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The Aurignacian way of life: Contextualizing early modern human adaptation in the Carpathian Basin

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ABSTRACT

The culture and dispersal of early modern humans are top priorities of many research agendas. While the debate primarily centers on genetics, dispersal trajectories and points of earliest presence, the context (climate, landscape, demography, culture) of the colonizing process is usually considered in a coarse-grained manner or even ignored. To understand the context of human dispersal and to decipher relevant push and pull factors requires the consideration of multiple environmental proxies and the research on different geographic scales. In this paper, we present the Late Quaternary Carpathian Basin as a specific context area of early modern human dispersal into Europe. The multitude of Early Upper Paleolithic sites in this region suggests that it was part of a major dispersal corridor along the Danube and its catchment area some 40,000 years ago. The Aurignacian land-use model describes the interaction of early modern humans with their environment. One important parameter is the specific distribution of archaeological sites that exemplifies their boundedness to specific eco-zones. To reconstruct the latter, paleo-environmental proxies and archaeological data are examined together in regional vector models and in a GIS based landscape archaeology approach. In the final section, we present the Carpathian Basin as an idiosyncratic habitat that mirrors the dynamics and complexity of early modern human adaptation.

1. Introduction

The archaeological record left by the earliest modern humans in Europe marks the beginning of a new period in human history some 40,000 years ago. A specific set of innovative technological and symbolic elements characterizes the earliest phase of the Upper Paleolithic, which is referred to as Aurignacian in Europe (Hahn, 1977; Davies, 2001; Bolus and Conard, 2008; Clark and Riel-Salvatore, 2009; and see references in Zilhão and d'Errico, 2003 as well as in Bar-Yosef and Zilhão, 2006). Earliest evidence for the Aurignacian is dated to around 43 ka cal. BP and it lasts until around 30 ka cal. BP. (Higham et al., 2011, 2012; Schmidt et al., 2013). Within this time slice, Aurignacian-type stone and organic tools mark the technological prerequisite of early modern humans for their colonization of the European continent. Subject of debate is the exact timing, route and evolutionary dynamics of human dispersal and associated culture change (Davies et al., 2015). Some models see the spread of the Upper Paleolithic as the result of a linear east-west trajectory of human dispersal and culture change whereas others suggest multiple centers of origin (e.g., Davies, 2001; Teyssandier, 2005; Mellars, 2006, 2009; Bar-Yosef, 2007; Le Brun-Ricalens and Bordes, 2007; Higham et al., 2012; Hublin, 2012).

Cultural complexity is, to a certain degree, the outcome of human adaptation to different environmental and climatic conditions. However, models of human-environment interaction in the Aurignacian are low in number and are often restricted to small areas (e.g., Hahn, 1977; Blades, 2002; Bon, 2002; Nigst, 2014). On a pan-European scale, Banks et al. (2013) interpret the Proto-Aurignacian - Early Aurignacian succession as an adaptive shift in the face of cooling conditions with the Heinrich 4 (H4) event. This model argues that both Aurignacian phases mirror eco-cultural niches of human adaptation that were confined by climatic conditions and that expanded after the adoption of technological innovations such as new hunting equipment in the early Aurignacian. This study has been criticized for its underlying radiocarbon age model (Higham et al., 2013) and its reliance on the Proto-Aurignacian - Early

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Aurignacian dichotomy (Ronchitelli et al., 2014). Although we consider the eco-cultural niche model as an innovative approach, we criticize it for its blurring of cultural variability.

It is very unlikely that the Aurignacian way of life was identical in hilly Franco-Cantabria and the vast steppe region of Eastern and Central Europe. Hence, cultural variability must be manifested on a much lower scale of definition (Le Brun-Ricalens and Bordes, 2007; Tafelmaier, 2017). It is the regional scale of analysis that best discloses the influence of human-environment interaction on technology. To describe this relationship and its causal factors, the Carpathian Basin is a suitable case in point. Here, archaeological research over the past few years provides important data for the reconstruction of a particular Early Upper Paleolithic landscape (Anghelinu et al., 2012; Nigst et al., 2014; Sitlivy et al., 2012, 2014a, 2014b).

Large rivers, such as the Danube and its catchment area, have repeatedly been described as important corridors for the dispersal of human populations and ideas (Conard and Bolus, 2003; Bolus and Conard, 2008; Floss et al., 2016). Furthermore, it appears that modern human land-use targeted open landscapes that facilitated a high level of mobility and social network maintenance (Nigst, 2014; Nigst et al., 2014; Henry et al., 2017). As the Carpathian Basin incorporates a long section of the Lower Danube and some major tributaries as well as extended lowlands and gentle mountain slopes in most parts, it appears to be a suitable Early Upper Paleolithic settlement area.

The reconstruction of paleoenvironments in the Carpathian Basin faces the challenge to extrapolate point data (e.g., bore holes, local sediment sections) to a larger surface. A 3D paleo-landscape model requires the translation of recent surface data (e.g., modern soil charts, vegetation maps, climate records) into the past. While this is fairly possible for large scale models depending on the low resolution of paleo-climate simulations, it is currently impossible on a regional scale for MIS 3 (Feurdean et al., 2014). This explains the lack of MIS 3 paleo-landscape maps for the Carpathian Basin. Despite the plethora of loess archives for our study region, it is not possible to transfer coherent information on the MIS 3 paleoenvironment on a regional scale.

As concerns loess distribution, the most recent map for entire Europe is provided by Haase et al. (2007). It is mainly based on (local) geological maps of different countries. However, the mapping of loess and loess derivatives incorporates geographical, geological and pedological datasets from different countries or geological surveys, each employing their own set of definitions. This explains the inconsistencies, such as abrupt shifts or unnatural delimitations of loess and loess derivate distribution, across national borders (Nilson et al., 2007 and references therein). Hence, a synthetic view of loess distribution for larger areas necessitates the correlation of high-resolution sequences. For the eastern Carpathian region, a high-resolution map of loess distribution is now available (Lindner et al., 2016).

This paper reviews and discusses the available paleoenvironmental proxies for landscape reconstruction in the Carpathian Basin. Of special importance are loess-paleosol sequences. Against this background, the spatial distribution of Aurignacian sites is examined to better understand past land-use strategies. Due to the lack of MIS 3 paleo-landscape models, we delineate representative geo-transects along major upland-lowland vectors. Furthermore, site catchment analysis (SCA) is used to investigate Aurignacian land-use strategies in more detail. Finally, we conclude that the dispersal and manifestation of early modern humans in this part of Europe was linked to a specific landscape configuration that guaranteed access to different eco-zones.

2. Materials and methods

2.1. Regional setting: The Carpathian Basin in upper pleistocene times

The Carpathian Basin covers a surface of more than 250,000 km^2 and stretches from Lower Austria in the west to the Romanian and Serbian Banat in the east and from northern Hungary until northern Slovenia and central Serbia in the south (Fig. 1). It encompasses a sedimentary depocenter that has been active since the Oligocene/Miocene (e.g. Royden et al., 1983). During the (Late) Quaternary, thick and widespread deposits of windblown dust accumulated (Buggle et al., 2009; Fitzsimmons et al., 2012; Marković et al., 2015), which were transformed to loess over large areas of the region. Loess deposits, intercalated by paleosols, are reported from the last million years (Hambach et al., 2009; Marković et al., 2011), with most of the research having been conducted on the last glacial cycle, as these deposits are most widespread and close to the surface.

2.2. Paleoenvironmental proxies

In the Carpathian Basin, loess-paleosol sequences are the most important archive for the reconstruction of past environmental conditions. Physical property data, mainly the magnetic susceptibility and its frequency dependence are commonly studied to obtain a relative measure for the intensity of soil formation (Buggle et al., 2014). This rather simple relationship has however been challenged especially in regions with higher moisture conditions (Hošek et al., 2015).

In the best dated lowland sections in Serbia and Hungary such as Crvenka, Stari Slankamen, Surduk and Süttö (Fuchs et al., 2008; Schmidt et al., 2010; Novothny et al., 2011; Stevens et al., 2011), the MIS 3 is usually represented by soil formation, which is most intense around ca. 35 ka BP. Before- and after this peak phase weaker soil formation in loess can be observed from ca. 45/40-30/25 ka BP in profiles macroscopically and by physical property records (e.g., Novothny et al., 2011; Stevens et al., 2011). In several cases the MIS 3 soil formation seems to represent multiple phases (Bokhorst et al., 2009; Stevens et al., 2011; Marković et al., 2012; Basarin et al., 2014). In general, field descriptions and physical property records show a MIS 3 phase of soil formation that is weaker than the MIS 5 and Holocene, but also clearly distinguished from the (late) MIS 4 and MIS 2 loess (see e.g., Fuchs et al., 2008; Novothny et al., 2011; Schmidt et al., 2010; Stevens et al., 2011; Terhorst et al., 2014).

A correlation of loess-paleosol sections along representative transects is a suitable approximation of the paleolandscape. This method was first designed to correlate high-resolution lowland sediment archives with shorter and more fragmentary archives in exposed foothill ranges by the use of suitable geo-markers (Kels et al., 2014). In our study, the chosen transects follow vectors with sufficient point data and cover the transition from the Carpathian Mountains to the foothill zone and towards the plain (Fig. 2). Along these transects, the most probable extension of characteristic sediment units and soil types is modelled and serves as a proxy for paleoenvironmental reconstruction. Hence, the upland-lowland transects illustrate landscape diversity along altitudinal belts.

Compared to the significant number of loess-paleosol sequences, the information potential of fluvial archives is much more limited due to late sedimentation and limited numerical geochronologies (Gábris and Nádor, 2007). The same holds true for

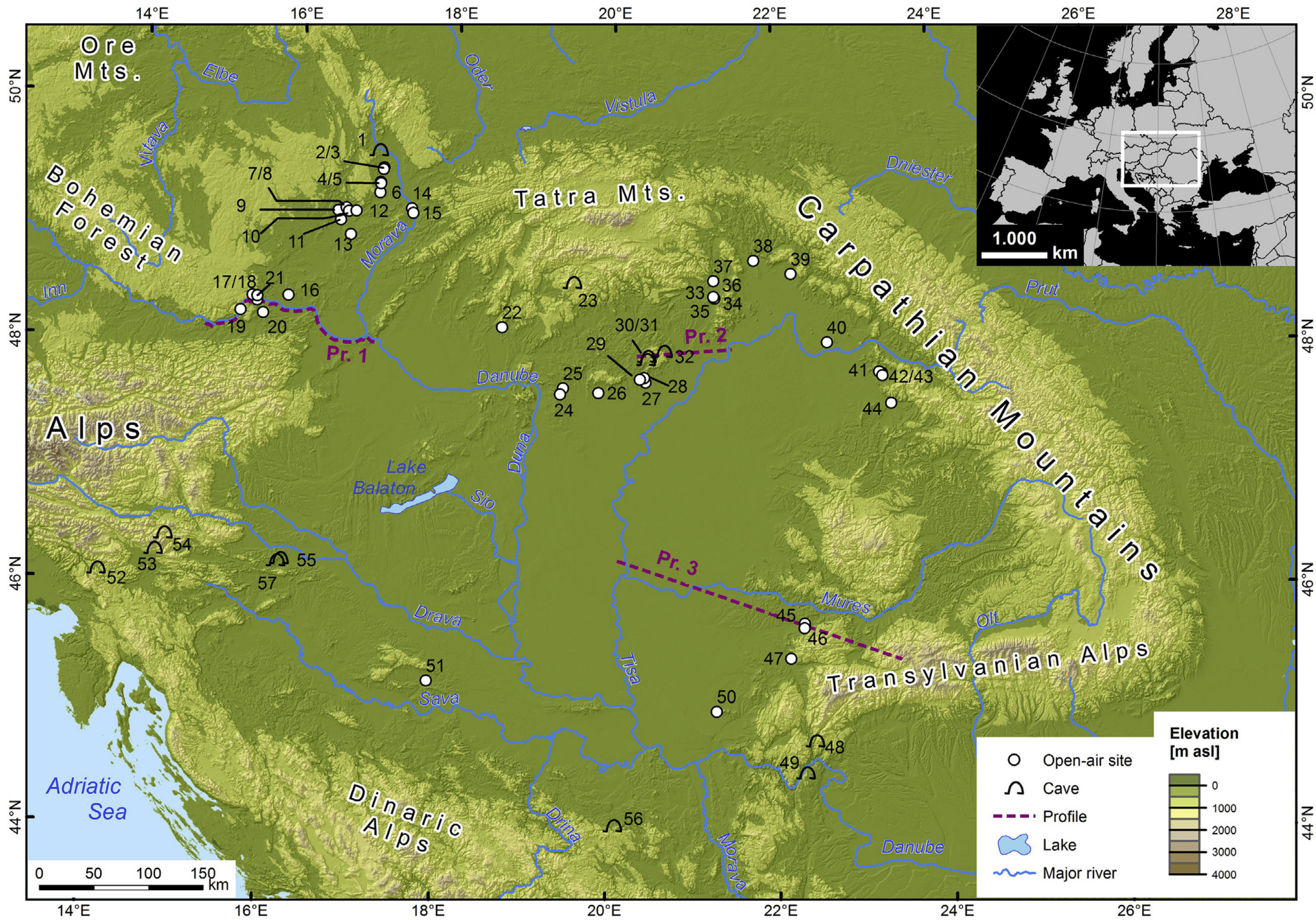

Fig. 1. Map of the Carpathian Basin showing the distribution of Aurignacian open-air and cave sites (Elevation: USGS 2006). Archaeological sites are listed in Table 1 according to No. Vector lines (Pr.1-3) mark the position of upland-lowland transects shown in Fig. 2.

palynological data, (micro)mammal biome reconstruction as well as malacological data (Sümegi and Krolopp, 2002; Willis and van Andel, 2004; Kovacs, 2012; Feurdean et al., 2014).

2.3. Database of Aurignacian sites

Archaeological data collection included a simple counting of early Upper Paleolithic sites in the Carpathian Basin (Table 1). Data was mainly taken from the literature (e.g., Hahn, 1977; Karavanić, 1998; Dobosi, 2005; Nigst and Haesaerts, 2012; Anghelinu and Niţă, 2014; Kaminska, 2014; Moreau et al., 2015). Additional data comes from survey campaigns conducted in the framework of the CRC806 project “Our Way to Europe” (Chu et al., this issue).

Three factors are responsible for the incoherence of data quality in Table 1. The first is chronological control. At the current state of research, 18 sites are radiometrically dated to the Early Upper Paleolithic; the remaining 39 sites only provide unambiguous Aurignacian artefact assemblages. This explains the need to define a broad time frame of 13,000 years for the Aurignacian land-use model and the inability to recognize short-term changes in land-use strategies. The second factor is the burial context. Of the 57 localities incorporated in this study, 12 are caves, 44 are open-air sites and one is a rock-shelter. Among the open-air sites, 17 localities represent surface finds that are deprived of stratigraphic context, and hence, any time resolution. The third factor is the unequal state of research in parts of Slovenia, Serbia western Romania, Serbia, Bosnia and Croatia that stand out with an absence of archaeological data.

The distribution pattern of archaeological sites given in Fig. 1 was analyzed with the ArcGIS v10.2.2 software including the Spatial Analyst Extension. Statistical analysis was conducted in R. When not published, the elevation of some sites was read out of the digital elevation model (DEM). We also applied a site catchment analysis (SCA) for seven selected Aurignacian sites to check for common parameters in settlement location. Our SCA model is based on the DEM from Shuttle Radar Topography Mission (SRTM) data. We identified slope as a decisive parameter. The inclusion of other parameters, such as the presence of water bodies, rivers or vegetation was problematic as they changed profoundly in kind and distribution since the early MIS 3.

We used SCA to examine the proximity of Aurignacian sites to major eco-zones, such as the lowland steppe, the foothill range, and higher mountainous zone. To do so, the distance to these eco-zones within a one-day walk that likely reflects the potential foraging radius of hunter-gatherer groups was calculated (e.g., Henry et al., 2017). The possible walking range strongly depends on terrain configuration and was calculated for a 1 h, 2 h, 5 h and 10 h interval in this study. Determination of the hiking speed in relation to slope was calculated according to Tobler (1993). The spatial range of daily foraging activities is likely indicated by the 1 h–5 h circles. Longer distance moves of 10 h minimum were more likely accomplished by special task groups that stay away from the camp for one night or

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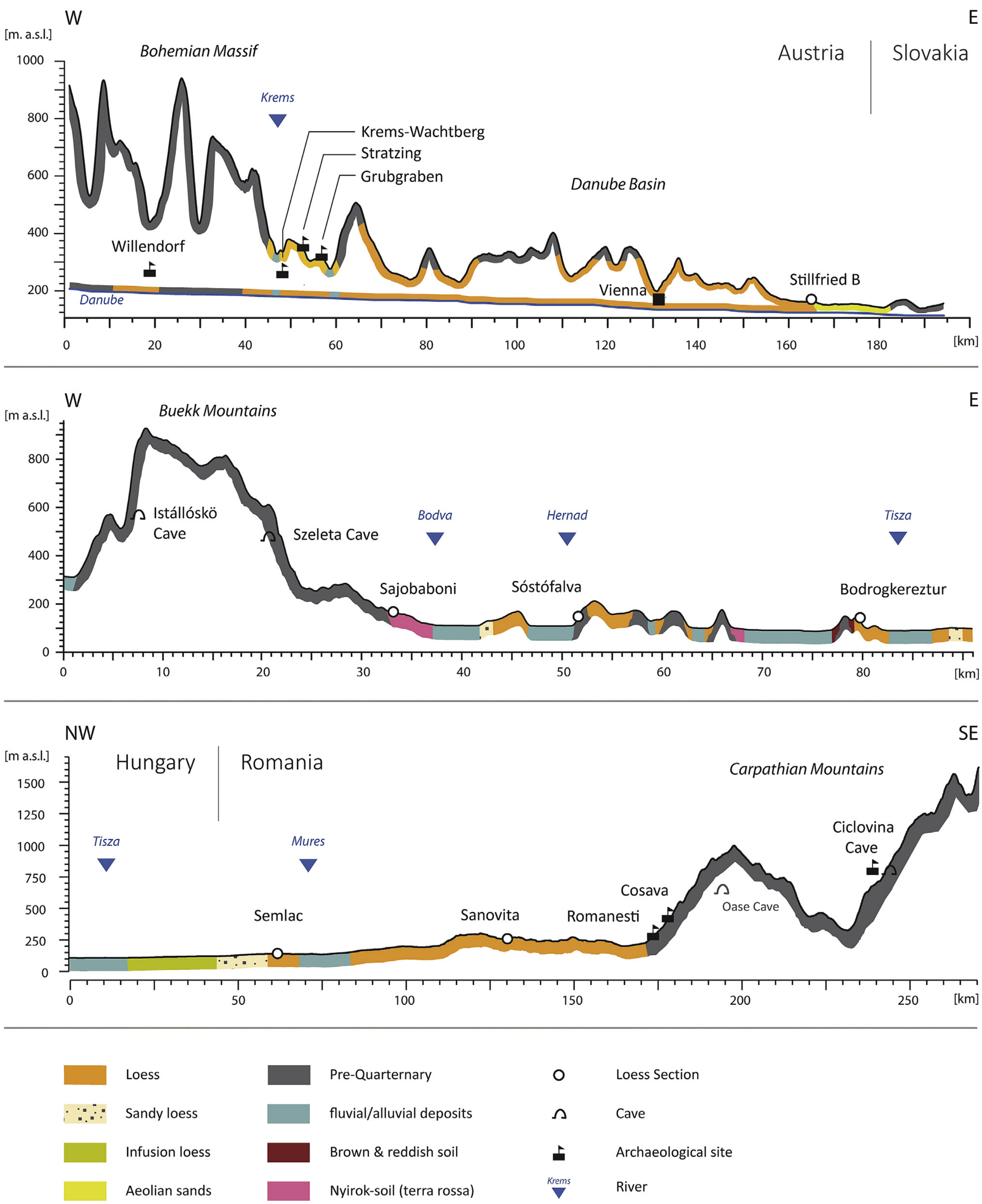

Fig. 2. Regional upland-lowland transects; transect vectors are depicted in Fig. 1. Figure 2A shows the distribution of loess at the northeastern margin of the Carpathian Basin from the Bohemian Massif towards the Vienna Basin. Here, loess and Aurignacian sites are restricted to the foothill zone. Figure 2B and C illustrate the distribution of Quaternary sediments in northeastern Hungary (Bükk Mountains and Hernad valley) and western Romania, from the Tisza River towards the Carpathian Mountains. There is no loess in the mountain zone and sediment variety is richest in the basin, which acted as a deposition center.

Table 1
List of Aurignacian sites in the Carpathian Basin and associated radiocarbon dates. For multi-layered sites, only the Aurignacian layers are listed. Radiocarbon dates were calibrated using CalPal 2007 (Weniger and Jöris, 2008; Weninger et al., 2010). The asterisk marks the modelled age for layer AH3 of Willendorf II based on ten radiocarbon dates for overlying layer C8-2 and ten dates for underlying layer D1-D2.

N°	Site	Country	Site type	Height (m.a.s.l.)	Layer	Lab. N°	Age cal. BP	Std	Artefact Sample	References
1	Mladeč	Czech Republic	Cave	343		VERA-3073	35152	402	41	Hahn, 1977; Svoboda, 2000, 2001; Wild et al., 2006
1	Mladeč	Czech Republic	Cave	343		VERA-3074	35273	412	41	Hahn, 1977; Svoboda, 2000, 2001; Wild et al., 2006
1	Mladeč	Czech Republic	Cave	343		VERA-3075	34656	360	41	Hahn, 1977; Svoboda, 2000, 2001; Wild et al., 2006
1	Mladeč	Czech Republic	Cave	343		VERA-3076A	35437	428	41	Hahn, 1977; Svoboda, 2000, 2001; Wild et al., 2006
2	Slatinice	Czech Republic	Open-air	310	Surface				67	Mlejnek, 2008
3	Slatinky	Czech Republic	Open-air	298	Surface					Mlejnek, 2013
4	Seloutky	Czech Republic	Open-air	345	Surface				71	Mlejnek, 2008, 2013
5	Určice	Czech Republic	Open-air	320	Surface				148	Mlejnek, 2008
6	Ondratice I	Czech Republic	Open-air	330	palaeosoil				>2000	Mlejnek et al., 2012
7	Maloměřice-Borky II	Czech Republic	Open-air	210	Surface				1173	Hahn, 1977
8	Maloměřice-Občiny	Czech Republic	Open-air	210	Surface				460	Hahn, 1977
9	Kohoutovice	Czech Republic	Open-air	336					>100	Hahn, 1977
10	Stránská Skála II + III	Czech Republic	Open-air	300	S.S. IIa-Layer 4	GrN-14829	36676	1097		Hahn, 1977; Svoboda, 2003
10	Stránská Skála II + III	Czech Republic	Open-air	300	S.S. IIIa-Layer 3	GrN-12605	34941	364		Hahn, 1977; Svoboda, 2003
10	Stránská Skála II + III	Czech Republic	Open-air	300	S.S. IIIb-Layer 4	GrN-16918	37424	1992		Hahn, 1977; Svoboda, 2003
10	Stránská Skála II + III	Czech Republic	Open-air	300	S.S. IIIc-upper palaeosoil	AA-41479	37297	776		Hahn, 1977; Svoboda, 2003
10	Stránská Skála II + III	Czech Republic	Open-air	300	S.S. IIIf-hearth	AA-41472	33070	541		Hahn, 1977; Svoboda, 2003
11	Želešice	Czech Republic	Open-air	210	Surface				779	Hahn, 1977
12	Tvarožná I	Czech Republic	Open-air	360	Surface				1000	Mlejnek, 2010
13	Křepice	Czech Republic	Open-air	234	Surface				358	Hahn, 1977
14	Kvasice	Czech Republic	Open-air	192	Surface				>50	Hahn, 1977
15	Žlutava	Czech Republic	Open-air	315	Surface				619	Hahn, 1977
16	Grossweikersdorf	Austria	Open-air	212	upper	GrN-16244	35521	284		Hahn, 1977; Svoboda, 2003
16	Grossweikersdorf	Austria	Open-air	212	upper	GrN-16263	36831	401		Hahn, 1977; Svoboda, 2003
17	Senftenberg	Austria	Open-air	290		GrN-16887	40943	565	1818	Hahn, 1977; Hinterwallner, 2006; Nigst and Haesaerts, 2012;
18	Krems-Hundssteig	Austria	Open-air	230	AH 4.14	KN-654	37795	876		Hahn, 1977; Neugebauer-Maresch, 2008a, 2008b
19	Willendorf II	Austria	Open-air	230	3	GrN-17805	42769	112		Haesaerts et al., 1996
19	Willendorf II	Austria	Open-air	230	3	GrN-11192	38589	98		Haesaerts et al., 1996
19	Willendorf II	Austria	Open-air	230	3	GrA-896	42231	558		Haesaerts et al., 1996
19	Willendorf II	Austria	Open-air	230	4	GrN-1273	35951	274		Hahn, 1977
19	Willendorf II	Austria	Open-air	230	4	GrA-501	35129	277		Haesaerts et al., 1996
19	Willendorf II	Austria	Open-air	230	4	H-249/1276	36653	2198		Felgenhauer, 1959; Nigst and Haesaerts 2012
19	Willendorf II	Austria	Open-air	230	?	GrN-1287	34490	232		Felgenhauer, 1959; Nigst and Haesaerts 2012
19	Willendorf II	Austria	Open-air	230	AH3		43500*		522	Nigst et al., 2014
19	Willendorf II	Austria	Open-air	230		GrN-11195	45112	165		Haesaerts et al., 1996
19	Willendorf II	Austria	Open-air	230		GrN-17807				Haesaerts et al., 1996
19	Willendorf II	Austria	Open-air	230		GrN-17806	45030	165		Haesaerts et al., 1996
19	Willendorf II	Austria	Open-air	230		GrN-11190	43164	123		Haesaerts et al., 1996
20	Getzersdorf	Austria	Open-air	230					263	Felgenhauer, 1954; Brandtner, 1954; Hahn, 1977; Nigst and Haesaerts, 2012
21	Stratzing	Austria	Open-air	374	AH2	GrN-15641	34744	568		Neugebauer-Maresch, 1996
21	Stratzing	Austria	Open-air	374	AH2	GrN-15642	35150	393		Neugebauer-Maresch, 1996
21	Stratzing	Austria	Open-air	374	AH2	GrN-15643	33346	1196		Neugebauer-Maresch, 1996
21	Stratzing	Austria	Open-air	374	AH2	GrN-16135	35683	313		Neugebauer-Maresch, 1996
21	Stratzing	Austria	Open-air	374	AH2	KN-3941	32490	739		Neugebauer-Maresch, 1996
21	Stratzing	Austria	Open-air	374	AH2	KN-3942	34019	584		Neugebauer-Maresch, 1996
21	Stratzing	Austria	Open-air	374	AH2	KN4140	33335	520		Neugebauer-Maresch, 1996
21	Stratzing	Austria	Open-air	374	AH2	KN4141	32256	592		Neugebauer-Maresch, 1996
21	Stratzing	Austria	Open-air	374	AH2	VERA-961	37194	594		Neugebauer-Maresch, 1996
21	Stratzing	Austria	Open-air	374	AH2	VERA-963	36738	637		Neugebauer-Maresch, 1996
21	Stratzing	Austria	Open-air	374	AH2	VERA-964	35155	348		Neugebauer-Maresch, 1996
21	Stratzing	Austria	Open-air	374	AH2	VERA-965	37521	601		Neugebauer-Maresch, 1996
21	Stratzing	Austria	Open-air	374	AH2	VERA-966	35133	312		Neugebauer-Maresch, 1996
22	Nova Dědina	Czech Republic	Open-air	195	Surface				1227	Hahn, 1977
23	Dzerava skála	Slowakei	Rock-shelter	450	9	OxA-15535	35400	1271	>20	Kaminská, 2014; Neruda and Nerudová, 2013
23	Dzerava skála	Slowakei	Rock-shelter	450	9	OxA-15534	35868	1057	>20	Kaminská, 2014; Neruda and Nerudová, 2013

(continued on next page)

Table 1 (*continued*)

N°	Site	Country	Site type	Height (m.a.s.l.)	Layer	Lab. N°	Age cal. BP	Std	Artefact Sample	References
23	Dzerava skála	Slowakei	Rock-shelter	450	9	Wk-16829	37662	999	>20	Kaminská, 2014; Neruda and Nerudová, 2013
23	Dzerava skála	Slowakei	Rock-shelter	450	5a'	Wk-14866	37882	744		Kaminská, 2014; Neruda and Nerudová, 2013
23	Dzeravá skala	Slowakei	Rock-shelter	450	5a'	OxA-13860	39669	470		Kaminská, 2014; Neruda and Nerudová, 2013
23	Dzeravá skala	Slowakei	Rock-shelter	450	5a'	Wk-14865	42302	2197		Kaminská, 2014; Neruda and Nerudová, 2013
24	Galgagyörk	Hungary	Open-air	145						Markó et al., 2002
25	Acsa	Hungary	Open-air	270	Palaeosoil (Arcy Interstadial?)				800	Markó, 2009; Dobosi, 2013
26	Nagyréde	Hungary	Open-air	200	Surface				3190	Lengyel et al., 2006
27	Egerszalók-Kövágó	Hungary	Open-air	250	Surface					Kozlowski et al., 2009; Budek et al., 2013
28	Andornaktálya	Hungary	Open-air	180	II: Palaeosoil	Poznan	34247	277	160	Kozlowski and Mester, 2004; Budek et al., 2013
29	Eger-Köporos	Hungary	Open-air	230	?	?	33710	2624	2413	Kozlowski et al., 2012; Budek et al., 2013
30	Peskő	Hungary	Cave	540	Lowest	GrN-4950	39838	722		Vogel and Waterbolk, 1972
30	Peskő	Hungary	Cave	540	Lowest	OxA-17964	37749	613		Davies and Hedges, 2008
30	Peskő	Hungary	Cave	540	Lowest	OxA-17965	41940	1585		Davies and Hedges, 2008
30	Peskő	Hungary	Cave	540	Lowest	OxA-17966	40950	728		Davies and Hedges, 2008
30	Peskő	Hungary	Cave	540	Lowest	OxA-17967	42838	1423		Davies and Hedges, 2008
31	Istállóskő	Hungary	Cave	535	8	GrN-1935	37109	768		Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	8	ISGS-A-0188	35506	325		Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	8	ISGS-A-0185	33217	299		Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	8	GrN-1501	35565	658		Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	8	GrN-1935	34954	586		Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	8	ISGS-A-0186	31777	325		Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	8	OxA-16638	34917	316		Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	8	OxA-16916	33668	184		Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	8	OxA-16917	33454	207		Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	8	OxA-16093	34470	179		Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	8	OxA-16904	33997	158		

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Table 1 (*continued*)

N°	Site	Country	Site type	Height (m.a.s.l.)	Layer	Lab. N°	Age cal. BP	Std	Artefact Sample	References
										Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	9	GrN-4659	47567	1370	435	Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	9	GrN-4658	43628	751	435	Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	9	ISGS-A-0187	36808	487	435	Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	9	ISGS-A-0184	37347	668	435	Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	9	OxA-X-2244-32	39414	317	435	Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	9	P-20543	38439	361	435	Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	9	P-20541	37125	454	435	Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	9	P-20534	36722	420	435	Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
31	Istállóskő	Hungary	Cave	535	9	OxA-X-2170-18	37976	1102	435	Vértes, 1955; Vogel and Waterbolk, 1963, 1972; Dobosi, 2002; Vörös, 2003; Davies and Hedges, 2008; Markó, 2015
32	Szeleta	Hungary	Cave	345	Hearth					Kadić, 1918; Vertes, 1968; Adams and Ringer, 2004; Lengyel and Mester, 2008
33	Kechnec	Slovakia	Open-air	215	Surface				>300	Hahn 1977; Kaminská 2014
34	Milhost	Slovakia	Open-air	170	Surface					Hahn 1977; Kaminská 2014
35	Seňa	Slowakei	Open-air	196	Palaeosoil				>1000	Kaminská, 2014
36	Barca I	Slovakia	Open-air	214	VI				>50	Hahn, 1977; Kaminská, 2014
37	Barca II	Slowakei	Open-air	214	2				1680	Hahn, 1977; Kaminská, 2014
38	Nižný Hrabovec	Slovakia	Open-air	125	Surface				>1000	Kaminská, 2001, 2014
39	Tibava	Slovakia	Open-air	130					866	Kaminská, 2014
40	Beregovo I	Ukraine	Open-air	120	Palaeosoil (Vytachiv type)				>1000	Usik, 2008; Usik et al., 2013
41	Călinești I	Rumänien	Open-air	200					1595	Anghelinu and Niță, 2014
42	Boinești	Romania	Open-air	170						Anghelinu and Niță, 2014
43	Remetea Șomoș I	Romania	Open-air	143					>39	Hahn, 1977; Anghelinu et al., 2012
44	Bușag	Romania	Open-air	150						Anghelinu and Niță, 2014
45	Coșava I	Rumänien	Open-air	282	GH1-4: Palaeosoil				2018	Kels et al., 2014; Sitlivy et al., 2014a
46	Românești-Dumbrăvița I	Rumänien	Open-air	212	GH3-4: Palaeosoil	Rom35	44100	3300	7505	

(*continued on next page*)

Table 1 (*continued*)

N°	Site	Country	Site type	Height (m.a.s.l.)	Layer	Lab. N°	Age cal. BP	Std	Artefact Sample	References
										Mogoşanu, 1978; Schmidt et al., 2013; Kels et al., 2014; Sitlivy et al., 2014a
46	Româneşti-Dumbrăviţa I	Rumänien	Open-air	212	GH3-4: Palaeosoil	Rom72	39700	3300	7505	Mogoşanu, 1978; Schmidt et al., 2013; Kels et al., 2014; Sitlivy et al., 2014a
46	Româneşti-Dumbrăviţa I	Rumänien	Open-air	212	GH3-4: Palaeosoil	Rom116	37600	3600	7505	Mogoşanu, 1978; Schmidt et al., 2013; Kels et al., 2014; Sitlivy et al., 2014a
46	Româneşti-Dumbrăviţa I	Rumänien	Open-air	212	GH3-4: Palaeosoil	Rom239	39200	3200	7505	Mogoşanu, 1978; Schmidt et al., 2013; Kels et al., 2014; Sitlivy et al., 2014a
46	Româneşti-Dumbrăviţa I	Rumänien	Open-air	212	GH3-4: Palaeosoil	Rom346	42300	3500	7505	Mogoşanu, 1978; Schmidt et al., 2013; Kels et al., 2014; Sitlivy et al., 2014a
47	Tincova	Rumänien	Open-air	220	Palaeosoil				1421	Mogoşanu, 1978; Sitlivy et al., 2014b
48	Hoţilor Cave	Rumänien	Cave	166	II	GrN-16980	34897	371		Anghelinu and Niţă, 2014
49	Tabula Traiana	Serbien	Cave	90	207	OxA-23651	38692	709		Borić et al., 2012
50	Crvenka-At	Serbien	Open-air	90	8				>1000	Chu et al., 2014
51	Zarilac	Kroatien	Open-air	155	5m					Karavanić, 1995
52	Divje Babe I	Slowenien	Cave	450	2	OxA-28219	33906	304	<1000	Moreau et al., 2015
52	Divje Babe I	Slowenien	Cave	450	2	RIDDL-734	39941	744	<1000	Moreau et al., 2015
53	Mokriška jama	Slowenien	Cave	1495	7	OxA-2517-X-52	39367	671		Moreau et al., 2015
53	Mokriška jama	Slowenien	Cave	1495	7	OxA-27855	36765	637		Moreau et al., 2015
54	Potočka zijalka	Slowenien	Cave	1630	5	VERA-2521	34933	105		Moreau et al., 2015
54	Potočka zijalka	Slowenien	Cave	1630	5	VERA-2522	34156	106		Moreau et al., 2015
54	Potočka zijalka	Slowenien	Cave	1630	5	OxA-27850	34403	318		Moreau et al., 2015
54	Potočka zijalka	Slowenien	Cave	1630	5	OxA-27853	35431	409		Moreau et al., 2015
54	Potočka zijalka	Slowenien	Cave	1630	5	OxA-27854	34766	364		Moreau et al., 2015
54	Potočka zijalka	Slowenien	Cave	1630	5	OxA-28038	35898	531		Moreau et al., 2015
54	Potočka zijalka	Slowenien	Cave	1630	5	OxA-28061	36725	691		Moreau et al., 2015
54	Potočka zijalka	Slowenien	Cave	1630	7	VERA-2523	35358	130		Moreau et al., 2015
54	Potočka zijalka	Slowenien	Cave	1630	7	VERA-2524	33885	89		Moreau et al., 2015
54	Potočka zijalka	Slowenien	Cave	1630	7	VERA-2525	33871	89		Moreau et al., 2015
54	Potočka zijalka	Slowenien	Cave	1630	7	VERA-2526	33725	251		Moreau et al., 2015
54	Potočka zijalka	Slowenien	Cave	1630	7	OxA-27849	35180	402		Moreau et al., 2015
54	Potočka zijalka	Slowenien	Cave	1630	7	OxA-27851	34878	380		Moreau et al., 2015
54	Potočka zijalka	Slowenien	Cave	1630	7	OxA-27852	35306	404		Moreau et al., 2015
55	Vindija	Croatia	Cave	275	G1	ETH-12714	37221	577	56	Karavanić, 1995
55	Vindija	Croatia	Cave	275	Fd	Z-551	31117	671		Karavanić, 1995
56	Šalitrena	Serbia	Cave	277						Mihailović et al., 2014
57	Velika Pećina	Croatia	Cave	428	I	GrN-4979	38188	706		Karavanić, 1998; Smith et al., 1999

longer. This implies a logistical mobility system that entails the use of task localities (e.g. hunting camp, raw material extraction site) in the surrounding region.

3. Results

3.1. The chronological range

Taking the 98 dating results that were obtained for 20 Aurignacian sites at face value, the Aurignacian period seemed to have lasted for about 15,000 years (Table 1). However, imprecise sample provenience, contamination and lack of pre-treatment for older radiocarbon dating techniques render some of the dates too old and too young (Davies and Hedges, 2008; Higham, 2011; Higham et al., 2011). A reliable time marker for the beginning of the Aurignacian in the Carpathian Basin is provided by recent dates from the key sites of Willendorf II and Romaneşti-Dumbraviţa, setting it between 44 and 43 ka cal. BP (Schmidt et al., 2013; Nigst et al., 2014). If it is supposed that Anatomically Modern Humans were the makers of the Aurignacian, the earliest direct evidence for their presence in the region is given by the Peştera Cu Oase fossils dated to around 40 ka cal. BP (Trinkaus et al., 2003; Zilhão et al., 2007; Trinkaus, 2013). The end of the Aurignacian and the beginning of the subsequent Gravettian period is more difficult to determine and differs from region to region. The earliest Gravettian begins at around 34 ka cal. BP in Lower Austria and Hungary (Haesaerts et al., 1996; Lengyel, 2008). Complicating the matter is the erroneous attribution of Gravettian sites to a supposedly late Aurignacian phase, sometimes labelled as “Epi-Aurignacian”, which was based on the presence of a few distinct stone tool types (Steguweit, 2010).

3.2. Spatial clustering of Aurignacian sites

The spatial distribution of 57 Aurignacian sites included in this study shows that the majority are situated along the fringe of the Carpathian Basin in the foothill zone of the Carpathian Mountains (Fig. 1). Preferred locations of many sites are river terraces or prominent spurs. A few are found at lower elevations, but not a single Aurignacian site is known in the center of the Carpathian Basin so far. A few caves and rock-shelters are located further inside the mountainous hinterland. In terms of altitude, the site cluster in the foothill zone corresponds with the 150–300 m.a.s.l. altitudinal belt (Fig. 3). Of the 44 open-air sites, 80% are located within this range. The lowest open-air site known is Crvenka-At at 89 m.a.s.l. Among the 13 caves, 11 are situated higher than 500 m.a.s.l.

The SCA results illustrate the distance of Aurignacian sites to

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different topographies and landscape types (Fig. 4). At all examined localities, the 150–300 m.a.s.l. belt is in reach within the radius of a one or 2 h walk, as the sites are placed within this belt or are very close to it. More importantly, the 5 h walk radius gives access to a much wider array of landscape types. This includes the lowland steppe, the foothill zone, and the higher mountainous area above 300 m.a.s.l. The same holds true for the 10 h walk radius except for Willendorf and surrounding sites in Lower Austria that have no access to the steppe lowlands below 150 m.a.s.l.

The few caves in the higher mountain range (19% of all sites) suggest a systematic frequentation of the Carpathian mountains in the later phase of the Aurignacian (Kaminská et al., 2005; Teschler-Nicola, 2006 and references therein). In northern Slovenia, Early Upper Paleolithic hunter-gatherers mounted over 1000 m.a.s.l. for hunting activities (Moreau et al., 2015). In all cases, this coincided with a systematic use of bone points.

Our investigations in the Caraş-Severin karst area in southwest Romania undermine the scarcity of Aurignacian cave and rock-shelters sites within the Carpathian Mountains. Here, many south to southwest facing shelters in proximity to water sources are devoid of early UP occupation traces. This is all the more surprising, as some caves contain modern human fossils, such as Peştera Cu Oase (Trinkaus, 2013; Zilhão et al., 2007), Peştera Muierii (Soficaru et al., 2006), and Peştera Cioclovina (Soficaru et al., 2007; Harvati et al., 2007). We searched for occupation remains in an 8 m long section at one of the former entrances to Peştera Cu Oase. Radiocarbon samples collected at Plopa Ponor rock-shelter provide an age model for this section that ranges from the Holocene back to around 34 ka cal. BP. However, evidence for early Upper Paleolithic occupations is missing.

3.3. Paleo-landscape reconstruction

The regional transects in Fig. 2 illustrate the topographic choice of Aurignacian sites at the intersection between the higher mountain zone and the lowlands. This pattern coincides with the distribution of loess along the foothill zone in many areas. Loess does not occur in the higher mountain zone. Further important aspects is the close proximity of Aurignacian sites to rivers and the complexity of soils in their immediate surrounding. The latter points to a considerable diversity of MIS 3 landscape development.

A closer look at stratified Aurignacian sites in loess-paleosol sequences shows that archaeological material is usually found within a soil formation. Typical examples are the Aurignacian open-air sites Romaneşti-Dumbraviţa, Coşava and Tincova in the Romanian Banat (Fig. 5). At all three sites, the Aurignacian layers are embedded in well-developed albeluvisols (Sitlivy et al., 2012; Kels et al., 2014). This indicates that humans preferred to occupy stable surfaces that were covered with higher vegetation during interstadials. The Banat data fit the larger picture of the Carpathian Basin where MIS 3 soil formation was more intense at the edge of the basin (Bösken et al., in presss; Obreht et al., 2017). The MIS 3 soil distribution suggests that the Carpathian foothill range was covered with a forest steppe and higher vegetation compared to the basin itself. Here, soil formation was too weak to be comparable to recent soils of the area.

A holistic view on paleolandscape evolution is given by the combination of the loess-paleosol data with other proxies, such as fluvial archives, pollen samples, botanical macro remains, micromammal remains as well as land snails. The emerging picture is a dynamic MIS 3 landscape that shows a successive spatial shift of

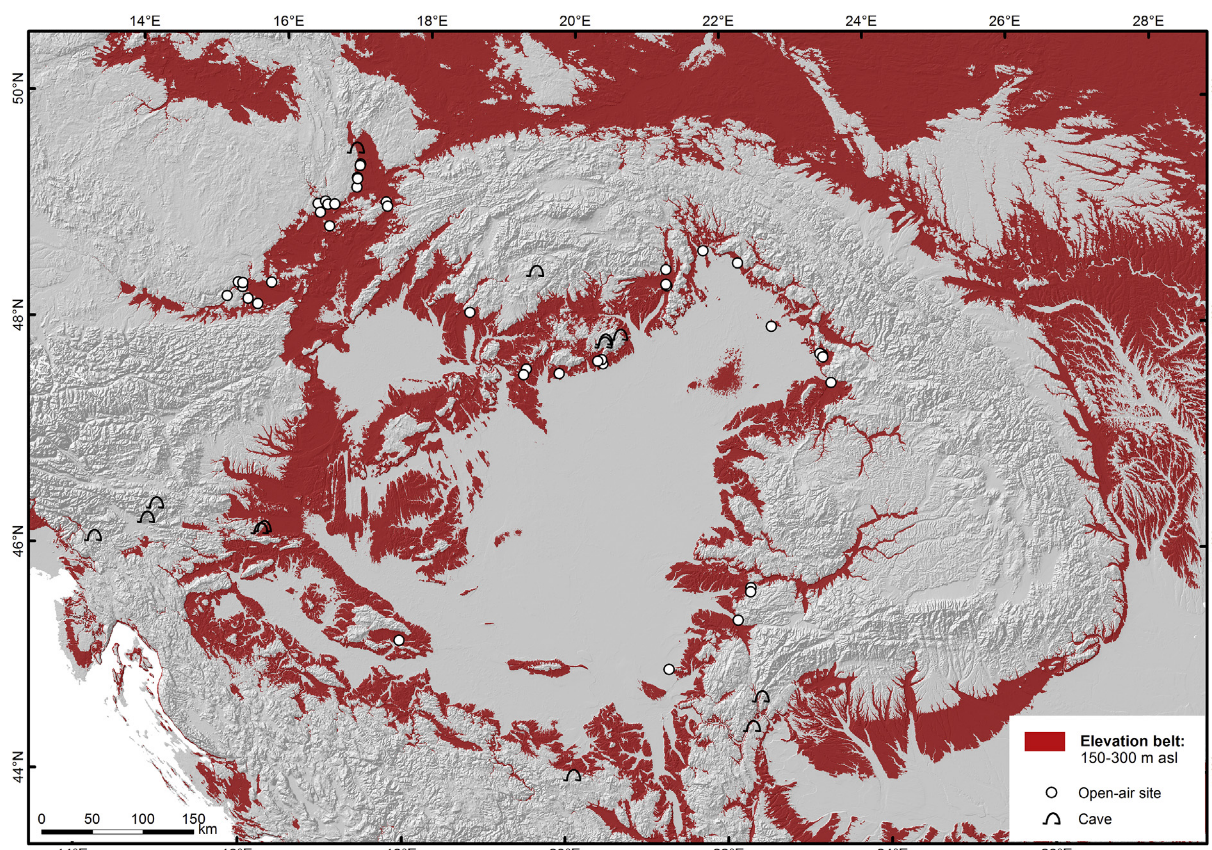

Fig. 3. A: Distribution of Aurignacian sites in relation to the 150–300 m altitudinal belt (marked in red color). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

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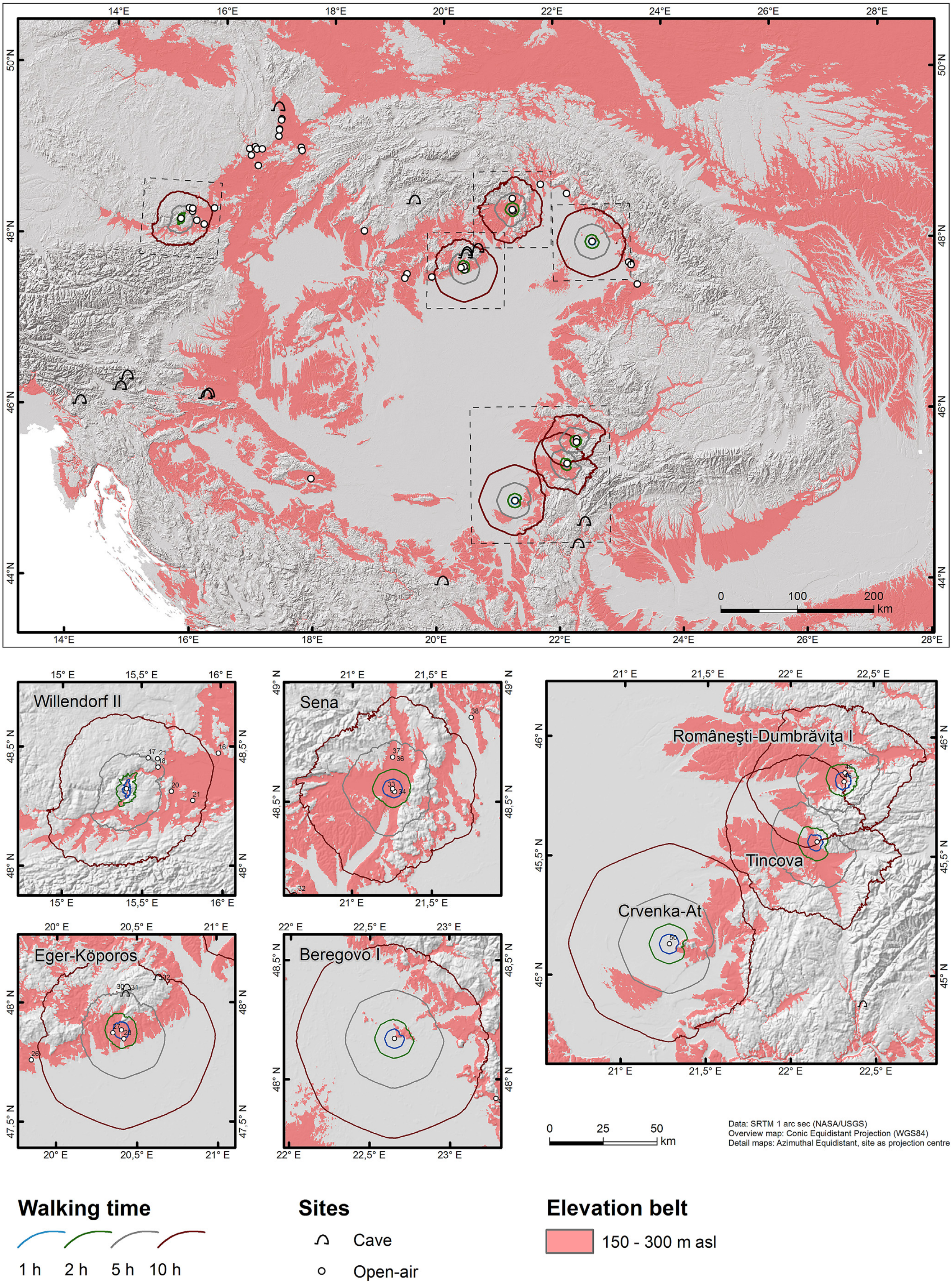
Willendorf II
Sena
Eger-Köporos
Beregovo I
Româneşti-Dumbrăviţa I
Tincova
Crvenka-At
0 100 200 km
0 25 50 km
Data: SRTM 1 arc sec (NASA/USGS)
Overview map: Conic Equidistant Projection (WGS84)
Detail maps: Azimuthal Equidistant, site as projection centre
Walking time
1 h
2 h
5 h
10 h
Sites
Cave
Open-air
Elevation belt
150 - 300 m asl

major ecozones, resulting in a dry lowland steppe, a boreal forest steppe and denser taiga forests in higher mountainous zones (Rudner and Sümegi, 2001; Nádor et al., 2003, 2011; Gábris and Nádor, 2007; Cserkész-Nagy et al., 2012; Feurdean et al., 2014).

North of 45° latitude, a successive shift between dry steppe and boreal forest steppe occurred, the latter including the spread of temperate deciduous trees in some regions (Willis et al., 2000; Sümegi and Krolopp, 2002; Willis and van Andel, 2004; Nádor et al., 2011; Sümegi et al., 2012a, 2012b). South of 45° latitude, the more or less permanent presence of a warm Artemisia-dominated steppe is inferred from terrestrial proxies (Zech et al., 2013; Feurdean et al., 2014). Above 300 m.a.s.l., the higher mountain ranges with limestone or volcanic substrates offered a well-watered, ecologically rich environment that was covered with dense taiga forests. Pollen spectra of Lake St. Anne in the Eastern Carpathians show a stable presence of conifer and thermophilous trees that survived in favorable micro-habitats during the Last Glacial Maximum (Magyari et al., 2014). The Carpathian Basin was a periglacial refugium for many more temperate plant and animal species (Schmitt and Varga, 2012). The most favorable environments were the higher altitudes that received more rainfall and river valleys along the northern rim of the basin.

The MIS 3 lowland forest steppe was the habitat of a specific macromammal biome that includes mammoth (*Mammuthus primigenius*), cave bear (*Ursus spelaeus*), reindeer (*Rangifer tarandus*), and moose (*Alces alces*) (Rabeder, 1996; Pazonyi, 2011; Kovacs, 2012). This mammoth steppe is suggested to have been maintained mainly by mammoths themselves (Putshkov, 2003), and had a high biomass productivity (Zimov et al., 2012). Generally, biodiversity often decreases with altitude, as seen in the Alps recently (Sergio and Pedrini, 2007). This phenomenon, however, does not necessarily correlate to bioproductivity (Velichko and Zelikson, 2005). It could, however, explain the necessity of placing Aurignacian sites in close proximity to the lowland steppe.

4. Discussion

The distribution pattern of Aurignacian sites in the Carpathian Basin is best explained by the preference of early modern humans for a specific landscape structure. Considering altitude, relief and vegetation, this structure divides three major landscapes: the mammoth steppe below ca. 150 m.a.s.l., the foothill range between 150 and 300 m.a.s.l., and the mountainous upland/highland above 300 m.a.s.l. (Fig. 6).

4.1. An Aurignacian land-use model for the Carpathian Basin

The cluster of Aurignacian sites in the Carpathian foothill zone can be explained by the strategic benefits this position offers. Important factors in this respect are:

1. Intermediate position between the dry and open mammoth steppe and the denser forested Carpathian Mountains. Catchment analysis shows that the distance to these particular landscapes was kept low and ranges within a 10 h walking radius maximum (Fig. 4).
2. Positioning of sites in open air on hilltops or prominent spurs. From these positions, a wide-ranging view over the surrounding area is possible and gives the localities a strategic advantage. Some places are even found in visual range, and provided that occupations were contemporaneous, this could have facilitated communication between them.
3. Freshwater availability in the intermediate mountain zone (springs, rivers).
4. Access to lithic raw material sources in gravel deposits of nearby river valleys.

Reliability of lithic raw material supply in secondary as well as primary sources was an important pull factor for human settlement activity. The Northern Carpathians are the source of a wide spectrum of rocks, such as volcanic rocks, chert, obsidian, limnosilicites, quartz porphyry, opals, chalcedonies, jaspers and other silicified rocks that are procurable in primary or secondary outcrops (Kaminská, 2001; Mester et al., 2012; Brandl et al., 2015; Moník and Hadraba, 2016). A clear-cut correlation between raw material outcrops and open-air work shop sites is apparent in some regions (Oliva, 2005; Dobosi, 2008; Markó, 2009). High-quality raw materials, such as obsidian, were transported over long distances, in some cases over more than 100 km (Kaminská, 2001). This indicates the existence of far ranging exchange networks.

Determining the function of Aurignacian sites in the foothill zone is severely hampered by the strong preservation bias. In contrast to caves and rock-shelters, open-air sites are especially prone to the weathering of organic remains (Nicholson, 1996; Hedges, 2002). In the Carpathian Basin, it is the decalcification of loess deposits that mainly affected the preservation of archaeological layers (Kels et al., 2014).

The possible function of a Paleolithic site (e.g., workshop, base camp) within the broader frame of technological organization can, however, be judged from the structure of the lithic artefact assemblages and its proximity to raw material sources (e.g., Nelson, 1991; Kuhn, 1995; Odell, 2004; Richter, 2006; Andrefsky, 2009). At important Aurignacian sites such as Willendorf II, Krems-Hundssteig or Romaneşti-Dumbraviţa, an abundance of archaeological material is spread over large surfaces (Neugebauer-Maresch, 2008a, 2008b; Nigst, 2006, 2008; Nigst et al., 2014; Sitlivy et al., 2012, 2014a, b). Moreover, the spectrum of core reduction and tool manufacturing techniques is broad at these sites. This was probably caused by the repeated occupation of these places and the extended range of activities that were executed there. At the other end of the density and diversity spectrum, small artefact scatters with a high number of finished tools, such as the ones at Slatinice, Seloutky and Kvasice in Moravia or Remetea Şomoş in western Romania, probably represent brief and task-specific occupations (Hahn, 1977; Mlejnek, 2008, 2013; Anghelinu et al., 2012).

It is possible that the cultural complexity we observe in the Carpathian Basin is the result of a logistical mobility pattern. The clustering of Aurignacian sites in the Carpathian foothill range suggests a more or less stable presence of human populations in this topographic range. From here, logistical forays were organized into the higher mountain zone or the lowland steppe according to season and resource availability. Unfortunately, the meagre organic record in most sites does not allow a determination of the kinds of resources that were acquired and processed and during which season this happened. However, an analogue to the proposed vertical organization of technology with key sites at intermediate positions along the lowland-upland vector is given by Epigravettian site clusters at the Adriatic coastal of Albania and northwestern Greece (Sturdy et al., 1997; Hauck et al., 2017)

Due to the high biomass offered by the mammoth steppe, the dry lowland was certainly part of the Aurignacian activity range but

Fig. 4. Site Catchment Analysis for chosen Aurignacian sites in the Carpathian Basin. The distance to nearby topographic features and landscapes is given as 1 h, 2 h, 5 h and 10 h walking ranges, calculated according to Tobler (1993).

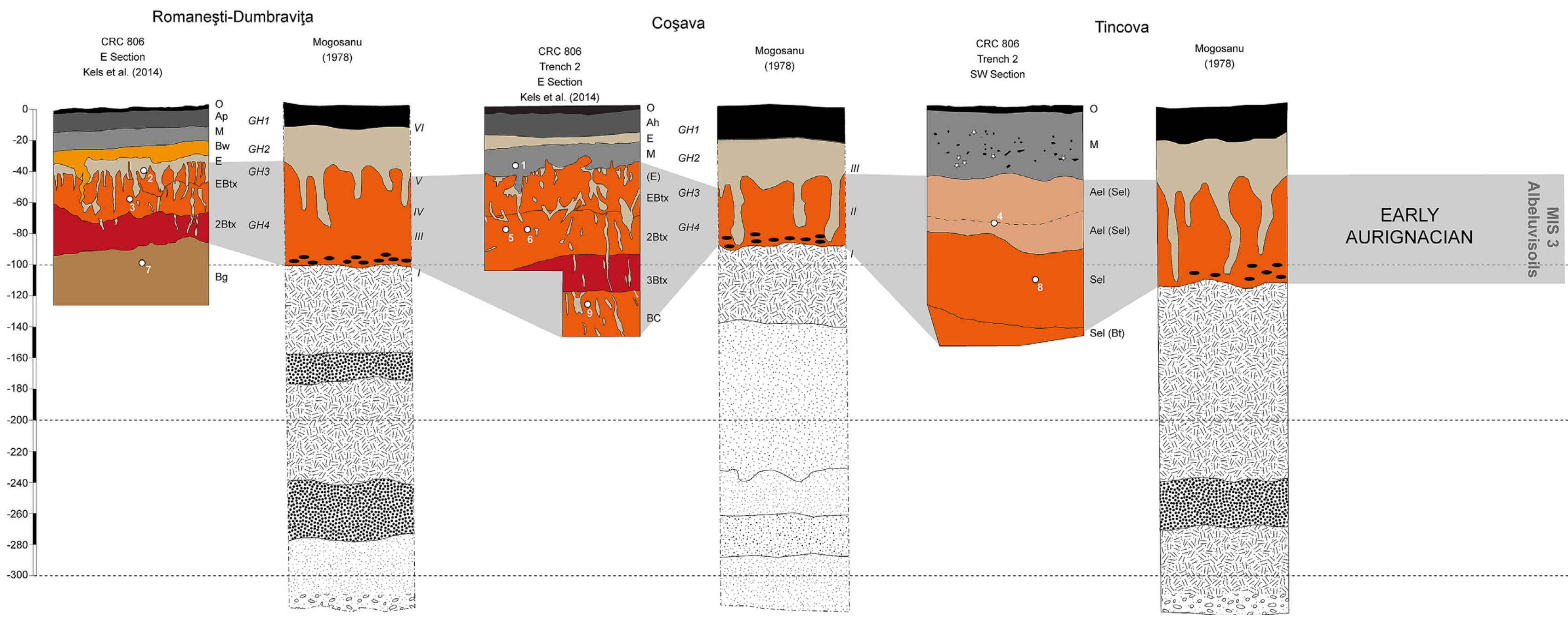

Fig. 5. Synthetic cross-section and correlation of excavated loess-paleosol sequences at Romaneşti-Dumbraviţa, Coşava and Tincova (Banat region, western Romania). Excavations were done by Mogoşanu (1978) and by the CRC806 project (Kels et al., 2014). Note that the well-developed succession of albeluvisols (marked in orange and red color) contains Early Aurignacian occupation remains at all three localities. The archaeological layers are partly affected by root channels that are the result of higher vegetation during interstadials. Numbered circles mark the position of dated OSL samples (Schmidt et al., 2013; Kels et al., 2014). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

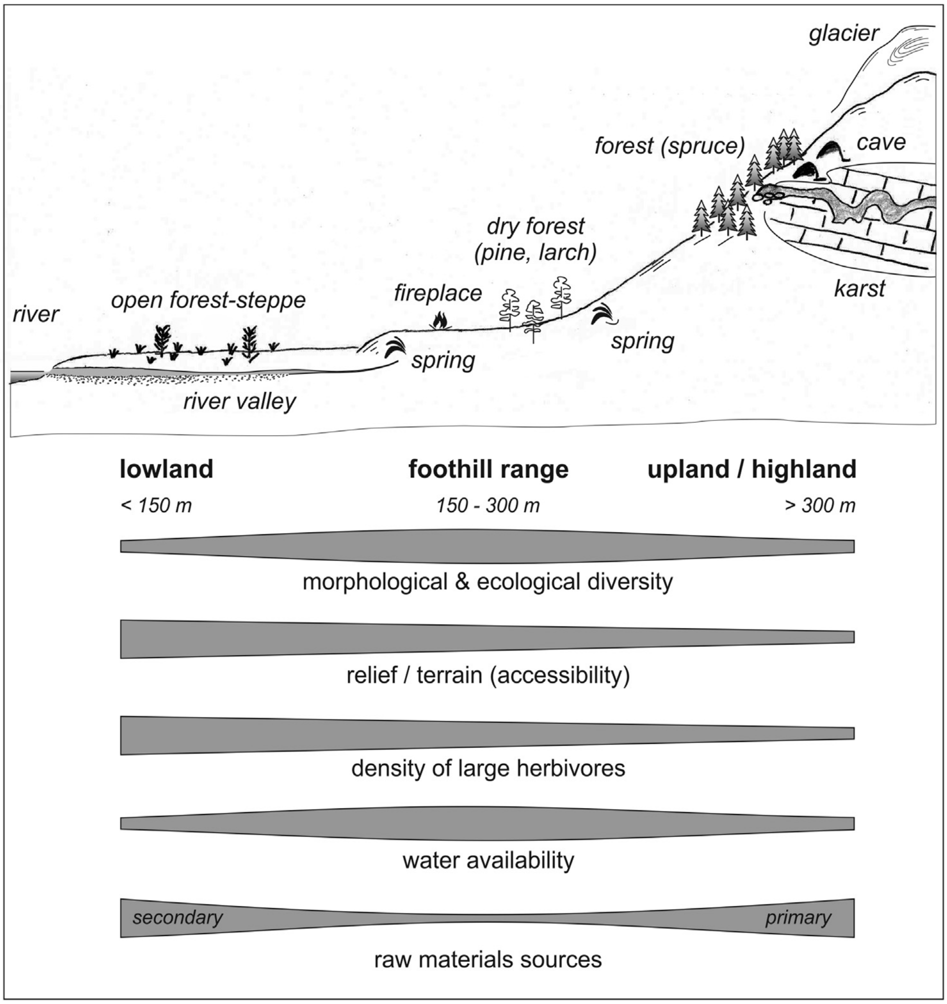

Fig. 6. Idealized MIS 3 upland-lowland transect. The grey bars mark the importance or frequency of major parameters of the Aurignacian land-use model according to altitude and topography.

presumably avoided for longer term settlements. There is, however, a certain likelihood that low archaeological visibility is caused by the rapid aggradation of sediments, the deep burial of sites and the difficulty to identify short-term activity sites, such as hunting posts or kill sites (e.g., Bosch, 2012; Nikolskiy and Pitulko, 2013). This is especially due for potential Aurignacian sites situated close to rivers that cross the Carpathian lowland. Nevertheless, we argue that the lack of Aurignacian sites reflects past reality for two reasons. Firstly, despite a considerable number deep geo-scientific sections, excavations and drillings at different parts of the Carpathian Basin, not a single trace of Early Upper Paleolithic occupations has yet been found in the exposed sections. And secondly, a number of environmental factors make a long-term occupation of the Pleistocene steppe rather unlikely. These factors are the lack of strategic or sheltered positions, the frequent presence of swamps or marshy terrain, the lack of stable water sources, and the exposure to strong wind. It is only in much later times that Paleolithic hunter-gatherers possess the necessary adaptations (long-distance networks, high degree of logistical mobility) to survive in very cold and dry regions. Evidence for this becomes visible in the late Gravettian and Epigravettian period (e.g. Maier et al., 2016; Bösken et al., in press).

From an ecological point of view, the limestone areas in the Western Carpathian mountain range offer the benefit of a great diversity in plant and animal communities. However, from the viewpoint of human subsistence, it is fairly likely that the caloric input of many vegetal and animal resources does not pay off the high energetic costs for their retrieval. This may explain the low number of early UP cave and rock-shelter sites in the higher range taiga forests. It may also explain the low find density that can be observed in Aurignacian cave sites (Vértes, 1955; Karavanić, 1995; Zilhão et al., 2007; Anghelinu et al., 2012; Borić et al., 2012; Anghelinu and Niţa, 2014; Dogandžić et al., 2014; Kuhn et al., 2014). We interpret the existing record as the result of regular lowland-upland moves of Aurignacian hunter-gatherers that intensified during the later phase of the early Upper Paleolithic. The low find density and high number of bone points probably signals small task groups that occupied the shelters for short periods to prepare for hunting activities, as is the case at Istállóskő Cave (Patou-Mathis et al., 2016). Considering the formation of glaciers above 1000 m.a.s.l (Urdea et al., 2011). and the lowering of the snowline during winter months, it is possible that the warmer summer months were the most likely period for these lowland-upland moves.

4.2. Implications for cultural complexity of the Aurignacian

The concentration of most activities within the narrow Carpathian foothill zone is paralleled by a broad scope of technological diversity in corresponding archaeological assemblages. Studies of

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larger artefact samples show that this is the case from the beginning of the Aurignacian period onwards (Hahn, 1977; Sitlivy et al., 2012, 2014a, 2014b; Nigst et al., 2014). The cultural phenotype of the Aurignacian in the Carpathian Basin is expressed by variability and flexibility. Variability is witnessed by the broad spectrum of blanks (e.g., flakes, blades, bladelets) that enable the manufacture of a broad spectrum of tools, such as various endscraper types, burins and retouched implements. Flexibility is reflected by the scope of core reduction strategies that were used for blank production. These include the removal of laminar implements from prismatic cores or carinated pieces as well as the burin technique. We observe a sophisticated entanglement of blank production, core shaping, and tool manufacture. Furthermore, raw material circulation between sites incorporated all kinds of reduction stages, ranging from finished tools to complete nodules (Nigst, 2014; Nigst et al., 2014; Sitlivy et al., 2012, 2014a, 2014b; Brandl et al., 2015).

Hahn (1977) already observed that the Central European Aurignacian does not conform to the cultural stages that were defined for the Western Europe. The material record only reflects some general tendencies, such as the increase of certain lithic tool types (e.g., nosed endscrapers, Dufour bladelets of Roc de Combe subtype) and split-based bone points. Furthermore, certain stone tool types that are markers of succeeding Aurignacian phases in other parts of Europe co-occur in key assemblages from larger open-air sites (Sitlivy et al., 2012; Nigst et al., 2014). Therefore, the Carpathian data add to the growing skepticism towards the distinction of an early Proto-Aurignacian (Aurignacian 0) and a later early Aurignacian phase (Aurignacian I) at least in this part of Europe (Sitlivy et al., 2014a, 2014b; contra Bon, 2002; Bordes and Tixier, 2002; Teyssandier, 2005).

5. Conclusion

The Carpathian Basin acted as one of the most important periglacial refuge areas for many plant and animal species and holds a considerable number of endemic taxa. Therefore, it is of no surprise that humans were attracted to this favorable environment. The considerable density of Aurignacian sites indicates a stable presence of early modern humans in this macro-region between 43 and 30 ka cal. BP.

The most crucial parameter of the proposed Aurignacian land-use model is the preference of early modern humans to occupy the Carpathian foothill zone. This is indicated by a significant cluster of Aurignacian sites within the altitudinal belt between 150 and 300 m.a.s.l. Sites are less numerous in the higher mountain range and even absent in the basin itself. Furthermore, the site distribution pattern shows that early modern humans occupied open-air localities because of preference and/or due to the lack of natural shelters in the foothill zone. The open-air sites are frequently placed on river terraces or prominent spurs that allow a wide ranging overview of the surrounding landscape and facilitate communication.

Another important land-use parameter is the landscape diversity and the access to productive ecozones. The study of high-resolution loess sections and their upland-lowland correlation shows that MIS 3 soil formation is most intense within the Carpathian foothill zone and corresponds with an interstadial forest steppe. Furthermore, the majority of Aurignacian sites is positioned in such a way as to guarantee short-distance access to the dry lowland mammoth steppe and to the taiga forests in the higher mountain range.

A major problem for the reconstruction of Aurignacian settlement dynamics is the lack of organic remains in decalcified loess deposits. Therefore, it is impossible to classify many sites according to function and to determine their role in the seasonal cycle. Nevertheless, we argue that the site distribution pattern mirrors a vertical organization of technology. The record of some larger Aurignacian sites reflects long-term occupation and an extended range of on-site activities. It is from these key sites that task-specific forays were made into the surrounding low- and uplands. This in turn correlates with a logistical organization of mobility.

The Carpathian Basin belongs to an important natural corridor that is shaped by the Danube and its catchment. This corridor certainly played an important role for the dispersal of human populations and their communication networks. However, it is unclear how such a corridor figured in the model of human dispersal. Was it a least-cost pathway along a string of productive environments? The MIS 3 landscape structure that we can reconstruct for the Carpathian Basin was certainly a productive environment. Its topographic and ecological uniqueness triggered specific adaptive solutions among early modern humans. Some of these solutions are idiosyncratic such as the strong link between habitation sites and certain landscapes or the broad scope of production techniques for stone artefacts. Others conform to the Aurignacian phenomenon on a pan-European scale. The Carpathian Basin was certainly part of the early modern dispersal trajectory into Europe. Nevertheless, it was not simply crossed, but constituted a preferred habitat of Aurignacian people for some 13,000 years, which is more than 400 generations.

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