KOSTIENKI 14 (VORONEZH, CENTRAL RUSSIA): NEW DATA ON STRATIGRAPHY AND RADIOCARBON CHRONOLOGY

Paul HAESAERTS, Freddy DAMBLON, Andrei SINITSYN & Johannes VAN DER PLICHT

Abstract: In the present paper, the stratigraphy and chronology of Kostienki 14 are reconsidered to the light of 20 selected radiocarbon dates on charcoal and 5 dates on bones, the former ones appearing the most accurate. Based on the new stratigraphy of the most representative section E, the chronological sequence of Kostienki 14 is discussed aiming at a better dating of the successive cultural layers and climatic events. In this way, a coherent reconstruction of the pedosedimentary events and of the main occupation phases is proposed within a well documented time sequence between 37 ka and 27 ka (uncalibrated ^{14}C BP). Palaeoenvironmental implications are inferred not only from stratigraphy and pedology but also from previous palynological data more precisely situated in the time-scale. The Kostienki 14 sequence is now used as a reference for integrating other Middle Pleniglacial sites in the Russian Plain and from Central Europe; it also allows good correlation with the West European palaeoclimatic sequence issued from the Upper Pleistocene fluviatile deposits of the Netherlands.

Résumé: Le present travail reconsidère la stratigraphie et la chronologie de Kostienki 14 à la lumière d'une selection de 20 dates radiocarbone sur charbon de bois et de 5 dates sur os, les premieres apparaissant comme les plus fiables. Sur la base d'une nouvelle stratigraphie de la section E, la plus representative du site, la sequence chronologique de Kostienki 14 est discutee avec pour objectif de mieux dater les couches culturelles et les evenements climatiques successifs. De cette manière, une reconstitution coherente des evenements pédosedimentaires et des principales phases d'occupation est proposée pour une sequence de temps bien documentée entre 37 ka et 27 ka (^{14}C BP non calibre). Les implications paleo-environnementales sont déduites non seulement des donnees stratigraphiques etpédologiques mais aussi de donnees palynologiques anterieures mieux situees dans l'echelle de temps. La sequence de Kostienki 14 est utilisee maintenant comme une réference pour ['integration d'autres sites du Pléniglaciaire Moyen de la plaine rasse et d'Europe centrale; elle permet egalement une bonne correlation avec la sequence paléoclimatique etablie pour l'Europe occidentale à partir des formations fluviatiles du Pleistocène superieur aux Pays-Bas.

1. GENERAL BACKGROUND

The Kostienki-Borshevo archaeological area is located south of Voronezh along the western bank of the Don (Fig. 1); it comprises more than twenty Palaeolithic sites preserved in cover deposits which encompass the most part of the Middle and Late Pleniglacial and record the different Upper Palaeolithic phases of development in Central Russia: Gorodtsovian, Spitsynian, Streletskaian, Aurignacian and Gravettian (Praslov and Rogachev, 1982). At Kostienki, the stratigraphy of the different sites is controlled by their morphological position with regard to the terrace system. The sites located on the first terrace intersect Late Pleniglacial cover deposits and Late Glacial alluvium, whilst those located on the second terrace present a more elaborate stratigraphy; it generally comprises a Middle Pleniglacial two-folded humic complex separated by whitish loamy deposits with volcanic ash. The whole is overtopped by Late Pleniglacial cover deposits. The stratigraphie structure of the system is further complicated by the fact that real loess is almost absent at Kostienki, the sedimentary successions generally consisting of local deposits accumulated at the bottom slope of large ravines.

The site of Kostienki 14, also named Markina gora, has long been considered one of the most representative within the Kostienki-Borshevo Area. The site is located on a small promontory along the Pokrovsky ravine, almost 1.5 km from the Don, at the connection of the Yermishin ravine (Fig. 1). Its stratigraphie succession, established by A.N. Rogachev in 1957, consists of at least four specific pedosedimentary bodies (Fig. 2). Deposits of loessic loams including cultural layer I (units 2 to 11) lie below the surface chernozem (unit 1); two humic beds separated by loamy deposits containing volcanic ash occur underneath. Cultural layers II and III were found in the upper humic bed and cultural layer IV in the lower one (Praslov and Rogachev, 1982). The site is also known for the burial discovered in 1954 in section C where it was associated with a pit cut prior to cultural layer III, through the whitish loam containing the volcanic ash layer.

From 1953 to 1994, several sections were opened and excavated in different positions on the promontory, respectively at the western slope (sections A and B), in the middle and at the eastern slope (sections C, D and E respectively), revealing the complexity of a changing stratigraphy with regard to the position of the excavated area (Sinitsyn, 1996). A similar problem arose in the identification of the cultural layers of the site as most of them have limited local distribution, and were named by A.N. Rogachev (1957) after the 1953-54 excavations.

The labeling of the cultural layers underneath the volcanic ash is of particular complexity. The index IV was used in 1954 for a cultural layer encountered in colluvial deposits under the upper humic bed in the central part of the promontory (section B) where volcanic ash and lower humic bed were absent. The same label was used for cultural layers occurring underneath the volcanic ash, although the indexes IVa and IVb refer to two distinct cultural layers in the lower

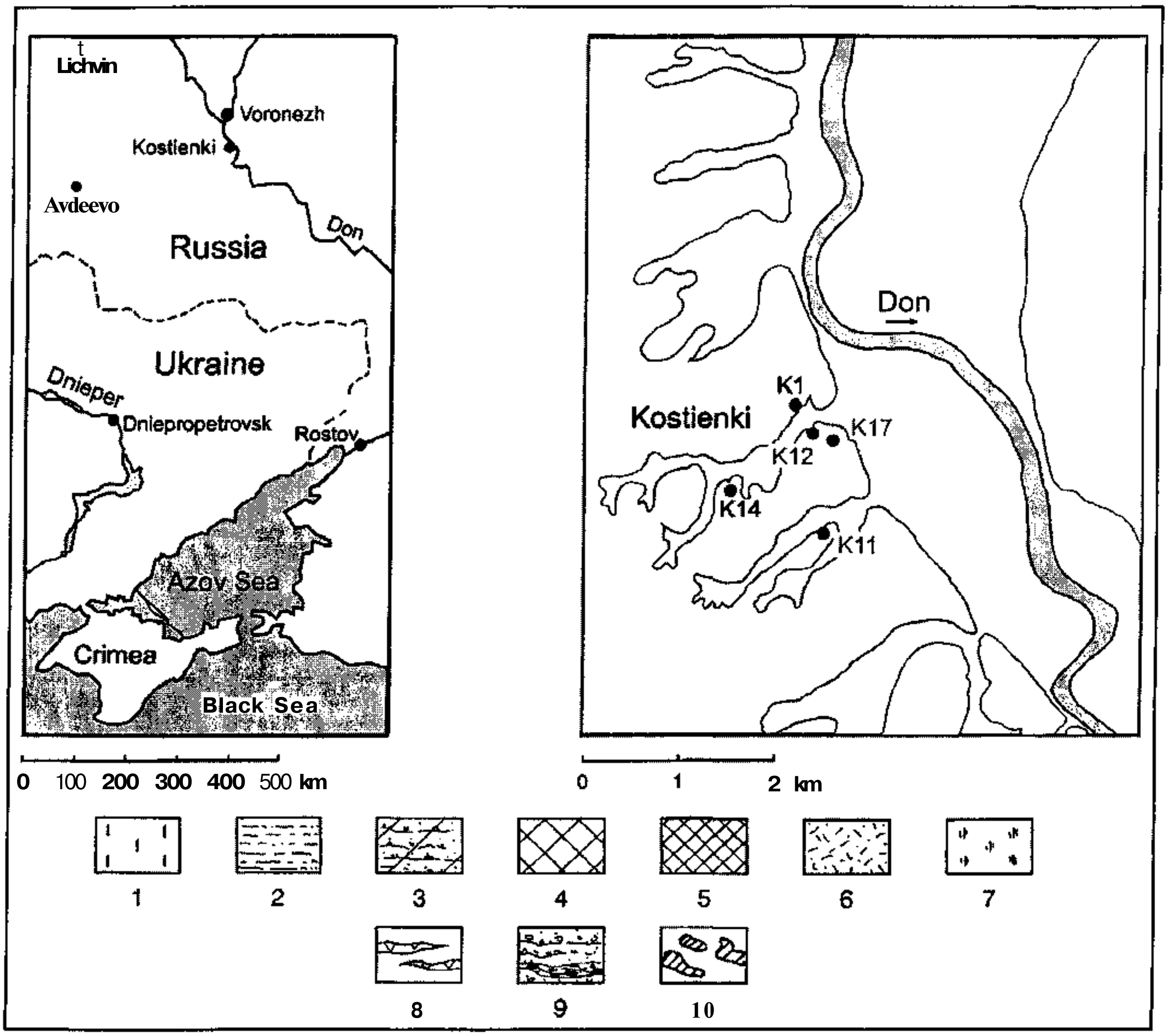

Figure 1. Situation of the site Kostienki 14 in Central Russia.
Graphic symbols of figures 2 to 4. 1: loess; 2: whitish homogeneous loam; 3: loam; 4: weak humiferous horizon; 5: strong humferous horizon; 6: tundra gley; 7: iron staining; 8: volcanic ash; 9: chalky pellets and gravel; 10: bones.

humic bed on the eastern slope of the promontory (Praslov and Rogachev, 1982). From 1994 to 2001, the excavations were located on the eastern slope of the promontory (section E) and mainly concern cultural layers Ilia, IVa and IVb present below the upper humic bed, cultural layers II and III being absent in section E (Sinitsyn, 1996).

2. STRATIGRAPHIC SETTING

The stratigraphic sequence of section E on the eastern slope of the promontory excavated from 1994 to 2001 provided a much more complex picture than the traditional representations mainly for what units 18 and 19 in the lower part of the succession are concerned (Damblon *et al.,* 1996; Sinitsyn *et al.,* 2002; Sinitsyn, this volume). The brief description of the following units from base to top integrates the observations made in 1994 for the whole units 2 to 18 as well as the complementary data gathered during the period 1998 - 2001 for subunits 19a to 19e of the lower humic bed (Fig. 2).

2.1. The cover loam (units 2 to 11)

With regard to the 1994 record (Sinitsyn, 1996), the cover deposits consist of ± 4 m loam (units 2 to 11) capped by the surface chernozem with increasing loessic component in the upper part (unit 2); four light brown horizons of initial soil formation were identified (units 3, 5, 7 and 9), most of them being affected by oblique fine wedges in a row. In section E cultural layer I was found in unit 7 although in sections B and C cultural layer I was encountered in unit 5. Further, in section E the lower part of the cover deposits shows evidences of erosion related to deep frost processes as demonstrated by the occurrence of chalky gravel (unit 10) filling melt water gullies.

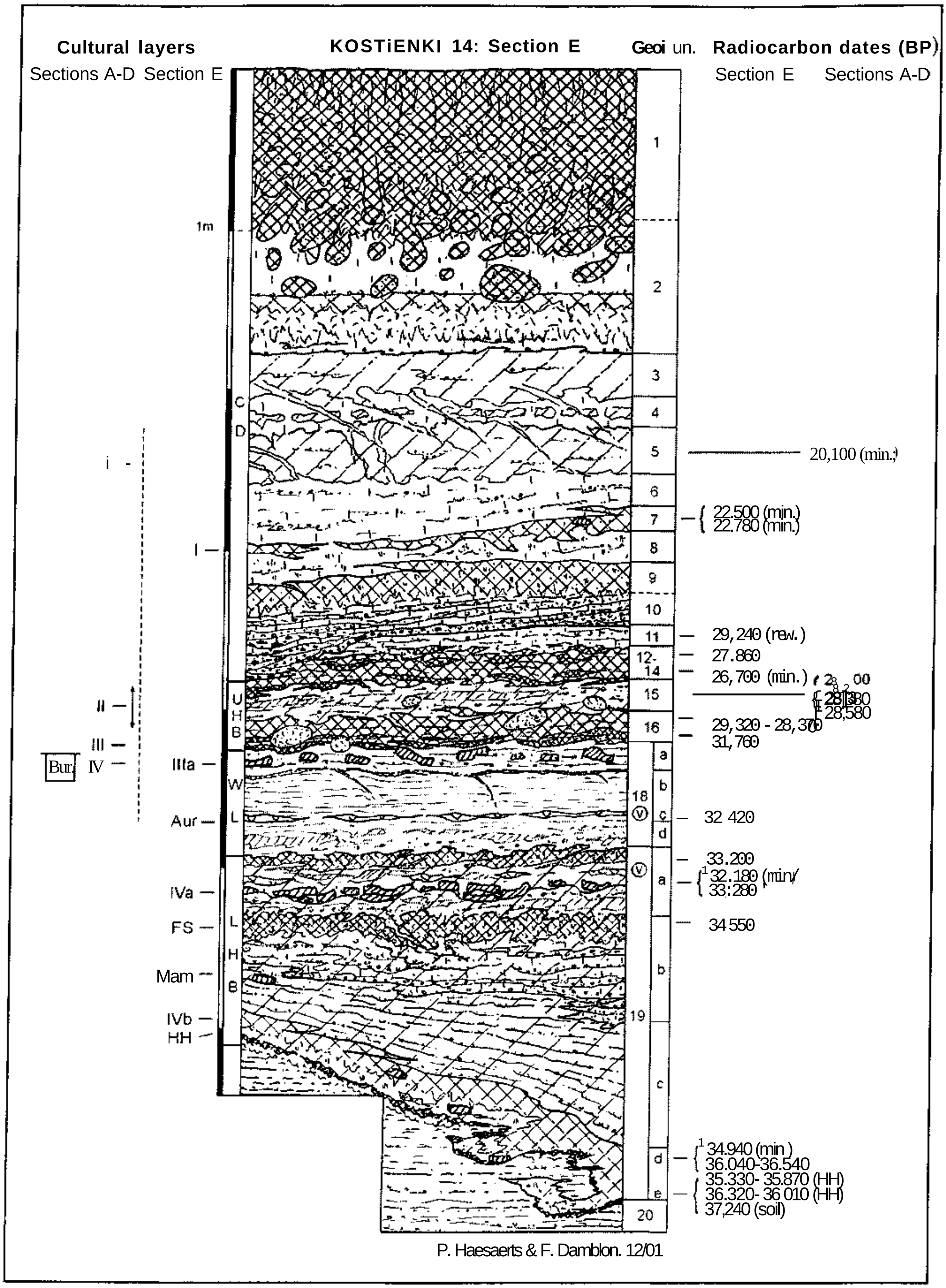

Figure 2. Stratigraphy and selected radiocarbon dates at Kostienki 14.
Abbreviations. Bur.: burial; Aur: Aurignacian; FS: fossil soil; Mam.: horizon with mammoth; HH: horizon of hearth; Geol. Un.: geological units; min.: minimum age.

2.2. The upper humic bed (units 12 to 16)

In section E, the upper humic bed occurs usually as a set of two subhorizontal humic "horizons" (respectively units 12 to 14 and unit 16) separated by ± 20 cm of pale yellowish chalky loam (unit 15). Each "horizon" shows a lenticular internal structure, with dark brown to black humic lenses in the lower part, grading to more homogeneous grey brown loam in the upper part. Locally the upper "horizon" is two-folded (units 12 and 14) with pale yellowish brown loam in between (unit 13). At the difference of sections B, C and D where cultural layers II and III occurred respectively in units 14-15 and in unit 16, no artifacts and almost no bone remains were found in the upper humic bed of section E; still, some bones were uncovered at the bottom of unit 16, but they clearly belong to the bone layer Ilia occurring in the upper part of unit 18, and were probably pushed upwards into unit 16 by frost and thaw or during solifluction process affecting this unit.

2.3. The whitish loam with volcanic ash (unit 18)

Occurring as a marker between the upper and the lower humic bed, the core of unit 18 consists of ± 0.50 m of homogeneous whitish loam with subhorizontal laminations (subunit 18b); it contains the main lenticular ash layer at the bottom (subunit 18c) which caps an Aurignacian cultural layer excavated in 2001. Below this layer, the lower part of unit 18 consists of heterogeneous stratified pale yellowish brown loam with chalky pellets (subunit 18d). In the 1994-98 profiles, the upper part of unit 18 underlined by a row of oblique wedges, is also less homogeneous and again contains chalky pellets (subunit 18a); it incorporates rather abundant large bones corresponding to find horizon Ilia.

2.4. The lower humic bed (unit 19) and the underlying chalky loam (unit 20)

The specificity of section E with regard to the other sections of Kostienki 14 rests on the high differentiation of the lower humic bed (unit 19), which encompasses a succession of ± 1.50 m of loamy deposits with at least three *in situ* humic soil horizons. Such a development is seemingly related to the presence to the east of the promontory of a deep gully cutting through subhorizontally stratified whitish chalky loam (unit 20). As a result of this, several cultural layers distinct from IVa and from IVb were found in different stratigraphic positions, the nomenclature of these layers being still informal (Sinitsyn, this volume).

The upper part of the unit 19 again consists of subhorizontally stratified heterogeneous loam with rather abundant chalky pellets and lenses of brownish loam (subunit 19a). Cultural layer IVa occurs in the middle of the deposit as a rich concentration of horse bones and charcoal filling locally some small depressions. Just above layer IVa, thin discontinuous lenses of ash similar to the volcanic ash layer 18c occur in the loam, which also shows evidence of humification in its upper part, this horizon being later partly truncated and slightly disturbed by erosion process active just before the deposition of unit 18.

The middle part of the gully filling is two-folded (subunits 19b and 19c). At first it consists of pale yellowish brown loam with thin oblique chalky layers following the edge of the gully (subunit 19c); higher up the loam is almost horizontally stratified and contains an important concentration of mammoth bones with local charcoal lenses, but deprived of archaeological material. Further, subunit 19b corresponds to a second generation of loamy deposits with abundant chalky pellets filling a large pocket-like gully which cuts through 19c. In the upper part of the loam a ± 15 cm thick, subhorizontal grey brown humiferous horizon developed, almost *in situ* and continuous all over the section. This horizon provided a few bone fragments together with some artifacts and small charcoal fragments ascribed to the so-called "cultural layer in fossil soil" (Sinitsyn *etal,* 2002; Sinitsyn, this volume).

The lower part of the gully filling (subunits 19d and 19e) shows at the base a thin humic horizon related to a micro-podzolic soil development (subunit 19e), following the erosional limit of the gully up-slope. An important concentration of charcoal with burned reddish loam and some bone material and artifacts named "horizon of hearth" was encountered in the lowermost part of the gully in close relation with the thin humic horizon, mainly together with pocket-like structures (Fig. 2). The humic horizon and the "horizon of hearth" are both covered by ± 20 cm of light yellowish brown loam with decreasing thickness along the edge of the gully (subunit 19d); still the upper 10 cm of the loam shows more grey brownish colour and incorporates thin lenses of charcoal mixed with rather abundant bone and stone artifacts ascribed to cultural layer IVb.

3. RADIOCARBON CHRONOLOGY

3.1. Significance of the radiocarbon dates

Many parameters can be taken into account for evaluating the chronological significance of a radiocarbon date (in the present paper, all dates are uncalibrated BP). They deal not only with the positioning of the sample with regard to the sedimentary, pedological, climatic or archaeological event which has to be dated, but also with the nature and the quality of the material submitted to dating. Most often indeed, many dates on bone appeared to have been rejuvenated with regard to dates on charcoal. For example, in cultural layer II, three dates are from 3,000 to 9,000 radiocarbon years younger than the oldest ones on charcoal and on bone (Tabl. 1: n° 9a to 13). In the same line, cultural layer IVa provided dates on horse bone rejuvenated of about 3,500 to 5,900 years with regard to the most ancient date on charcoal (Tabl. 1: n° 28 to 31). The cause of rejuvenation is well known (Waterbolk 1971, Mook and Waterbolk 1985, Gowlett and Hedges 1987, Bowman 1990) and can often be amounted to persistent contamination after percolation of humics and precipitation of recent carbonate on the bone fragments. Such contamination can be chemically eliminated from charcoal which is made of inert carbon. Therefore all charcoal samples treated at the R.B.I.N.S were chemically cleaned and the fragments strongly selected for dating after removing any intrusive material like rootlets and after taxonomic identification (Damblon *et aL,* 1996). This identification process was important for controlling the homogeneity of the sample while the selection of fragments from conifer, essentially *Picea,* aimed at discarding any disputable taxa.

In addition to the quality of the dated material, the accuracy and the precision of a date also depend on the effective duration of the event to be dated and on the resolution degree of the radiometric measurement. Finally, some secondary factors like colluvial reworking can disturb the chronology

Table 1. List of the entire set of radiocarbon dates from Kostienki 14. n° PH-FD: number of the date in table 1 and in figure 3; Geol. unit (G.U.): number of the geological unit and subunit in the present work; Cult. L: number of the cultural layer; n°A: number of the charcoal preparation; C weight (g): weight of the charcoal sample given to the Groningen laboratory for dating; authors: reference number to publication. 1: Anikovich 1993; 2: Boriskovsky 1984; 3: Cherdyntsev et al. 1966; 4: Damblon etal. 1996; 5: Hedges etal. 1996; 6: Praslovand Rogachev 1982; 7: Praslov and Soulerjytsky 1997; 8: Sinitsyn 1996; 9: Sinitsyn etal. 1996; 10: Sinitsyn and Praslov 1997; 11: Svezhentsev 1993; 12: Svezhentsev and Popov 1993.

Kostenki 14 (Markina gora)

n° PH-FD	Geol. unit	Cult. L.	section	n° date	14C age (BP)	material	n° A	C weight (g)	selection	authors
1	G.U. 5	I	D	LE-5269	20 100 ± 1500	Bone (1982)	-	-	accepted (min.)	10
2	G.U.7	I	E	LE-5567	19 700 ± 1300	Mammoth bone (1998)	-	-	-	unpubl.
3	G.U.7	I	E	GIN-8024	19 900 ± 850	Mammoth rib (1987)	-	-	-	7
4	G.U.7	I	E	LE-5274	22 500 ± 1000	Bone(1994)	-	-	accepted (min.)	10
5	G.U.7	I	E	OxA-4114	22 780 ± 250	Bone (1987)	-	-	accepted (min.)	8,5
6	G.U.11	-	E	GrA-13312	29 240 ± 330/320	Picea charcoal	A779	0,0049	accepted (rew.)	unpubl.
7	G.U.12	-	E	GrA-13292	27 860 ± 270/260	Picea charcoal	A771	0,1420	accepted	unpubl.
8	G.U. 14	-	E	GrA-10945	26 700 ± 190	Picea charcoal	A774	0,0080	accepted (min.)	unpubl.
9a	G.U. 15	II	B	LE-1400	19 300 ± 200	Bone	-	-	-	6
9b	G.U.15	II	B	lab. LU	25 090 ± 310	Bone	-	-	-	11,12
10	G.U. 15	II	B	GIN-8030	25 600 ± 400	Bone	-	-	-	11,12
11a	G.U.15	II	B	LU-59a	26 400 ± 660	Bone (fract.A)	-	-	-	6
11b	G.U. 15	II	B	LU-59b	28 200 ± 700	Bone (fract.B)	-	-	accepted	6
12	G.U. 15	II	B	GrN-12598	28 380 ± 220	Charcoal	-	-	accepted	1
13	G.U.15	II	B	OxA-4115	28 580 ±420	Bone	-	-	accepted	8
14	G.U. 16	II-III	C	GrN-10510	15 260 ± 260	Charcoal	-	-	-	10
15	G.U. 16	II-III	C	AA-4798	14 355 ± 120	Charcoal	-	-	-	10
16	G.U.16	III	C	GIN-79	14 300 ± 460	Bone	-	-	-	3
17a	G.U.16	IIIa	E	GrA-15955	29 320 ± 150	Picea charcoal	AB61	0,1415	accepted	unpubl.
17b	G.U.16	IIIa	E	GrA-15960	28 370 ± 140	Picea charcoal (duplo)	A861	0,1415	accepted (min.)	unpubl.
18	G.U.16	IIIa	E	GrA-13288	31 760 ± 430/410	Picea charcoal	A775	0,0632	accepted	unpubl.
19	G.U. 16-17	Burial pit	C	OxA-7126	4 705 ± 40	Human bone	-	-	-	unpubl.
20	G.U. 16-17	Burial pit	C	GrA-9303	3 730 ± 40	Human bone	-	1,9800	-	unpubl.
21	G.U. 16-17	Burial pit	C	GrA-18232	20 640 ± 170/160	Bone	-	-	-	unpubl.
22	G.U.18a+16	IIIa+b	E	GrN-21802	30 080 ± 590/550	Picea charcoal	A22 6	2,9880	-	4
23	G.U. 17	(IV)	D	OxA-4116	27 460 ± 390	Horse bone	-	-	-	8
24	G.U. 17	(IV)	D	OxA-4117	27 710 ± 410	Horse bone	-	-	-	8
25	G.U.18c	Aur.(v.a.)	E	GrA-18230	20 640 ± 170/160	Bone	-	-	-	unpubl.
26	G.U. 18c	Aur.(v.a.)	E	GrA-18053	32 420 ±440/420	Charcoal	-	-	accepted	unpubl.
27	G.U. 19a	-	E	GrA-13301	33 200 ± 510/480	Picea charcoal	A776	0,0312	accepted	unpubl.
28	G.U. 19a	IVa	E	LE-5271	27 400 ± 5500	Horse bone	-	-	-	10
29	G.U. 19a	IVa	E	GIN-8025	29 700 ± 400	Horse bone	-	-	-	7
30	G.U. 19a	IVa	E	GrA-13293	32 180 ± 450/420	Picea charcoal	A770	0,2740	accepted (min.)	unpubl.
31	G.U. 19a	IVa	E	GrN-22277	33 280 ± 650/600	Picea charcoal	A310	4,0700	accepted	4
32	G.U. 19b	-	E	GrA-18231	20 890 ± 280	Bone	-	-	-	unpubl.
33	G.U. 19b	-	E	GrA-13297	34 550 ± 610/560	Picea charcoal	A778	0,0238	accepted	unpubl.
34	G.U.19d	IVb	E	GrA-13302	34 940 ± 630/590	Picea charcoal	A748	0,0121	accepted (min.)	unpubl.
35a	G.U. 19d	IVb	E	GrA-15957	36 040 ± 250	Picea charcoal	A857	0,2051	accepted	unpubl.
35b	G.U. 19d	IVb	E	GrA-15961	36 540 ± 270/260	Picea charcoal (duplo)	A857	0,2051	accepted	unpubl.
36a	G.U. 19e	H. hearth	E	GrA-15958	35 330 ± 240/230	Picea charcoal	A859	0,1825	accepted (min.)	unpubl.
36b	G.U. 19e	H. hearth	E	GrA-15962	35 870 ± 250	Picea charcoal (duplo)	A859	0,1825	accepted	unpubl.
37a	G.U. 19e	H. hearth	E	GrA-15956	36 320 ± 270/260	Picea charcoal	A858	0,1646	accepted	unpubl.
37b	G.U. 19e	H.hearth	E	GrA-15965	36 010 ± 250/240	Picea charcoal (duplo)	A858	0,1646	accepted	unpubl.
38	G.U. 19e	humic soil	E	GrA-10948	37 240 ± 430/400	Picea charcoal	A749	0,0010	accepted	unpubl.

and lead to inversion of dates. In such a context, dating small charcoal fragments dispersed in solifluated layers must be avoided (cf. §3.2.1.).

3.2. The chronological sequence of Kostienki

The interest of the site of Kostienki 14 lies in particular in its long stratigraphic sequence which contains a great number of Upper Palaeolithic occupations with high amounts of paleontological material - charcoal and bone - used for radiocarbon dating (Sinitsyn *et al.,* 2002). In total, some 44 dates were obtained for the whole sections at Kostienki 14 among which 23 on charcoal and 21 on bone (Tabl. 2). Moreover, repeated dating from successive layers allowed a good control of the accuracy of the results. However, these advantages were sometimes lowered by various factors complicating the interpretation of some data, notably the importance of the loamy and chalky layers reworked by run-off and deposited in a ravine position. This resulted in certain dispersion of the radiocarbon dates from some layers, a fact which needed a critical analysis of the results leading to selection of the most accurate radiocarbon dates. So, it was out of the question to perform statistical analyses on the whole set of dates and to work with means (Dolukhanov et al., 2001), but rather to put the radiometric data in accordance with stratigraphic, pedological and archaeological observations.

Table 2. Comparison of the radiocarbon dates obtained on charcoal and on bone at Kostienki 14.

material	charcoal	bone	total
sections A - E	23	21	44
treated RBINS	19	1	20
acceptable	20	5	25
section E	20	8	28
treated RBINS	19	-	19
acceptable	19	2	21

From the 44 radiocarbon dates available for the whole sections, it ensues that 20 of the 23 dates made on charcoal, but only 5 of the 21 dates from bone turned out to be acceptable (Tabl. 1 and 2). Consequently, the chronological sequence of Kostienki 14 was established essentially with dates on conifer charcoal from section E (Fig. 2) while the validity of the dates on bone was estimated by taking into account the distribution of the ages in the sequence so as to preserve the internal coherence of the system (Fig. 3). In the case of the duplos made on some samples, the oldest date was systematically preferred.

3.2.1. The cover deposits (units 2 to 11)

Units 5 and 7 (cultural layer I)

In section E, four dates on bone material are available for cultural layer I which is undoubtedly related to unit 7, at the difference of sections A to D where cultural layer I dated to 20,100 BP was encountered in unit 5 (Sinitsyn, 1996). In section E, the four dates are distributed in two chronological groups, respectively 19,700 -19,900 BP and 22,500 - 22,780 BP (Tabl. 1). As mentioned before about rejuvenation, the two latter dates are the only ones acceptable for unit 7, taking into account the date of 20,100 BP from unit 5 in section D. However, these two sets of accepted dates should be considered with caution owing to possible contamination which are so frequently observed on bone remains.

Unit 11

An age of 29,240 BP was produced by AMS on 5 mg of charcoal selected from small fragments scattered in layered chalky debris (unit 11) reworked from the hill slope; nevertheless this age seems somewhat too old when considering the dates between 26,700 and 28,580 BP gathered for units 12 to 15 of the underlying upper humic bed. The cause of this down-dating thus lies partly in the low quality of the sample but also in its secondary origin as shown by the sedimentary environment, which suggests that dating such a material was probably a mistake.

3.2.2. The upper humic bed (units 12 to 16)

The upper humic bed is subdivided in three humiferous entities showing dark brown lenses stretched out by solifluction (units 12, 14 and 16) and separated by slope deposits dominated by loam and chalk (units 13 and 15). Actually, the main chronological markers in this complex for the whole set of sections are on the one hand, cultural layer II which occurred only in section B and D, and on the other hand, the lower humiferous horizon (unit 16) locally associated with cultural layer III in section C.

Units 12 to 15 (cultural layer II)

Cultural layer II, which was encountered only in the western sector of the promontory (sections B and D), provided a first set of three dates on bone comprised between 19,300 and 25,600 BP. They were discarded to the benefit of a second set of three dates on bone and charcoal that cover a coherent chronological span between 28,200 and 28,580 BP (Tabl. 1). Still the stratigraphic position of this cultural layer could not be fixed precisely as it appears to be situated in various stratigraphic positions from place to place, ranging from the base of the median humiferous horizon (unit 14) to the base of the underlying chalky loams (unit 15); although the most of the cultural layer probably belongs to unit 15 (Sinitsyn, 1996, Figs. 3 and 4).

In this connection, one should consider the dates 26,700 and 27,860 BP obtained in section E on small fragments of charcoal collected in the median humiferous horizon (unit 14) and in the overlying horizon (unit 12) respectively (Tabl. 1, n° 7 and 8). These dates seem well to be a point in favour of positioning cultural layer II at the level of the underlying chalky loam (unit 15). However, the inversion of the two dates is puzzling and in some way illustrates the complexity of a system affected by solifluction processes and partly supplied by slope material.

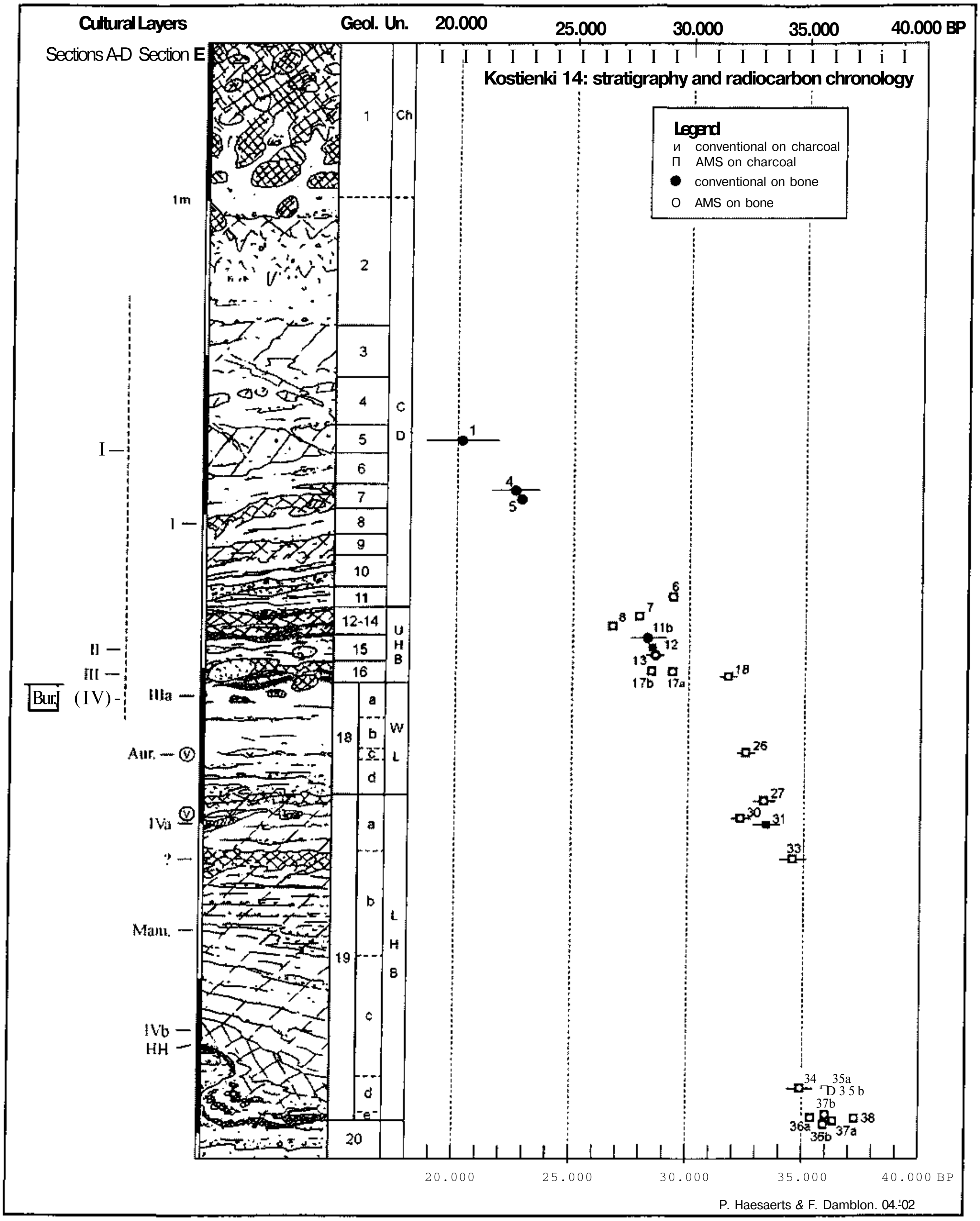

Figure 3. Stratigraphy and radiocarbon chronology; distribution of the dates in time and stratigraphy. Abbreviations. Ch.: top chernozem; CD: cover deposit, UHB: upper humic bed, WL: whitish loam, LHB: lower humic bed. Other shortenings: same as for figure 2; the number of each date refers to table 1.

Several hypotheses can be put forward to explain such an inversion. First, the possibility of a contamination of the sample from unit 14 by thin rootlets cannot be excluded. Second, some lateral supply of older charcoal fragments in unit 12 could have provoked a down-shift ofthe date similar to the one recorded in the overlying unit 11. Finally, an

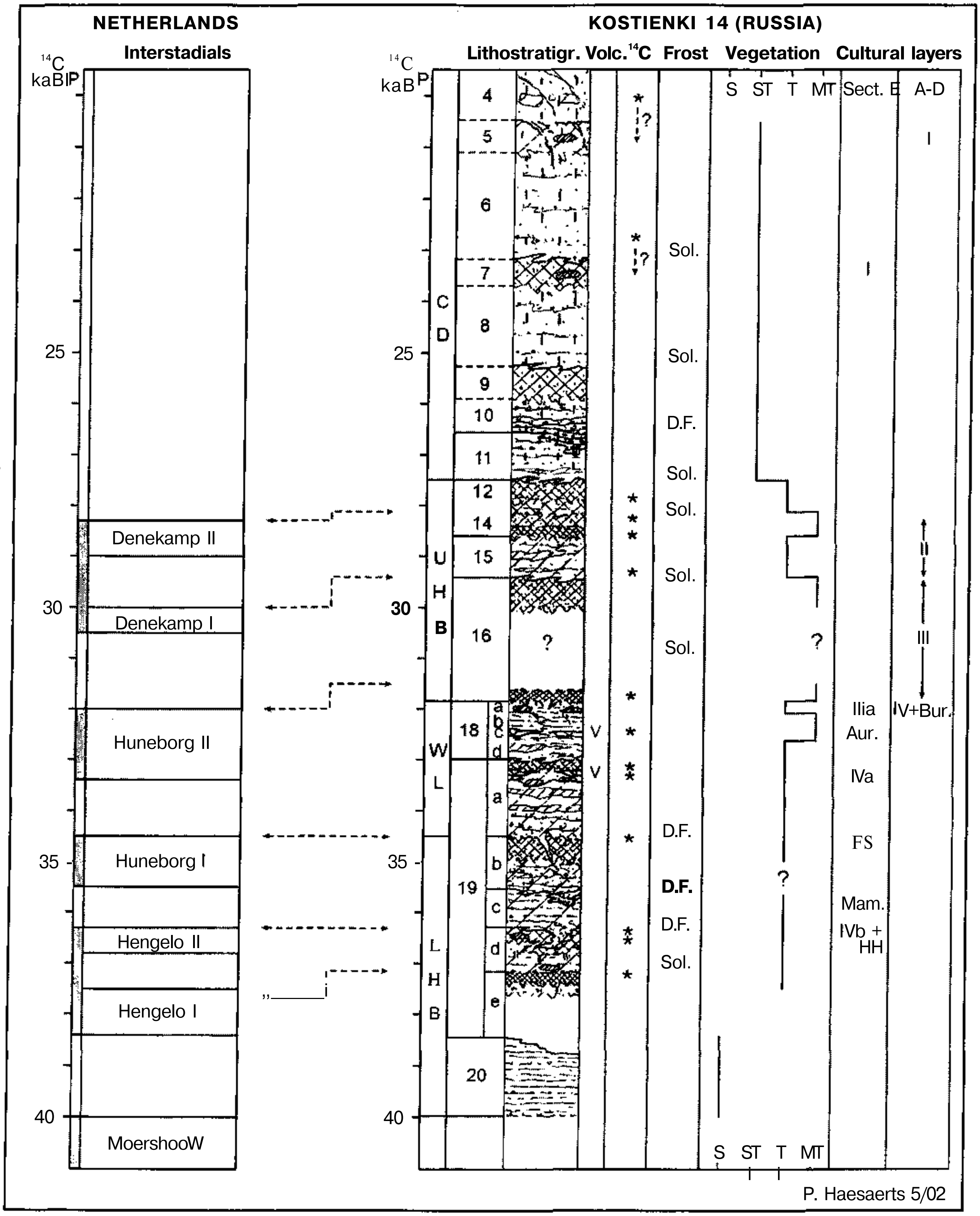

Figure 4. Correlation between the Kostienki 14 and the Dinkel Valley sequences.
Abbreviations. Vole: volcanic ashes; Sol.: solifluction; D.F.: deep frost; S: steppe;
ST: steppe-taTga; T: taîga; MT: mixed taiga.

eventual incidence ofan unusual low chronological resolution degree affecting this period should not be neglected. Such a difference in radiocarbon ages could have been induced by a wiggle in the 14C content ofthe atmosphere during the period considered (Kitagawa and van der Plicht, 1998, 2000; van der Plicht 2000).

Unit 16 (cultural layer III)

The case of the lower humic horizon, corresponding to unit 16 which contains cultural layer III in section C, is also complex. In particular, no coherent explanation can be proposed for the important chronological gap between the dates around 15,000 BP formerly obtained on charcoal and bone from section C (Tabl. 1, n° 14 - 16) and the dates comprised between 29,320 and 31,760 BP on charcoal samples from section E (Tabl. 1, n° 17 and 18). Nevertheless, only the latter dates were accepted because they appear as globally coherent with the chronological sequence of section E (Figs. 2 and 3). From this moment the humiferous horizon of unit 16 should represent a contraction of the time of about 2,500 years by integration of two pedogeneses as traced by the double structure of the horizon, taking into account the fact that the charcoal sample dated to 31,760 BP was selected in 1998 by one of us (P.H.) from the basal dark humiferous lenses of unit 16. However, once again a possible extension of the time by radiocarbon measurements should be considered as it is suggested by the gap of about 1000 years between the two dates (17a and 17b) from sample n°17 (i.e. 29,230 BP for the first date and 28,370 BP for its duplo).

In any case, the set of dates accepted for the upper humic bed plays in favour of a relatively coherent distribution of the pedosedimentary events in the time scale, allowing in a first step to situate unit 16 between ± 31.7 ka and ± 29.5 ka and units 15 to 12 between ± 28.5 and ± 27.5 ka.

3.2.3. The whitish loam (subunits 18a to 18d)

Unit 18 containing the main volcanic ash layer in its lower third (subunit 18c) can be distinguished from the above-lying humiferous complex by a predominance of homogeneous pale loamy sedimentation with very low lateral input, excepted in the lower part of the deposit (subunit 18d).

Subunit 18a (cultural layers IIia and IV)

In section E the concentration of bone remains attributed to layer IIia which was preserved in the upper part of the whitish loam (subunit 18a) provided an age of 30,080 BP. However, this date was obtained from a charcoal sample of mixed origin with a part coming from the whitish loam that contained bones, accidentally mixed with another part from the humiferous horizon of unit 16. Therefore the date 30,080 BP gives a minimum age for subunit 18a which is probably some centuries older.

In other respects, layer IIia appears to be in a similar stratigraphic position to cultural layer IV identified by Rogachev in sections B and D, and also to the burial in section C, whose pit opened under the humiferous horizon of unit 16 and was cutting the whitish loam of subunit 18b which contains the main volcanic ash (18c) (Sinitsyn 1996). However, the ages on bones obtained in both cases cannot be taken into consideration because they are too much rejuvenated with regard to the chronological context of the sequence (Tabl. 1, n° 23 - 24 and n° 19 - 21).

A comparable situation also occurs concerning the Aurignacian cultural layer put to light in section E during the 2001 excavations and associated with the main volcanic ash of subunit 18c (Sinitsyn *et al.,* 2002; Sinitsyn, this volume). From this layer, the date 20,640 BP on bone is clearly too young with regard to the date 32,420 BP on charcoal, the latter being quite compatible with the chronological scheme of section E (Figs. 2 and 3).

3.2.4. The lower humic bed (subunits 19a to 19e)

As mentioned before, the extensive development of this complex of colluviated loams in section E is linked to the presence of a gully cut through the whitish loams of unit 20.

Subunit 19a (cultural layer IVa)

Cultural layer IVa is included in the median part of the colluviated loams of subunit 19a where it is overlain by a generation of thin lenses of volcanic ash. This layer provided two dates on charcoal, respectively 33,280 BP on a former 4 g sample and 32,180 BP on a second one by AMS. The latter date seems a little rejuvenated - either by a slight pollution or by an eventual wiggle in the 14C content of the atmosphere (cf. § 3.2.2) - if the AMS date of 33,200 BP on a charcoal sample from the humiferous horizon at the top of 19a is taken into consideration.

This set of dates clarifies the ages of both volcanic ash layers, the main layer associated to the Aurignacian in 18c being around 32.5 ka and the underlying in 19a around 33.2 ka. These dates also lead to narrowing the chronological context of the burial in section C for which an age near 32.0 ka seems the most probable.

Subunit 19b (cultural layer in fossil soil) and 19c (mammoth)

As for the Aurignacian layer sealed by the volcanic ash in 18c, two dates showing a gap of more than ten millennia were obtained on isolated remains from a cultural layer in the humiferous soil at the top of subunit 19b, respectively 20,890 BP on bone and 34,550 BP on charcoal (Tabl. 2, n°32 and 33). Here again the most ancient age appears in good accordance with the general chronology of the sequence and can be considered as tracing the pedogenesis. The occurrence of a mammoth bone concentration in the upper part of subunit 19c should be mentioned. No Palaeolithic artefact was associated with this concentration apart some charcoal fragments preserved under the mammoth skull.

Subunits 19d and 19e (cultural layer IVb and horizon of hearth)

The archaeological material of cultural layer IVb included in the upper part of subunit 19d was associated with lenses of charcoal. For this layer, a first date on small charcoal fragments collected in 1998 provided a date of 34,940 BP while another date (36,040 BP) and its duplo (36,540 BP) were obtained on more abundant material taken in 2000. The most ancient age is thus considered as the most accurate when the whole set of dates from 19d gives a time span between 35.0 and 36.5 ka.

The horizon of hearth (HH) underneath layer IVb and associated to the humiferous horizon of subunit 19e at the bottom of the channel provided four dates including two duplos on two charcoal samples collected in 2001. They are distributed between 35,330 and 36,320 BP which represents a time span very comparable to the one obtained from layer IVb in subunit 19d.

Finally, a sample of charcoal collected in the humiferous soil in 19e appears as slightly older, with an age of 37,240 BP. This result seems to confirm the hypothesis of a reworking of the material from the horizon of hearth at the level of cultural layer IVb as it could be assumed from the nature and the distribution of the archaeological material (Sinitsyn *et al.,* 2002; Sinitsyn, this volume). The humiferous soil in 19e appears a few anterior to the human occupation associated with the horizon of hearth.

4. GENERAL OVERVIEW

4.1. Radiocarbon chronology

Because of the local occurrence of a gully at the convergence of two ravines, section E at Kostienki 14 provided the most documented stratigraphic sequence; this situation allowed a dilated record of the lower part of the sequence including the whitish loam with volcanic ash (unit 18) and the underlying lower humiferous bed (unit 19). On the other hand, remains of a great number of Palaeolithic occupations well distributed in the stratigraphy, provided good quality material for radiocarbon dating. Globally, from the 44 dates available for the whole set of the 5 sections at Kostienki 14, some 28 dates mostly on charcoal come from section E, which was used as a guide for establishing the reference sequence (Fig.2).

In other words, Kostienki 14 is well illustrative of the methodological questions asked by the establishment of an accurate radiocarbon chronology for a Palaeolithic site in a loamy environment influenced by lateral input from the slope. Notably, the analysis of the radiometric data allowed a better evaluation of the validity of the dates on the ground of their distribution in the stratigraphic sequence and also with regard to the nature and the quantity of the material for dating. Actually, most of the dates on charcoal appear to be accurate when the ones on bone were rather systematically rejuvenated. At Kostienki 14, the differences in dates from charcoal and from bone cannot be attributed to an eventual old wood effect which appears hard to detect for the time span considered. This does not mean of course that dates on bone and on charcoal are never in accordance as demonstrated by close results at Cosautsi for the period 19 - 17 ka (Haesaerts et al. 1998).

Another aspect deals with the accuracy and the reproducibility of the dates from a same unit or layer, and even for a same sample dated twice by duplo. Clearly at Kostienki 14, the sigma gives only a relative indication of the precision of the result as suggested by the gaps rising up to a millennium between the ages obtained from a same series of samples, the cause of such variations being difficult to clarify.

Still, taken globally, the new stratigraphy established for Kostienki 14 and the complete series of radiocarbon dates gathered and accepted in the frame of the last investigations allow a coherent reconstruction of the pedosedimentary events and of the main occupation phases of the site within a time sequence documented mainly for the period between ± 27 ka and 37 ka.

4.2. Stratigraphy and palaeoenvironment

The first point deals with the upper humic bed (units 12 to 16) which seems to record two complex phases clearly distinct in time with stabilisation of the landscape and formation of humiferous horizons.

The first probably doubled phase should be situated between ± 27 and 28 ka (units 12 to 14), probably just after cultural layer II dated around 28.2 - 28.5 ka. In this phase the pollen record from Kostienki 14 established by Malyasova and Spiridonova (1982) gives local indication of a shift from a local taiga with mesophilous trees (unit 14) to a spruce tai'ga vegetation (unit 12) growing in the ravines. This precedes the climatic cooling with deep frost (units 11 and 10) recorded at the base of the cover deposits which contains cultural layer I dated between ± 22.8 and ± 20.1 ka and occurring in various stratigraphic positions (units 7 and 5) in the different sections.

The second phase also associated to the formation of humiferous horizons (unit 16) would integrate a rather long period of time probably comprised between ± 29.5 and 31.8 ka during which the occupation of cultural layer III occurred. Each time these episodes of pedogenesis appear as a consequence of a climatic amelioration also expressed in the pollen diagram by a slight extension of mesophilous taxa, notably *Tilia.*

A third set of specific deposits corresponds to the whitish loam of unit 18 which appears to be separated from overlying unit 16 by a slight erosion phase on the slope (subunit 18a). The concentration of bone named Ilia in section E and the famous burial in section C with a probable age around 32 ka should be placed in this context. The median part of unit 18, composed of homogeneous laminated loam (subunit 18b) that follows a first generation of colluvium (subunit 18d), was deposited in low energy conditions without lateral input. The corresponding pollen record shows a rise of meadow indicators while the arboreal component with dominant *Pinus,* rising *Picea* and development of mesophilous deciduous taxa point to rather milder conditions. Finally, at the base of the whitish loam 18b the main volcanic ash layer including the Aurignacian cultural layer excavated in 2001 (subunit 18c) is dated precisely 32.4 ka.

The lower humic bed (unit 19) presents an exceptionally high degree of resolution because the presence of a gully favoured a pedosedimentary record lasting almost 4,000 years, from ± 33.0 ka to ± 37.2 ka. Indeed, this part of the sequence records not less than four distinct humiferous horizons dated respectively around 33,2 ka (subunit 19a), around 34,5 ka (subunit 19b), probably around 36,5 ka (subunit 19d) and around 37,2 ka (subunit 19e). Each time, these episodes of pedogenesis alternate with colluvial phases most often preceded by deep frost episodes. By another way, despite the fact that pollen record available for the lower humic bed concerns only a part of the sedimentary episodes in section E (Malyasova and Spiridonova, 1982: fig. 80), it nevertheless testifies to the persistence between 37 and 33 ka in the bottom of the ravine of a spruce taiga-type vegetation in a climatic context globally humid. In this way, the lower humic bed is clearly distinguished from the underlying pale loams (unit 20) which clearly represent a cold steppic environment.

As a result, a coherent and well documented stratigraphic and chronological scheme becomes available and allows for the first time to situate with precision not less than three distinct Upper Palaeolithic occupations in the lower humic bed. It is particularly the case of cultural layer IVa occurring in subunit 19a and well dated to 33.3 ka just prior to a first volcanic fallout close to 33.2 ka. Consequently this ash layer would be about one millennium anterior to the main volcanic layer in 18c associated with the Aurignacian occupation dated to 32.4 ka. Finally, apart from some lithic pieces present in the humiferous soil 19b dated 34.5 ka, the strongest archaeological evidence in the lower part of the sequence is represented by cultural layer IVb and the underlying horizon of hearth. Actually, both concentrations well dated between ± 36.0 and 36.5 ka probably belong to the same occupation phase characterized by a remarkable Upper Palaeolithic industry comprising a human figurine considered as the oldest manifestation of art in the Eastern Europe (Sinitsyn, this volume). Their age appears in a good agreement with the date 37.2 ka obtained for the humiferous horizon 19e at the base of the lower humic bed.

4.3. Chronostratigraphic background

By comparison with the sequences preserved at Kostienki on the first and second terraces of the Don, the Kostienki 14 sequence represents the best documented one concerning the period 27.5 - 37 ka. Consequently, it will be used as a reference for integrating the Kostienki 12 and Kostienki 17 stratigraphies where radiocarbon ages on charcoal of about 36.4 ka have been obtained at the level of the lower humic bed (Praslov and Rogachev, 1982).

In a larger frame, Kostienki 14 also constitutes a reference sequence for the loess of the Great Russian Plain insofar as the Middle Pleniglacial is generally represented by the Briansk soil dated between 28 and 45 ka without more precision (Velichko et al, 1997). On the contrary, the succession of pedosedimentary and climatic events during the Middle Pleniglacial is better expressed in the East Carpathian Area especially at Molodova V on the Dniester and at Mitoc Malu Galben on the Prut (Haesaerts et al. 2003). In particular, a series of 3 to 4 humiferous soils associated there to interstadial episodes well dated between 32.5 and 27 ka, named Malu Galben 12 to 8, seem to be equivalent to the upper humic bed at Kostienki 14. Likewise at Molodova V, which represents one of the single records for the period 32.5 - 37 ka in the loessic field of Central Europe, several distinct humiferous soils could correspond to this period but the lack of radiocarbon date prevents clarification of their age.

Consequently, in the present work, the Kostienki 14 sequence is put in parallel with the succession of palaeoclimatic events obtained in the Netherlands from the Middle Pleniglacial deposits of the Dinkel Valley (Fig. 4), whose chronological framework was established on a large number of accurate radiocarbon dates (van der Hammen 1995). Such an approach is justified by the necessity of developing the correlative system within a chronological framework founded on radiocarbon dates while other attempts at correlation, notably by considering the volcanic ashes or the magnetic excursion ascribed to "Laschamp" (Sinitsyn *et al.,* 2002), remain premature in the present context.

Indeed, the comparison of both sequences from Kostienki 14 and from the Netherlands which were established quite independently, highlight numerous similarities in the succession of climatic events which appear to be remarkably synchronous for the period 32.5 - 37 ka. This reinforces the validity of the record at Kostienki 14 as a reference sequence for the Middle Pleniglacial in Central Russia.

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Authors' addresses

Paul HAESAERTS
Freddy DAMBLON
Royal Belgian Institute of Natural Sciences
Department of Paleontology
Vautierstreet 29
B-1000 Brussels, BELGIUM

Andrei SINITSYN
Institute of the History of the Material Culture
R.A.S.; Dvortsovaia nab., 18
Saint-Petersburg, 191186 RUSSIA

Johannes van der PLICHT
Centrum voor Isotopen Onderzoek
Rijksuniversiteit Groningen
Nijenborgh 4
NL-9747 Groningen, THE NETHERLANDS

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