C ages confirm the archaeological assessment of the site to the Gravettian time period. According to the uncalibrated ^{14}C ages, the formation time of the living floor is ~27.0 ^{14}C kyr BP. ^{14}C data of ~28.6 ^{14}C kyr BP determined for an archaeological horizon below the living floor indicate that the location may have been used earlier by people in the Middle Upper Paleolithic.

INTRODUCTION

A number of Upper Paleolithic open-air sites are located in the loess region of Lower Austria and have been known for more than a century. Among these are the important archaeological sites at Willendorf (Felgenhauer 1959; Haesaerts et al. 1996; Antl-Weiser 2008; Nigst et al. 2008), Stillfried (Felgenhauer 1980; Antl and Fladerer 2004), and Krems (Strobl and Obermaier 1909; Neugebauer-Maresch 2007, 2008; Wild et al. 2008). In the urban region of Krems, 2 areas of interest (Figure 1) exist: Krems-Wachtberg, the topic of our present study, has been known since 1930 when Josef Bayer uncovered a Gravettian camp area. The artifacts collected from this site were first investigated in 1995 (Einwögerer 2000). Only recently, the Krems-Wachtberg site, located just 100 m from the classic site of Krems-Hundssteig, obtained special importance and attracted considerable attention by the scientific community with the discovery of a double and a single burial of infants during new excavation campaigns in 2005 and 2006 (Einwögerer et al. 2006, 2008).

NEW EXCAVATIONS

Since 1999, new investigations have been carried out at Krems in areas adjacent to the Paleolithic find spots discovered earlier. New excavations at the well-known Krems-Hundssteig site from 2000 to 2002 indicate that it was not only used in the Aurignacian, but also in the Gravettian (Neugebauer-Maresch 2008; Wild et al. 2008). This fact raised questions regarding a possible correlation of the Gravettian horizons at Krems-Hundssteig and Krems-Wachtberg.

From 2005 to 2008, new systematic excavations were conducted at Krems-Wachtberg. In the new campaigns, a Gravettian layer (archaeological horizon AH 4), which was very abundant in archaeological finds, was excavated.

The base of this horizon is characterized by a high density of compactly deposited lithic implements, bone chips, charcoals, and bone coals in a dark ash-colored matrix. Due to these characteristics, it is interpreted as a living floor (AH 4.4). In comparison, the archaeological material in AH 4.11 above the living floor is less dense and embedded in light-colored loess sediment (Figure 2). AH 4.11

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yields a mixed inventory of finds from AH 4.4 and material originating from an unknown position. All material had apparently moved downhill, e.g. by solifluction (Händel et al. 2009).

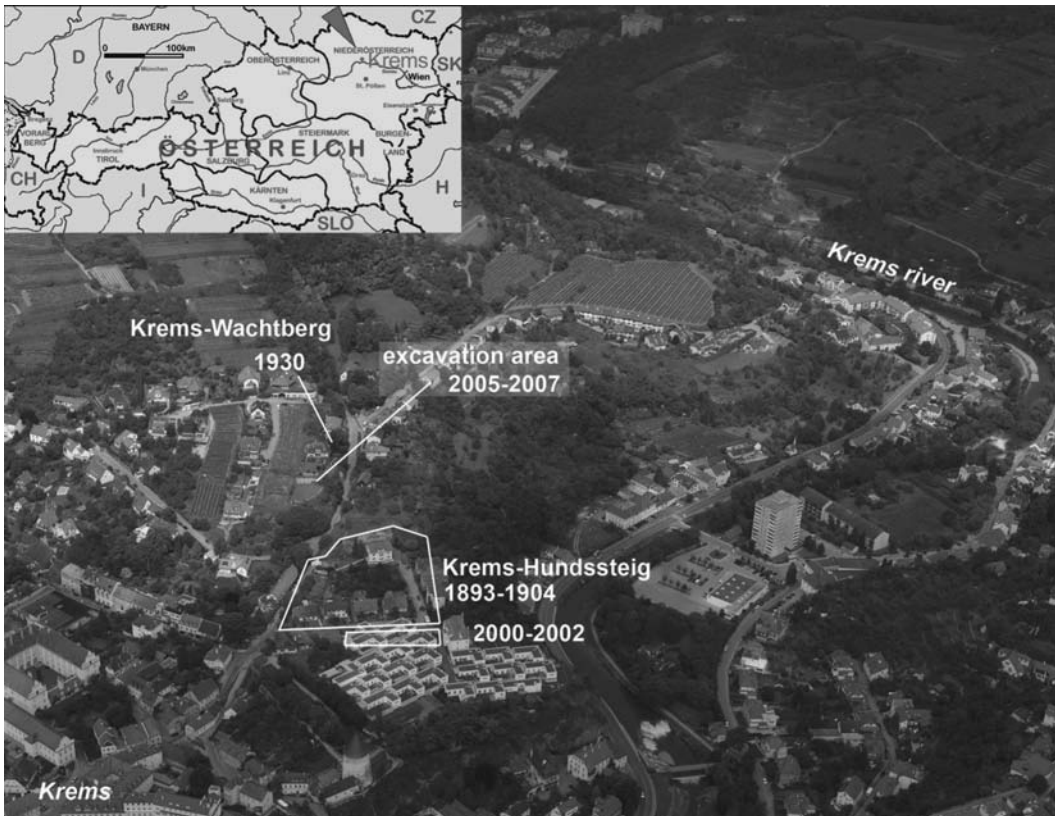

Figure 1 Map of Austria with an aerial view of the Paleolithic sites at Krems. (Photo taken from the south; Aerial Archive, Institute for Prehistory and Protohistory, University Vienna, graph: Austrian Academy of Sciences, Prehistoric Commission).

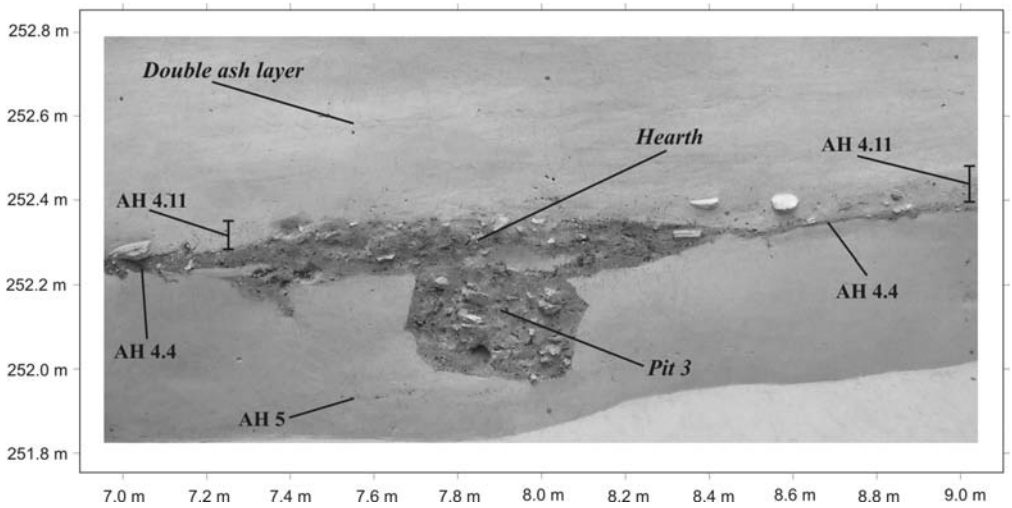

Figure 2 Krems-Wachtberg 2005–2008: rectified photo of a west profile intersecting the hearth and *Pit 3*. (Photo: Austrian Academy of Sciences, Prehistoric Commission).

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Two thin layers of organic ash with a vertical spacing of 2 cm are situated about 20 cm above AH 4. Since no artifacts or faunal remains are associated with this so-called *double ash layer*, a natural formation can be assumed, maybe by a steppe fire. The same phenomenon was observed at the modern excavations at Krems-Hundssteig (Neugebauer-Maresch 2008:72–8, Figure 65/3).

Another archaeological horizon (AH 5) detected at Krems-Wachtberg is situated 20–30 cm underneath AH 4. In this scatter of charcoals, anthropogenic activities are indicated by the presence of some lithics and burnt faunal remains.

Several distinct features are associated with the living floor AH 4.4 (Figure 3). A multiphased hearth is located in the center of the finds' distribution. Three larger pits are connected with the hearth, among them *Pit 3*. The living floor is best developed around the hearth area. *Burial 2* is placed within the limits of AH 4.4. The double burial (*Burial 1*) and the depression *"Mulde 5"* are situated in the eastern periphery, where the continuation of AH 4.4 is characterized by much fewer finds, mainly small charcoals and pieces of red ocher, forming a thin red-colored layer (AH 4.3).

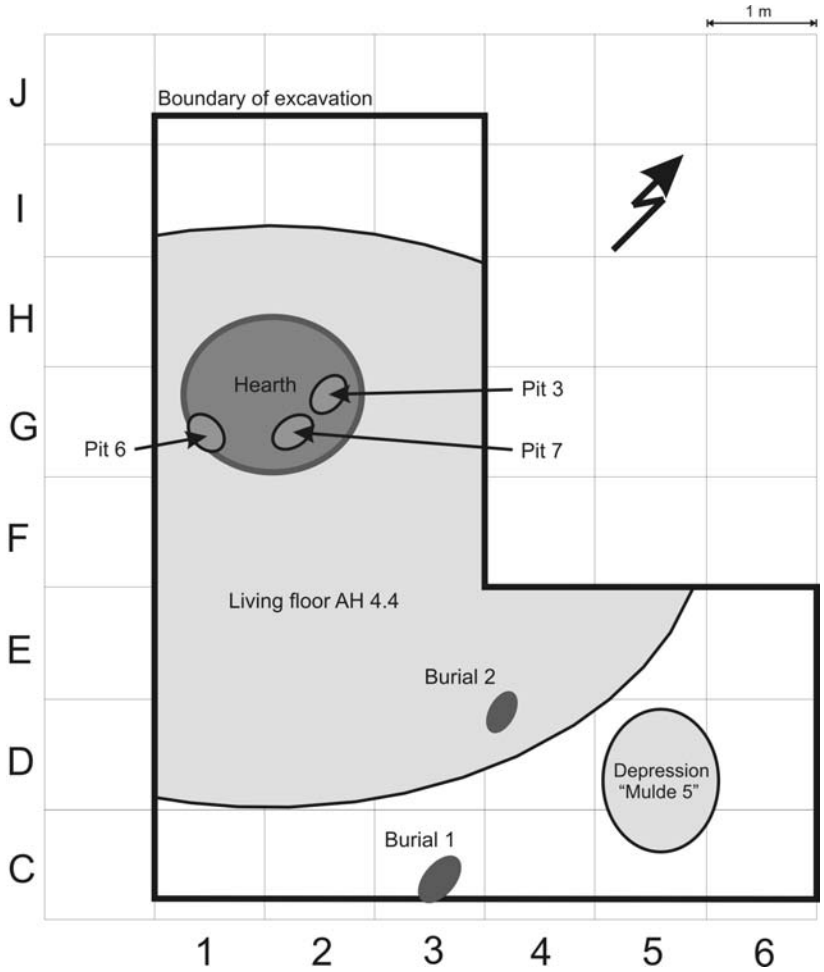

Figure 3 Krems-Wachtberg 2005–2008: schematic plan of the excavated area with the principle features of archaeological horizons AH 4.4 and AH 4.3. (Graph: Austrian Academy of Sciences, Prehistoric Commission).

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THE INFANT BURIALS

By the discovery of 2 infant burials in 2005 and 2006, the Gravettian site of Krems-Wachtberg became not only relevant in respect to questions pertaining Upper Paleolithic mortuary rituals, but also for questions regarding early human ontogeny (Einwögerer et al. 2006, 2008).

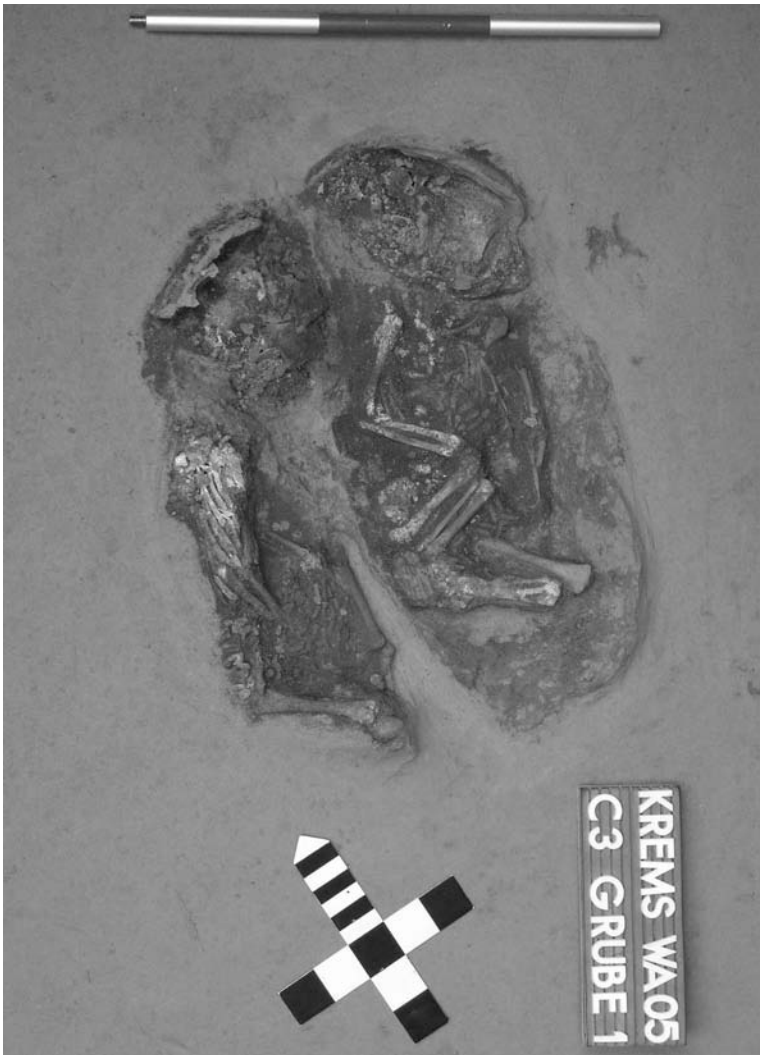

Figure 4 Krems-Wachtberg 2005–2008: *Burial 1*. (Photo: Austrian Academy of Sciences, Prehistoric Commission).

Burial 1 is a double burial (Figure 4). The dead were deposited in a pit and covered by a mammoth shoulder blade, which was supported by a piece of mammoth tusk. They were buried in a flexed position with their heads to the north, facing east. The skeletons were nearly completely preserved with only a few portions of the upper extremity (e.g. left arm of the baby in the east) entirely absent. The corpses were embedded in red ocher. A string of more than 30 drop-shaped ivory beads, which had been placed near the pelvis of the baby to the west, must represent either personal adornment or offering. According to the mineralization degree of an isolated incomplete tooth crown of a decidu-

ous maxillary incisor, we concluded an age-at-death in the 9th to 10th lunar month (=newborn). Bearing in mind that the degree of skeletal development of both individuals is identical, we assume that they could represent (twin) siblings.

In contrast to the first grave, *Burial 2* was not protected by construction elements. The baby with an age-at-death of 3 months was also buried in a grave pit and embedded in red ocher. The corpse had been deposited in a flexed position with the head to the south but also facing east. The skeletal remains are very badly preserved and fragile. Only 2 cm above the skull, an ivory pin was found in the same orientation as the individual. The object is therefore considered as a part of the burial context. Both burials were recovered as blocks, investigated by CT-scanning techniques and will be kept *in situ* for further analysis.

RADIOCARBON DATING

In order to support the assessment of the archaeological horizon AH 4 to the Gravettian period by additional data and also to determine the time of formation of the other horizons identified in the course of the new excavations at Krems-Wachtberg, several charcoal samples were dated with the ^{14}C method using the AMS technique at the Vienna Environmental Research Accelerator (VERA) laboratory. The samples selected for ^{14}C dating originated from different locations in the excavation area and from different vertical positions. The wood type of the majority of the charcoal samples was identified as *Pinus* (genus).

Although abundant at the archaeological site, faunal remains were currently not selected as dating material in order to avoid problems of ^{14}C dating of bones with poorly preserved collagen, which is likely for Paleolithic samples.

Fortunately, during fieldwork the archaeologists could obtain material suitable for ^{14}C dating from the double infant burial (*Burial 1*) without destroying the valuable finds themselves. The samples derive directly from the grave and comprise a 3-mg piece of charcoal, which was identified as coniferous wood (genus unknown) and a sample of fragmented mammoth ivory. The latter originated from the piece of tusk supporting the mammoth shoulder blade. The ages of both samples should be very closely connected to the burial time of the infants.

For sample preparation of the charcoals from the Krems-Wachtberg 2005–2008 excavation, the standard (acid-base-acid) ABA method used at VERA for charcoals was applied. In a recently performed laboratory comparison of pretreatment methods for charcoals from Krems-Hundssteig, no ^{14}C age differences were detected between samples that were treated with the ABOx-SC (acid-base-wet oxidation with stepped combustion) method in Oxford and the ABA method in Vienna (Wild et al. 2008). Based on this fact, application of the ABOx-SC method was omitted for the Krems-Wachtberg samples.

Collagen was extracted from the mammoth ivory sample and converted into gelatin with a modified (i.e. NaOH treatment added) version of the Longin method (e.g. Wild et al. 2000). The collagen yield of this sample was only ~0.2 wt% of the initial sample material and thus did not meet the criterion of a collagen yield >1 wt%, which is applied by many laboratories to bone samples for reliable ^{14}C dating (see e.g. Brock et al. 2007). The pretreated samples were further processed and measured as described earlier (Wild et al. 1998, 2008; Steier et al. 2004)

RESULTS AND DISCUSSION

Results of the ^{14}C age determinations are given in Table 1 together with their stratigraphic position (geological and archaeological horizons) and their location in the excavation area. All ^{14}C data listed

in Table 1 and discussed below are uncalibrated ^{14}C ages due to the still-existing lack of a generally agreed calibration curve for the time period beyond 26 kyr cal BP. (The presently recommended calibration curve IntCal04 [Reimer et al. 2004] covers the last 26 kyr cal BP.) A calibration of the data using one of the already available, but still divergent, data sets from ^{14}C archives spanning the time range of interest, was omitted (van der Plicht et al. 2004). However, it can be expected from the existing calibration data sets that the "final" >26 kyr cal BP calibration curve will show a relatively constant trend with long-term variations. The amplitudes of short-term wiggles in a >26 kyr cal BP calibration curve should be comparable with those of the respective IntCal04 wiggles. (For the younger, dendro-derived part of the IntCal curves, e.g. IntCal98, $\Delta^{14}C$ variations <20‰ were determined, Beer 2000.) and will not be resolved in the older part of the calibration curve with the achievable precision of the ^{14}C determinations (e.g. Chiu et al. 2007). Assuming such a smooth curve, a tentative interpretation of the relative chronology based on the uncalibrated ^{14}C dates may be justified for the Krems-Wachtberg sequence.

Table 1 ^{14}C data determined for charcoal samples from the Krems-Wachtberg 2005–2008 site.

Lab nr (VERA-)	Sample name	Geo. horizon	Archaeo. horizon	Sq. meter	Sample context	^{14}C age[a] (BP)
4538	ID 100362	GH 25	–	D1	*double ash layer*	26,050 ± 200
3932	ID 8886	GH 26	AH 4.11	I2	horizon with dislocated material	28,300 ± 270
3933	ID 17176	GH 26	AH 4.11	C3	horizon with dislocated material above *Burial 1*	27,420 + 240/–230
3934	ID 17775	GH 26	AH 4.11	E3	horizon with dislocated material	27,190 + 230/–220
4533	ID 39440	GH 26	AH 4.11	C6	horizon with dislocated material	27,230 + 230/–220
4534	ID 40983	GH 26	AH 4.11	D5	horizon with dislocated material above *"Mulde 5"*	28,000 + 250/–240
3935	ID 19771	GH 26	AH 4.4	G2	hearth	27,220 + 230/–220
3937	ID 21423	GH 26	AH 4.4	G2	*Pit 3*	28,240 + 270/–260
3938	ID 22056	GH 26	AH 4.4	G2	*Pit 3*	27,000 ± 220
4536	ID 71968	GH 26	AH 4.4	H1	hearth	26,980 ± 210
3941	ID 23775	GH 26	AH 4.4	H3	living floor	26,870 ± 220
3819	ID 18075	GH 26	AH 4.3	C3	*Burial 1*	26,520 + 210/–200
4532	ID 33435	GH 26	AH 4.4	D6	living floor	26,840 ± 220
3939	ID 22156	GH 28	AH 5	G2	layer below AH 4	28,750 ± 270
3940	ID 22191	GH 28	AH 5	G2	layer below AH 4	28,470 + 280/–270
4535	ID 64186	GH 28	AH 5	E1	layer below AH 4	28,700 + 290/–280

[a]1-σ uncertainty.

Further, in our interpretation of the ^{14}C data, possible age offsets caused by the so-called old-wood effect are ignored, since we believe they should be much smaller than the uncertainties of the data and are therefore negligible. As mentioned above, most of the charcoals originate from wood identified as the genus *Pinus*, but no information of the species is available. The individual species reach different maximum ages. The average lifespan of *Pinus sylvestris* is only 300 yr, although some specimens may reach a maximum age of 600 yr (e.g. Wagenführ 1984), whereas *Pinus cembra* is a long-lived tree with a lifespan of up to 1000 yr. Thus, an age offset of several hundred years can be expected for charcoal samples originating from the inner part of logs from old trees. On the other hand, it is also probable that people in the Gravettian time period preferentially used twigs and branches for their fireplaces, and not logs. Due to the vicinity of the rivers Danube and Krems, it can also be assumed that driftwood may have been available as firewood. However, also for this case, we expect mainly contemporaneous wood. We therefore assume that a possible old-wood effect would be small compared to the relatively large uncertainties of the ^{14}C ages. In addition, the old-

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wood effect would be variable between the individual pieces of samples from the same horizon. This would result in a scatter of their ^{14}C ages. We conclude that consistent sample ages of several samples (judged by a χ^2 test) indicate the absence of a significant (larger than the uncertainties of the data) old-wood effect. We are aware that—if successful—^{14}C dating of animal bone samples from the individual horizons would be another possibility to verify the above assumptions.

The uncalibrated ^{14}C data determined for Krems-Wachtberg 2005–2008 clearly place this archaeological site into the Gravettian period and confirm its archaeological assessment. Furthermore, the uncalibrated ^{14}C ages determined for the *double ash layer* and the horizons AH 4.4 and AH 5 follow the stratigraphy of these horizons.

After the removal of 1 outlier (VERA-3937 from *Pit 3*), all ^{14}C ages of charcoals from AH 4.4 agree at ~27.0 kyr BP ($n = 5$, $\chi^2 = 1.82$; limit for a 5% significance at 4 degrees of freedom: $\chi^2 = 9.5$). A ^{14}C age of 26,520 + 210/–200 yr BP was determined for the small charcoal sample that was retrieved directly from the double burial. This ^{14}C age deviates ~500 ^{14}C yr from the mean value of the AH 4.4 samples. The deviation is in the magnitude of the 2-σ uncertainty and allows the assumption that the burial age is consistent with the ages determined for the AH 4.4. Ignoring the unlikely possibility of a large plateau in the calibration curve, this seems to be concordant with the archaeological observation that the double burial originates from the time period when the Krems-Wachtberg site was intensively used. For a more accurate age estimate of the infant burial, direct ^{14}C dating of the human remains would be required.

A ^{14}C age of 26,580 ± 160 yr BP (POZ-12920) was determined in Poznań for the same horizon. The difference from the ^{14}C data determined at VERA for the AH 4.4 is marginally outside of the 2-σ uncertainty interval. It is unclear whether a real age difference can be deduced from this fact. In addition, this age is in agreement within the limits of error with the ^{14}C age of the charcoal from *Burial 1*.

The ^{14}C ages of the samples originating from AH 4.11 exhibit a larger scatter with some dates obviously not in sequence with the data from the other horizons. These data can be explained by the observation that the material of this horizon is in a secondary position and older sediments may have been deposited on top of the living floor by solifluction (Händel et al. 2009). A proper calibration of the data would be necessary to estimate the time difference between both layers. Although an old-wood effect cannot be completely excluded for these samples, it is unlikely that it can account for the full scatter of these data. The same consideration must be made about the ^{14}C ages of the charcoals originating from *Pit 3*, where the ^{14}C data indicate that the filling contained material (VERA-3937, see above) older than layer AH 4.4. At the present stage, however, we do not have a sufficient archaeological explanation for this finding.

The charcoal samples from the archaeological horizon AH 5 located beneath the living floor yielded consistent ^{14}C ages of ~28.6 kyr BP ($n = 3$, $\chi^2 = 0.58$, limit for a 5% significance at 2 degrees of freedom: $\chi^2 = 6.0$). As mentioned above, human activities are documented by lithics and burned animal bones occurring in this horizon. People have thus occupied the site before AH 4.4 was developed. Krems-Wachtberg is therefore one of the open-air sites in Austria that provide evidence for a repeated presence of man in the Upper Paleolithic.

It must be emphasized again that all ^{14}C ages discussed and given above are uncalibrated ^{14}C ages. A calibration of the data will place the Krems-Wachtberg site onto a calendar timescale, with a shift of the ^{14}C data to older ages and may affect the relative time intervals between the individual archaeological horizons (Bard et al. 2004; van der Plicht et al. 2004).

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CONCLUSION

The present study confirms the archaeological assessment of the Krems-Wachtberg site. According to the determined ^{14}C ages, the excavated archaeological horizons belong to the Gravettian. With some limitations, a tentative view of the time sequence of the Krems-Wachtberg site may be deduced from the uncalibrated ^{14}C data.

The ^{14}C data of samples from archaeological horizon AH 4.4 are consistent within the limits of error. The ^{14}C date of the small piece of charcoal from the double burial of newborns is in agreement with the archaeological interpretation that the graves originate from the time period when the living floor developed. ^{14}C ages from the archaeological horizon beneath the rich living floor indicate that the Krems-Wachtberg area had already been used earlier. This finding matches the view that the Krems-Wachtberg - Krems-Hundssteig area offered favorable conditions for Upper Paleolithic people.

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