The stratigraphy of the Gravettian sites at Krems

Die Stratigraphie der Gravettienfundstellen in Krems

Marc Händel*

Austrian Academy of Sciences, Institute for Oriental and European Archaeology OREA, Quaternary Archaeology, Hollandstraße 11-13, 1020 Vienna, Austria; email: marc.haendel@oeaw.ac.at

Abstract - Overlooking the Danube, several Gravettian sites cluster on the Wachtberg hill above the old town of Krems. The area has been well-known for its Upper Palaeolithic findings for more than a century. Initially, this was due to the large Krems-Hundssteig assemblage of mainly lithics collected in the course of large-scale loess quarrying, a great part of which has been classified as Early Upper Palaeolithic. Most Palaeolithic assemblages recovered from the loess-covered promontory since, however, can be attributed to the Gravettian, beginning with a site situated further uphill and excavated by J. Bayer in 1930. Modern research began focussing on the area in the 1990s with the assessment of the old collections, documentation of sections, and core sampling. From 2000 to 2002, excavations were carried out by the Austrian Academy of Sciences at Krems-Hundssteig. These provided evidence for a sequence of Mid-Upper Palaeolithic find layers. Ongoing investigations led to long-term research excavations at Krems-Wachtberg from 2005 to 2015. The site became renowned by the discovery of two graves of infants. Salvage excavations in the east part of the Wachtberg area between 2012 and 2013 provided important complementary information. Gravettian *in situ* remains first were documented in 1930 in the lower part of J. Bayer's so-called "main layer". Several patches of *in situ* contexts – mainly hearths, but also find scatters and horizons with evidence of tree remains (calcified wood) have been documented at Krems-Hundssteig. The modern excavations at Krems-Wachtberg documented a well-preserved occupation surface with a range of evident features. While the most extensive and best preserved *in situ* remains of the Wachtberg area can be attributed to the Pavlovian (occupation phase III) in terms of material culture and chronology, the Gravettian contexts at Krems-Hundssteig belong to at least two main chronological phases of the Early Gravettian whereas the earliest phase (occupation phase I) is also evidenced uphill at the Krems-Wachtberg sites. Phase I is associated with a palaeosol. At Krems-Hundssteig it is marked by the extensive occurrence of calcified wood in the form of trunk parts, branches, and primarily and most significantly, roots. Further uphill at the Krems-Wachtberg sites calcified wood is rare, but the according sediments also show pedogenic signals. Gravettian occupation phase II has been documented *in situ* in three small patches at Krems-Hundssteig only. Some calcified wood is still present, but the sediments consist of unaltered or slightly altered aeolian loess. In phase III the occurrence of calcified wood is reduced to few single specimens, although charcoal is abundantly present. However, no pedogenesis is evidenced. Omnipresent at all sites and truncating the *in situ* contexts are horizons with relocated Gravettian finds. These layers were formed by periglacial and/or slope processes, and in most cases represent palimpsests of more than one occupation. In the entire Wachtberg area, as assessed by all excavations and numerous core samples, the end not only of the Gravettian occupation but also of post-occupational relocation of Gravettian material is marked by two thin layers of organic ash spaced ca. 2 cm apart.

Zusammenfassung - *Auf dem Wachtberg über der heutigen Altstadt von Krems gelegen und mit Blick auf die Donau liegt eine Gruppe von Gravettienfundstellen. Das Gebiet ist schon seit über einem Jahrhundert bekannt für seine jungpaläolithischen Funde. Maßgeblich dazu beigetragen hat die umfangreiche, größtenteils aus Steinartefakten zusammengesetzte Sammlung, die im Zuge des Lössabbaus an der Wende vom 19. zum 20. Jahrhunderts zusammengetragen wurde. Der Großteil dieses Materials wurde dem frühen Jungpaläolithikum zugewiesen. Die meisten Inventare, die seitdem auf dem lössbedeckten Hügel geborgen wurden, können jedoch dem Gravettien zugeordnet werden, angefangen mit einer weiter hangaufwärts gelegenen Fundstelle, die J. Bayer 1930 ausgegraben hat. Moderne archäologische Untersuchungen zum und auf dem Wachtberg haben in den 1990er Jahren begonnen, als die Sammlungen neu erfasst und die Grabung von 1930 aufgearbeitet wurde. Dies wurde ergänzt durch die Anlage neuer Profile und die Durchführung von Rammkernsondierungen. Großräumige baubegleitende Ausgrabungen fanden von 2000 bis 2002 am Hundssteig statt und wurden von der Österreichischen Akademie der Wissenschaften durchgeführt. Hierbei konnte eine umfangreiche Fundschichtsequenz des mittleren Jungpaläolithikums dokumentiert werden. Weitergehende Untersuchungen führten zu langjährigen Forschungsgrabungen unweit der Fundstelle von 1930, die von 2005 bis 2015 andauerten. Schon im Zuge der ersten beiden Grabungsjahre wurde Krems-Wachtberg durch die Auffindung zweier Säuglingsbestattungen bekannt. Baubegleitende archäologische Untersuchungen auf dem östlichen Teil des Hügels von 2012 bis 2013 erbrachten auch entscheidende Informationen zur Gesamtstratigrafie des Gravettien am Wachtberg. Gravettienzeitliche in situ Befunde wurden auch bei der Grabung von 1930 im basalen Teil der von J. Bayer sogenannten „Hauptkulturschicht" dokumentiert. Dazu gehört eine große Feuerstelle mit mehreren Gruben. Eine Reihe von in situ erhaltenen Befunden wurden auch bei den Krems-Hundssteig Grabungen belegt und konnten mehreren Begehungsphasen zugeordnet werden. Dabei handelt es sich in der Mehrzahl um Feuerstellen, aber auch latente Befunde wie Fundstreuungen sowie Fundschichten mit den kalzifizierten Resten von Bäumen wurden dokumentiert. Die neueren Krems-Wachtberg Grabungen belegen einen gut erhaltenen Begehhorizont, zu dem eine ganze Reihe evidenter*

*corresponding author

Befunde wie Feuerstellen, zahlreiche Gruben unterschiedlicher Größe, sowie die schon erwähnten Bestattungen, gehört. Während die am besten erhaltenen und großräumigsten Befunde aufgrund der materiellen Kultur und Chronologie in das Pavlovien gestellt werden (Besiedlungsphase III), können die Befunde am Hundssteig mindestens zwei chronologischen Phasen des frühen Gravettien zugeordnet werden. Dabei ist die früheste Phase (Besiedlungsphase I) auch hangaufwärts am Wachtberg belegt. Phase I steht im Zusammenhang mit einem Paläoboden. Am Hundsteig ist dieser assoziiert mit kalzifizierten Hölzern: Stammteile, Äste und in erster Linie Wurzeln. Hangaufwärts bei den Krems-Wachtberg Fundstellen ist kalzifiziertes Holz selten, aber die entsprechenden Sedimente zeigen ähnliche pedogene Merkmale. Besiedlungsphase II konnte nur kleinräumig mit drei Befunden am Hundssteig belegt werden. Kalzifiziertes Holz kommt zwar noch in kleineren Mengen vor aber die Sedimentkörper bestehen jetzt aus nicht oder kaum verändertem äolischen Löss. In Besiedlungsphase III beschränkt sich das Vorkommen kalzifizierter Hölzer auf wenige Funde, obwohl Holzkohle in großen Mengen vorkommt. Pedogenese ist hier nicht nachgewiesen. An allen Fundstellen belegt sind Fundschichten mit verlagerten gravettienzeitlichen Funden. Diese überlagern und schneiden in situ erhaltene Bereiche. Diese Schichten sind durch periglaziale Hangprozesse entstanden und repräsentieren meist Palimpseste mehr als einer Begehung. Im gesamten Gebiet des Wachtbergs wurden bei allen Ausgrabungen sowie in zahlreichen Rammkernsondagen zwei feine Bänder aus organischer Asche mit einem Abstand von etwa 2 cm zueinander belegt, die nicht nur das Ende gravettienzeitlicher Besiedlung sondern auch das Ende der Verlagerung gravettienzeitlicher Funde markieren. Ein chronostratigraphisches Modell platziert das Gravettien vom Wachtberg zwischen Grönland Interstadial 6 und Heinrich-Ereignis 3. Die Klimaentwicklung bietet auch Erklärungen an für das Zusammenspiel zwischen Erosion einerseits und Erhaltung andererseits, d.h. für die Formation des archäologischen Befunds.

Keywords - Chronostratigraphy, site formation, occupation phases, Pavlovian, Krems-Wachtberg, Krems-Hundssteig
Chronostratigraphie, Fundschichtformation, Besiedlungsphasen, Pavlovien, Krems-Wachtberg, Krems-Hundssteig

Introduction

The city of Krems is located on the north bank of the Danube River between Linz and Vienna in the northern part of east Austria. The eastern fringes of the Alps extend south of Krems, and the Bohemian Massif to the west and northwest. The Krems area represents the westernmost limit of the east Austrian loess area which broadens in easterly directions where it connects to the Carpathian basin. The Upper Palaeolithic sites of Krems are concentrated on the Wachtberg promontory above the medieval town centre. The 16 ha area includes the Krems-Wachtberg (WA) and Krems-Hundssteig (HU) sites. While the HU sites are located on the lower part of the promontory, the WA sites are situated further uphill (Fig. 1). The Wachtberg overlooks an extensive alluvial plain, the so-called Tullnerfeld, and is positioned where the Danube, after its passage through the Wachau gorge, is joined by the Krems River. The spur-shaped Wachtberg slopes gently to the south in the direction of the Danube, and descends steeply to the Krems valley in the east. Up to 20 m thick sequences of loess sediments cover the bedrock of the Bohemian Massif on the slopes to the valleys and represent the sedimentary matrix for the archaeological remains. This matrix provides a high potential for the preservation of finds and anthropogenic structures.

The Wachtberg area has been well-known for its Upper Palaeolithic findings for more than a century. Initially, this was due to the large Krems-Hundssteig assemblage collected in the course of extensive loess quarrying (HU 1893-1904). The collection contains mainly lithic material, a great part of which has been classified as Early Upper Palaeolithic (Strobl & Obermaier 1909). Considering the entire inventory as chronologically homogeneous and trying to place it in the Aurignacian of Central Europe has, however, turned out to be problematic (Broglio & Laplace 1966). Most Palaeolithic assemblages recovered from the loess-covered promontory in the course of subsequent excavations can be attributed to the Gravettian, beginning with a site situated further uphill and excavated by J. Bayer, Krems-Wachtberg 1930 (WA 1930). In 1953, a private collection recovered in the course of excavations at Krems-Hundssteig carried out between 1890 and 1893 by a local teacher, A. Kesseldorfer, (HU 1890-1893), was transferred to the Natural History Museum Vienna (Hahn 1972; Jungwirth & Strouhal 1972). The lithic inventory has been attributed to the older Gravettian by Hahn (1972). Unfortunately, it was not possible to localize the exact position of the site.

In the 1990s modern research began to focus on the area with the re-assessment of old collections, processing of material from J. Bayer's 1930 excavation (WA 1930), documentation of sections, and core sampling. Large-scale salvage excavations were carried out by the Austrian Academy of Sciences at Krems-Hundssteig (HU 2000-2002), which substantiated the presence of multiple Mid-Upper Palaeolithic find layers (Neugebauer-Maresch 2008a). Further investigations led to the long-term research excavations at Krems-Wachtberg (WA 2005-2015). These have become well-known by the discovery of two infant graves (Einwögerer et al. 2006). Salvage excavations at Krems-Wachtberg East in 2012-2013 (WA East; Einwögerer et al. 2015) and Krems-Hundssteig in 2014 (HU 2014) provided important complementary information for assessing the Upper Palaeolithic stratigraphy of the Wachtberg area.

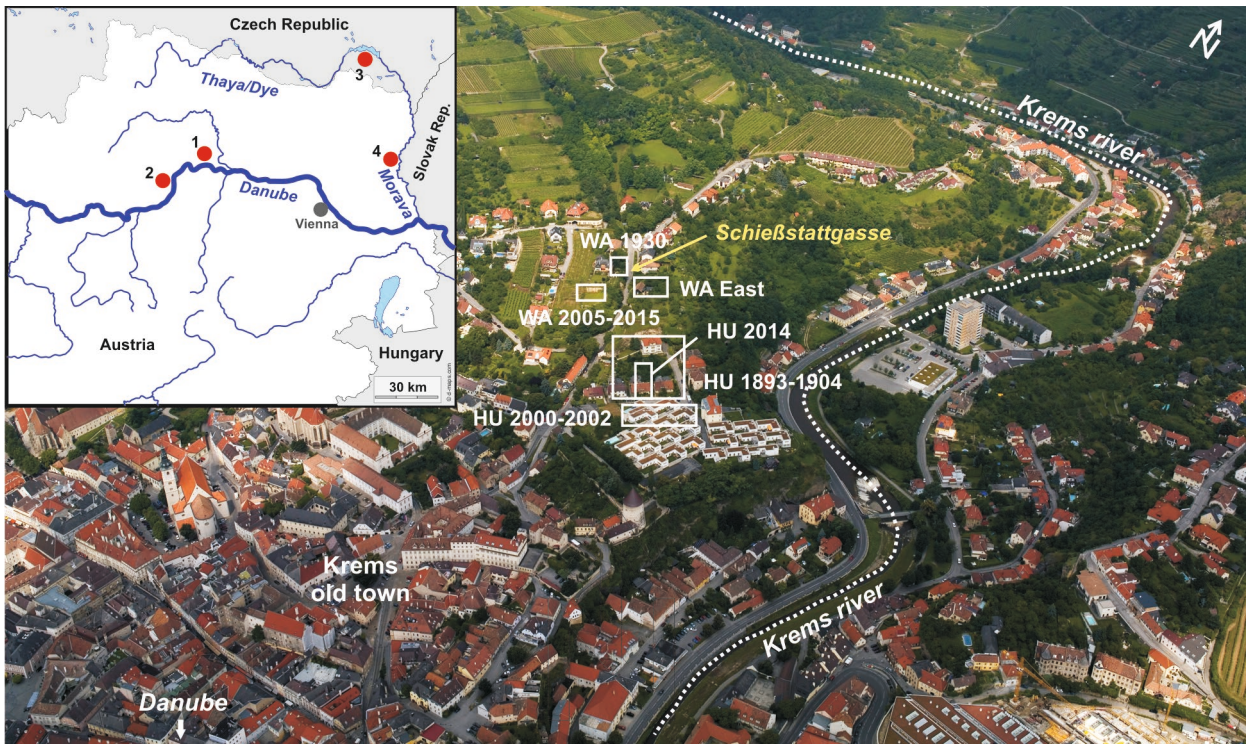

Fig. 1. Aerial photograph of the Wachtberg area in Krems from the southeast. The Hundssteig sites (HU) are located on the lower part of the promontory, whereas the Wachtberg sites (WA) are situated further uphill. Aerial photograph: Institute of Prehistoric and Historical Archaeology, University of Vienna. The inserted map shows northeast Austria and the locations of the Krems sites (1), Willendorf (2), Dolní Věstonice/Pavlov (3), and Stillfried (4). Map source: http://www.d-maps.com/carte.php?num_car=33844&lang=en>; modified.

Abb. 1. *Luftbild des Kremser Wachtbergs aus Südost. Die Hundssteig Fundstellen (HU) liegen im unteren und die Wachtberg Fundstellen (WA) im oberen Bereich des Hangs. Luftbild: Institut für Urgeschichte und Historische Archäologie, Universität Wien. Die Karte zeigt Nordostösterreich und die Lage der Kremser Fundstellen (1), Willendorf (2), Dolní Věstonice/Pavlov (3) und Stillfried (4). Kartengrundlage: http://www.d-maps.com/carte.php?num_car=33844&lang=en; modifiziert.*

Gravettian *in situ* remains have first been documented at WA 1930 in the lower part of the so-called "main layer". The HU 2000-2002 excavations exposed several patches of *in situ* contexts – mainly hearths but also find scatters and horizons with evidence of tree remains (calcified wood) that belong to different occupation phases (Neugebauer-Maresch 2008b). The excavations at WA 2005-2015 documented a well-preserved occupation surface with a range of evident features, most important of which are the infant burials, hearths, and numerous pits of different sizes (Händel et al. 2009a). While the most extensive *in situ* remains of the Krems-Wachtberg sites can be placed in the Early Pavlovian in terms of material culture and chronology (Simon et al. 2014), the multiple occupations at Krems-Hundssteig belong to at least two stratigraphically separated chronological phases of the Early Gravettian (Neugebauer-Maresch 2008a). At the Krems-Wachtberg sites there is also a stratigraphically distinct layer beneath the main Gravettian layers. Anthropogenic inclusions, however, consist mainly of charcoals. Omnipresent at all Hundssteig and Wachtberg sites are horizons with relocated finds (Einwögerer et al. 2014). These layers were formed by periglacial and/or slope processes and, in most cases, represent palimpsests of different occupation events (Händel et al. 2009b).

Materials and methods

This section is based on a review of previously published material and chronometric radiocarbon data, taking into consideration only the Gravettian layers and contexts. An assessment of the relative stratigraphy of these contexts is based on stratigraphic markers and considers a site formation model developed by Händel et al. (2014) for WA 2005-2015. The model is extrapolated to include the other investigated sites of the Wachtberg area. The material evidence is grouped based on archaeological and stratigraphic considerations, and the radiocarbon dates are then grouped accordingly.

Quantitative comparisons, although with limitations, are presented for archaeofaunal material and chipped stone inventories. Constraints are imposed by varying standards of excavation, documentation, and analyses, as well as by the state of research in case of the more recent excavations. Faunal data is comparable in terms of NISP and MNI, while numerical and typological comparisons are possible for the lithic assemblages. Criteria and standards for lithic raw material analyses differ considerably, and refitting rates can only be given when the studies are completed.

Gravettian sites of the Wachtberg area

Five of the above named sites provided material and/or chronometric data attributed to the Gravettian: HU 1890-1893, WA 1930, HU 2000-2002, WA 2005-2015, and WA East (Fig. 2).

The material collected from the HU 1890-1893 site consists mainly of lithic artefacts, only very few faunal remains, and one piece of charcoal (Hahn 1972). The material had been gathered in the course of private excavations by A. Kesseldorfer somewhere at the Hundssteig in Krems but the exact location let alone stratigraphic position is unknown. Most probably, collecting has been carried out selectively, i.e. not everything has been recovered and/or kept. Hahn (1972) describes the assemblage as fragmentary. Tentatively, Hahn attributes the lithic inventory to the early Gravettian, comparable to Willendorf II/5 due to the dominance of backed pieces (gravettes, micro-gravettes, and different varieties of backed bladelets), and he states that it does not include Aurignacian types. Several refittings (11 refitted pieces) and a high portion of pieces showing traces of fire (30 %) suggest that the find context may have been *in situ*, e.g. a hearth with a circumjacent find scatter. The other finds, one piece of charcoal and several fragments of burnt animal bones (mammoth?), also point in this direction. The collection also included human remains. These have first been described and published by Jungwirth & Strouhal (1972) and were compared to Pavlovian finds from Moravia since the authors assumed a Gravettian attribution. The human bones, however, turned out to be much younger when radiocarbon-dated to an age of only 3'500 years (Trinkaus & Pettitt 2000).

The excavation at WA 1930 was conducted by J. Bayer of the Natural History Museum Vienna and can be considered as the first systematic field investigation in the Wachtberg area from a scientific perspective. Bayer's early death prevented the publication of the results. His field notes ("Blaue Bücher"), however, as well as photographs survive in the Natural History Museum and are available for study. The findings were first reported on by Kießling (1934) who also mentions an object made of fired clay that looks like the head of an animal. Hahn (1972) compares the lithics to the HU 1890-1893 assemblage and attributes WA 1930 to a younger phase of the Gravettian. Hahn also notes that the Dufour bladelets in the WA 1930 inventory most probably represent post-excavation contamination by Early Upper Palaeolithic material from the HU 1893-1904 collection in the storeroom. Re-evaluation of the material and documentation started in 1993. Based on Bayer's notes and the photographs, Einwögerer (2000) was able to reconstruct the excavation process together with the substantial *in situ* settlement structures. He attributes the site to the Pavlovian based on the structures, economy, and finds spectrum which includes micro-denticulates and mobile art produced by ceramic technology. The subsistence is based on mammoth but the faunal assemblage includes a considerable portion of carnivore remains (Fladerer 2001, 2003). Although the find assemblages, at least for their greater part, i.e. with the exception of the Dufour bladelets, provide a coherent conclusion and justify a Pavlovian attribution, it must be noted that Bayer in fact claimed to have observed three different find layers (upper, main, and lower find layer). However, he neither excavated stratigraphically nor separated the material according to the observed layers. Also, Bayer's documentation does not allow for a distinction. Based on the photographs it is only apparent that the vast majority of the finds most probably derives from the main layer. Although this has already been noted by Einwögerer (2000), the relevance of this negligence became apparent only later in the course of fieldwork at WA 2005-2015, where a similar stratigraphic sequence was observed (Einwögerer et al. 2014) and explained (Händel et al. 2014). Furthermore, in analogy to WA 2005-2015 and WA East, it must be

Site	material collected	documentation	excavation	stratigraphic excavation	multi-disciplinary analyses	^{14}C dates
HU 1890-1893	selective: mainly lithics; few faunal remains, one charcoal (*Pinus sp.*)	none	(yes)	(no)	no	no
WA 1930	selective: lithics, fauna, charcoal, colour materials, adornments, art	photographs, diary	yes	no	no	yes
HU 2000-2002	all > 1.4 mm (water-screening in excavation squares with occurrence of lithic artefacts)	photographs, drawings, reports, spatial data	yes	yes	yes	yes
WA 2005-2015	all > 1.4 mm	photographs, drawings, diaries, reports, spatial data	yes	yes	yes	yes
WA East	all > 1.4 mm	photographs, drawings, diary, reports, spatial data	yes	yes	yes	yes

Fig. 2. Sites of the Wachtberg area in Krems which provided Gravettian contexts in the form of material, layers, features, and/or chronometric data. The indication of size > 1.4 mm given for the material collected relates to the mesh size of the sieves used for water-screening.

Abb. 2. *Fundstellen auf dem Kremser Wachtberg mit gravettienzeitlichem Kontext in Form von Material, Fundschichten, Befunden oder chronometrischen Daten. Die Größenangabe > 1,4 mm bezieht sich auf die Maschenweite der Siebe, die beim Schlämmen verwendet wurden.*

considered highly probable that Bayer's main layer consisted of two separate stratigraphic units with different sedimentary properties: a preserved occupation layer superimposed by a layer with re-located material.

A first opportunity for modern excavations on the Wachtberg promontory was given by a construction project at the Hundssteig that required the investigation of an area of more than 260 m^2. The HU 2000-2002 excavations were conducted by the Austrian Academy of Sciences and provided evidence for multiple Gravettian occupations (Neugebauer-Maresch 2008a). Five hearths, four of which were preserved with circumjacent find scatters, represent *in situ* archaeological contexts, together with a partly calcified burnt log in midst of an artefact distribution. Analyses of the lithic artefacts and refittings confirmed the stratigraphic and contextual integrity of these find scatters (Einwögerer & Simon 2008; Simon 2010). Different layers with re-located finds, mostly faunal hard tissue remains, have been interpreted as dump zones and/or result of natural post-depositional processes (Fladerer & Salcher-Jedrasiak 2008, 2010). Of crucial importance are the documentation and sampling of profiles and the interdisciplinary analyses conducted in this context: sedimentology and palaeopedology (Peticzka 2008), malacology (Frank 2008), investigation of floral microfossils and charred microscopic plant fragments (Urban 2008), analyses of macroscopic charcoals (Cichocki 2008). In addition, extensive remains of calcified wood have been documented and analysed (Neugebauer-Maresch & Cichocki 2008; Neugebauer-Maresch 2008b).

Core sampling in the Wachtberg area on plots that were, for the most part, vineyards with no private housing yet constructed, provided evidence for a high density find zone with a well-defined anthropogenic layer not far from WA 1930 (Einwögerer et al. 2014; Händel et al. 2009a). Excavations by the Austrian Academy of Sciences started in 2005 in the scope of a research project and have been conducted until 2015. WA 2005-2015 provided a wealth of material and data. Several Gravettian find layers were documented, two of which are characterized by *in situ* remains. One of these represents the remains of an occupation surface preserved around a hearth with multiple phases of use which gave detailed insights into human behaviour during the Gravettian (Fladerer et al. 2014; Thomas & Ziehaus 2014). Connected to this occupation surface are two extraordinarily preserved burials, a double burial of newborns, and a single burial of a ca. 3 month old infant (Einwögerer et al. 2006). In addition, the find layers with relocated material provided the data that enabled modelling the post-occupational sedimentary processes which are responsible for both erosion of an unknown portion of the campsite as well as for the excellent conservation of its preserved part (Händel et al. 2014). Archaeological investigations have been supplemented by a broad range of interdisciplinary analyses which are still ongoing. The site, however, has been closed and covered in 2015 as land use shifted from agriculture (vineyards) to residential construction in the course of the excavations. A range of important results of multi-disciplinary analyses have been published within the last few years. These include sedimentology and palaeopedology (Terhorst et al. 2014); sedimentation processes based on palaeomagnetic investigations (Zeeden et al. 2015); various chronometric approaches including optically stimulated luminescence (OSL) dating of the entire loess sequence (Lomax et al. 2014), Thermoluminescence (TL) dating of the baked loess directly underlying the central hearth of the occupation layer (Zöller et al. 2014), as well as palaeomagnetic approaches (Hambach 2010). Results of innovative approaches regarding resource studies have been presented for lithic raw materials, in particular radiolarite provenance (Brandl et al. 2014), as well as for firewood where several floating dendrochronological curves have been constructed based on tree ring data from charcoal (Cichocki et al. 2014). The latter study provided direct evidence for a contemporaneous use of two hearths, one of these being the central hearth mentioned above, and possibly even the simultaneous use of the wood of a single tree as fuel for both hearths. Today, the Krems-Wachtberg profiles of WA 2005-2015, in particular the thoroughly studied North Profile, are considered as important reference for the loess stratigraphy of Central Europe (Marković et al. 2015) and significant record for the regional climate and stratigraphy of the Late Pleistocene (Heiri et al. 2014; Terhorst et al. 2015).

WA East is located 60 m east of WA 2005-2015, and is separated from WA 1930 and WA 2005-2015 by a hollow-way, the so-called Schießstattgasse (Fig. 1). A construction project demanded the investigation of a 550 m^2 area in 2012 and 2013 (Einwögerer et al. 2015). The Austrian Bundesdenkmalamt commissioned the Austrian Academy of Sciences to carry out the investigations. Results of core sampling provided the base for limiting a destructive depth of intervention to a minimal area. In addition, find densities were rather low throughout the greater part of the affected area. A cellar located on the plot in an area with higher find densities had to be removed during the course of this incentive and later refilled. This provided the opportunity for high-resolution excavation and sampling of around 8 m^2 and creation of a 3 m high profile. The stratigraphy turned out to be a "missing link" between the Wachtberg sites and HU 2000-2002. The upper part of the Gravettian sequence closely resembles the stratigraphy at the other Wachtberg sites whereas the lower part is more closely analogous to the observations at Hundssteig. While analyses of sedimentology and palaeopedology (Meyer-Heintze et al. 2017), as well as radiocarbon (Einwögerer et al. 2014) and OSL (Meyer-Heintze et al. 2017) age determinations have produced results, the

data provided by the study of archaeological and archaeofaunal material must be considered as preliminary.

Gravettian contexts and find layers

This range of archaeological contexts and layers can be attributed to different Gravettian occupations. The contexts differ widely and range from old collections implying at least some degree of uncertainty as to their provenance to evident anthropogenic structures and from concentric find distributions to find layers with re-deposited material. The material evidence is heterogeneous, as are excavation and documentation standards (Appendix, Tab. 1). Accordingly, the potential for an interpretation of the data relies primarily on its context. For WA 2005-2015, this has been shown systematically for the archaeofaunal remains (Händel et al. 2015). While a find layer with re-deposited material that represents a palimpsest of different Gravettian occupations (WA-AH 4.11) allows only for general statements on the Gravettian subsistence, the preserved occupation surface (WA-AH 4.4) enables the contextual and spatial isolation of specific activities. Furthermore, the microstratigraphy showing different phases of use in a complex hearth feature allows for assessing a chronological depth within this occupation event.

The potentially high degree of integrity of the HU 1890-1893 lithic collection, despite lack of documentation, was documented by Hahn (1972) and has been discussed above. It seems likely that the assemblage is biased by the collector's selection, especially as it seems that the "excavations", i.e. recovery of finds, had been carried out in the course of several years. The Holocene human remains which were part of the assemblage also point to a lack of continuity and stratigraphic control. Radiocarbon ages of the charcoal or animal bones which are part of this assemblage have not been produced. The only stratigraphic hint, besides the inventory's comparability to the earliest Gravettian layer at Willendorf (II/5) and the assessment that it is, therefore, earlier than the WA 1930 material, is provided by the observation that yellow loess is attached to the charcoal. This stands in contrast to grey gleyic sediment into which the Hundssteig's Aurignacian finds were reported to have been embedded (Hahn 1972).

The problems connected to the WA 1930 material have already been pointed out above. It seems likely that the Dufour bladelets represent post-excavation contamination which could have occurred in the course of re-packing and storage in the museum. Similar contamination has not been reported for other objects or materials. A stratigraphic separation of the material, however, is not possible. Although complex anthropogenic features had been documented that can be attributed to the Pavlovian (Fig. 3: A) and although the material culture and archaeofaunal data strongly suggest a Pavlovian attribution (Einwögerer 2000; Fladerer 2001), the specific assignation of the individual objects to a layer remains unknown. Four radiocarbon ages have been produced for this context.

Modern excavation standards at HU 2000-2002, WA 2005-2015, and WA East enable a stratigraphic separation of finds and findings. The main archaeological contexts and layers, i.e. archaeological horizons (AH) are listed in Appendix Tab. 1 together with their most important properties. The arrangement corresponds to their stratigraphic position. The excavated area at HU 2000-2002 is not entirely contiguous and has been subdivided into four find zones for evaluation (Neugebauer-Maresch 2008a, 61). The zones are also reflected in the horizon's denomination: the "3" to the left of the decimal point stands for the Gravettian horizon in general; the first digit to the right of the decimal point represents the relative stratigraphic position; and the second digit stands for the find zone. If the second digit is missing the find zones are considered collectively. HU-AH 3.1/3.23/3.24 represents a sequence of layers with material re-deposited in the course of solifluction or other slope processes. Evident features are therefore missing. It is thus likely that the finds derive from different occupations. HU-AH 3.21 encompasses a heavily eroded and only partly excavated hearth B (construction-related regulations limited excavation to the area and depth of intervention) with a surrounding find scatter (Fig. 3: D). The finds' distribution in this scatter suggests a formation comparable to HU-AH 3.1/3.23/3.24 for most parts of HU-AH 3.21. This is supported by a comparatively low find density and low portion of refitted lithics (Einwögerer & Simon 2008). Less eroded is hearth D which forms context HU-AH 3.22 together with a surrounding finds distribution (Fig. 3: C). It seems that most finds of this scatter are directly connected to the hearth although they had been moved to some extent in the course of post-occupational processes. Faunal remains show two distinct concentrations (Fladerer & Salcher 2008); lithics show high densities and a pronounced spatial pattern (Einwögerer & Simon 2008).

HU-AH 3.34 has been assigned to a spatially limited layer in find zone 4 with charcoal, a few lithics and faunal remains, and, most noticeably, the stratigraphically latest remains of calcified wood (Neugebauer-Maresch 2008a: 131-132). The material, including the calcified remains, appears to have been re-located, presumably in close chronological proximity to its deposition. HU-AH 3.44 is stratigraphically earlier, but exhibits very similar properties. In contrast, HU-AH 3.43 (Fig. 4: A) represents an *in situ* context consisting of a partly burnt log (ca. 0.6 x 0.2 m in size) with a circumjacent find scatter of mainly charcoal, relatively few animal hard tissue remains, and few lithic artefacts of which two are fire-influenced (Neugebauer-Maresch 2008a: 131 & 133). Both contexts together represent the intermediate layer with calcified wood remains.

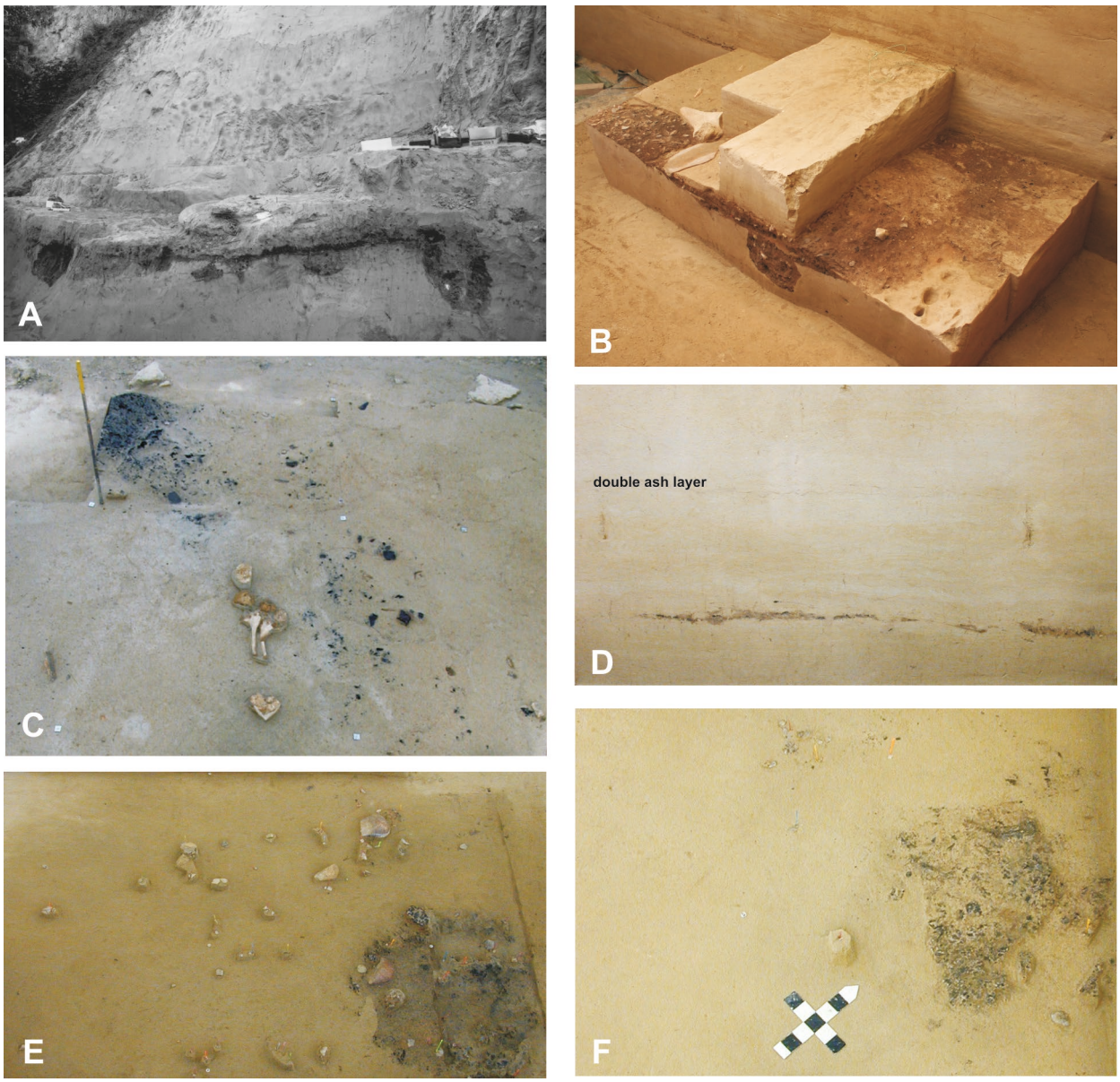

Fig. 3. Evident Gravettian structures documented at the Wachtberg and Hundssteig sites. A: Pavlovian occupation horizon with hearth and pits at WA 1930. B: Pavlovian occupation horizon WA-AH 4.4/4.3 with hearth 1 and pit 3. C: HU-AH 3.22 with hearth D. D: hearth B in profile (HU-AH 3.21). E: HU-AH 3.51 with hearth A. F: HU-AH 3.54 with hearth C. Photographs: Austrian Academy of Sciences.

Abb. 3. *Evidente gravettienzeitliche Befunde der Wachtberg- und Hundssteigfundstellen in Krems. A: Pavlovienzeitlicher Begehhorizont mit Feuerstelle und Gruben an der Fundstelle WA 1930. B: Pavlovienzeitlicher Begehhorizont WA-AH 4,4/4,3 mit Feuerstelle 1 und Grube 3. C: HU-AH 3,22 mit Feuerstelle D. D: Feuerstelle B im Profil (HU-AH 3,21). E: HU-AH 3,51 mit Feuerstelle A. F: HU-AH 3,54 mit Feuerstelle C. Fotos: Österreichische Akademie der Wissenschaften.*

The best-preserved evident structure exposed in the course of the HU 2000-2002 excavations has been hearth A in find zone 1. Together with the surrounding find scatter of mainly lithics and charcoal it forms context HU-AH 3.51 (Fig. 3: E). It is separated from the upper find layers by ca. 30-40 cm of sterile loess and is surrounded by sediment interspersed with brown, humic spots (Neugebauer-Maresch 2008a: 131 & 135-139). Faunal remains are sparse, but the lithic inventory is the richest among the HU 2000-2002 contexts and shows a high refitting rate (14.8 %) as well as a high portion (23.8 %) of blades and bladelets (Einwögerer & Simon 2008). Hearth C in find zone 4 is situated in a similar stratigraphic position and sediment, and it forms context HU-AH 3.54 with its associated charcoal and lithic scatters (Fig. 3: F). It is noticeable that most lithics are concentrated in a small area west of the structure (Neugebauer-Maresch 2008a: 136 & 140). The lithic assemblage is relatively small and homogeneous in terms of raw material consisting almost exclusively of locally available siliceous limestone and exhibits the highest refitting rate (19 %) of the site (Einwögerer & Simon 2008).

HU-AH 3.64 is composed of heavily eroded hearth E and its surroundings. The preserved base of the hearth consists of fire-influenced sediment with

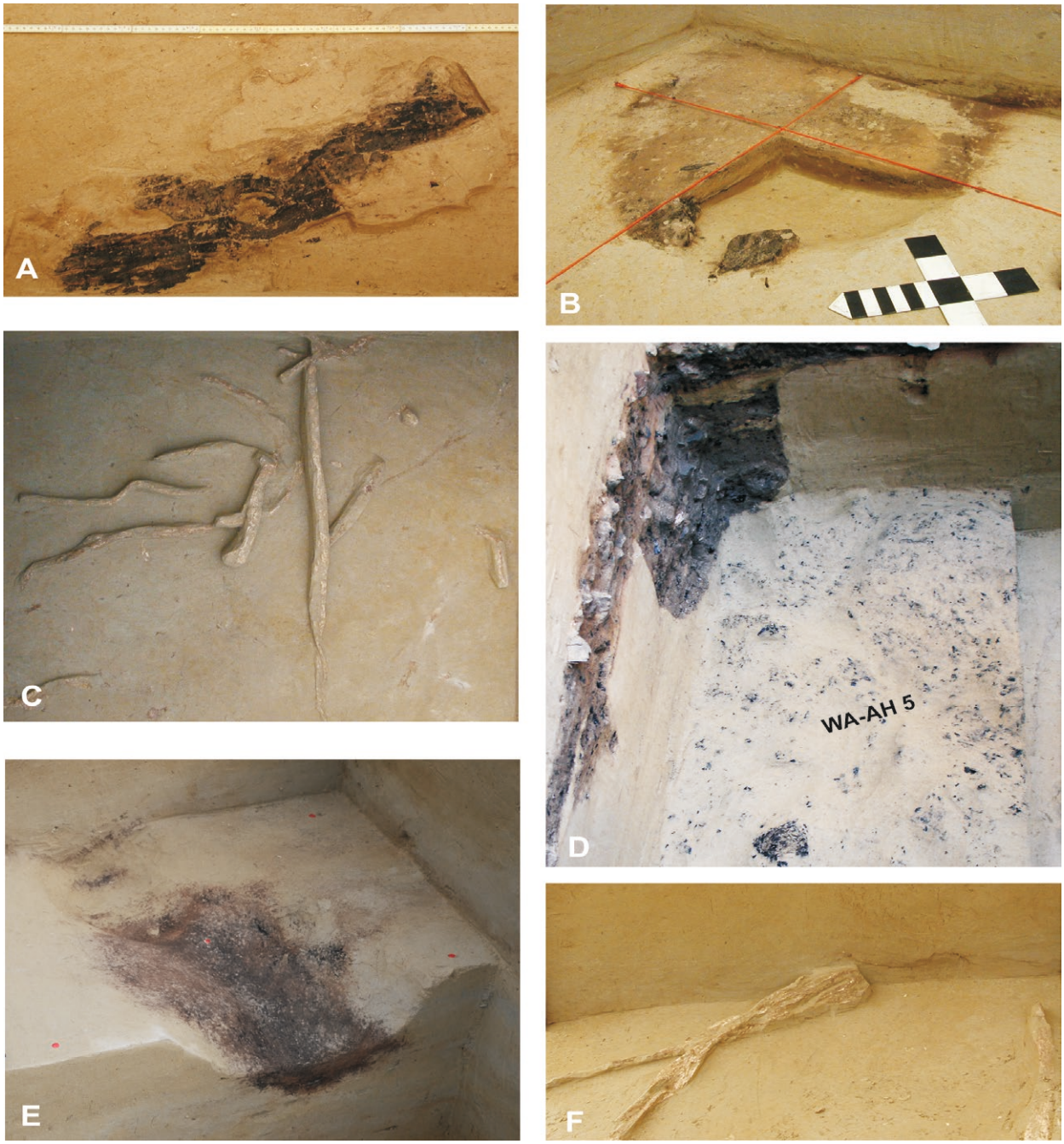

Fig. 4. Evident Gravettian and contemporaneous natural structures documented at the Wachtberg and Hundssteig sites. A: burnt log in the centre of find concentration HU-AH 3.43. B. preserved base of hearth E in HU-AH 3.64. C. *in situ* network of calcified root remains in palaeosol HU-AH 3.7. D: concentric charcoal scatter in WA-AH 5 in palaeosol matrix beneath pit 3 and hearth 1 of Pavlovian occupation horizon WA-AH 4.4/4.3. E: preserved base of hearth in WA East-AH 104. F: calcified root remains in palaeosol HU-AH 3.7; noticeable is the difference between planar and profile views. Photographs: Austrian Academy of Sciences.

Abb. 4. *Evidente gravettienzeitliche und zeitgleiche natürliche Befunde der Wachtberg- und Hundssteigfundstellen in Krems. A: Stark angebranntes Holz im Zentrum der Fundverteilung HU-AH 3,43. B: Erhaltene Basis der Feuerstelle E in HU-AH 3,64. C: Natürlich miteinander verflochtene kalzifizierte Wurzeln in Paläobochen HU-AH 3,7. D: Die konzentrische Holzkohlestreuung WA-AH 5 ist eingebettet in einen Paläoboden und liegt unter Grube 3 und Feuerstelle 1 des pavlovienzeitlichen Begehhorizonts WA-AH 4,4/4,3.E: Erhaltene Basis der Feuerstelle in WA Ost-AH 104. F: Kalzifizierte Wurzeln in Paläoboden HU-AH 3,7. Bemerkenswert ist der Unterschied bei den Ansichten der Wurzeln in Planum und Profil hinten rechts. Fotos: Österreichische Akademie der Wissenschaften.*

charcoal fragments and larger pieces of burnt wood (Fig. 4: B). The only artefact associated with this structure is a core documented in a peripheral position. Faunal remains are absent. Stratigraphically, the context is considered part of layer HU-AH 3.7 (Fig. 4: C, F), a grey-coloured palaeosol with abundant remains of calcified wood, most of which have been interpreted as the remains of roots (Neugebauer-Maresch 2008a: 136 & 141-143). An exception is a bundle of several objects measuring up to more than 2 m long and 2-3 cm wide that show no branching. The bundle was exposed on the palaeosol's surface. An

anthropogenic origin has been discussed for this finding (Neugebauer-Maresch & Cichocki 2008; Neugebauer-Maresch 2008b). HU-AH 3.7 has been referred to as the lower layer with calcified wood remains. The layer underneath, HU-AH 3.8, which is another greyish palaeosol, shows neither anthropogenic influence – and is therefore not considered here, nor are there calcified structures identifiable as remains of wood. In this layer, devoid of anthropogenic influence, precipitated carbonates in amorphous structures in shallow depressions that resemble puddles were found (Neugebauer-Maresch 2008a: 143 & 148). Radiocarbon ages attributable to an Early Upper Palaeolithic context have been retrieved from horizons HU-AH 4.14, HU-AH 4.21 and HU-AH 5.11 (Appendix, Tab. 2). However, these layers have been assessed in very small soundings or core samples and, with the exception of a single fire-influenced pebble, yielded only charcoal.

It is noticeable that no refittings between the *in situ* contexts at Krems-Hundssteig have been documented among the lithics. The faunal remains provided three connections between find zones for the upper contexts HU-AH 3.21, HU-AH 3.22, and HU-AH 3.24 (Fladerer & Salcher 2008).

The recent Krems-Wachtberg excavations, WA 2005-2015, also exposed a multi-layered Gravettian stratigraphy. The intermediate layer is an occupation horizon with a number of evident features (Fig. 3: B). It is directly superimposed and truncated by a stratigraphic unit representing multiple events of erosion and re-deposition. Both layers feature high find densities and broad find diversities. A scatter of mainly charcoal lies around 30 cm beneath the occupation layer (Händel et al. 2009b, 2014). Starting from above, WA-AH 4.11/4.01-4.22 consists of a sequence of layers with re-deposited finds. Among these, WA-AH 4.11 is the only layer that extends over the entire excavation area. The other units occur only locally, in most cases above WA-AH 4.11 and thus represent later re-deposition events. Morphologically, these layers are thin (2-5 cm) and gently waved bands with alternating colour properties depending on the degree of oxidation/reduction, i.e. range from beige to grey. The colour differences are, however, rather weak. Grain sizes also vary slightly, including more or less sandier components. Not all of these bands bear anthropogenic inclusions – where this is not the case there is no archaeological horizon assigned. The banded sediment unit as such is denominated geological horizon (GH) 26. Since WA-AH 4.11/4.01-4.22 cuts and truncates the occupation horizon WA-AH 4.4/4.3, it also took up a substantial amount of its sediment and finds. This has been observed in the field and confirmed in the process of refitting (Ziehaus 2007; Thomas & Ziehaus 2014).

The *in situ* occupation surface WA-AH 4.4/4.3 consists of WA-AH 4.4, a substantial living floor with on-surface preservation of densely packed finds, and WA-AH 4.3 that is merely preserved as an interface on the surface leaving only sub-surface structures unaffected by erosion. A series of evident structures is connected to WA-AH 4.4/4.3 ranging from pits and postholes to hearths and burials (Einwögerer et al. 2006; Händel et al. 2009a; Simon et al. 2014).

Finally, WA-AH 5 is a more or less concentric charcoal scatter with some faunal remains and very few lithic artefacts. It is noticeable, however, that the layer is embedded in a horizon characterized by brown and humic spots, GH 28, where the most pronounced pedogenic signals have been documented for WA 2005-2015 (Terhorst et al. 2014).

The Gravettian sequence exposed at WA East in 2012-13 features similarities to both, the WA 2005-2015 and the HU 2000-2002 sequences. The upper find layer, WA East-AH 101, shows clear signs of re-deposition of find material. The assessment of the underlying find layer, WA East-AH 102 separated only by a few centimetres of sterile sediment, is not entirely clear. The layer looks disturbed, but its stratigraphic position corresponds to WA-AH 4.4. WA East-AH 103/104 is connected to sediment unit GH 211, a palaeosol with few remains of calcified wood and many ashy patches. It also encompasses the only Palaeolithic evident structure documented at the site, a heavily eroded and disturbed combustion feature (Fig. 4: E). Only a small amount of lithics and faunal remains derive from WA East-AH 103/104 (Einwögerer et al. 2015).

Stratigraphic and archaeological assessment

The stratigraphic assessment of the contexts and layers described above is based on their relative position to each other and to stratigraphic marker horizons documented in the Wachtberg area (Fig. 5). These marker horizons allow for the extrapolation of a site formation model based on data collected from the main Gravettian stratigraphic units at WA 2005-2015, WA-AH 4.11/4.01-4.22, and WA-AH 4.4/4.3 (Händel et al. 2014), which can be applied to the other sites of the Wachtberg area. Archaeological assessment is based mainly on typology and/or the occurrence of findings, artefacts, and archaeofaunal material. The Gravettian contexts are then grouped according to these criteria.

The relative positions of the structures and layers within the individual sites have been presented above. It has also been mentioned that the earlier Gravettian contexts are connected to sediments exhibiting pedogenic signals as far as the sediments have been investigated. This can be confirmed for HU 2000-2002 (Peticzka 2008), WA 2005-2015 (Terhorst et al. 2014), and WA East (Meyer-Heintze et al. 2017). At HU 2000-2002, the Gravettian contexts HU-AH 3.51, HU-AH 3.54, HU-AH 3.64, and HU-AH 3.7 are connected to palaeosols. At WA 2005-2015, this is the case only for WA-AH 5, and at WA East it applies to WA East-AH 103/104. At HU-2000-2002 these layers

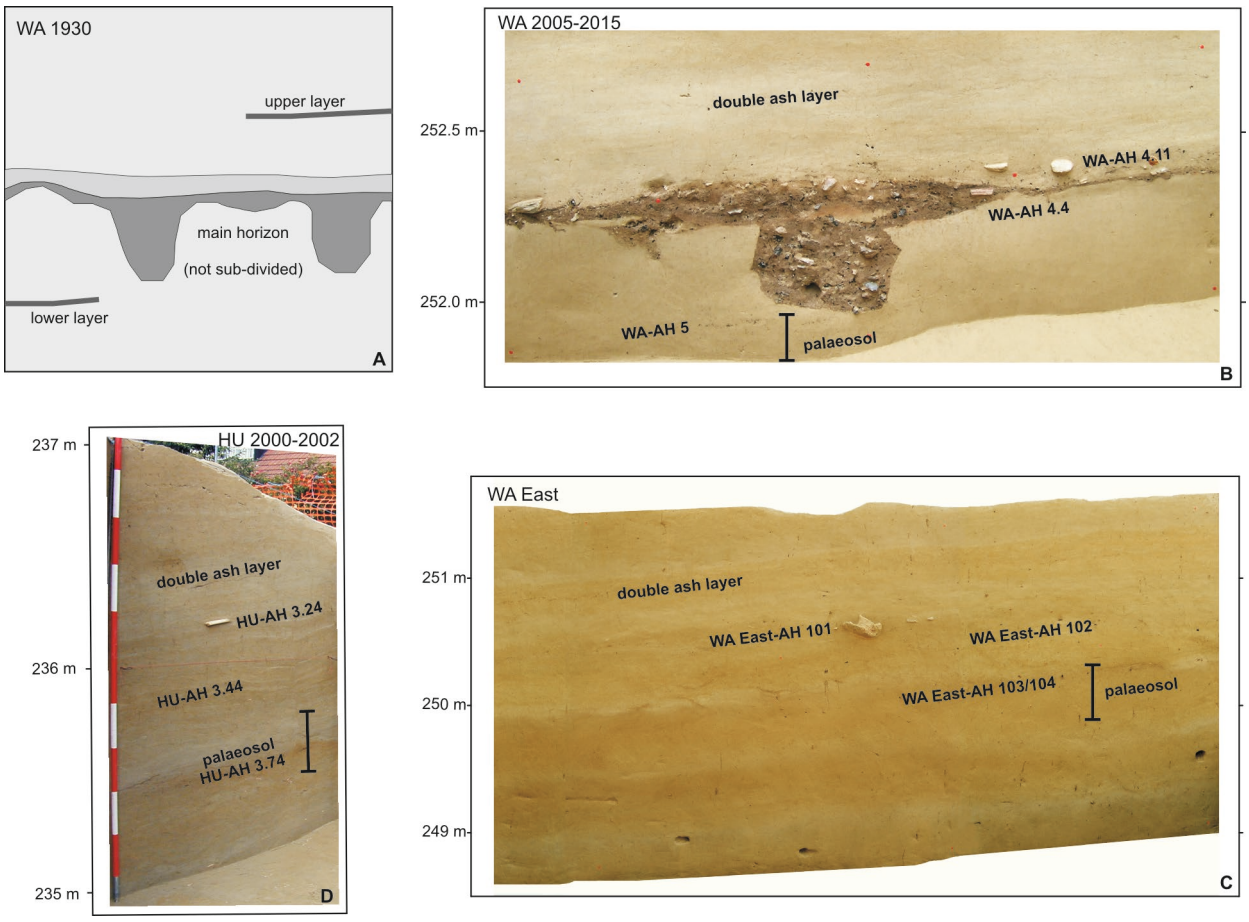

Fig. 5. Stratigraphic marker horizons connecting the sites of the Wachtberg area. The base of the Gravettian sequence is marked by a palaeosol which is connected to the earliest Gravettian occupation (phase I). Two thin layers of organic ash spaced ca. 2 cm apart ("double ash layer") are omnipresent on the Wachtberg hill and mark the end of Gravettian occupation. Please note that the thickness of the sediment sequence sandwiched between these two markers increases downhill from WA 2005-2015 (B) to WA East (D) to HU 2000-2002 (C). Absolute elevation values are not available for WA 1930. The stratigraphy has been modelled based on photographs and notes (A). Photographs: Austrian Academy of Sciences. Graph (A) is modified after Einwögerer et al. (2014).

Abb. 5. *Stratigrafische Markerhorizonte ermöglichen Verbindungen zwischen den Fundstellen am Wachtberg. An der Basis der Gravettiense-quenz liegt ein Paläoboden, der mit der frühesten gravettienzeitlichen Besiedlung (Phase I) verknüpft ist. Zwei dünne Bänder aus organischer Asche ("Doppeltes Ascheband") sind auf dem gesamten Wachtberg nachgewiesen und markieren das Ende der gravettienzeitlichen Besiedlung. Die Mächtigkeit der dazwischen liegenden Sedimente nimmt hangabwärts von WA 2005-2015 (B) nach WA Ost (D) und weiter nach HU 2000-2002 (C) zu. Für WA 1930 sind keine absoluten Höhenwerte vorhanden. Die Stratigrafie wurde nach Fotos und Notizen modelliert (A). Fotos: Österreichische Akademie der Wissenschaften. Grafik (A) modifiziert nach Einwögerer et al. (2014).*

feature large quantities of calcified remains of wood, in particular roots, while WA East provides much scarcer evidence and the corresponding unit at WA 2005-2015 provides none. Only very few and small amorphous traces of secondary carbonates occur here, and these cannot be identified as wood, i.e. there is no cell structure preserved. Faunal remains are rare (Appendix, Tab. 3) and in most cases not well-preserved, suggesting low sedimentation rates and unfavourable soil chemistry. This is in accordance with interpreting these sediment units as palaeosols. On the other hand, the potential for the preservation of structures, be it evident or latent, seems to have been rather favourable. Even though the hearth in WA East-AH 104 is heavily disturbed and the hearth in HU-AH 3.64 is partly eroded, two other hearths at Krems-Hundssteig, as well as the palaeosol itself with the abundant root remains, but also WA-AH 5, and the palaeosol at WA East suggest a relatively stable and vegetated, surface for the earliest Gravettian occupation (phase I) in the Wachtberg area. Please note that it is not suggested here that contexts grouped to one phase represent contemporaneous occupations in the narrower sense. A phase can obviously include multiple occupations.

The second important marker horizon is apparently post-occupational as it is positioned above the Gravettian horizons. Since no later occupations have been documented for the Pleistocene in the entire Wachtberg area, and no archaeological material can securely be attributed to it, the horizon in fact marks the end of Upper Palaeolithic occupation. The marker consists of in most cases two fine ash layers spaced ca. 2 cm apart. It has mainly been referred to as "double ash layer" (e.g. Neugebauer-Maresch 2008a; Händel et al. 2009b). This horizon is omnipresent in the

Wachtberg area and has been documented in the same stratigraphic position on all sites and in a number of core samples (Einwögerer et al. 2014). The ash is organic and interpreted as remains of a steppe fire (Händel et al. 2009b). The layers are wavy and follow ripples which presumably indicate the morphology of the former surface. The layers consist almost exclusively of ash with some microscopic charcoal fragments. In very rare cases, these fragments are slightly larger, and one specimen from WA 2005-2015 was radiocarbon dated (Appendix, Tab. 2). The age represents the *terminus ante quem* not only for the Gravettian occupation but also for the re-location of Gravettian material.

These two omnipresent marker horizons, the palaeosol sequence and the ash layers, thus form the bracket for the Gravettian occupation, the earliest of which, phase I, is connected to the soil. The sediment above the palaeosol is represented by a 20-50 cm thick deposit of homogeneous, archaeologically mostly sterile loess. The loess is interpreted to have been formed by aeolian input and influenced to a limited extent by post-depositional bioturbation. At WA 2005-2015, where this layer is thicker and more homogeneous, its uppermost part is compacted beneath WA-AH 4.4, probably caused by trampling and frost (Terhorst et al. 2014). The later Gravettian contexts are positioned on top of aeolian loess and extend into the banded sequence of loess sediments, which contains re-located context WA-AH 4.11/4.01-4.22 at its base and the thin ash layers towards its upper part. Although the banded sequence has been documented in the course of all modern excavations in the Wachtberg area, the individual bands beneath the ash layers cannot be synchronized as they are not continuous. Since the underlying aeolian loess varies in thickness it must be assumed that its top had been, at least partly eroded. This is also supported by the formation model developed for AH 4 at WA 2005-2015 (Händel et al. 2014; see below). It is therefore not possible to generate a precise inter-site stratigraphic relationship between the post-phase I contexts. A differentiation of these later contexts and find layers must rely on the general assessment of archaeological properties.

With few exceptions (HU-AH 3.34 and HU-AH 3.44) the faunal inventories of these contexts and layers point to a mammoth-dominated subsistence, and it can be generally stated that animal hard tissue remains are well-preserved (Fladerer 2001; Fladerer & Salcher-Jedrasiak 2008; Fladerer et al. 2014). Focussing on the *in situ* contexts, it is apparent that there are significant differences in terms of complexity, i.e. range of evident structures as well as artefact spectrum. WA-AH 4.4/4.3 and WA 1930 feature complex evident structures. This is not only a matter of preservation. For instance, the large hearths of these two stratigraphic units are each connected to pits (Einwögerer 2000; Händel et al. 2009a) and, thus, unquestionably represent more complex structures than the hearths at HU 2000-2002 (Fig. 3: A, B vs. C-F). In the case of the uppermost hearths B and D (HU-AH 3.21 and HU-AH 3.22) we must assume that sub-palaeosurface, i.e. dug-out features, would certainly have survived given that the findings on the surface are preserved. In contrast to WA 1930, which did not yield human remains, findings at WA-AH 4.4/4.3 furthermore include a double (Fig. 6: F) and a single infant burial, both with excellent preservation. All three individuals had been embedded in red ochre, and the pit of the double burial was covered with a mammoth scapula (Einwögerer et al. 2006). Together with the artefact spectrum which includes one indubitable zoomorphic figurine and several formed fragments of baked clayish sediment (ceramic technology), range of adornments, decoration (an ivory fragment with incised herringbone pattern), documentation of a complex *chaîne opératoire* for red ochre processing, microdenticulates among the lithic tools, and dominance of mammoth among the faunal remains (Appendix, Tab. 3, 4, 5), WA-AH 4.4/4.3 can be attributed to the Pavlovian (Svoboda 1996, 2007; Simon et al. 2014). Besides the complex hearth, WA 1930 features a similar artefact spectrum as well as a mammoth-based subsistence and has therefore also been attributed to the Pavlovian (Einwögerer 2000; Fladerer 2001, 2003). In a strict sense, this can only apply to the "main layer" with the evident structures on one hand, and the typologically diagnostic artefacts on the other hand, because the finds had not been separated by layers. In addition, there is the problem of potential contamination (Dufour bladelets, see above). WA-AH 4.11/4.01-4.22 also exhibits a similar artefact spectrum that includes Pavlovian types. Noticeably this is not the case in the HU 2000-2002 inventories, which can only be attributed to an unspecified early Gravettian. It is therefore plausible to assign the according *in situ* contexts HU-AH 3.21, HU-AH 3.22, and HU-AH 3.43 to a different group, as well as, hypothetically, to a separate phase. The radiocarbon ages for these contexts suggest assigning the latter to phase II and the *in situ* Pavlovian WA-AH 4.4/4.3 to phase III. All radiocarbon data of re-located, disturbed, or insecure provenance are compiled in a fourth group.

The site formation model developed for AH 4 at WA 2005-2015 provides the explanatory framework for this assessment (Fig. 6). Occupation layer WA-AH 4.4/4.3 was preserved in an area with a considerably lower slope gradient. WA-AH 4.11/4.01-4.22 has been documented immediately above and around it. Whereas the occupation layer is mainly a direct result of human activities, the layer with re-deposited finds has the potential of providing detailed insights into sedimentation processes. Slope dynamics and loess sedimentation, together with other periglacial processes, are responsible for conservation in some cases and relocation of objects as well as disintegration and eventually destruction of archaeological

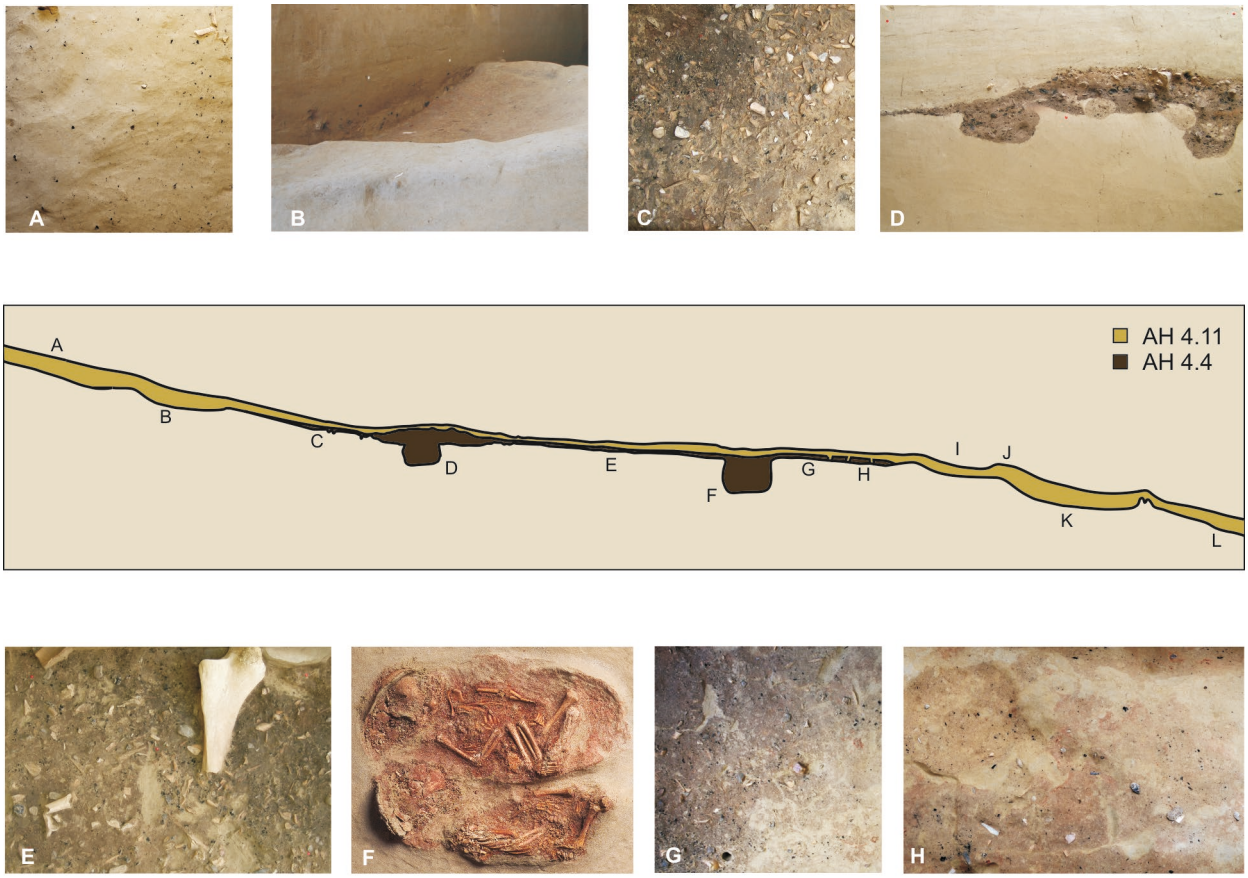

Fig. 6. Formation model of the main Gravettian layers at WA 2005-2015 (WA-AH 4.11 and WA-AH 4.4/4.3). The model shows an idealized transect and corresponds to a distance of ca. 12 m in reality. The slope angles are realistic. Selected positions (A-L) are illustrated by photographs. (A) WA-AH 4.11 contains relocated archaeological material from an unknown position uphill; (B) periglacial slope processes form shallow circular depressions by a succession of erosion and depositional processes; (C, E) occupational horizon WA-AH 4.4's base remained preserved in areas with reduced slope angle; (D) together with evident anthropogenic structures like hearth 1; (F) and dug-in features like the infant double burial. (G, H) As the slope's angle increases, WA-AH 4.4 decreases in thickness, breaks up, and is eventually truncated by (I) WA-AH 4.11 which has eroded and absorbed material from the occupation layer. Increase in slope angle is connected to periglacial features like (J) stacks of sediment clods pushed together and (K) the shallow circular depressions that eventually open in to (L) erosional gullies. Photographs: A-E; G-L: Austrian Academy of Sciences; F: Natural History Museum Vienna. Graph modified after Händel et al. (2014).

Abb. 6. *Formationsmodell der Hauptgravettienschichten WA-AH 4,11 und WA-AH 4,4/4,3. Das Modell zeigt einen idealisierten Querschnitt durch die Fundstelle über eine Distanz von etwa 12 m. Die Hangneigungen wurden realistisch wiedergegeben. Ausgewählte Positionen (A-L) sind mit Fotos illustriert. (A) WA-AH 4,11 enthält verlagertes archäologisches Material von einer unbekannten hangaufwärts gelegenen Fundstelle; (B) periglaziale Hangprozesse formen durch Erosions- und Ablagerungsprozesse flache runde Mulden. (C,E) Die Basis des Begehhorizonts WA-AH 4,4 hat sich bei reduzierter Hangneigung erhalten; (D) zusammen mit anthropogenen Strukturen wie Feuerstelle 1; (F) und eingetieften Befunden wie der Doppelbestattung von Neugeborenen. (G, H) Mit erneuter Zunahme der Hangneigung nimmt die Mächtigkeit von WA-AH 4,4 ab, bis sich der Begehhorizont allmählich auflöst, (I) und von WA-AH 4,11 geschnitten wird. Die stärkere Hangneigung ist verbunden mit periglazialen Erscheinungen wie (J) ineinander geschobenen Sedimentfladen ("Überschiebungen"), (K) und den flachen runden Mulden, die letztlich zu (L) Erosionsrinnen aufbrechen. Fotos: A-E; G-L: Österreichische Akademie der Wissenschaften; F: Naturhistorisches Museum Wien. Grafik modifiziert nach Händel et al. (2014).*

structures in others. Towards its edges, WA-AH 4.4/4.3 decreases in thickness and is eventually truncated by WA-AH 4.11. It is unknown how much of the original occupation deposit is missing. It seems likely that a considerable part of the finds has been embedded in layer WA-AH 4.11/4.01-4.22 in the course of these processes. A high degree of mixing obviously results in very similar find assemblages. On the other hand, the finds reflect the presence of some elements in WA-AH 4.11/4.01-4.22 that do not occur in WA-AH 4.4/4.3. The differences include the following: microlithic elements are more pronounced among the lithic tools of WA-AH 4.4/4.3 (Appendix Tab. 5; see also Thomas et al. 2016); faunal remains are more fragmented in WA-AH 4.4/4.3 as the bones have been intentionally fractured next to the large hearth for accessing marrow and bone fats (Fladerer et al. 2014); the faunal spectrum is broader and *Capra ibex* is significantly more frequent in the WA-AH 4.11 assemblage (Appendix, Tab. 3, 4; see also Händel et al. 2015). Among the colour pigments, red ochre is more dominant in WA-AH 4.4/4.3 whereas yellow ochre and graphite occur more often in WA-AH 4.11. Also, the radiocarbon ages are more heterogeneous in WA-AH 4.11 including samples that pre-date layer WA-AH 4.4/4.3 (Appendix, Tab. 2). Apparently, WA-AH 4.11/4.01-4.22 represents a palimpsest of different occupations, i.e. the occupation represented

by WA-AH 4.4/4.3 plus at least one other, most probably earlier occupation. WA-AH 4.11/4.01-4.22 includes several natural features that provide explanations for its formation. These include stacks of sediment clods, sometimes pushed into each other. They represent multiple short-range solifluction events. Shallow, almost circular depressions and gullies are other naturally formed structures. They correlate with the slope angle being most pronounced and frequent where the slope decreases or increases. It seems that these features represent a natural pattern connected to periglacial solifluction at the transition from sheet to rill erosion (Bertran et al. 2010). The excellent state of preservation of the anthropogenic features in WA-AH 4.4/4.3, of the human remains in the graves, the faunal material, and charcoals speaks in favour of a rapid succession of this series of events.

Extracting and summarizing the main lines of thought, it can be stated that the earliest Gravettian contexts are connected to a palaeosol. A soil implies a relatively stable surface due to vegetation. It is superimposed by loess, i.e. sediment of aeolian origin, which has accumulated for some time before later Gravettian occupations took place. Among these, the Pavlovian occupations seem to represent the latest stages. Apparently, this loess layer was either more vulnerable to erosion, or the environmental conditions were more favourable for erosion. A combination of both factors is of course also plausible. In any case, an increase in thickness from ca. 0.7 to 1.2 m was observed for the sediment sequence contained within the bracket formed by the upper palaeosol and the thin ash layers following the slope from WA 2005-2015 to HU 2000-2002. At WA East, the bracketed sequence looks similar to WA 2005-2015 and WA 1930 but is considerably thicker. Assuming consistent primary deposition rates for the loess independent of the slope position, this must be a result of post-depositional processes. As a result, phase I is omnipresent, phase II only preserved in patches in the lower part of the hill at the Hundssteig sites, and phase III, the Pavlovian, is only preserved at the Wachtberg sites (Händel 2016).

Radiocarbon ages

The radiocarbon samples and ages determined for the Wachtberg area are listed in Appendix Tab. 2. Most dates have been obtained from charcoal; three from animal bone. The table includes calibrated ages based on the Greenland-Hulu U/Th timescale (CalPal-Beyond the Ghost, Version 2016.2, http://monrepos-rgzm.de/forschung/ausstattung.html#calpal; Weninger & Jöris 2008). Included in the list is the small number of available Early Upper Palaeolithic (EUP) ages. They appear to correlate with Greenland Interstadials 9, 8, and 7. The EUP ages have been produced from charcoals deriving from either the HU 1893-1904 collection or from soundings or sampling cores at HU 2000-2002. The contexts of the four samples with EUP ages are therefore insecure.

The Gravettian dates have been grouped according to stratigraphy and archaeological assessment (see above). This allows a discrimination of three phases of Gravettian occupation that are represented by *in situ* remains. A fourth group is formed by radiocarbon data of re-located, disturbed, or insecure provenances. Furthermore, a single age derives from the fine ash layers (named WA-GH 25 at WA 2005-2015) and represents the *terminus ante quem* not only for the Gravettian occupation but also for the relocation of Gravettian material.

Three of the listed samples require some discussion. The charcoal sample with the laboratory number VERA-3937 was recovered from the base of a pit connected to the complex hearth feature at WA 2005-2015. It should therefore be attributed to WA-AH 4.4, i.e. phase III. Its determined age, however, is significantly too old and corresponds with phase I. This has been discussed previously, and it has been concluded that this sample should be regarded as an outlier (Einwögerer et al. 2009; Wild & Steier 2010). The assessment can be supported by the fact that the pit cuts the charcoal scatter of WA-AH 5 (Fig. 4: D) such that contamination cannot be excluded. The sample was, therefore, not considered for phase III. The other two charcoal samples that need to be discussed, VERA-3943 and VERA-3944, derive from HU-AH 3.7, the palaeosol layer with extensive calcified root remains. The ages are younger than those obtained for the stratigraphically equivalent evident structure hearth E (HU-AH 3.64) and the stratigraphically later hearth C (HU-AH 3.54). The two samples do not quite fit into the sequence constructed for HU 2000-2002 from calibrated ages (Neugebauer-Maresch & Stadler 2008). Considering that both evident and latent anthropogenic features are absent from HU-AH 3.7, an intrusion of the charcoals used for dating cannot be excluded. This is not unlikely despite an interpretation of HU-AH 3.7 as an *in situ* palaeosol. Bioturbation would be a potential explanation for intrusion. The according radiocarbon samples have therefore been excluded from phase I (Appendix, Tab. 2).

Results

The groups of radiocarbon ages for Gravettian contexts discussed above (Gravettian in total, occupation phases I-III, ash layers, and relocated contexts) were calibrated with the CalPal-2007-Hulu calibration curve and graphed with CalPal-Beyond the Ghost, Version 2016.2 (Weninger & Jöris 2008). The GICC05 timescale (Greenland Ice Core Chronology 2005, 15 - 42 ka; 20 yr $\delta^{18}O$, http://www.iceand-climate.nbi.ku.dk; given in calBP) was added to the multiple group graph to reference climate data (Andersen et al. 2006). In the resulting chronostratigraphic model, a clear chronological separation can be seen between the groups of phases II and III,

whereas the separation of phases I and II is not as distinct (Fig. 7). This is remarkable because it implies relatively rapid sedimentation between the two earlier phases of occupation. Also, the faunal spectra of the two phases are rather similar.

Highlighted in grey bars are potential phases for the relocation of archaeological material (A-C). The samples deriving from the group of relocated contexts can be subdivided (a-c) and chronologically attributed to these phases (a-c to A-C respectively).

Little relocation is observed after occupation phase I, which can be explained by a more stable surface due to pedogenesis and the occurrence of trees as evidenced by large amounts of calcified wood in the form of mainly roots, but also trunk parts and branches as documented at HU 2000-2002. Further uphill, at the WA sites, calcified wood is rare, but the sediment of the horizon with the embedded Early Gravettian contexts (WA-AH 5; WA East-AH 103/104) reflects similar pedogenic developments. In occupation phase II, calcified wood is still present, although in much lower quantity. The sediments do not show pedogenesis but instead consist of unaltered or only slightly altered aeolian loess. Large-scale relocation is highly probable after occupation phase II. This is supported by the small number of *in situ* contexts documented for this phase (only 3 isolated features at HU 2000-2002, but none upslope at the WA sites) in contrast to the relatively high number of dates produced from the layers with relocated finds from the entire Wachtberg area. In the Pavlovian contexts (phase III) the amount of calcified wood is considerably reduced to very few single specimens, although charcoal is abundantly present.

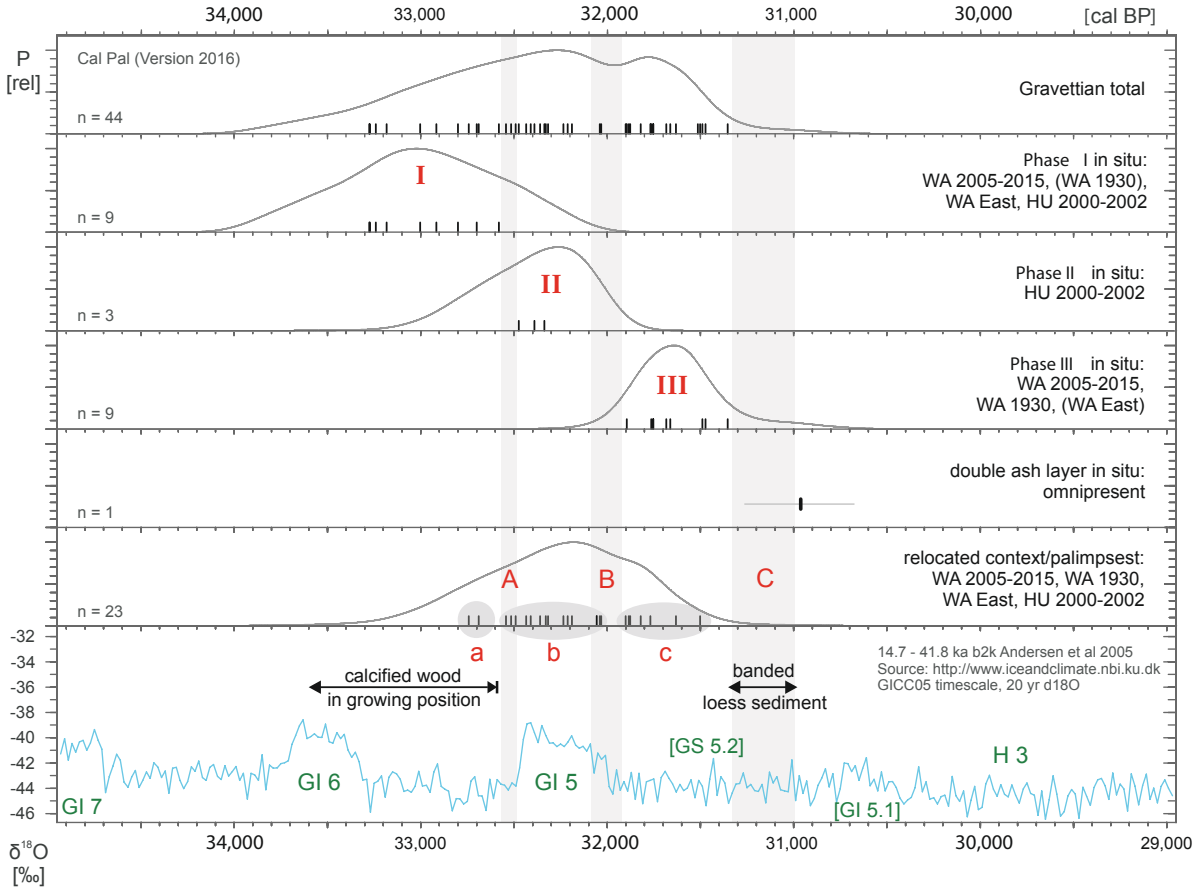

Fig. 7. Multigroup graph of calibrated ^{14}C dates (calBP) of Gravettian contexts of the Wachtberg area produced with CalPal-Beyond the Ghost, Version 2016.2, http://monrepos-rgzm.de/forschung/ausstattung.html#calpal (Weninger & Jöris 2008). The dates have been grouped according to stratigraphic and archaeological considerations. This led to the discrimination of three Gravettian occupation phases (I-III). Furthermore, the date of the omnipresent "double ash layer" (sample derives from WA-GH 25) has been plotted as it represents the *terminus ante quem* for not only the Gravettian occupation but also for the relocation of Gravettian material. Highlighted in grey bars are potential phases of relocation (A-C). The group of ^{14}C dates from relocated contexts or palimpsest find horizons can be chronologically subdivided and attributed to these phases (a-c to A-C, resp.).

Abb. 7. *Multigroup Grafik von kalibrierten ^{14}C Daten (calBP) der Gravettienfundstellen vom Wachtberg erstellt mit CalPal-Beyond the Ghost, Version 2016.2, http://monrepos-rgzm.de/forschung/ausstattung.html#calpal (Weninger & Jöris 2008). Die Daten wurden auf Grundlage ihres stratigrafischen und archäologischen Kontexts gruppiert. Dadurch konnten drei gravettienzeitlicher Besiedlungsphasen (I-III) differenziert werden. Dazu wurde das Datum des omnipräsenten "doppelten Aschenbands" (Probe stammt aus WA-GH 25) geplotted. Dies gibt den Terminus ante quem an für die gravettienzeitliche Besiedlung und die sedimentären Prozesse, die gravettienzeitliche Funde verlagert haben. Mit grauen Balken hervorgehoben sind potentielle Phasen der Verlagerung von Sedimenten und Funden (A-C). Die Gruppe der ^{14}C Daten aus verlagertem Kontext bzw. aus Palimpsesten kann chronologisch unterteilt und diesen Phasen zugeordnet werden (a-c entsprechend zu A-C).*

Post-Pavlovian relocation has been observed in detail for WA 2005-2015. Relocated, partly older, material had been deposited on top of the Pavlovian find contexts in a series of post-occupational sedimentary events (relocation phase C) triggered by periglacial and/or slope processes (Fig. 6). Indirectly, this is also documented by the absence of Pavlovian *in situ* contexts at the Hundssteig sites as opposed to the presence of samples producing chronologically according ages in layers with re-deposited finds. It must be emphasized, however, that this process – while destructive in some parts of the area – conserved the Pavlovian occupation horizons at the Wachtberg sites by deposition of a large quantity of sediment in a relatively short time. This provided cover and protection for finds and findings. In the entire Wachtberg area, as assessed by all excavations and numerous core samples, two thin layers of organic ash, spaced ca. 2 cm ("double ash layer"), mark the end not only of Gravettian occupation but also of post-occupational relocation of Gravettian material at around 31'000 calBP.

According to the CalPal-2007-Hulu calibration curve the Gravettian sequence of the Wachtberg area correlates with the climatic change from Greenland Interstadial (GI) 6 to 5, and, subsequently, in the Pavlovian (occupation phase III) and in course of post-occupational sedimentary processes, is explained by the oscillating and increasingly unfavourable conditions as approaching Heinrich event 3 in Greenland Stadial (GS) 5.1.

Discussion

In general, the radiocarbon ages for the Gravettian occupation in the Wachtberg area reflect the regional Mid-Upper Palaeolithic occupation pattern as compiled by Jöris et al. (2010) who used the same calibration curve. Hahn's (1972) observation that the Gravettian lithic inventories HU 1890-1893 and WA 1930 correspond tentatively to Willendorf II/5 and Willendorf II/6 respectively, is well within the realm of possibility from a chronological point of view when comparing the radiocarbon ages (Haesarts et al. 1996). Unfortunately, unlike the HU 1890-1893 assemblage, the stratified contexts of occupation phase I at Wachtberg do not provide enough diagnostic material to allow for a comparison with Willendorf II/5. Stratigraphically, however, there are evident similarities: Willendorf II/5 is connected to sediment subunit C2 which is described as a "brownish humiferous" horizon. Above it, C1 is referred to as a light grey horizon, and B4, the subunit connected to Willendorf II/6, as yellow loess with thin lengthy pale grey lenses, sketched as bands (Haesarts et al. 1996). Unit C beneath C2 is characterized by a sequence of loess, humic, and gleyic horizons, whereas unit B is dominated by loess. This is similar to, although not quite congruent with, the Wachtberg stratigraphy at HU 2000-2002 (Peticzka 2008), WA 2005-2015 (Händel et al. 2009b; Terhorst et al. 2014), and WA East (Meyer-Heintze et al. 2017).

The Gravettian chronology of the Wachtberg sites also compares well to the sites clustered at the Pavlov Hills in Moravia (Czech Republic) where very early Gravettian dates have recently been published in addition to the well-known Pavlovian ages for both Dolní Věstonice IIa (Svoboda et al. 2015) and Pavlov I (Svoboda et al. 2016). The samples derive from layers that contain Gravettian artefacts. Their ages fall within the chronology for occupation phase I at Krems. At Pavlov I the earliest Gravettian is situated on top of a palaeosol. The soil itself, however, contained charcoal associated with lithic artefacts (undiagnostic but raw material different from Gravettian), which provided older dates not far beneath the earliest Gravettian layer. Similar polygenetic palaeosols have been documented at Dolní Věstonice (Antoine et al. 2013) and further south when regarding the Stillfried B palaeosol (Peticzka et al. 2010).

Whether the Gravettian occupation phases in the Wachtberg area can be correlated to the GICC05 timescale as presented in figure 7, is dependent upon whether the CalPal-2007-Hulu calibration curve is accepted or not. The stratigraphic context, however, suggests either this model, or else a comparable chronostratigraphic model with a similar correlation between occupation phases and a comparable stadial-interstadial succession. Hambach (2010) and Terhorst et al. (2014) suggested placing the Pavlovian occupation horizon WA-AH 4.4/4.3 into GI 5-6. The weighted mean age of 33.9 ± 2.3 ka determined by various thermoluminescence dating methods of the baked loess beneath the large hearth (Zöller et al. 2014) supports placing the occupation into GI 6. In contrast, Meyer-Heintze et al. (2017) rely on the IntCal 13 calibration curve (Reimer et al. 2014) together with OSL dates, and therefore suggest placing the same horizon into GI 5.1, which dates to between 30'800 and 30'600 b2k (Rasmussen et al. 2014). The OSL dates, however, feature comparatively broader ranges and the age sequence exhibits an inversion in the decisive part of the profile (Meyer-Heintze et al. 2017). The OSL age sequence at WA 2005-2015 shows a gap between the palaeosol and the overlying loess, i.e. between WA-AH 5 and WA-AH 4. The authors have interpreted this gap as induced by erosion (Lomax et al. 2014). Sediment stratigraphy, field observations, and radiocarbon dates cannot confirm this interpretation. At present, neither of these chronostratigraphic options can be entirely excluded. It does, however, not seem convincing to place WA-AH 4.4/4.3 into a fully developed interstadial because the Pavlovian occupation phase III is not connected to pronounced pedogenic features. At the most, only very incipient pedogenic processes can be attributed to the banded sediment sequence connected to WA-AH 4.4/4.3 and

the series of re-location events WA-AH 4.11/4.01-4.22 (Terhorst et al. 2014). Bioturbation of invertebrates in the occupation layer as indicated in micromorphology samples can also be explained by the local, post-occupational and short-term development of an anthrosol induced by the high concentration of organic waste (Schilt et al. 2017). On the other hand, WA-AH 4.4/4.3 unquestionably features high amounts of charcoal. Pryor et al. (2016) place the Pavlovian occupation in the Pavlov Hills area in GS 5, or more precisely GS 5.2, following the definition by Rasmussen et al. (2014). This corresponds more or less to the chronostratigraphic model presented here. The authors provide substantial data to support their claim that sufficient firewood available in the surrounding landscape despite prevailing stadial conditions (Pryor et al. 2016). Local depletion of firewood could however be considered a potential explanation for why Pavlovian occupation ceased in the Wachtberg area while Gravettian hunter-gatherer groups continued frequenting other localities in the region as evidenced e.g. at Willendorf II or the Pavlov Hills. This is supported by the multiple post-occupational re-deposition events which suggest a lack of a sufficiently vegetated and therefore stabilized surface.

These re-deposition events have been responsible for rapid sedimentation and conservation of the *in situ* contexts of phase III. Aeolian sedimentation by itself is a comparatively slow process. As shown above, accumulation of aeolian loess occurred between phases I and III. This provided the sediment reservoir for the post-occupational re-deposition processes. A picture of the local slope processes' potential for sedimentation is drawn by the increasing thickness of the Gravettian sequences as moving downhill (Fig. 5). Preservation of phase II contexts, as well as of organic materials from the layers with relocated finds, was most likely caused by the same variables. In contrast, phase I provides only a very small amount of faunal hard tissue remains, most probably due to low sedimentation rates and unfavourable soil chemistry in a forested environment. The palaeosol connected to phase I proved to be stable enough to prevent contamination of the Gravettian layers with earlier material. With the exception of the Dufour bladelets' presence in the WA 1930 inventory, which can be explained by post-recovery intermixture with EUP material from HU 1893-1904 in the storeroom, no other case of comparable contamination has been observed. At the same time, the occupation hiatus after phase III lasted into the Holocene and prevented, together with continuous loess sedimentation, an intrusion of younger material into the Gravettian find layers. This is reflected by the stratigraphy and chronometric data of all investigated sites in the Wachtberg area.

Acknowledgements: I would like to thank Christine Neugebauer-Maresch for her unwavering support since introducing me to the investigation of the Krems sites in 2002. Furthermore, I am grateful to William Davies for permission to use two hitherto unpublished radiocarbon dates. Last but not least, I would like to thank the Quartär team and two anonymous reviewers for valuable suggestions and discussion.

Context/Layer	Assessment	Pedogenesis	Evident anthropogenic structures	^{14}C dates	Lithics	Fauna	Colour materials	Adornments	Art	Human remains	Main synoptic references
HU 1890-1893	collection biased by selection; lithics show high integrity	no data	unclear (possibly a hearth - 30 % lithics show fire influence; 1 charcoal Pinus)	no	yes	yes (very few)	no	no	no	no (6 long bones; none Palaeolithic)	Hahn 1972
WA 1930	*in situ* structures; stratigraphically mixed material; selection probably biased; stratigraphy like WA 2005-2015 and WA East	no data, but probably not	hearth, pits, ditch?	yes	yes	yes	yes	17 serpulides	2 ceramic zoomorphic figurines, 1 ceramic object	no	Einwögerer 2000; Fladerer 2001
HU 2000-2002											Neugebauer-Maresch 2008a
HU-AH 3.1/3.23/3.24	find layers with re-deposited material	no	no	yes	yes	yes	yes	no	no	no	
HU-AH 3.21	partly *in situ*; hearth B with surrounding find scatter (surrounding finds presumably re-deposited)	no	hearth	yes	yes	yes	yes	no	no	no	
HU-AH 3.22	partly *in situ*; hearth D with surrounding find scatter	no	hearth	yes	yes	yes	yes	no	no	no	
HU-AH 3.34	find layer with re-deposited material	no	no	yes	yes	yes	no	no	no	no	
HU-AH 3.43	*in situ*; burnt log with surrounding find scatter	no	no	yes	yes	yes	no	no	no	no	
HU-AH 3.44	find layer with re-deposited material	no	no	yes	yes	yes	no	no	no	no	
HU-AH 3.51	*in situ*; hearth A with surrounding find scatter	(yes)	hearth	yes	yes	yes	yes	no	no	no	
HU-AH 3.54	*in situ*; hearth C with surrounding find scatter	(yes)	hearth	yes	yes	yes	yes	no	no	no	
HU-AH 3.64	unsure: *in situ* but heavily eroded; hearth E	yes	hearth	yes	yes	no	no	no	no	no	
HU-AH 3.7	unsure: palaeosol with significant amounts of calcified wood remains; many roots	yes	no	yes	no	yes	no	no	no	no	

Appendix, Tab. 1. continued next page.

Appendix, Tab. 1. *Fortsetzung nächste Seite.*

Context/Layer	Assessment	Pedogenesis	Evident anthropogenic structures	^{14}C dates	Lithics	Fauna	Colour materials	Adornments	Art	Human remains	Main synoptic references
WA 2005-2015											Händel et al. 2009a; Simon et al. 2014
WA-AH 4.11/4.01-4.22	find layers with re-deposited material; palimpsest of different occupations (WA-AH 4.4 and earlier)	no	no	yes	yes	yes	yes	5 serpulides, 9 ivory pins, 3 pierced animal teeth, 1 pierced mollusk	11 formed ceramic objects, 3 painted bone and ivory objects	yes (1 rib, adolescent)	
WA-AH 4.4/4.3	*in situ*; occupation surface (living floor)	no	hearths, pits, burials, postholes	yes	yes	yes	yes	2 serpulides, 6 ivory pins, 6 pierced animal teeth, 3 pierced mollusks, 53 ivory beads	1 ceramic zoomorphic figurine, 3 formed ceramic objects, 1 ivory fragment with incised herringbone pattern	yes (3 infants)	
WA-AH 5	*in situ*; concentric charcoal scatter (= latent anthropogenic structure); calcified traces	yes	no	yes	yes	yes	no	no	no	no	
WA East											Einwögerer et al. 2015
WA East-AH 101	find layer with re-deposited material	no	no	yes	yes	yes	yes	no	no	no	
WA East-AH 102	unclear; layer looks disturbed but stratigraphic position corresponds to WA-AH 4.4	no	no	yes	yes	yes	yes	no	no	no	
WA East-AH 103/104	palaeosol with few calcified wood remains, ashy patches, heavily disturbed combustion feature	yes	(yes)	yes	yes	yes	yes	no	no	no	

Appendix, Tab. 1. Compilation and assessment of Gravettian contexts and/or layers documented at the sites of the Wachtberg area.
Appendix, Tab. 1. *Zusammenstellung und Bewertung der Gravettienschichten und -fundzusammenhänge des Wachtberggebiets.*

Phase	Context	Labnumber	Field ID	Material	^{14}C age BP	STD	CalAge P(68 %) cal BP	cal STD	Reference	Comment
EUP	HU-AH 5.11	VERA-3516	ID 301001	charcoal	41'000	1'300	44'504	1'098	Neugebauer-Maresch 2008a	core sampling
EUP	HU 1893-1904	KN-654	old collection	charcoal	35'500	2'000	39'532	2'147	Hahn 1977	unknown
EUP	HU-AH 4.21	VERA-2289	ID 232001	charcoal	32'810	450	37'157	848	Neugebauer-Maresch 2008a	sounding
EUP	HU-AH 4.14	VERA-1616	ID 9003	charcoal	30'750	290	34'857	319	Neugebauer-Maresch 2003	sounding
Gravettian - Phase I	HU-AH 3.51	VERA-2292	ID 60001	charcoal	28'780	270	33'273	368	Neugebauer-Maresch 2008a	*in situ* (hearth A)
Gravettian - Phase I	HU-AH 3.51	VERA-2293	ID 63012	charcoal	28'550	250	33'003	353	Neugebauer-Maresch 2008a	*in situ* (hearth A)
Gravettian - Phase I	HU-AH 3.54	VERA-3282	ID 121027	charcoal	28'250	280	32'699	337	Neugebauer-Maresch 2008a	*in situ* (hearth C)
Gravettian - Phase I	HU-AH 3.64	VERA-3283	ID 188007	charcoal	28'360	280	32'800	351	Neugebauer-Maresch 2008a	*in situ* (hearth E)
Gravettian - Phase I	HU-AH 3.64	VERA-3912	ID 188007	charcoal	28'110	270	32'581	316	Neugebauer-Maresch 2008a	*in situ* (hearth E)
Gravettian - Phase I	WA-AH 5	VERA-3939	ID 22156	charcoal	28'750	270	33'241	371	Einwögerer et al. 2009	*in situ*
Gravettian - Phase I	WA-AH 5	VERA-3940	ID 22191	charcoal	28'470	280	32'915	368	Einwögerer et al. 2009	*in situ*
Gravettian - Phase I	WA-AH 5	VERA-4535	ID 64186	charcoal	28'700	290	33'183	392	Einwögerer et al. 2009	*in situ*
Gravettian - Phase I	WA East-AH 104	POZ-51492	ID 1687	charcoal	28'780	260	33'275	360	Einwögerer et al. 2014	*in situ*
Gravettian - Phase II	HU-AH 3.21	VERA-3281	ID 225018	charcoal	27'970	270	32'474	304	Neugebauer-Maresch 2008a	*in situ* (hearth B)
Gravettian - Phase II	HU-AH 3.22	VERA-3279	ID 446001	charcoal	27'800	250	32'336	269	Neugebauer-Maresch 2008a	*in situ* (hearth D)
Gravettian - Phase II	HU-AH 3.43	VERA-3513	ID 413005	charcoal	27'860	270	32'390	290	Neugebauer-Maresch 2008a	*in situ* (burnt log)
Gravettian - Phase III	WA-AH 4.4	VERA-3935	ID 19771	charcoal	27'220	230	31'895	160	Einwögerer et al. 2009	*in situ*
Gravettian - Phase III	WA-AH 4.4	VERA-3938	ID 22056	charcoal	27'000	220	31'764	142	Einwögerer et al. 2009	*in situ*
Gravettian - Phase III	WA-AH 4.4	VERA-4536	ID 71968	charcoal	26'980	210	31'753	137	Einwögerer et al. 2009	*in situ*
Gravettian - Phase III	WA-AH 4.4	VERA-3941	ID 23775	charcoal	26'870	220	31'682	151	Einwögerer et al. 2009	*in situ*
Gravettian - Phase III	WA-AH 4.4	VERA-4532	ID 33435	charcoal	26'840	220	31'662	155	Einwögerer et al. 2009	*in situ*
Gravettian - Phase III	WA-AH 4.4	POZ-12920	ID 9105	charcoal	26'580	160	31'473	178	Einwögerer et al. 2006	*in situ*
Gravettian - Phase III	WA-AH 4.3	VERA-3819	ID 18075	charcoal	26'520	210	31'354	266	Einwögerer et al. 2009	*in situ* (burial 1)
Gravettian - Phase III	WA-AH 4.3	OxA-18529	ID 15940.99	bone; mammoth scapula	26'980	210	31'753	137	W. Davies unpubl. data	*in situ* (cover of burial 1)
Gravettian - Phase III	WA East-AH 102	POZ-51491	ID 1315	charcoal	26'660	210	31'514	195	Einwögerer et al. 2014	(*in situ*)
Post-occupational	WA-GH25	VERA-4538	ID 100362	charcoal	26'050	200	30'962	313	Einwögerer et al. 2009	double ash layer; steppe fire

Appendix, Tab. 2. continued next page.

Appendix, Tab. 2. *Fortsetzung nächste Seite.*

Phase	Context	Labnumber	Field ID	Material	^{14}C age BP	STD	CalAge P(68 %) cal BP	cal STD	Reference	Comment
Gravettian unspec.	HU 1893-1904	VERA-670	old collection	charcoal	27'000	150	31'768	110	Neugebauer-Maresch 2008a	unknown
Gravettian unspec.	WA 1930	GrN-3011	old collection	charcoal	27'400	300	32'039	227	Vogel & Zagwijn 1967	unsure
Gravettian unspec.	WA 1930	Groningen	old collection	charcoal	27'910	510	32'515	460	Heinrich 1973	unsure
Gravettian unspec.	WA 1930	VERA-669	old collection	charcoal	27'700	200	32'234	217	Einwögerer 2000	unsure
Gravettian unspec.	WA 1930	VERA-671	old collection	charcoal	27'100	170	31'821	118	Einwögerer 2000	unsure
Gravettian unspec.	HU-AH 3.21	VERA-2291	ID 46008	charcoal	27'200	240	31'884	165	Neugebauer-Maresch 2008a	re-deposited
Gravettian unspec.	HU-AH 3.21	VERA-3280	ID 27005	charcoal	27'640	260	32'212	246	Neugebauer-Maresch 2008a	re-deposited
Gravettian unspec.	HU-AH 3.24	VERA-1615	ID 14017	charcoal	27'940	210	32'434	266	Neugebauer-Maresch 2003	re-deposited
Gravettian unspec.	HU-AH 3.24	OxA-18525	ID 177020	bone; mammoth vertrebra	26'600	150	31'502	159	W. Davies unpubl. data	re-deposited
Gravettian unspec.	HU-AH 3.44	VERA-3514	ID 235002	charcoal	28'070	240	32'543	295	Neugebauer-Maresch 2008a	re-deposited
Gravettian unspec.	HU-AH 3.44	VERA-3515	ID 261001	charcoal	27'630	230	32'190	223	Neugebauer-Maresch 2008a	re-deposited
Gravettian unspec.	HU-AH 3.44	VERA-3910	ID 239003	charcoal	27'820	270	32'360	285	Neugebauer-Maresch 2008a	re-deposited
Gravettian unspec.	HU-AH 3.73	VERA-3944	ID 436001	charcoal	27'900	230	32'409	273	Neugebauer-Maresch 2008a	disturbance?
Gravettian unspec.	HU-AH 3.74	VERA-3943	ID 369003	charcoal	27'790	250	32'329	268	Neugebauer-Maresch 2008a	disturbance?
Gravettian unspec.	WA-AH 4.11	VERA-3932	ID 8886	charcoal	28'300	270	32'742	336	Einwögerer et al. 2009	re-deposited
Gravettian unspec.	WA-AH 4.11	VERA-3933	ID 17176	charcoal	27'420	240	32'031	188	Einwögerer et al. 2009	re-deposited
Gravettian unspec.	WA-AH 4.11	VERA-3934	ID 17775	charcoal	27'190	230	31'877	159	Einwögerer et al. 2009	re-deposited
Gravettian unspec.	WA-AH 4.11	VERA-4533	ID 39440	charcoal	27'230	230	31'901	161	Einwögerer et al. 2009	re-deposited
Gravettian unspec.	WA-AH 4.11	VERA-4534	ID 40983	charcoal	28'000	250	32'491	295	Einwögerer et al. 2009	re-deposited
Gravettian unspec.	WA-AH 4.11	VERA-5196	ID 10913	bone; brown bear phalanx	26'800	220	31'632	162	Simon et al. 2014	re-deposited
Gravettian unspec.	WA-AH 4	VERA-1767	RKS-B7/1a (later re-named RKS-M7)	charcoal	27'470	200	32'054	172	Ziehaus 2007 (but it's not from Museum Krems)	core sampling
Gravettian unspec.	WA-AH 4.4	VERA-3937	ID 21423	charcoal	28'240	270	32'688	329	Einwögerer et al. 2009	presumably intrusion from WA-AH 5
Gravettian unspec.	WA East-AH 101	POZ-51490	ID 1073	charcoal	27'780	240	32'317	260	Einwögerer et al. 2014	re-deposited

Appendix, Tab. 2. Radiocarbon dates of the Krems-Wachtberg and Krems-Hundssteig sites sorted according to occupation phases and archaeological context. The ages are given with 1 sigma deviations. The dates were calibrated with CalPal-Beyond the Ghost, Version 2016.2, http://monrepos-rgzm.de/forschung/ausstattung.html#calpal applying the CalPal-2007-Hulu calibration curve (Weninger & Jöris 2008).

Appendix, Tab. 2. *Radiokarbondaten der Krems-Wachtberg und Krems-Hundssteig Fundstellen gelistet nach Phase und archäologischem Kontext. Für die Alter sind 1-Sigma Abweichungen angegeben. Die Daten wurden mit CalPal-Beyond the Ghost, Version 2016.2, http://monrepos-rgzm.de/forschung/ausstattung.html#calpal unter Verwendung der CalPal-2007-Hulu-Kurve kalibriert (Weninger & Jöris 2008).*

		n	*Mammuthus primigenius*	*cf. Coelodonta antiquitatis*	*Equus sp.*	*Cervus elaphus*	*Rangifer tarandus*	*Ovibos moschatus*	*Capra ibex*	*Ursus arctos*	*Canis lupus*	*Vulpes vulpes/V. lagopus*	*Gulo gulo*	*cf. Mustela sp.*	*Castor fiber*	*Lepus timidus*	*Spermophilus sp.*	*Cricetus cricetus*	*Arvicola sp.*	*Microtus sp.*	*Aves spec. div.*	*Tetrao urogallus*	*Lagopus cf. Lagopus*	*Turdus cf. philomelos*	*Branta cf. bernicla*	Reference
Phase I	**WA-AH 5/GH 28**	96	9	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Händel et al. 2014; Austrian Quaternary Sites, unpub. Data
	WA East-AH 103/104	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Austrian Quaternary Sites, unpub. data
	HU-AH 3.51 (hearth A)	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Fladerer & Salcher-Jedrasiak 2008; 2010; Neugebauer-Maresch 2008a (database supplement)
	HU-AH 3.54 (hearth C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Fladerer & Salcher-Jedrasiak 2008; 2010; Neugebauer-Maresch 2008a (database supplement)
	HU-AH 3.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Fladerer & Salcher-Jedrasiak 2008; 2010; Neugebauer-Maresch 2008a (database supplement)
Phase II	**HU-AH 3.21 (hearth B)**	204	129	9	1	0	10	0	0	0	1	1	0	0	0	2	0	0	1	0	0	0	0	0	0	Fladerer & Salcher-Jedrasiak 2008; 2010; Neugebauer-Maresch 2008a (database supplement)
	HU-AH 3.22 (hearth D)	81	49	2	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Fladerer & Salcher-Jedrasiak 2008; 2010; Neugebauer-Maresch 2008a (database supplement)
	HU-AH 3.43	8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	Fladerer & Salcher-Jedrasiak 2008; 2010; Neugebauer-Maresch 2008a (database supplement)

Appendix, Tab. 3. continued next page.

Appendix, Tab. 3. *Fortsetzung nächste Seite.*

		n	Mammuthus primigenius	cf. Coelodonta antiquitatis	Equus sp.	Cervus elaphus	Rangifer tarandus	Ovibos moschatus	Capra ibex	Ursus arctos	Canis lupus	Vulpes vulpes/V. lagopus	Gulo gulo	cf. Mustela sp.	Castor fiber	Lepus timidus	Spermophilus sp.	Cricetus cricetus	Arvicola sp.	Microtus sp.	Aves spec. div.	Tetrao urogallus	Lagopus cf. Lagopus	Turdus cf. philomelos	Branta cf. bernicla	Reference
Phase III	WA-AH4.4/4.3	13'301	3'478	2	929	0	465	0	43	11	65	56	4	4	0	51	1	1	1	3	36	1	0	0	0	Fladerer et al. 2014; Händel et al. 2015
	WA East-AH102	71	45	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Austrian Quaternary Sites, unpub. data
mixed/ re-deposited	WA 1930	292	111	0	0	2	7	2	5	0	49	22	21	0	0	0	0	0	0	0	0	0	0	0	0	Fladerer 2001; 2003
	WA-AH 4.11	21'055	6'296	6	585	4	335	0	307	124	378	375	32	14	0	130	34	5	1	12	47	0	2	0	0	Fladerer et al. 2014; Händel et al. 2015
	WA East-AH 101	128	75	0	4	0	0	0	3	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	Austrian Quaternary Sites, unpub. data
	HU-AH 3.1/3.23/3.24	1'480	1'241	4	6	1	34	0	1	0	8	0	0	0	1	3	1	0	1	6	0	0	0	0	0	Fladerer & Salcher-Jedrasiak 2008; 2010; Neugebauer-Maresch 2008a (database supplement)
	HU-AH 3.34	26	7	1	0	0	11	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	Fladerer & Salcher-Jedrasiak 2008; 2010; Neugebauer-Maresch 2008a (database supplement)
	HU-AH 3.44	44	7	2	2	1	13	0	0	0	0	2	0	0	0	5	1	0	0	0	0	0	3	0	0	Fladerer & Salcher-Jedrasiak 2008; 2010; Neugebauer-Maresch 2008a (database supplement)
	HU-AH 3.7	8	1	0	0	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	Fladerer & Salcher-Jedrasiak 2008; 2010; Neugebauer-Maresch 2008a (database supplement)
	Total	**36'800**	**11'451**	**26**	**1'531**	**12**	**880**	**2**	**362**	**135**	**503**	**458**	**57**	**18**	**1**	**193**	**37**	**6**	**4**	**22**	**83**	**1**	**5**	**1**	**1**	

Appendix, Tab. 3. Faunal remains (NISP) of the Gravettian inventories of the Wachtberg area listed by occupation phases and archaeological contexts.
Appendix, Tab. 3. *Faunareste (NISP) der Gravettieninventare des Wachtberggebiets sortiert nach Besiedlungsphasen und archäologischem Kontext.*

Context	MNI total	*Mammuthus primigenius*	*cf. Coelodonta antiquitatis*	*Equus sp.*	*Cervus elaphus*	*Rangifer tarandus*	*Ovibos moschatus*	*Capra ibex*	*Ursus arctos*	*Canis lupus*	*Vulpes vulpes/V. lagopus*	*Gulo gulo*	*cf. Mustela sp.*	*Castor fiber*	*Lepus timidus*	*Spermophilus sp.*	*Cricetus cricetus*	*Arvicola sp.*	*Microtus sp.*	*Tetrao urogallus*	*Lagopus cf. Lagopus*	*Turdus cf. philomelos*	*Branta cf. bernicla*	Reference
WA-AH4.4/4.3	**22**	2	1	2	0	2	0	1	1	1	3	1	1	0	2	1	1	1	1	1	0	0	0	Händel et al. 2015
WA-AH 4.11	**43**	2	1	2	1	2	0	10	2	5	6	1	1	0	3	3	1	1	1	0	1	0	0	Händel et al. 2015
WA 1930	**28**	8	0	0	1	2	1	2	0	6	5	3	0	0	0	0	0	0	0	0	0	0	0	Fladerer 2001
HU-AH 3.21/3.22/3.23/3.24)	**36**	7	2	2	3	4	0	1	0	3	1	0	0	1	2	1	1	2	6	0	0	0	0	Fladerer & Salcher-Jedrasiak 2008; Neugebauer-Maresch 2008a (database supplement)
HU-AH 3.34/3.43/3.44	**21**	2	1	2	1	3	0	0	0	0	1	0	1	0	2	1	0	0	1	2	3	0	1	Fladerer & Salcher-Jedrasiak 2008; Neugebauer-Maresch 2008a (database supplement)
HU-AH 3.7	**5**	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	Fladerer & Salcher-Jedrasiak 2008; Neugebauer-Maresch 2008a (database supplement)
Total	**155**	**22**	**5**	**8**	**7**	**14**	**1**	**15**	**3**	**15**	**16**	**5**	**3**	**1**	**9**	**6**	**3**	**4**	**9**	**3**	**4**	**1**	**1**	

Appendix, Tab. 4. Faunal remains (MNI) of the Gravettian inventories of the Wachtberg area listed by archaeological context. MNI has only been determined for selected inventories.

Appendix, Tab. 4. *Faunareste (MNI) der Gravettieninventare des Wachtberggebiets sortiert nach archäologischem Kontext. MNI wurde nur für ausgewählte Inventare ermittelt.*

		n > = 1 cm	modified	endscraper	burin	backed points	point	microgravette	microdenticulate	microlith	backed bladelet	backed blade	backed denticulated blade	pointed blade	truncation	retouched pieces	notched piece	combination tool	splintered piece	discard	scraper	Dufour bladelets	Reference
Phase I	WA-AH 5	4	**1**	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	Thomas et al. 2016 (n updated)
	WA East-AH 103/104	2	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Austrian Quaternary Sites, unpub. data
	HU-AH 3.51 (hearth A)	676	**11**	2	0	0	0	0	0	0	1	0	0	0	1	7	0	0	0	0	0	0	Einwögerer & Simon 2008
	HU-AH 3.54 (hearth C)	100	**1**	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	Einwögerer & Simon 2008
	HU-AH 3.64 (hearth E)	1	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Einwögerer & Simon 2008
Phase II	HU-AH 3.21 (hearth B)	146	**3**	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	Einwögerer & Simon 2008
	HU-AH 3.22 (hearth D)	411	**8**	5	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	Einwögerer & Simon 2008
	HU-AH 3.43	8	**1**	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	Einwögerer & Simon 2008
Phase III	WA-AH 4.4/4.3	8'881	**115**	14	11	1	1	6	5	4	29	0	0	0	8	26	3	3	1	3	0	0	Thomas et al. 2016 (n updated)
	WA East-AH 102	62	**2**	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	Austrian Quaternary Sites, unpub. data
mixed/re-deposited	WA 1930	1'582	**133**	4	10	1	0	11	2	0	12	0	0	0	10	65	6	0	0	0	1	11	Einwögerer 2000
	WA-AH 4.11/4.01-4.22	32'941	**668**	46	103	12	6	24	22	9	107	0	0	4	65	236	12	8	4	10	0	0	Thomas et al. 2016 (n updated)
	WA East-AH 101	121	**4**	0	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	Austrian Quaternary Sites, unpub. data
	HU-AH 3.1/3.23/3.24	31	**1**	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	Einwögerer & Simon 2008
	HU-AH 3.34	4	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Einwögerer & Simon 2008
unknown	HU 1890-1893	259	**49**	0	4	2	1	11	0	0	19	2	0	1	3	2	0	0	0	4	0	0	Hahn 1972
	Total	**45'229**	**997**	**72**	**131**	**17**	**8**	**52**	**29**	**13**	**170**	**2**	**1**	**5**	**87**	**343**	**22**	**11**	**5**	**17**	**1**	**11**	

Appendix, Tab. 5. Chipped stone artefacts of the Gravettian inventories of the Wachtberg area listed by occupation phases and archaeological contexts. Listed are the sum of artefacts ≥ 1 cm, the sum of modified pieces, and tool types.

Appendix, Tab. 5. *Silexartefakte der Gravettieninventare des Wachtberggebiets sortiert nach Besiedlungsphasen und archäologischem Kontext. Aufgeführt sind die Summen der Artefakte ≥ 1 cm, die Summen der modifizierten Stücke sowie die Werkzeugtypen.*

Literature cited

Andersen, K. K., Svensson, A., Johnsen, S. J., Rasmussen, S. O., Bigler, M., Rothlisberger, R., Ruth, U., Siggaard-Andersen, M. L., Steffensen, J. P., Dahl- Jensen, D., Vinther, B. M. & Clausen, H. B. (2006). The Greenland ice core chronology 2005, 15-42 ka. Part 1: constructing the time scale. *Quaternary Science Reviews* 25: 3246-3257.

Antoine, P., Rousseau, D.-D., Degeai, J.-P., Moine, O., Lagroic, F., Kreutzer, S., Fuchs, M., Hatté, C., Gauthier, C., Svoboda, J. & Lisá, L. (2013). High-resolution record of the environmental response to climatic variations during the Last Interglacial–Glacial cycle in Central Europe: the loess-palaeosol sequence of Dolní Věstonice (Czech Republic). *Quaternary Science Reviews* 67:17-38.

Bertran, P., Klaric, L., Lenoble, A., Masson, B. & Vallin, L. (2010). The impact of periglacial processes on Palaeolithic sites: the case of sorted patterned grounds. *Quaternary International* 214: 17-29.

Brandl, M., Hauzenberger, C., Postl, W., Martinez, M. M., Filzmoser, P. & Trnka, G. (2014). Radiolarite studies at Krems-Wachtberg (Lower Austria): Northern Alpine versus Carpathian lithic resources. *Quaternary International* 351: 146-162.

Broglio, A. & Laplace, G. (1966). Études de typologies analytique des complexes leptolithiques de l'Europe centrale, I. Les complexes aurignacoïdes de la Basse Autriche. *Revista di Scienze Preistoriche* 21: 61-121.

Cichocki, O. (2008). Analyse der Holzreste der Paläolithgrabung Krems-Hundssteig 2000-2002. *In*: Neugebauer-Maresch, C. (Ed.) *Krems-Hundssteig – Mammutjägerlager der Eiszeit. Ein Nutzungsareal paläolithischer Jäger- und Sammler(-innen) vor 41.000-27.000 Jahren*. Mitteilungen der Prähistorischen Kommission Vol. 67, Vienna, 158-167.

Cichocki, O., Knibbe, B. & Tillich, I. (2014). Archaeological significance of the Palaeolithic charcoal assemblage from Krems-Wachtberg. *Quaternary International* 351: 163-171.

Einwögerer, T. (2000). *Die jungpaläolithische Station auf dem Wachtberg in Krems, NÖ. Eine Rekonstruktion und wissenschaftliche Darlegung der Grabung von J. Bayer aus dem Jahre 1930*. Mitteilungen der Prähistorischen Kommission 34, Wien 2000.

Einwögerer, T., Friesinger, H., Händel, M., Neugebauer-Maresch, C., Simon, U. & Teschler-Nicola, M. (2006). Upper Palaeolithic infant burials. Decorations on the bodies of newborns indicate that they were probably important in their community. *Nature* 444: 285.

Einwögerer, T. & Simon, U. (2008). Die Steingeräte der Ausgrabung Krems-Hundssteig 2000-2002. *In*: Neugebauer-Maresch, C. (Ed.) *Krems-Hundssteig – Mammutjägerlager der Eiszeit. Ein Nutzungsareal paläolithischer Jäger- und Sammler(- innen) vor 41.000- 27.000 Jahren*. Mitteilungen der Prähistorischen Kommission Vol. 67, Vienna, 177-215.

Einwögerer, T., Händel, M., Neugebauer-Maresch, C., Simon, U., Steier, P., Teschler-Nicola, M. & Wild, E. M. (2009). ^{14}C Dating of the Upper Palaeolithic site at Krems-Wachtberg, Austria. *Radiocarbon* 51(2): 847-855.

Einwögerer, T., Händel, M., Simon, U. & Neugebauer-Maresch, C. (2014). Upper Palaeolithic occupation in the Wachtberg area of Krems: The evidence of surveys, sections and core samples. *Quaternary International* 351: 50-66.

Einwögerer, T., Händel, M. & Simon, U. (2015). Krems-Wachtberg East – A new find spot in the Gravettian site cluster of Krems (Austria). *In*: Sázelova, S., Novák, M. & Mizerová, A. (Eds.): *Forgotten times and spaces: New perspectives in paleoanthropological, paleoetnological and archeological studies*. Institute of Archeology of the Czech Academy of Sciences. Masaryk University, Brno, 1st Edition, 161-168.

Fladerer, F. A. (2001). *Die Faunareste von Krems-Wachtberg, Ausgrabung 1930. Jagdwild und Tierkörpernutzung an der Donau vor 27.000 Jahren*. Mitteilungen der Prähistorischen Kommission 39, Vienna.

Fladerer, F. A. (2003). A calf-dominated mammoth age profile from the 27 kyBP stadial Krems-Wachtberg site in the middle Danube valley. *In*: Reumer, J.W.F., De Vos, J. & Mol, D. (Eds.) *Advances in mammoth research*. Proceedings of the Second International Mammoth Conference, Rotterdam, May 16-20 1999, DEINSEA 9, 135-158.

Fladerer, F. A. & Salcher-Jedrasiak, T. (2008). Krems-Hundssteig 2000-2002: Archäozoologische und taphonomische Untersuchungen (mit Beiträgen von E. Bauernfeind, M. Händel, G. Rabeder und L. Steguweit). *In*: Neugebauer-Maresch, C. (Ed.) *Krems-Hundssteig – Mammutjägerlager der Eiszeit. Ein Nutzungsareal paläolithischer Jäger- und Sammler(-innen) vor 41.000- 27.000 Jahren*. Mitteilungen der Prähistorischen Kommission 67, Vienna, 216-312.

Fladerer, F. A. & Salcher-Jedrasiak, T. (2010). Animal facts and human decisions, 27 ka ago: The Krems-Hundssteig 2000-2002 camp periphery. *In*: Neugebauer-Maresch, C. & Owen, L. (Eds.) *New aspects of the Central and Eastern European Upper Palaeolithic-methods, chronology, technology and subsistence*. Mitteilungen der Prähistorischen Kommission 72, Vienna, 163-181.

Fladerer, F. A., Salcher-Jedrasiak, T. A. & Händel, M. (2014). Hearth-side bone assemblages within the 27 ka BP Krems-Wachtberg settlement: Fired ribs and the mammoth bone-grease hypothesis. *Quaternary International* 351: 115-133.

Frank, C. (2008). Die Mollusken (Gastropoda terrestria) des Hauptprofils R-W84. *In*: Neugebauer-Maresch, C. (Ed.) *Krems-Hundssteig – Mammutjägerlager der Eiszeit. Ein Nutzungsareal paläolithischer Jäger- und Sammler(-innen) vor 41.000- 27.000 Jahren*. Mitteilungen der Prähistorischen Kommission Vol. 67, Vienna, 84-114.

Haesarts, P., Damblon, F., Bachner, M. & Trnka, G. (1996). Revised stratigraphy and chronology of the Willendorf II sequence, Lower Austria. *Archaeologica Austriaca* 80: 25-42.

Hahn, J. (1972). Eine Gravettien-Industrie von Krems-Hundssteig (Niederösterreich). *Homo* 23: 81-89.

Hahn, J. (1977). *Aurignacien: Das ältere Jungpaläolithikum in Mittel- und Osteuropa*. Fundamenta A9, Cologne.

Hambach, U. (2010). Palaeoclimatic and stratigraphic implications of high resolution magnetic susceptibility logging of Wurmian loess at the Krems-Wachtberg Upper-Palaeolithic site. *In*: Neugebauer-Maresch, C.& Owen, L. (Eds.) *New aspects of the Central and Eastern European Upper Palaeolithic – methods, chronology, technology and subsistence*. Mitteilungen der Prähistorischen Kommission 72, Vienna, 295-304.

Händel, M. (2016). The Gravettian occupation in the Wachtberg area of Krems, East Austria. *In*: Wojtal, P. & Wilczyński, J. (Eds.) *2nd Conference World of Gravettian Hunters – Abstracts*. Instytut Systematyki i Ewolucji Zwierząt, Polskiej Akademii Nauk, Kraków, 33-37.

Händel, M., Einwögerer, T., Simon, U. & Neugebauer-Maresch, C. (2009a). New excavations at Krems-Wachtberg – approaching a well-preserved Gravettian Settlement Site in the Middle Danube Region. *Quartär* 56: 187-196.

Händel, M., Simon, U., Einwögerer, T. & Neugebauer-Maresch, C. (2009b). Loess deposits and the conservation of the archaeological record - the Krems-Wachtberg example. *Quaternary International* 198: 46-50.

Händel, M., Einwögerer, T., Simon, U., Neugebauer-Maresch, C. (2014). Krems-Wachtberg excavations 2005-12: Main profiles, sampling, stratigraphy, and site formation. *Quaternary International* 351: 38-49.

Händel, M., Salcher-Jedrasiak, T. A. & Fladerer, F. A. (2015). Putting Gravettian hunters' behaviour under the microscope: The case of hearth 1 at Krems-Wachtberg. *Quaternary International* 359-360: 280-291.

Heinrich, W. (1973). *Das Jungpaläolithikum in Niederösterreich*. Unpublished dissertation, University of Salzburg.

Heiri, O., Koinig, K. A., Spötl, C., Barrett, S., Brauer, A., Drescher-Schneider, R., Gaar, D., Ivy-Ochs, S., Kerschner, H., Luetscher, M., Moran, A., Nicolussi, K., Preusser, F., Schmidt, R., Schoeneich, P., Schwörer, C., Sprafke, T., Terhorst, B. & Tinner,W. (2014). Palaeoclimate records 60-8 ka in the Austrian and Swiss Alps and their forelands. *Quaternary Science Reviews* 106: 186-205.

Jöris, O., Neugebauer-Maresch, C., Weninger, B. & Street, M. (2010). The radiocarbon chronology of the Aurignacian to Mid-Upper Palaeolithic transition along the Upper and Middle Danube. *In*: Neugebauer-Maresch, C. & Owen, L. (Eds.) *New aspects of the Central and Eastern European Upper Paleolithic – methods, chronology, technology and subsistence*. Mitteilungen der Prähistorischen Kommission 72, Vienna, 101-137.

Jungwirth, J. & Strouhal, E. (1972). Jungpaläolithische menschliche Skelettreste von Krems-Hundssteig in Niederösterreich. *Homo* 23: 100-113.

Kießling, F. (1934). Die Aurignacienstation am Wachtberge bei Krems an der Donau. *In*: F. Kießling, *Beiträge zur Ur-, Vor- und Frühgeschichte von Niederösterreich und Südmähren*. Vienna, 35-39.

Lomax, J., Fuchs, M., Preusser, F. & Fiebig, M. (2014). Luminescence based loess chronostratigraphy of the Upper Palaeolithic site Krems-Wachtberg, Austria. *Quaternary International* 351: 88-97.

Marković, S. B., Stevens, T., Kukla, G. J., Hambach, U., Fitzsimmons, K. E., Gibbard, P., Buggle, B., Zech, M., Guoi, Z., Haoi, Q., Wui, H., O'Hara Dhand, K., Smalley, I. J., Újvári, G., Sümegi, P., Timar-Gabor, A., Veres, D., Sirocko, F., Vasiljević, D. A., Jary, Z., Svensson, A., Jović, V., Lehmkuhl, F., Kovácsu, J. & Svirčeva, Z. (2015). Danube loess stratigraphy – Towards a pan-European loess stratigraphic model. *Earth-Science Reviews* 148: 228-258.

Meyer-Heintze, S., Sprafke, T., Schulte, P., Terhorst, B., Lomax, J., Fuchs, M., Lehmkuhl, F., Neugebauer-Maresch, C., Einwögerer, T., Händel, M., Simon, U., Castillo, B. S. (2017). The MIS 3/2 transition in a new loess profile at Krems-Wachtberg East – A multi-methodological approach. Quaternary International, DOI: 10.1016/j.quaint.2017.11.048.

Neugebauer-Maresch, C. (2003). Erste Ergebnisse der neuen Grabungen in Krems-Hundssteig im Rahmen eines Projektes der Österreichischen Akademie der Wissenschaften. *Preistoria Alpina* 39: 165-173.

Neugebauer-Maresch, C. (Ed.) (2008a). *Krems-Hundssteig – Mammutjägerlager der Eiszeit. Ein Nutzungsareal paläolithischer Jäger- und Sammler(-innen) vor 41.000-27.000 Jahren*. Mitteilungen der Prähistorischen Kommission 67, Vienna.

Neugebauer-Maresch, C. (2008b). Eine besondere Fundkategorie: kalzifizierte Hölzer der gravettienzeitlichen Schichten von Krems-Hundssteig, *Quartär* 55: 143-150.

Neugebauer-Maresch, C. & Cichocki, O. (2008). Holzbefunde. *In*: Neugebauer-Maresch, C. (Ed.) *Krems-Hundssteig – Mammutjägerlager der Eiszeit. Ein Nutzungsareal paläolithischer Jäger- und Sammler(-innen) vor 41.000-27.000 Jahren*. Mitteilungen der Prähistorischen Kommission Vol. 67, Vienna, 147-167.

Neugebauer-Maresch, C. & Stadler, P. (2008). Absolute Datierung. *In*: Neugebauer-Maresch, C. (Ed.) *Krems-Hundssteig – Mammutjägerlager der Eiszeit. Ein Nutzungsareal paläolithischer Jäger- und Sammler(-innen) vor 41.000-27.000 Jahren.* Mitteilungen der Prähistorischen Kommission 67, Vienna, 168-176.

Peticzka, R. (2008). Aussagen zur sedimentologischen Situation im Bereich Krems-Hundssteig. *In*: Neugebauer-Maresch, C. (Ed.) *Krems-Hundssteig – Mammutjägerlager der Eiszeit. Ein Nutzungsareal paläolithischer Jäger- und Sammler(-innen) vor 41.000-27.000 Jahren*. Mitteilungen der Prähistorischen Kommission 67, Vienna, 78-84.

Peticzka, R., Holawe, F. & Riegler, D. (2010). Structural analyses on the modified paleosol-sequence of "Stillfried B" with high resolution measurements of selected laboratory parameters. *Quaternary International* 222: 168-177.

Pryor, A. J. E., Pullen, A., Beresford-Jones, D. G., Svoboda, J. A. & Gamble, C. S. (2016). Reflections on Gravettian firewood procurement near the Pavlov Hills, Czech Republic. *Journal of Anthropological Archaeology* 43, DOI: 10.1016/j.jaa.2016.05.003.

Rasmussen, S. O., Bigler, M., Blockley, S. P., Blunier, T., Buchardt, S. L., Clausen, H. B., Cvijanovic, I., Dahl-Jensen, D., Johnsen, S. J., Fischer, H., Gkinis, V., Guillevic, M., Hoek, W. Z., Lowe, J. J., Pedro, J. B., Popp, T., Seierstad, I. K., Steffensen, J. P., Svensson, A. M., Vallelonga, P., Vinther, B. M., Walker, M. J. C., Wheatley, J. J. & Winstrup, M. (2014). A stratigraphic framework for abrupt climatic changes during the Last Glacial period based on three synchronized Greenland ice-core records: refining and extending the INTIMATE event stratigraphy. *Quaternary Science Reviews* 106: 14-28.

Reimer, P. J., Bard, E., Bayliss, A., Beck, J. W., Blackwell, P. G., Bronk-Ramsey, C., Buck, C. E., Cheng, H., Edwards, R. L., Friedrich, M., Grootes, P. M., Guilderson, T. P., Haflidason, H., Hajdas, I., Hatté, C., Heaton, T. J., Hogg, A. G., Hughen, K. A., Kaiser, K. F., Kromer, B., Manning, S. W., Niu, M., Reimer, R. W., Richards, D. A., Scott, E. M., Southon, J. R., Turney, C. S. M. & van der Plicht, J. (2014). IntCal13 and MARINE13 radiocarbon age calibration curves 0-50000 years calBP. *Radiocarbon* 55: 1869-1887.

Schilt, F., Verpoorte, A. & Antl, W. (2017). Micromorphology of an Upper Paleolithic cultural layer at Grub-Kranawetberg, Austria. *Journal of Archaeological Science: Reports* 14: 152-162.

Simon, U. (2010). Gravettian lithic assemblages of the excavation Krems-Hundssteig 2000-2002. *In*: Neugebauer-Maresch, C. & Owen, L. (Eds.) *New aspects of the Central and Eastern European Upper Paleolithic – methods, chronology, technology and subsistence*. Mitteilungen der Prähistorischen Kommission 72, Vienna, 245-254.

Simon, U., Händel, M., Einwögerer, T. & Neugebauer-Maresch, C. (2014). The archaeological record of the Gravettian open-air site Krems-Wachtberg. *Quaternary International* 351: 5-13.

Strobl, J. & Obermaier, H. (1909). Die Aurignacienstation von Krems (N.-Ö.). *Jahrbuch für Altertumskunde* 3: 129-148, plates 13-21.

Svoboda, J. (1996). The Pavlovian: typology and behaviour. *In*: Svoboda, J. (Ed.) *Paleolithic in the Middle Danube Region*. Anniversary Volume to Bohuslav Klíma. Archeologický ústav AV CR, Brno, 283-301.

Svoboda, J. (2007). The Gravettian on the Middle Danube. Le Gravettien: entités regionals d'une pléoculture européenne. Table ronde – Les Eyzies – juillet 2004. *Paleo* 19: 203-220.

Svoboda, J., Hladilová, Š., Horáček, I., Kaiser, J., Králik, M., Novák, J., Novák, M., Pokorný, P., Sázelová, S., Smolíková, L. & Zikmund, T. (2015). Dolní Věstonice IIa: Gravettian microstratigraphy, environment, and the origin of baked clay production in Moravia. *Quaternary International* 359-360: 195-210.

Svoboda, J., Novák, M., Sázelová, S. & Demek, J. (2016). Pavlov I: A large Gravettian site in space and time. *Quaternary International* 406: 95-105.

Terhorst, B., Kühn, P., Damm, B., Hambach, U., Meyer-Heinzte, S. & Sedov, S. (2014). Paleoenvironmental fluctuations as recorded in the loess-paleosol sequence of the Upper Paleolithic site Krems-Wachtberg. *Quaternary International* 351: 67-82.

Terhorst, B., Sedov, S., Sprafke, T., Peticzka, R., Meyer-Heintze, S., Kühn, P. & Solleiro Rebolledo, E. (2015). Austrian MIS 3/2 loess-palaeosol records – key sites along a west-east transect. *Palaeogeography, Palaeoclimatology, Palaeoecology* 418: 43-56.

Thomas, R. & Ziehaus, J. (2014). Spatial and chronological patterns of the lithics of hearth 1 at the Gravettian site Krems-Wachtberg. *Quaternary International* 351: 134-145.

Thomas, R., Brandl, M. & Simon, U. (2016). The Gravettian lithic industry at Krems-Wachtberg (Austria). *Quaternary International* 406: 106-119.

Trinkaus, E. & Pettitt, P. B. (2000). The Krems-Hundssteig "Gravettian" human remains are Holocene. *Homo* 51(2-3): 258-260.

Urban, B. (2008). Pflanzenbürtige Mikrofossilien, mikroskopische Holzkohlenpartikel und begleitende bodenchemische Analysen der Grabungen 2000-2002. *In*: Neugebauer-Maresch, C. (Ed.) *Krems-Hundssteig – Mammutjägerlager der Eiszeit. Ein Nutzungsareal paläolithischer Jäger- und Sammler(-innen) vor 41.000-27.000 Jahren*. Mitteilungen der Prähistorischen Kommission 67, Vienna, 114-121.

Vogel, J. C. & Zagwijn, W. H. (1967). Groningen radiocarbon dates VI. *Radiocarbon* 9, 63-106.

Weninger, B. & Jöris, O. (2008). A ^{14}C age calibration curve for the last 60ka: the Greenland-Hulu U/Th timescale and its impact on understanding the Middle to Upper Paleolithic transition in Western Eurasia. *Journal of Human Evolution* 55: 772-781.

Wild, E. M. & Steier, P. (2010). ^{14}C Dating of Krems-Wachtberg, Austria. *In*: Neugebauer-Maresch, C. & Owen, L. (Eds.) *New aspects of the Central and Eastern European Upper Paleolithic – methods, chronology, technology and subsistence.* Mitteilungen der Prähistorischen Kommission 72, Vienna, 305-310.

Zeeden, C., Hambach, U. & Händel, M. (2015). Loess magnetic fabric of the Krems-Wachtberg archaeological site. *Quaternary International* 372: 188-194.

Ziehaus, J. (2007). Die Silexindustrie der Gravettien-Fundstelle Krems-Wachtberg, Niederösterreich, Grabung 2005. *Archaeologia Austriaca* 91: 7-140.

Zöller, L., Richter, D., Blanchard, H., Einwögerer, T., Händel, M. & Neugebauer-Maresch, C. (2014). Our oldest children: age constraints for the Krems-Wachtberg site obtained from various thermoluminescence dating approaches. *Quaternary International* 351: 83-87.