Additional data to the stratigraphy and the chronology of the Kostenki 1 (Poliakov) sequence, Voronezh, Russia

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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 ~42,500¹⁴C 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 Paléolithique supérieur ancien et moyen laquelle comprend la Couche Culturelle V rapportée au Strelets- kian. 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 dates¹⁴C autour de 42.500 uncal BP pour 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 sec-
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 south-east. 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 centimetric black humic horizon (subunit 8-1). Unit 8 was not exposed in the 1981-1982 excavations, but during our 1994 fieldwork.
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 Streletsian 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

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.
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 (14C) 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 14C 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 14C 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 (Sbinsyn 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 14C 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 14C 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 (Sbinsyn, 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
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 

![Figure 5: Kostenki 1. Distribution of the 14C dates for CL IV and CL V. Black circle: Groningen ABA dates; red square: Oxford ABOx-SC dates; shaded area: accepted time range.](image)

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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 A-1606 were homogenized by reduction to very small fragments (0.5-1.0 mm) before being divided in two sub-samples (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 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

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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 14C 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 14C ages obtained for the sub-samples of A-374 present some 3,000 14C 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-55612 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 14C BP at 1 sigma (Fig. 5). In a similar way, the age of ~38,250 14C 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 14C ages. For the lower part of the sequence with CL IV and V we presented new 14C 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-Borschchevo 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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