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This study is dedicated to Nikolai Praslov (†2009). For long time he has been the memory of Kostenki. We keep in mind our fruitful discussions on various topics at Kostenki and Saint-Petersburg.

Abstract:

Kostenki 1 is one of the many sites of the Kostenki-Borshchevo site cluster south of Voronezh, which has a long sequence covering the Early and Mid Upper Palaeolithic, including the Streletskian Cultural Layer V. Here we present stratigraphic data from our 1994 fieldwork (sections of the 1981-1982 excavations) and radiocarbon dates for the CL IV and V. For dating we used our cross-dating approach on high quality conifer charcoal with ABA and ABOx-SC pre-treatment on sub-samples of the same charcoal sample. Our results show that the Streletskian CL V dates to ~42,500 ^{14}C uncal BP and is significantly older than previously thought.

Résumé

Kostienki 1 figure parmi les principaux sites du domaine archéologique Kostienki-Borshchevo au sud de Voronesh. Celui-ci présente une longue séquence couvrant le Paléolitique supérieur ancien et moyen laquelle comprend la Couche Culturelle V rapportée au Streletskien. Nous présentons ici les données stratigraphiques de Kostienki 1 acquises au cours de la campagne de 1994 (avec les profils mis au jour au cours des fouilles de 1981-1982) ainsi que les dates radiocarbone pour les couches culturelles CL IV et CL V. Une approche en cross-dating ABA et ABOx-SC a été mise en oeuvre sur des sous-échantillons de charbons de bois de conifère de haute qualité. Les résultats livrent des dates ^{14}C autour de 42.500 uncal BP pour le Streletskien de la couche culturelle CL V, lequel apparaît nettement plus ancien que l'âge attendu.

1 Introduction

The Kostenki-Borshchevo archaeological area spans several kilometres along the western side of the Don Valley, downstream of the city of Voronezh (Central Russia). Since the end of the 19th century, excavations and surveys have led to the discovery of almost 25 archaeological sites with abundant evidence of Upper Palaeolithic occupation. For the most part these sites are located on the second terrace of the Don, although there are also sites on the first terrace. Often these sites are located at the edge of small valley slopes which promote lateral sediment inputs (Sinistyn 1996; Holliday et al. 2007).

In this context, the site of Kostenki 1 (Poliakov) belongs to the group of sites on the second terrace. It is situated in an area of gentle slope, located north of the valley of Pokrovsky, about 700 m from its merger with the main Don Valley. The site is known since the 1920s (Efimenko 1958), but only the excavations by Rogachev between 1938 and 1953 worked out the main archaeological sequence of the loamy cover at the site (Praslov and Rogachev 1982). The sequence is ~4 m thick and includes three significant cultural levels: (a) the Gravettian cultural layer CL 1 with structures of dwellings and pits, located in the upper loess close to the surface chernozem; (b) the Aurignacian CL III, found in the middle part of the loamy deposits; (c) the Streletskian CL V, associated with a humic horizon towards the base of the loamy cover.

In this chapter, we mainly focus on the lower part of the stratigraphic sequence, which contains CL IV and CL V, recognized by N. Praslov during the 1981-1982 excavations in the southern part of the site. Our approach, in addition to the data published in recent years (e.g., Holliday *et al.*, 2007; Hoffecker et al., 2016), is based on the pedostratigraphic records of the sections of the1982 excavation. We had access to these sections in 1994, after removal of the 1981-1982 excavations refill. This allowed us - in cooperation with N. Praslov - to precisely position the cultural layers in the stratigraphy (Figs. 1 and 2). This work also aimed to control the context of charcoal samples collected by N. Praslov in 1981-1982 and stored in Saint- Petersburg, later used by us to improve the chronology of the sequence.

2 The 1994 stratigraphic sequence

The two orthogonal profiles recorded in 1994, delineate the area excavated in 1981-1982. The eastern excavation section was studied on a length of 5 m, while the southern section was exposed on 2 m length (Figs 1 and 2). At this location within the site, the upper part of the eastern section has been linked with the upper loess cover containing CL I, which was exposed in the central part of the site, via a plot where CL III was being excavated. In such a way we got access to a detailed pedosedimentary record covering the entire sequence of Kostenki 1.

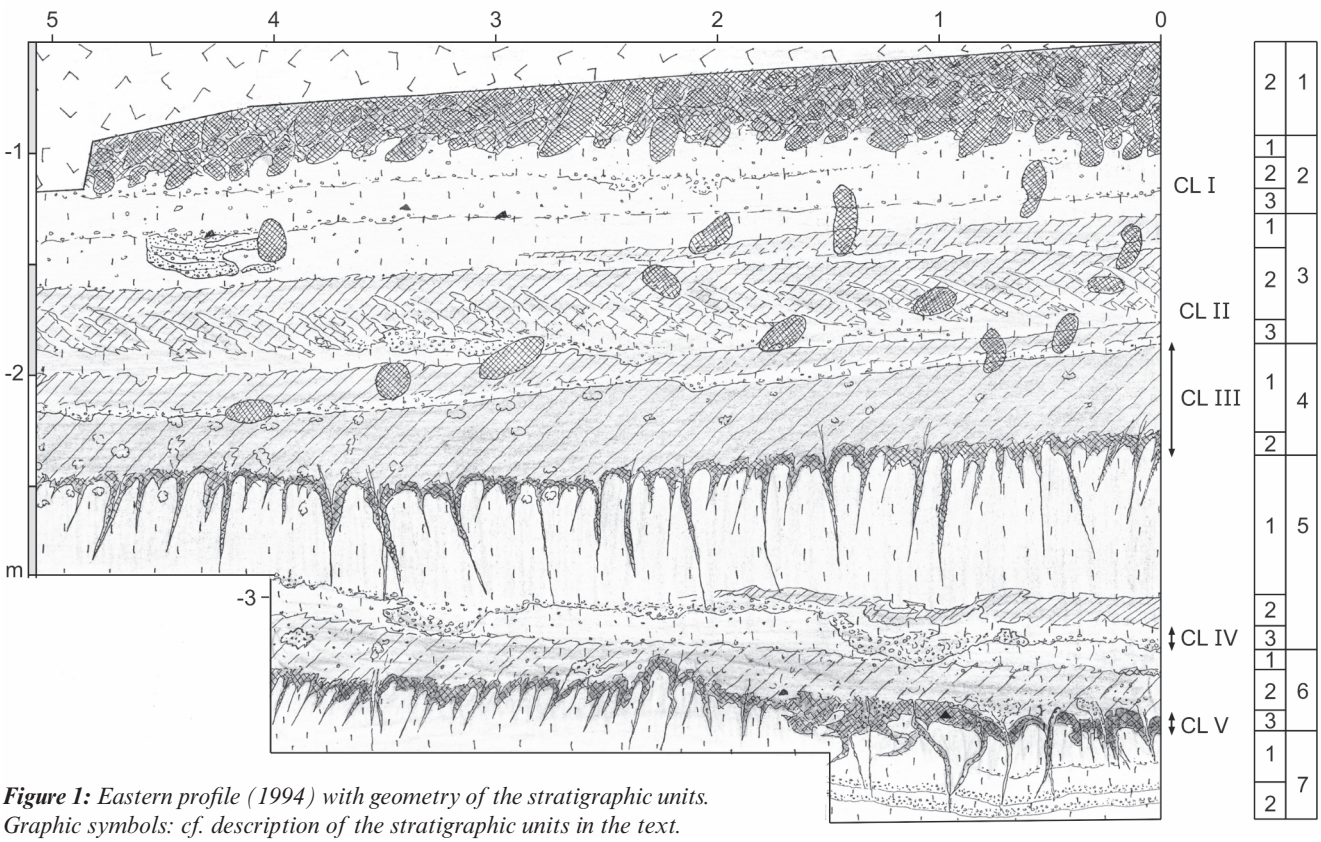

Figure 1: *Eastern profile (1994) with geometry of the stratigraphic units. Graphic symbols: cf. description of the stratigraphic units in the text.*

The location of these sections allowed to restore the geometry of the deposits. Based on this information, we subdivided the stratigraphic sequence in eight units following slight discordances (Fig. 1).

Unit 1 (thickness ~0.50 m)

Dark grey loam with abundant krotovinas, especially in its lower part.

Unit 2 (thickness ~0.40 m)

Pale yellow sandy silt subdivided into three subunits (2-1 to 2-3) by two thin sandy layers enriched in chalky fragments. Scattered lithic artefact occurred at the base of subunit 2-2 in the eastern section.

Unit 3 (thickness ~0.60 m)

Succession of three layers of pale yellow silt showing a parallel geometry, with a slight slope to the south (subunits 3-1, 3-2 and 3-3). Each subunit bears a clear ochre loamy horizon. The ochre horizon of subunit 3.2 is characterized by a tongued lower limit inflected to the southeast. The base of unit 3 slightly truncates the underlying unit 4.

Unit 4 (thickness ~0.50 m)

Pale ochre homogeneous loamy silt with some bioturbations and scattered carbonate concretions (subunit 4-1). Downwards it is passing into a ~10 cm dark brown humic horizon (subunit 4-2), slightly discordant on the underlying silty deposit (subunit 5-1). The 4-2 horizon is related to a dense polygonal network of deep wedges filled with humic sediment. It is also related to a second set of thin wedges filled with loam which opens in the lower part of subunit 4-1. The upper part of both sets of wedges is slightly stretched to the east (Fig. 2).

Unit 5 (thickness ~1.00 m)

Thick, homogeneous pale yellowish brown silt (subunit 5-1) and yellowish brown loam (subunit 5-2), which is overlying a light yellowish silt (subunit 5-3) with an erosional lower limit underlined by a continuous chalky gravel.

Unit 6 (thickness ~0.50 m)

This unit encompasses a yellow silt layer (subunit 6-1) and a pale yellowish brown silty loam layer (subunit 6-2) with small sandy pockets, capping a dark brown humic horizon (subunit 6-3), which characterized by a triangular lower limit. Subunit 6-3 is connected with a dense polygonal network of thin brown wedges slightly stretched to the east and locally disturbed by thin silty wedges starting from above.

Unit 7 (thickness ~0.50-0.75 m)

Pale yellowish homogeneous silt (subunit 7-1) with layers of white sand in the lower half (subunit 7-2).

Unit 8 (thickness ~1.00 m)

White clayey loam with recurring thin layers of chalky pellets (subunit 8-2). At the top, it is wearing a centrimetric black humic horizon (subunit 8-1). Unit 8 was not exposed in the 1981-1982 excavations, but during our 1994 fieldwork.

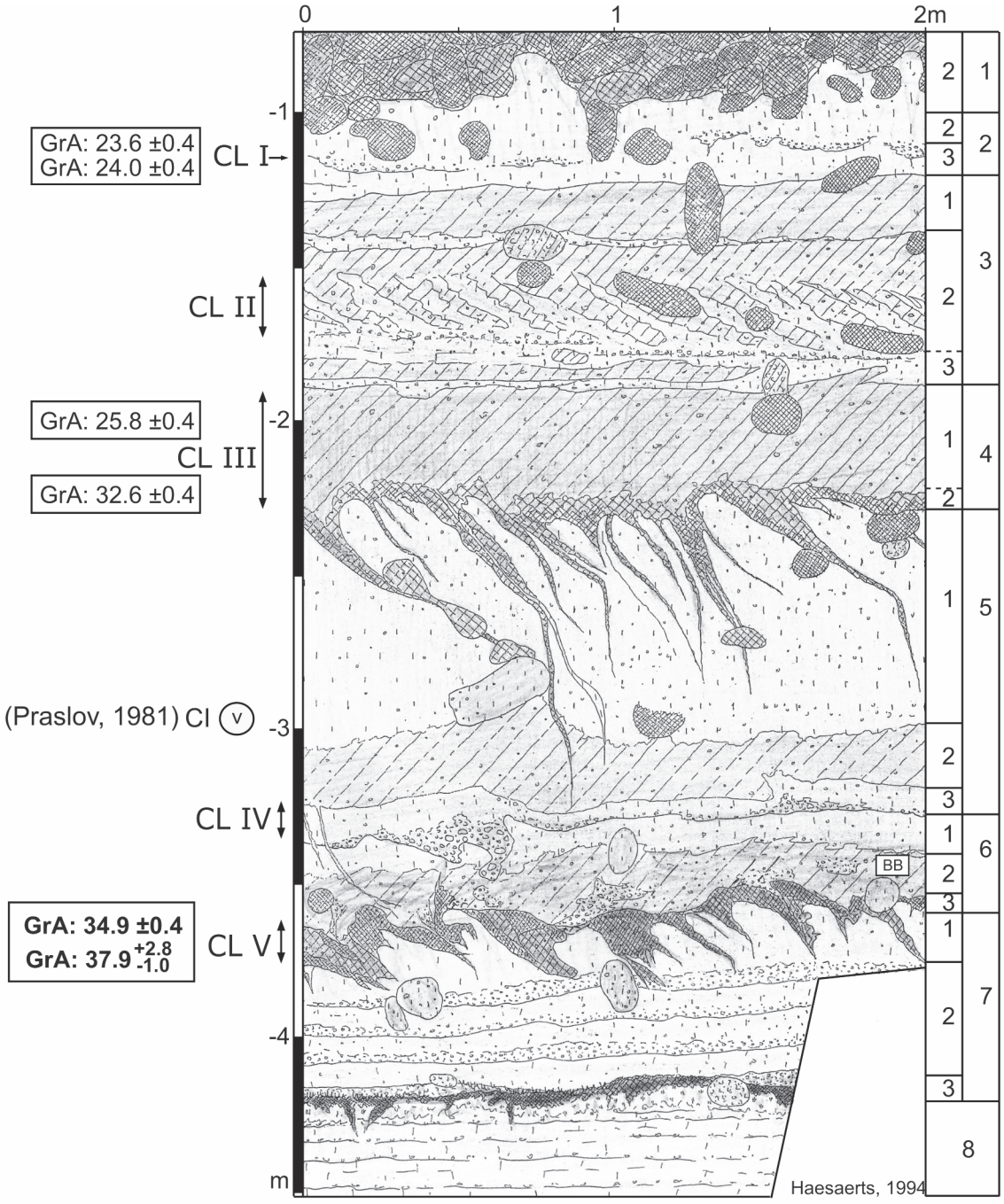

Figure 2: *South profile (1994). Stratigraphy with position of the cultural layers recorded by N. Praslov in 1981-1982 and with the first set of 14C dates (Sinitsyn and Praslov 1997)). The lower part of the profile (subunit 7-3 and unit 8) was not recorded in 1981-1982. Depths are reported to the top-soil in 1981-1982.*

3 Stratigraphic position of the cultural layers

In general, the probability to cross a cultural layer within a loess record during the cleaning of a section is relatively limited, even at Kostenki. A few scattered artefacts or bones are not necessarily indicative of a cultural layer. Therefore the stratigraphic positioning of CL I to V at Kostenki 1 is mainly based on the information provided on site by N. Praslov during our 1994 fieldwork (Figs 1 and 2). They have proved to be in good agreement with the excavation reports of 1981-1982 that we consulted in Saint-Petersburg in 1998.

In this context, all available data contribute to report the Streletskian assemblage of CL V at the level of the humic horizon 6-3. This is supported by one lithic artefact at that level in the eastern profile and of a charcoal concentration in the southern profile during our 1994 fieldwork (Fig. 1).

We have to mention here the presence of an isolated lithic artefact and a fine lens of charcoal close to the base and in the upper part of the yellow-ochre loam of subunit 6-2 during our 1994 fieldwork. In 1994 it was unclear whether this material is in a secondary position or it represents an up to then unknown cultural layer. The latter

hypothesis was verified in 2004 when a test pit was excavated close to the southern 1994 section. It showed a dense concentration of bones positioned in the upper half of the loam of subunit 6-2, which was clearly separated from CL V located within the humic horizon 6-3 (Fig. 3). This concentration of bones, labelled here BB (Bone Bed), should not be confused with CL IV, which according to N. Praslov is located within the overlying loess-loam of subunit 5-3, marked by chalky debris easily recognizable in both 1994 sections.

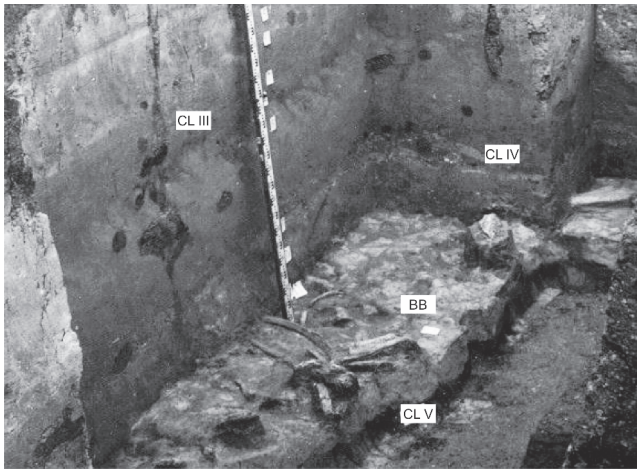

Figure 3: *Kostenki 1, 2004. Lower part of the sequence with the bone bed (BB) in between CL IV and CL V.*

CL III is traditionally attributed to the Aurignacian (Praslov and Rogachev 1982). According to M. Anikovich (pers. com.), who directed the excavation of this layer in 1994, it relates rather to a 'complex', the lithic artefacts and bones being distributed equally across the whole loam of subunit 4-1 and without preferential levels. Some lithic artefacts probably come from the underlying humic horizon (subunit 4-2).

The Gravettian CL II is located - according to N. Praslov - in the lower part of the tongue horizon 3-2. The archaeological sequence ends with a dozen lithic artefacts present in the loess cover of the eastern profile at the base of subunit 2-2 (Fig. 1). These are laterally in the extension of Gravettian CL I, which is well documented in the central part of the site (Fig. 4).

4 The radiocarbon dates

The analysis of the radiocarbon (^{14}C) ages requires that various parameters are taken into account (Damblon and Haesaerts 2002, Haesaerts *et al.* 2010): (a) the nature and quality of the material dated; (b) the collection and conservation mode of the sample; (c) the degree of stratigraphic resolution; (d) the pre-processing of the sample before dating; (e) the laboratory ^{14}C measurement method (conventional, AMS); (f) the relationship between the dated material and the event we wish to date (in this case, the human occupation); (g) the degree of coherence of the distribution of the ^{14}C ages in the stratigraphic record. It is worth to point out the necessity of specific identification of the charcoal fragments after cleaning them because we cannot exclude contamination by Holocene material from the surface chernozem by various ways, including during excavation.

Figure 4: *Kostenki 1, 1994. N. Praslov and A. Dodonov (Geological Institute, Moscow) during excavation of CL I.*

4.1 Cultural layer I

A set of 42 14C dates refers to this layer, obtained from the excavation area at the centre of the site. They are divided into 4 series (Sinitsyn and Praslov 1997): 24 dates on burned bones (between 18,280 ±620 BP and 24,100 ±500 BP), 13 dates on mammoth tooth (between 19,010 ±120 BP and 23,770 ±200 BP), 1 date on ivory (23,640 ±320 BP) and 3 dates on charcoal, respectively 22,330 ±150 BP (GrN-17118), 23,600 ±400 BP (GrA-5244) and 24,030 ±400 BP (GrA-5243).

In such a way, if we take into account the oldest ages of the 4 series (with less than 500 ^{14}C years sigma), we obtain a chronological range of 24,000 - 23,600 BP for CL I, which matches the 2 Groningen AMS dates on Picea charcoal cleaned and identified in Brussels at the Royal Belgian Institute of Natural Sciences (RBINS) (GrA-5243, GrA-5244).

4.2 Cultural layer III

There are 21 dates attributed to CL III, which are split in two series produced between 1980 and 1994 (13 dates) and after 1994 (8 dates), respectively. In the first series, 8 dates (between 20,900 BP and 38,080 BP) are not considered as presenting a sigma too high (between 1,100 and 5,460 ^{14}C years). Of the 5 remaining dates, 4 dates on burned bone and charcoal span between 25,400 ±400 BP and 25,820 ±400 BP, the latter date being obtained in Groningen on a sample of Picea charcoal collected in 1994 by M. Anikovich in the lower part of subunit 4-1, cleaned and identified at the RBINS. As for the fifth date, it gave an age of 32,600 ±400 BP on charcoal submitted to Groningen (Sinitsyn, 1993).

The 7 dates of the second series were obtained on charcoal from the humic horizon 4-2, collected first in 1989 and then between 2006 and 2012, during the extension of the area excavated on both sides of the central part of the site (Holliday et al. 2007; Hoffecker et al. 2015). With two dates of 29,130 ±320 BP and 29,400 ±370 BP and five dates between 31,880 ±500 BP and

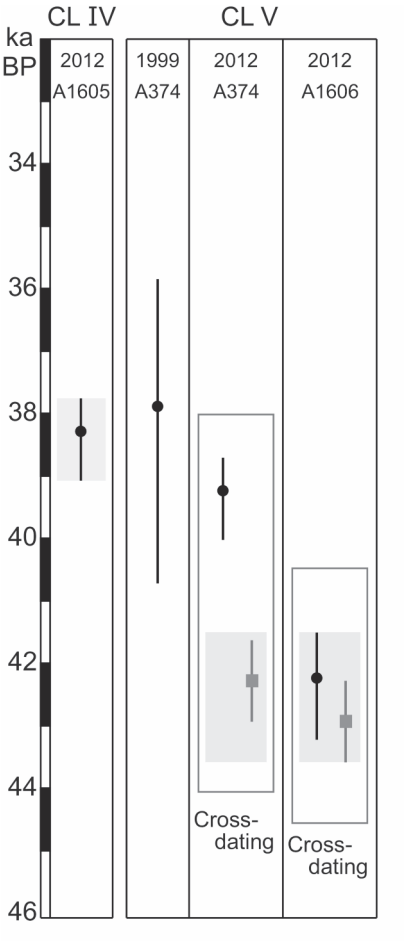

Figure 5: *Kostenki 1. Distribution of the ^{14}C dates for CL IV and CL V. Black circle: Groningen ABA dates; red square: Oxford ABOx-SC dates; shaded area: accepted time range.*

32,280 ±500 BP, the second series of dates is clearly distinguishable from the first series. Both series suggest a stratigraphic and chronological duplication of CL III.

4.3 Cultural layers IV and V

In addition to three significantly rejuvenated dates ranging from 27,400 BP to 32,300 BP attributed to CL V (Sinitsyn and Praslov, 1997), we have the doublet of dates 34,900 ±350 BP and 37,900 ±2,800/2,100 BP obtained in Groningen on conifer charcoal samples collected in 1994 in the humic horizon 6-3. Although these ages are compatible with the stratigraphic position of CL V, these two dates are, however, unsatisfactory due to their age differences and the large sigma, leaving us to suspect a problem with the quality of the sample or the pre-treatment to remove contaminants. As we still had samples of conifer charcoal collected by N. Praslov in the lower part of the sequence during the excavation in 1981-1982, we therefore decided to date them recently.

The evolution and improvement of radiocarbon AMS dating has allowed to increase precision and to refine the accuracy of the results, although the mass of available carbon material still remains a limiting factor. Accurate and precise dates require an effective pre-treatment at the AMS dating laboratory. The classic method ABA (Acid-Base-Acid) is sufficient for materials younger than 35,000 BP ^{14}C (Bird *et al.* 1999), although a recent comparative study observed up to 40,000 BP no significant differences (Haesaerts *et al.* 2013). However, for older charcoal samples approaching the limit of the radiocarbon method, a pre-treatment using ABOx-SC (Acid-Base-Oxidation - Stepped Combustion) proved more successful in elimination of contaminants (Bird *et al.* 1999). This method has already provided significant older results for the site of Kostenki 14 (Douka 2010; Wood *et al.* 2012) and also for various Palaeolithic sites in Central Europe (Haesaerts et al. 2013; Nigst *et al.* 2014).

In the case of Kostenki 1, and especially for the CL V (Streletzkian) it was important to test this type of dating by comparing the two methods of pre-treatment respecting the minimum requirements of carbonaceous mass used for dating. It was also interesting to compare the dates obtained in two different radiocarbon AMS laboratories (GrA: Groningen; OxA: Oxford).

The following charcoal samples were selected from the material available originating from the lower part of the Kostenki 1 sequence.
A-1605: sample labelled CL-IV, 1981 (depth 3.00 – 3.10 m)
A-1606: sample labelled CL-V, 1982 (depth 3.50 m)
A-374: rest of the sample from the humic horizon 6-3 dated already in 1994 (37,900 ±2,800/2,100 BP)

It has to be noted that the depths mentioned on the label of the samples A-1605 and A-1606 are in good agreement with the position of the corresponding cultural layers reported in 1994 by N. Praslov in the southern profile (Fig. 2).

Therefore, in 2012, we used our cross-dating approach (Haesaerts *et al.* 2013) on the samples A-374 and A-1606, both belonging to CL V. One sub-sample of each sample was sent to Groningen for ABA pre-treatment and AMS measurement and the other one to Oxford for ABOx-SC pre-treatment and AMS measurement. The sample A-1605 of CL IV did not provide the critical mass of charcoal necessary for a cross-dating and, hence, has only been dated after ABA pre-treatment in Groningen and resulted in an age of 38,250 ±700/550 BP (GrA-53616).

As part of our cross-dating approach, samples A-374 and A1606 were homogenized by reduction to very small fragments (0.5-1.0 mm) before being divided in two subsamples (one for ABA/Groningen and one for ABOx-SC/Oxford) in order to provide the laboratories with sub-samples considered identical. Given the aggressiveness of ABOx-SC pre-treatment, it was decided to deliver 150 mg of charcoal for this type of pre-treatment, while 100 mg were used to for ABA pre-treatment (T. Higham and J. van der Plicht, pers. com.).

A-374, ABA pre-treatment, 100 mg
GrA-53611: 39,200 ±800/750
A-374, ABOx-SC pre-treatment, 150 mg
OxA-26649: 42,150 ±750

A-1606, ABA pre-treatment, 100 mg
GrA-53612: 42,100 ±1,000/700
A-1606, ABOx-SC pre-treatment, 150 mg
OxA-26650: 42,800 ±900

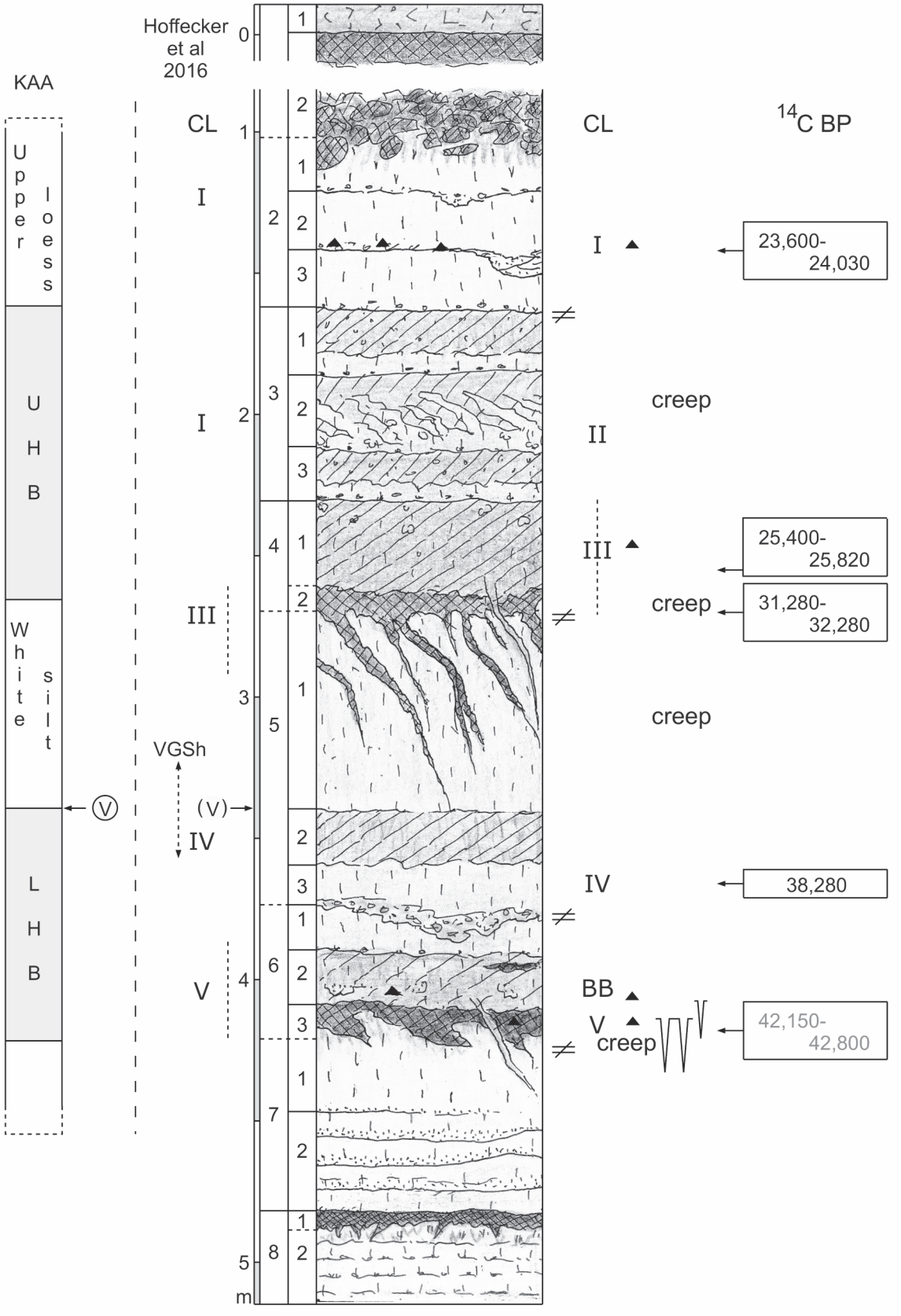

Figure 6: *Synthetic pedosedimentary sequence (cumulated thickness). Abbreviations: KBA: Kostenki-Borshchevo Area (Praslov and Rogachev 1982; Holloway et al. 2007) V: CI tephra. Tr.V: traces of volcanic ash (cf. Hoffecker et al. 2016, p. 315). Right side; = with oblique bar: geometric unconformity; (V): inferred position of volcanic ash lenses in the northern part of the excavation following Praslov (1981-1982); BB: bone bed; black triangle: position of the lithics in 1994 profiles; ^{14}C BP: accepted time intervals (red: ABOX-SC ages).*

The results of the two cross-dated samples are conclusive (Fig. 5). In particular, it should be noted that sample A-1606 produced two equivalent ^{14}C ages for the ABA- and ABOx-SC-pre-treated sub-samples. Both the ages as well as the sigma are comparable. On the contrary, the ^{14}C ages obtained for the sub-samples of A-374 present some 3,000 ^{14}C years of difference, with ABOx-SC-pre-treated sub-sample providing an older age. Such a difference at around 42,000 BP can be explained either by the slightest contamination in the ABA sub-sample of A-374 or by statistical variation in AMS measurement, which is very possible for the period under review (Haesaerts *et al.* 2013; Haesaerts et al. 2014). However, the cross-dating results show a very satisfying convergence between the GrA-53612 date of 42,100 ±1000/700 BP using ABA pre-treatment and the two OxA-26649 and OxA-22650 dates of 42,150 ±750 BP and 42,800 ±900 BP, respectively, using ABOx-SC. All three sub-samples come from CL V, which confirms the presence of the Streletzkian at Kostenki 1 between 43,500 and 41,500 ^{14}C BP at 1 sigma (Fig. 5). In a similar way, the age of ~38,250 ^{14}C BP obtained for CL IV fits with the position of this layer in the stratigraphic sequence. This shows once again the need to work on charcoal samples of well-controlled stratigraphic origin, uniform taxonomic composition and consistent with the period considered.

5 Conclusion

The starting point of our approach at Kostenki 1 concerned the positioning of the cultural layers I to V within the stratigraphic sequence established by N. Praslov during his excavations in 1981 and 1982. In 1994 we got access to the remaining sections which were cleaned and recorded. The chronological background, of the upper part of the sequence (CL I to III) resulted in critical analysis of the published ^{14}C ages. For the lower part of the sequence with CL IV and V we presented new ^{14}C dates based on cross-dating between ABA pre-treated samples (Groningen) and ABOx-SC pre-treated samples (Oxford).

Within the Kostenki I sequence, the humic horizons 4-2 (Aurignacian CL III) and 6-3 (Streletskian CL V) dated respectively 31,880 - 32,280 BP and 43,500 - 45,500 BP, represent interstadial episodes under continuous herbaceous cover. They occur as major chronostratigraphic markers, allowing a better integration of the pedosedimentary record at the scale of the Kostenki-Borshchevo archaeological area, locked by the ash layer (Fig. 6). These markers may also be linked with the interstadial episodes Malu Galben 13 around 32,500 BP in Romania (Damblon and Haesaerts 2007; Haesaerts 2007), Willendorf D1 between 43,400 and 45,100 BP in Austria (Nigst *et al.* 2014) and further with GI-8 and GI-12, respectively, of the Greenland-Ice sequence (Haesaerts *et al.* 2009; 2010).

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