CLIMATIC EVENTS AND UPPER PALEOLITHIC CHRONOLOGY IN THE DNIESTER BASIN: NEW ^{14}C RESULTS FROM COSAUTSI

PAUL HAESAERTS,[1] ILIC BORZIAK,[2] JOHANNES VAN DER PLICHT[3] and FREDDY DAMBLON[1]

ABSTRACT. We discuss the radiocarbon chronology of the loess deposited during the Upper Pleniglacial (Isotope Stage II) for the key site of Cosautsi (Republic of Moldova), which presents some major problems in ^{14}C dating. Special care was paid to accurate microstratigraphic positioning of samples, collection of top-quality material (mainly conifer charcoal), and selection of uncontaminated pieces for dating and crossdating with bones by accelerator mass spectrometry (AMS) and/or conventional ^{14}C dating. The results provide reliable and precise information on the sedimentation processes, the succession of short climatic events and the cycle of recurrent human settlements on the site between ~20,000 and 16,000 BP. Two sets of climatic improvements can be ascribed to interstadial oscillations named, successively, Cosautsi VI (19,500–19,000 BP) and Cosautsi V (18–17,500 BP).

INTRODUCTION

The vast loess sheets that cover the great Eurasiatic plain provide essential data on Quaternary paleoenvironments. Their microstratigraphic study can give detailed information about the smallest climatic fluctuations that affected the continental field during the Pleistocene. This observation is hampered, however, by the scarcity of long continuous sequences and by the problems connected with dating the recorded events.

Cosautsi, located on the west bank of the Dniester River in northeast Moldova (Fig. 1), is an Upper Paleolithic site excavated by Borziak since 1985 (Borziak 1991, 1993). The interest of the site lies, first, in a 18.5-m-thick stratigraphic sequence encompassing the whole Upper Pleniglacial and the Late Glacial and, second, in the preservation in the upper 12 m of 21 distinct occupation layers with numerous artifacts, bone remains and charcoal concentrations, all related to the Late Gravettian industry (Borziak 1993; Otte *et al.* 1996). *Ca.* 15 ^{14}C datings were performed in various Russian and American laboratories for cultural layers 1 to 6 with varying levels of success (Svezhentsev 1993). Given the importance of the climatic and archaeological data, a new stratigraphic sequence of the site was recorded by us beginning in 1994; this completed the multidisciplinary approach to the site undertaken in conjunction with archaeological teams from Kishinev (Moldova) and from Liège (Belgium). This work is part of a large project involving Upper Paleolithic chronology and climatic events in Central Europe and the Russian plain (Damblon, Haesaerts and van der Plicht 1996; Haesaerts *et al.* 1996).

METHODS

This Cosautsi sequence has been subjected to a detailed stratigraphic study illuminating the sedimentary processes and climatic events recorded in the deposits. The paleontological material (charcoal, bones and molluscs) was systematically sampled, extracted and analyzed for ^{14}C dating and for paleoenvironmental reconstruction.

The first methodological challenge involved the spatial and stratigraphic origin of the dated samples. Each sample was very precisely positioned in the stratigraphic sequence. After our experience in the field, such an operation, which seems elementary, is not always guaranteed to be successful during archaeological excavations in loess. In order to avoid any mixing of material, the samples

[1]Royal Belgian Institute of Natural Sciences, Vautierstreet 29, B-1000 Brussels, Belgium
[2]Insitutul de Archeologie, Academia de Stinte, Pr. Stefan cel Mare 1, 277612 Chisinau, Republic of Moldova
[3]Centre for Isotope Research, University of Groningen, Nijenborgh 4, 9747 AG Groningen, The Netherlands

Proceedings of the 16th International ^{14}C Conference, edited by W. G. Mook and J. van der Plicht
RADIOCARBON, Vol. 40, No. 2, 1998, P. 649–657

https://doi.org/10.1017/S0033822200018580 Published online by Cambridge University Press

Fig. 1. Location of the Cosautsi site

were taken out of sections or out of small benches, allowing a continuous control of the stratigraphy and avoiding distortions caused by, *e.g.*, krotovinas or cryoturbations.

The second concern was the biological material selected for dating. When possible, preference was given to charcoal, which is considered to be one of the most reliable materials for ^{14}C dating because of its high inert carbon content and its easy purification by chemical pretreatments (Mook and Waterbolk 1985; Gowlett and Hedges 1987; Bowman 1990; Lanting and van der Plicht 1993/1994). In addition, bone remains were also used to crossdate most of the cultural layers. Charcoal and bone samples were taken preferentially out of concentrations, either from hearth remains, or from clusters. However, in some cases scattered pieces had to be collected from some clearly delimited horizons without concentrations.

The charcoal was collected by water sieving and, in some cases, treated with HF and HCl to eliminate the silicates and carbonates. The material intended for dating was very carefully chosen after remains of rootlets, mycelium, concretions and other pollutants were removed through a minute binocular selection procedure. Finally, each piece of charcoal was identified by anthracological analysis, which allowed a final control of the material's quality. In light of the period under consideration and the large predominance of conifers in the anthracological assemblages, we preferentially chose *Picea* and *Pinus* charcoal (Table 1). *Salix* fragments were discarded to avoid the slightest risk of intrusive mixing.

The samples were dated by means of ^{14}C, either conventionally or by AMS depending on the available quantities and the quality of material. All the charcoal samples from 13 archaeological layers were dated in Groningen to guarantee the consistency of the treatments and measurements. A series of bone remains taken out of 12 cultural layers was dated in Oxford for purposes of comparison.

https://doi.org/10.1017/S0033822200018580 Published online by Cambridge University Press

TABLE 1. Anthracological Composition of the Cosautsi Samples

Sedimentary cycle	IV		V						VI							VII
Subcycles	1	2	1	2	3	3	4	4	1	1	2	2	3	4	4	1
Cultural layer	1b	1	2a	2c	3b	3	3a	4	5	6a	6b	6d	7	8	9	10
Picea sp.	**	*	***	***	***	**	***	***	***	***	***	**	***	***	***	***
Pinus t. cembra	**	***	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Salix sp.	--	*	--	--	--	--	--	--	--	--	--	--	--	--	--	--

* = <25%, ** = 25–50%, *** = > 50% of the total.

RESULTS

The lithological sequence is essentially made up of eolian sediment deposited on a gentle slope toward the river at the outlet of a small lateral valley. The sequence has been subdivided into nine sedimentary cycles (I–IX), each of them including several subcycles (32 in total). In its lower half, the loess sedimentation is interstratified with silt beds and interrupted by chalky layers. Various slight humus-bearing horizons also represent short stabilization phases, mainly in cycles VI and V. Cycle IV is characterized by sandy deposits with skewed stratification filling a network of ice-wedges in its upper part (subcycle IV-1). Cycles III and II are made of loess crossed by chalky screening deposits and by at least four humic horizons. Cycle I corresponds to surface soil developed in colluvium. Only the upper 14-m sequence containing the datable material is discussed in the present work (Fig. 2).

Each of the 21 human occupation layers has been precisely located in the stratigraphy. So far, 31 new dates have been obtained from the lowermost layer 10 up to layer 1. Some 17 AMS dates on bone remains collected by I. Lopez-Bayon from layers 10 to 2c were measured at the Oxford laboratory (Otte *et al.* 1996); 14 various dates on *Picea* and *Pinus* charcoal collected by F. Damblon and P. Haesaerts from layers 9 to 1b were measured in Groningen (Fig. 3). Together with the 15 previous datings, some 46 ^{14}C dates are presently available to frame 17 cultural layers encompassing 18 sedimentary subcycles.

Table 2 and Figure 3 allow an easy comparison between the previous dates on charcoal (Svezhentsev 1993) and the new dates for charcoal and bones.The contrast between previous dates from Russian laboratories and new dates from Groningen and Oxford is striking. Large differences occur between LE- and GIN-dates, notably for layers 2b and 3. On the other hand, some satisfactory concordance can be seen between the dates of layer 1 (no. 2, GrA-5217: 17,130 ± 180 and no. 3, GIN-4146: 17,200 ± 300), of layer 2a (no. 5, SOAN-2452: 16,940 ± 1215 and no. 6, GrN-21792: 17,230 ± 140), of layer 3b (no. 13, SOAN-2462: 17,840 ± 550 and no. 15, GrN-21360: 17,910 ± 80), of layer 4 (no. 24, LE-3308: 17,640 ± 830 and no. 26, GrN-21794: 17,950 ± 100) and also of layer 6c (no. 37, AA-1864: 18,935 ± 160 and no. 36, OxA-5255: 18,860 ± 200). There appears to be a systematic shift (up to 300 BP, and more with GIN) between SOAN/LE (old data set) and GrA/GrN/OxA (present data). Clearly, the new Groningen and Oxford dates present somewhat older ages and more precise values than the previous ones.

The distribution of the 14 new dates on charcoal shows a coherent evolution between layer 9 (no. 45, GrN-21795: 19,410 ± 100) and layer 1b (no. 1, GrA-4209: 16,050 ± 170). The most salient feature from the data is the evidence of two sets of dates, the former being associated with the lower layers 9 to 6b and the latter linked with the layers 5 to 1b. The first set of dates between layers 9 and 6b ranges from *ca.* (no. 45) 19,400 and (no. 35) 19,200 BP, and inside the second set the dates obtained from layers 5 to 1 range from (no. 30) 18,260 to (no. 2) 17,130 BP, indicating a high sedimentation rate. Therefore, a break is apparent between layers 6b and 5, suggesting a slowing down of the sed-

TABLE 2. Cosautsi ^{14}C Dates

No. in Fig. 3	Sedimentation cycle	Sub-cycle	Cultural layer	Laboratory code	^{14}C age (yr BP)	Material	Weight (g)
*1	IV	1	1b	GrA-4209	16,050 ± 170	Charcoal	0.023
*2	IV	2	1	GrA-5217	17,130 ± 180	Charcoal	0.555
3		2	1	GIN-4146	17,200 ± 300	Charcoal	--
4	V	1	2a	LE-3304	16,860 ± 770	Charcoal	--
5		1	2a	SOAN-2452	16,940 ± 1215	Charcoal	--
*6		1	2a	GrN-21792	17,230 ± 140	Charcoal	2.747
7	V	2	2b	LE-3305	15,520 ± 800	Charcoal	--
8		2	2b	GIN-4148	18,200 ± 500	Charcoal	--
9		2	2b	SOAN-2461	19,620 ± 925	Charcoal	--
*10	V	2	2c	GrN-21793	17,620 ± 210	Charcoal	2.210
*11		2	2c	OxA-5233	17,900 ± 200	Bone	--
12	V	3	3b	LE-3307	17,390 ± 580	Charcoal	--
13		3	3b	SOAN-2462	17,840 ± 550	Charcoal	--
*14		3	3b	OxA-5234	17,900 ± 180	Bone	--
*15		3	3b	GrN-21360	17,910 ± 80	Charcoal	8.400
*16		3	3b	OxA-5235	18,000 ± 180	Bone	--
17	V	3	3	GIN-4149	16,160 ± 250	Charcoal	--
18		3	3	LE-3306	17,400 ± 340	Charcoal	--
*19		3	3	OxA-5236	17,840 ± 180	Bone	--
*20		3	3	GrN-21359	18,030 ± 150	Charcoal	3.700
*21	V	4	3a	GrA-7554	17,780 ± 90	Charcoal	0.448
*22		4	3a	OxA-5237	18,000 ± 180	Bone	--
23	V	4	4	GIN-4150	17,100 ± 250	Charcoal	--
24		4	4	LE-3308	17,640 ± 830	Charcoal	--
*25		4	4	OxA-5257	17,840 ± 180	Bone	--
*26		4	4	GrN-21794	17,950 ± 100	Charcoal	5.700
27	VI	1	5	GIN-4152	17,030 ± 180	Charcoal	--
*28		1	5	OxA-5238	18,060 ± 180	Bone	--
*29		1	5	OxA-5247	18,140 ± 200	Bone	--
*30		1	5	GrA-5218	18,260 ± 210	Charcoal	0.517
31	VI	1	6a	AA-1862	18,140 ± 165	Charcoal	--
*32		1	6a	OxA-5248	18,780 ± 200	Bone	--
*33	VI	2	6b	OxA-5256	18,560 ± 200	Bone	--
*34		2	6b	OxA-5249	18,940 ± 220	Bone	--
*35		2	6b	GrN-21361	19,200 ± 130	Charcoal	2.100
*36	VI	2	6c	OxA-5255	18,860 ± 200	Bone	--
37		2	6c	AA-1864	18,935 ± 160	Charcoal	--
*38	VI	2	6d	GrA-7555	19,120 ± 100	Charcoal	0.215
*39	VI	3	7	OxA-5250	18,980 ± 220	Bone	--
*40		3	7	GrA-6746	19,440 ± 100	Charcoal	0.260
*41	VI	4	8	GrA-7557	19,070 ± 100	Charcoal	0.122
*42	VI	4	9	OxA-5251	19,060 ± 220	Bone	--
*43		4	9	OxA-5252	19,060 ± 200	Bone	--
*44		4	9	OxA-5253	19,080 ± 220	Bone	--
*45		4	9	GrN-21795	19,410 ± 100	Charcoal	6.000
*46	VII	1	10	OxA-5254	18,980 ± 200	Bone	--

*Sc-004 date (*i.e.*, from the present research project).

https://doi.org/10.1017/S0033822200018580 Published online by Cambridge University Press

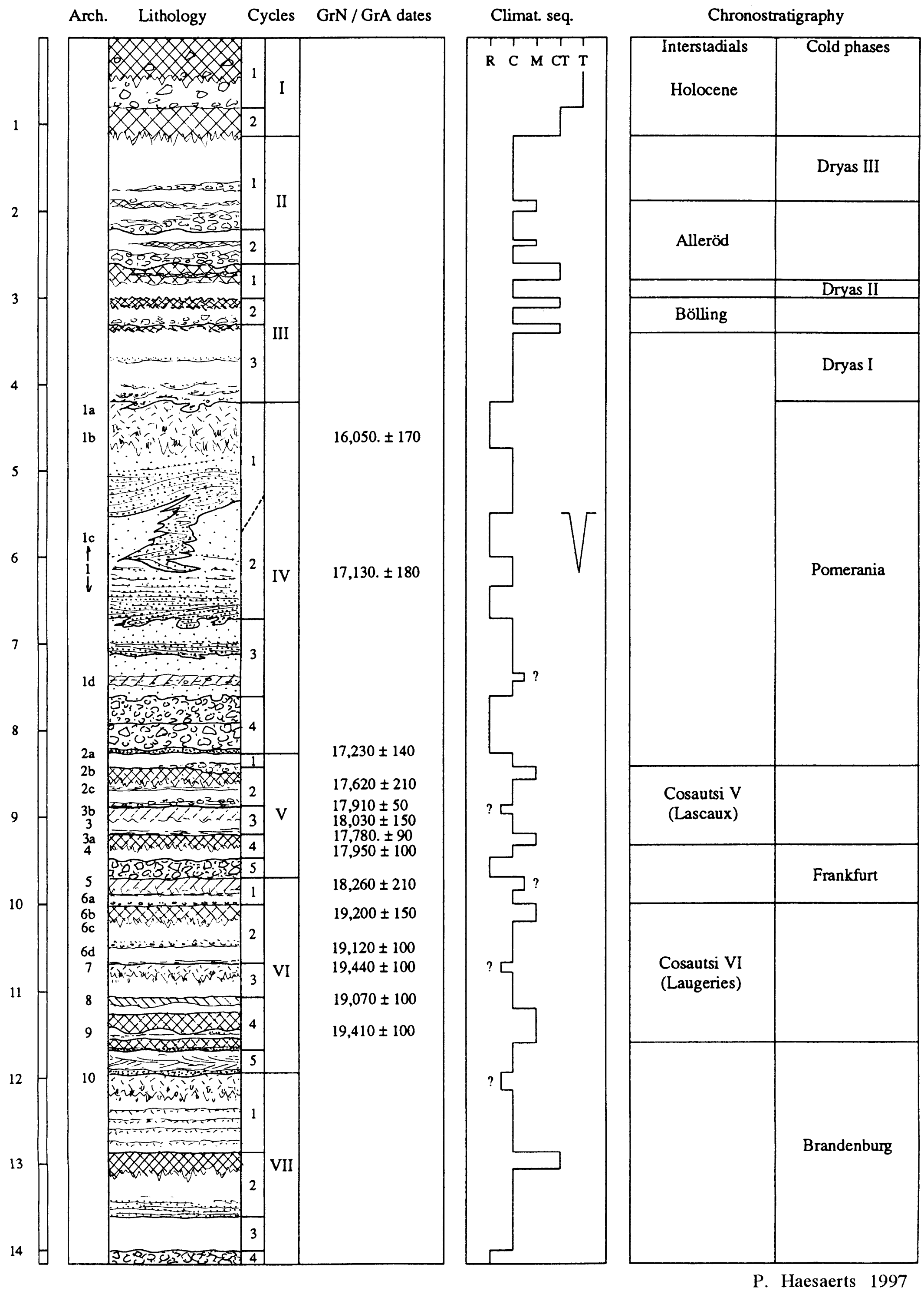


Fig. 2. Stratigraphy, chronology, climatic sequence and chronostratigraphy of the Cosautsi site. Climatic sequence: R = rigorous, C = cold, M = medium cold, CT = cold-temperate, T = temperate.

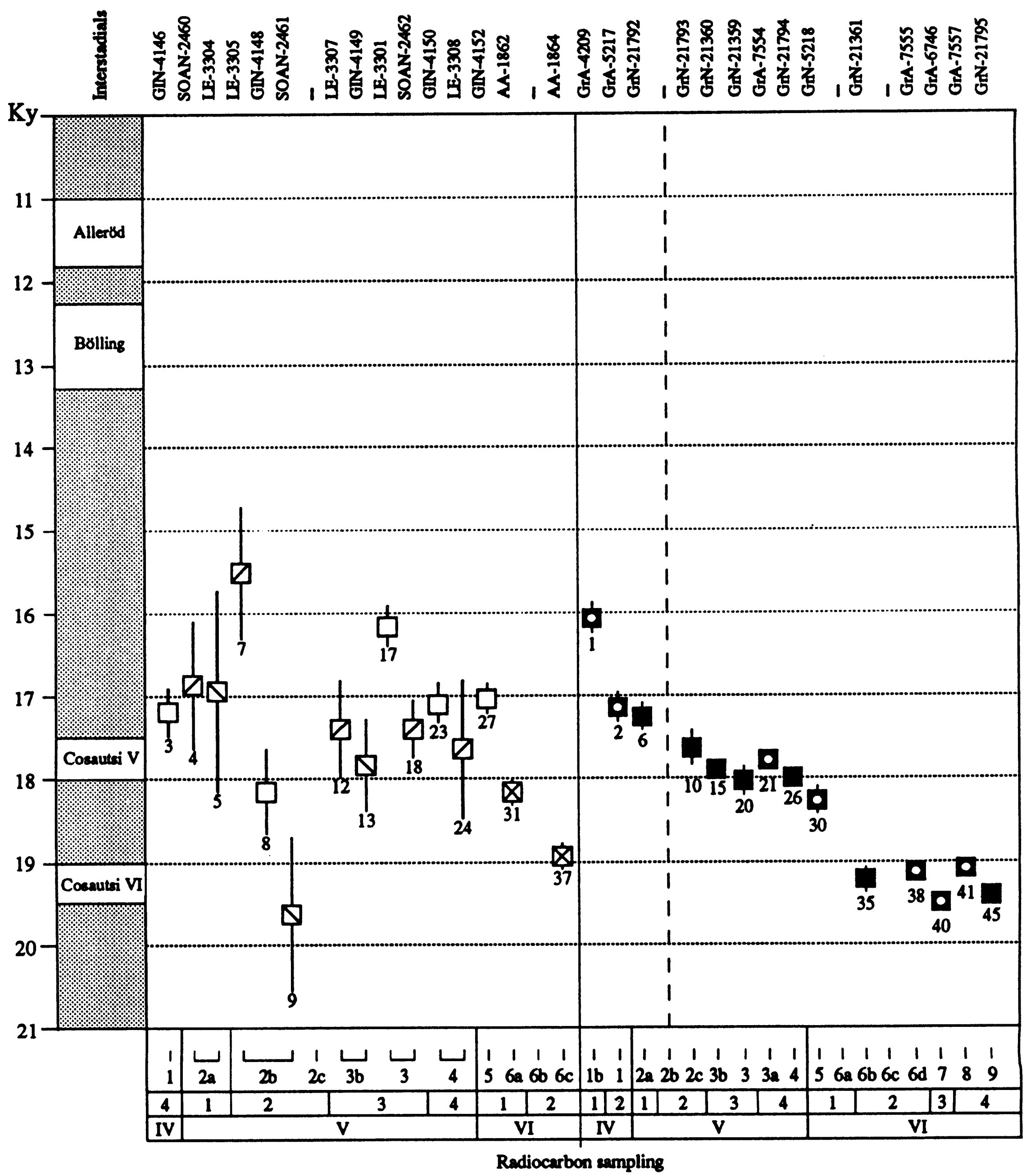
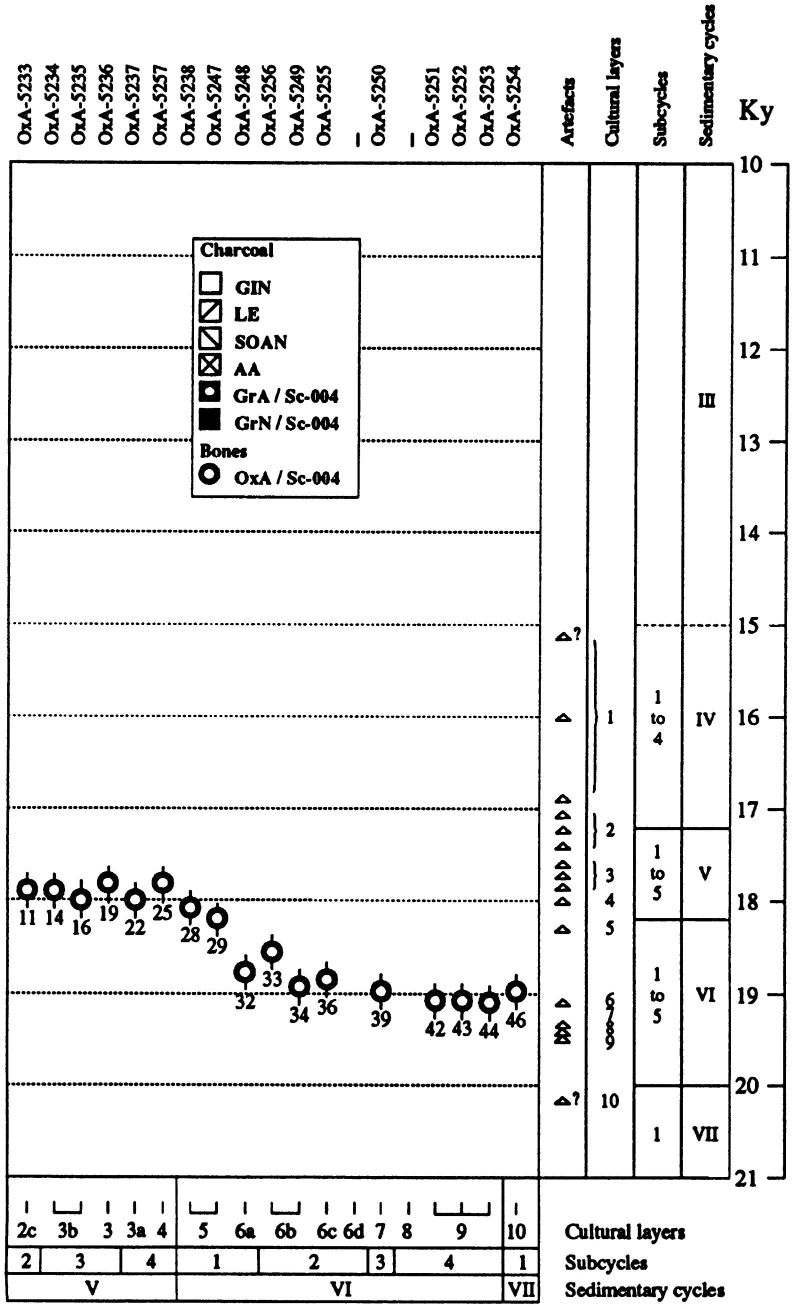


Fig. 3 *(above and facing page)*. Chronostratigraphy and chronology of the Cosautsi site. Distribution of the dates by sedimentary subcycle and by cultural layer. First group: previous published Russian and American dates; second group: new Groningen dates on charcoal; third group: new Oxford dates on bones.

https://doi.org/10.1017/S0033822200018580 Published online by Cambridge University Press



https://doi.org/10.1017/S0033822200018580 Published online by Cambridge University Press

imentation rate in the upper part of the sedimentary cycle VI. On the other hand, the chalky layers do not appear as important time lags but rather as very sudden flow injections coming from the hill following ice melting. Such a distribution of the dates on charcoal is in good accordance with the stratigraphic data.

Figure 3 clearly shows a parallelism between the distribution line of the Oxford dates on bones and the trend of the Groningen dates on charcoal between the layers 9 and 2c. The agreement is obvious, for example, in the cultural layers 3b, 3, 4 and 5. Moreover, the same lag is apparent between layers 6a and 5, also pointing to a sedimentation break in subcycle VI-1. However, the comparison of both sets of results shows some flattening of the distribution of the dates on bones, whereas the dates on charcoal appear a little more spread out, especially near the top and the bottom layers. If the GrN or GrA dates on charcoal are somewhat older than OxA dates on bones from layers 7 and 9, the contrary happens in 3b and 2c. Such a situation could be explained either by the effect of some contamination of the bone material by humics or by an old-wood effect on *Picea*. Still, such an effect, which should amount to 460 yr (the difference between dates nos. 40 and 39), does not appear obvious for the Upper Pleniglacial period, notably since conventional dates on charcoal are younger than AMS on bones from layers 3b and 2c.

It is also true that some AMS dates for charcoal, as in layers 8 (no. 41), 6d (no. 38) and 3a (no. 21) appear too young compared with the conventional dates from layers above (nos. 40, 35, 20) or with the OxA equivalent date from layer 3a (no. 22). Because a reliable date for layer 9 was obtained on a 6 g charcoal sample (no. 45), AMS dating seems very sensitive to the least contamination, undetectable under the microscope.

Altogether, the distribution of the ^{14}C dates on charcoal frames a relatively short period of *ca.* 3300 yr for accumulation of >6 m of loess, loam and sand, but evidently with a varying deposition rate. A quasi sedimentation break of *ca.* 1000 yr is present in subcycle VI-1, between cultural layers 6b and 5.

The new succession of dates from the loess sequence at Cosautsi allows the chronological establishment of two main climatic ameliorations indicated by sets of humic horizons. The first set (subcycle VI-4) is dated from *ca.* 19,500 up to 19,000 BP. This episode is named here "Cosautsi VI Interstadial". The second set (subcycles V-4 to 2) is limited from 18,000 up to *ca.* 17,500 BP and is named "Cosautsi V Interstadial". Most likely this pair of positive climatic variations are similar to the Laugeries and Lascaux Interstadials recognized by Leroi-Gourhan (1968) in southwest France, and are recorded by palynology as well in the sequence of Maisières-Canal in central Belgium (Bastin 1971; Haesaerts and de Heinzelin 1979).

The new ^{14}C dates also provide information on the last phase of sedimentation of the Upper Pleniglacial, which seems to have begun *ca.* 17,200–17,100 BP. Nearly 4 m of sandy loess was deposited during cycle IV and between 17,200 and 16,000 BP. The evidence for active permafrost in this part of the sequence (subcycle IV-4) points to very cold climatic conditions that form a sharp contrast with the uppermost loess series, including at least four humus-bearing horizons provisionally ascribed to the Late Glacial.

The new series of GrN/GrA/OxA dates also gives crucial information on the human occupations in Cosautsi, which was frequented by hunters during >3000 yr, from *ca.* 19,500 up to 16,000 BP. The strategic position of the site, facing a ford at the outlet of a lateral valley and near a spring, may explain the recurrence of the Upper Gravettian settlements at Cosautsi.

Conclusion

Reliable and precise new ^{14}C dates were obtained from the Cosautsi Upper Pleistocene site. The results are based on minute microstratigraphic studies and radiometric datings on charcoal and bone pieces, selected for their quality and purity. Multiple crossdatings on charcoal and bone were quite satisfactory, but with somewhat older dates on charcoal. Some differences may also appear between conventional and AMS dates, the latter being very sensitive to the least contamination.

Precise information on sedimentary processes, deposition rate and paleosol formation for the sequence can be obtained. The combination of the stratigraphic data and the radiochronology from the sections allows the characterization of two climatic improvements between *ca.* 19,500 and 19,000 BP (Cosautsi VI) and between 18,000 and 17,500 BP (Cosautsi V) during the Upper Pleniglacial. A very cold phase with active permafrost is also documented here between 17,000 and 16,000 BP, just before the last loessic deposit ascribed to the Late Glacial.

Acknowledgments

This text presents research results of the Belgian program Service Centres and Research Networks (Projects Sc-004 and Sc-01/009), initiated by the Belgian State, Prime Minister's Office, Federal Services of Scientific, Technical and Cultural Affairs. The research was also supported by INTAS project no. 1963. We are thankful to H. J. Streurman and A. T. Aerts (CIR Groningen) for sample handling. H. de Potter and C. Herzé (IRSNB) provided effective assistance in the technical accomplishment of the project.

References

Bastin, B. 1971 Recherches sur l'évolution du peuplement végétal en Belgique durant la glaciation du Würm. *Acta Geographica Lovaniensia* (Louvain) 9: 1–136.

Borziak, I. 1991 Quelques données préalables sur l'habitat tardipaléolithique pluristratifié de Cosseoutsy sur le Dniestr moyen. *In* Chirica, V., ed., *Le Paléolithique et le Néolithique de la Roumanie en contexte européen*. Bibliotheca Archaeologica Iassiensis 4. Iasi, Rumania, Académie Roumaine, Filiale Iasi: 56–71.

____1993 Les chasseurs de renne de Kosoioutsy, site paléolithique tardif à plusieurs niveaux sur le Dniestr moyen (rapport préliminaire). *L'Anthropologie* (Paris) 97(2–3): 331–336.

Bowman, S. 1990 *Radiocarbon Dating*. London, British Museum Publications: 64 p.

Damblon, F., Haesaerts, P. and van der Plicht, J. 1996 New datings and considerations on the chronology of Upper Palaeolithic sites in the Great Eurasiatic Plain. *Préhistoire Européenne* 9: 177–231.

Gowlett, J. A. J. and Hedges, R. E. M. 1987 Lessons of context and contamination in dating the Upper Palaeolithic. *In* Gowlett, J. A. J. and Hedges, R. E. M., eds., *Archaeological Results from Accelerator Dating*. Oxford University Committee for Archaeology, Monograph 11. Oxford, Oxford University Committee for Archaeology: 63–71.

Haesaerts, P., Damblon, F., Bachner, M. and Trinka, G. 1996 Revised stratigraphy and chronology of the Willendorf II sequence, Lower Austria. *Archaeologia Austriaea* 80: 25–42.

Haesaerts, P. and de Heinzelin, J. 1979 *Le site paléolithique de Maisières-Canal.* Dissertationes Archaeologicae Gandenses 19. Brugge, De Tempel: 119 p.

Lanting, J. N. and van der Plicht, J. 1993/1994 ^{14}C-AMS: Pros and cons for archaeology. *Palaeohistoria* 35/36: 1–12.

Leroi-Gourhan, A. 1968 Dénomination des oscillations würmiennes. *Bulletin de l'Association Française du Quaternaire* 4: 281–287.

Mook, W. G. and Waterbolk, H. T. 1985 *Radiocarbon Dating*. Handbooks for Archaeologists 3. Strasbourg, European Science Foundation: 65 p.

Otte, M., Lopez-Bayon, I., Noiret, P., Borziak, I. and Chirica, V. 1996 Recherches sur le Paléolithique supérieur de la Moldavie. *Anthropologie et Préhistoire* (Bruxelles) 107: 1–36.

Svezhentsev, Yu. S. 1993 Radiocarbon chronology for the Upper Paleolithic sites on the East European plain. *In* Soffer, O. and Praslov, N. D., eds., *From Kostenki to Clovis: Upper Paleolithic – Paleo-Indian Adaptations.* New York, Plenum Press: 23–30.