Szeletian, Not Aurignacian: A Review of the Chronology and Cultural Associations of the Vindija G1 Neandertals

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Abstract Analysis of the lithic assemblages from provenience units Fd/d + G1, G/F, and G1 of Vindija confirms that a significant proportion correspond to items bearing edge damage and/or abraded dorsal scar ridges. Diagnostic Aurignacian items exist in the stratigraphically mixed G/F assemblage, and they may well have been discarded in the context of the same occupation as the split-based bone point recovered in G1. This level, however, also contains fragments of bone points of the Mladeč type, as well as a typically Szeletian bifacial foliate point. Thus, G1 is best explained as a post-depositionally disturbed palimpsest, one where the co-occurrence of finds is no sufficient indicator of true contemporaneity. This hypothesis is corroborated by the >10,000 years age difference between the two cave bear bones from that level that have been AMS radiocarbon dated. Given the regional archeological and human paleontological context, and the evidence suggesting that the direct dates obtained for the Neandertal remains from G1 are minimum ages only, it is concluded that such remains are likely to be Szeletian- rather than Aurignacian-related. The fact that Mladeč bone points are the only diagnostic tools throughout the F and E units further indicates that these deposits belong to the later Aurignacian, not the Gravettian. This pattern implies a major stratigraphic discontinuity at Vindija during the Last Glacial Maximum, thus providing an analog for the site formation processes inferred for G1 times on the basis of the level's mixed content.

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Introduction

The cave site of Vindija, Croatia (Fig. 1), is one of the key sequences for the study of the late Middle and the early Upper Paleolithic of Europe. Unfortunately, the data set has several shortcomings (Karavanić and Smith 2000): modern excavation standards were not used, cryoturbation affected the site at least in part, and the exact stratigraphic provenience of some key finds is uncertain. However, AMS dating of cave bear and human bone samples (Smith et al. 1999; Wild et al. 2001; Higham et al. 2006a), analysis of the artifact assemblages (Malez 1988; Karavanić 1994, 1995, 2000; Karavanić and Smith 1998; Blaser et al. 2002; Ahern et al. 2004), and paleonutrition and ancient DNA studies of the human remains themselves (Krings et al. 2000; Richards et al. 2000; Serre et al. 2004) have made it possible to overcome some of these problems and to obtain information of major relevance for the Middle-to-Upper Paleolithic transition (henceforth, the Transition) in this part of the world.

Of the 22 stratigraphic levels recognized at the site, the c. 3.2 m of deposits comprised between the top of layer D and the base of complex G, with subdivisions (*g* for *gore,* top; *s* for *sredina,* middle; *d* for *dolje,* infra), contain Upper and late Middle Paleolithic occupations (Fig. 2). According to Karavanić (1994, 1995), the succession is as follows: level D, Epigravettian; level E, Late Gravettian or

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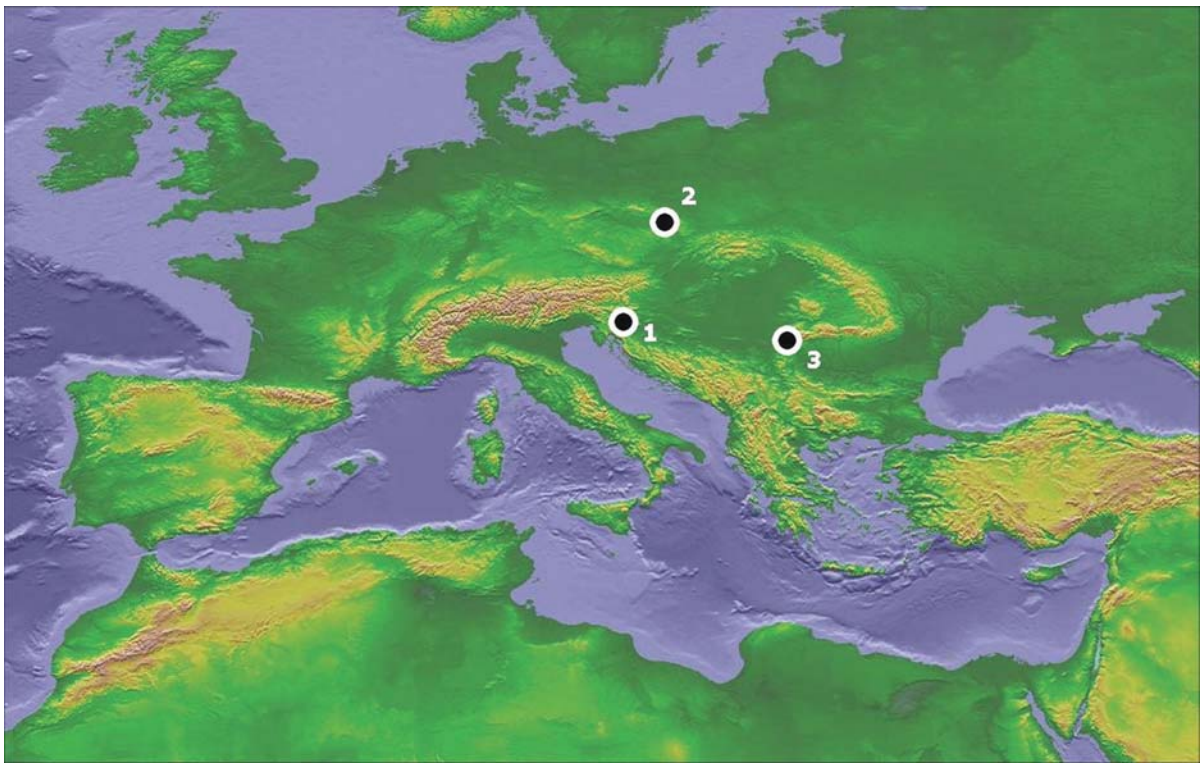

Fig. 1 The location of Vindija cave (1) on a physiographic map of Europe. The site is located at the western boundary of the Pannonian basin, at the northern and eastern boundaries of which are located two sites that yielded diagnostic modern human remains in the time range indicated by the direct dating of the Neandertals in Vindija level G1: Mladeč (2), and Oase (3)

Epigravettian; levels Fg, Fs and Fd/s, possibly Gravettian (given their position in the succession, but lacking diagnostic stone tools); level Fd, undefined; levels Fd/d and G1, Aurignacian; and levels G2–G5, Mousterian. Karavanić (2000) since has suggested that the assemblage in G1 better might be referred to the Olschewian, an entity that, following Montet-White (1996), he defined as a regional variant of the Aurignacian embodied in the assemblages rich in bone points recovered at several central European cave sites in levels dated to around the time of the Transition.

Besides bone points, level G1 also contained a bifacial foliate, as well as human remains that are clearly Neandertal (Malez et al. 1980; Smith 1984; Ahern et al. 2004). Such an association has been variously interpreted as evidence that Neandertals made split-based bone points and were at least in part the authors of the Aurignacian (Wolpoff 1996); or as evidence that Neandertals still inhabited northern Croatia long after Aurignacian bone and stone tool technology first spread across central Europe (Karavanić 2000), thus providing a temporal and spatial framework for considerable biological and cultural interaction with modern humans in the region (Karavanić and Smith 2000).

All of these interpretations are contingent upon the acceptance, most recently reasserted by Janković et al. (2006), of (1) the integrity of level G1, (2) the true contemporaneity of the different find categories recovered therein, and (3) the accuracy of the direct radiocarbon dating results obtained for the Neandertal remains. Such an acceptance, however, carries implications that are at odds with patterns well established by decades of research. For instance, now that the situation at the Hungarian cave site of Istállós-kõ finally has been clarified (Adams 2002; Ringer 2002; Adams and Ringer 2004), Vindija remains as the only find locality where split-based bone points would co-occur with bifacial foliates in the same occupation horizon. The anomalies have not gone unnoticed and,

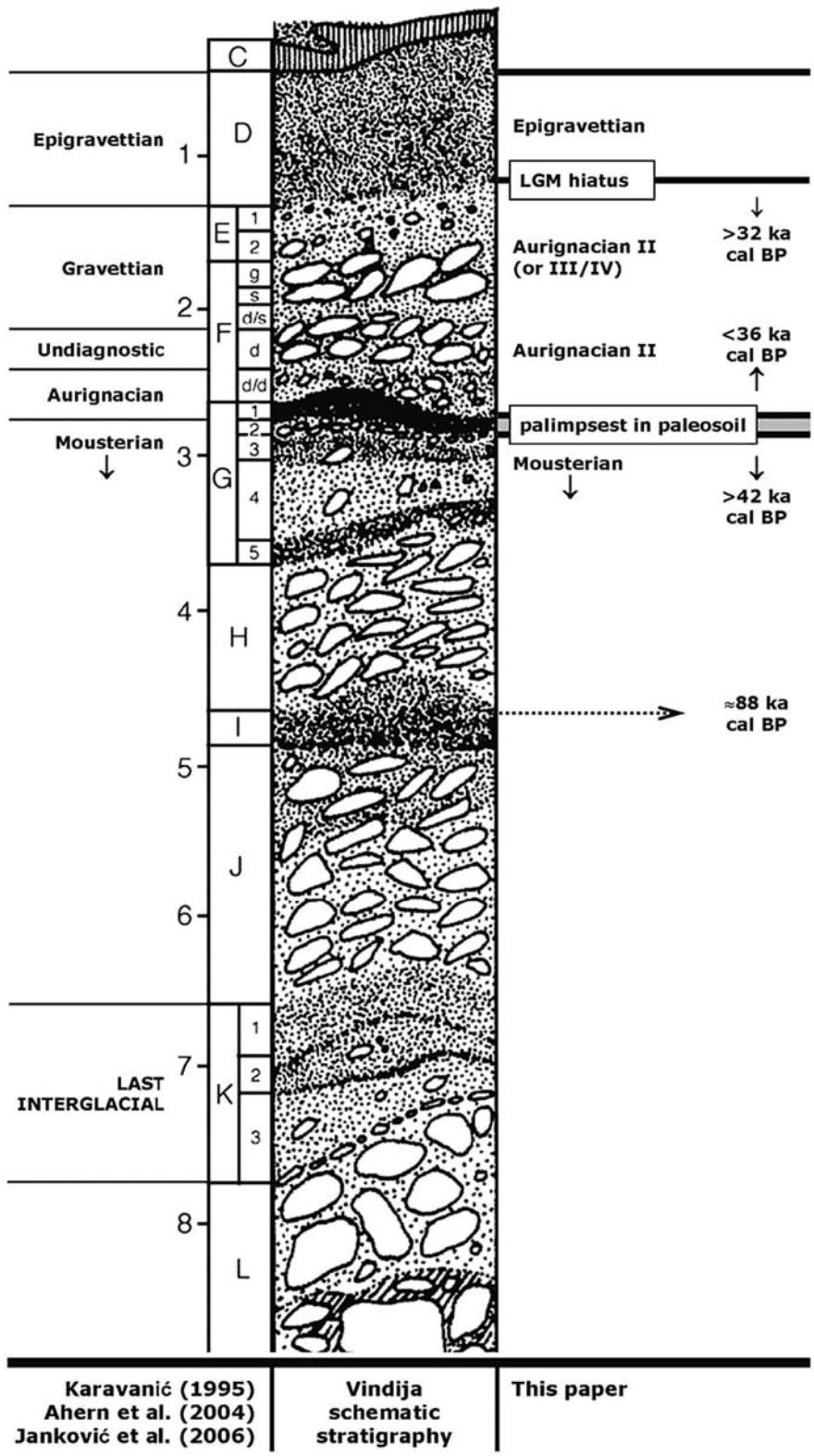

Fig. 2 The Vindija succession and its chronostratigraphic interpretation. Note that Ahern et al. (2004) interpret the presence of a few Upper Paleolithic elements in G3 as a reflection of cultural process (local Mousterian innovations), while they may simply constitute further examples of the post-depositional displacement of artifacts across recognized level boundaries. Where G1 is concerned, the mix therein of Szeletian, Aurignacian I, and Aurignacian II items is consistent with its being either a palimpsest, a byproduct of erosion and redeposition, or a combination of both (see text for discussion)

following previous reservations, notably by Kozłowski (1996), have led to suggestions that the G1 association is spurious and, as indicated by the edge damage of stone tools, an artifact of geological processes, cryoturbation in particular (d'Errico et al. 1998; Zilhão and d'Errico 1999a).

Typology, Distribution, and Condition of the Diagnostic Tools

Results from personal examination, in April 2004, of the Vindija artifact collection housed in the Croatian Academy of Sciences, Zagreb, support previous objections to the integrity of G1 (Table 1; Fig. 3). Of the fifteen retouched stone tools mentioned by Karavanić (1994, 1995), ten were present, of which three are typologically unambiguous: the bifacial foliate, a Szeletian point made on a reddish, exogenous raw material, biconvex in cross-section, and bearing a clear impact fracture on the distal end; a straight dihedral burin; and a small proximal blade fragment with regular, continuous retouch on both sides. The other seven, however, are no more than unretouched blanks bearing post-depositional damage to different degrees: the "endscraper on a flake" Vi-174, for instance, is a small patinated flake with abraded, rounded dorsal edges and featuring marginal, peripheral, irregular, and alternate "retouch," a rather typical combination of attributes indicative of water transport or turbation; and the "sidescraper" Vi-3383 is simply a small 2.5 cm flake where the "retouch" is crushing of the cutting edges and the dorsal edges are clearly abraded.

Edge damage, but no dorsal abrasion, is also apparent in the four "retouched tools" (out of five

Table 1 Classification, compared with Karavanić's (1994, 1995), of the lithic items from G1 and from other provenience units conceivably sampling material from G1 kept at the Croatian Academy of Sciences, Zagreb, with the indication "retouched tools" (as of April 2004)

		G1 (1977–1979 and 1984)		Fd/d + G1 (1984)		G/F (1975–77)	
Type-list #	Description	Karavanić (1995)	Zilhão (unpublished)	Karavanić (1995)	Zilhão (unpublished)	Karavanić (1995)	Zilhão (unpublished)
1	Endscraper, simple on blade	–	–	1	–	–	–
1	Endscraper, simple on flake	–	–	–	1	–	–
2	Endscraper, simple on blade, atypical	–	–	–	–	1	–
3	Endscraper, double, on flake	–	–	1	1	–	–
5	Endscraper, on retouched blade	1	–	–	–	–	1
6	Endscraper, on Aurignacian blade	–	–	–	–	1	–
8	Endscraper on flake	2	–	–	–	–	–
12	Endscraper, keeled, atypical	–	–	–	–	1	–
13	Endscraper, thick-nosed	–	–	–	–	1	–
16	*Rabot*	–	–	1	–	–	–
29	Burin, dihedral, straight	1	1	–	–	1	–
30		–	–	–	–	1	–

Table 1 (continued)

Type-list #	Description	G1 (1977–1979 and 1984)		Fd/d + G1 (1984)		G/F (1975–77)	
		Karavanić (1995)	Zilhão (unpublished)	Karavanić (1995)	Zilhão (unpublished)	Karavanić (1995)	Zilhão (unpublished)
	Burin, dihedral, on angle						
35	Burin, on oblique truncation	–	–	–	–	1	–
65	Blade with one continuously retouched edge	–	–	1	–	2	–
66	Blade with two continuously retouched edges	1	1	–	–	5	1
67	Blade with Aurignacian or Aurignacian-like retouch	–	–	–	–	1	3
70	Bifacial foliate point	1	1	–	–	–	–
75	Denticulate	4	–	1	–	–	–
77	Sidescraper	4	–	–	–	–	1
92	Blade with partial retouch	–	–	–	–	–	1
92	Hammerstone	1	–	–	–	–	–
92	Chopper	–	–	–	–	1	–
92	Other	–	–	–	–	4	–
	Prismatic bladelet core	–	–	–	–	–	1
	Unretouched blade	–	–	–	–	–	1
	Flake or blade with edge damage or irregular, marginal, alternate "retouch"	–	7	–	2	–	6
	Heavily patinated, *concassé* piece	–	–	–	–	–	3
	TOTAL	15	10	5	4	20	18

mentioned by Karavanić) that bear the label "Fd/d + G1"—two are indeed retouched (a simple endscraper and a double endscraper on a thick flake); the other two are edge-damaged blade fragments, and all bear adhering remnants of a brownish sediment identical to that seen in the pieces labelled G1. The best preservation was observed among the eighteen "retouched tools" labeled "G/F" (two of the twenty mentioned by Karavanić were not found) (Fig. 4). Although five were broken, edge-damaged blanks, and three were severely *concassé* and heavily patinated pieces, the remaining ten were in good condition. The latter include a prismatic bladelet core, one endscraper on a bilaterally retouched blade, four blades with continuous, Aurignacian-like retouch, one partially retouched blade, two unretouched blades, and one sidescraper.

These observations are consistent with the notion that an Aurignacian component exists among the site's lithics, and it is quite possible that

Fig. 3 The ensemble of G1 lithic artifacts kept at the Croatian Academy of Sciences, Zagreb, with the indication "retouched tools" (as of April 2004): **a**–**g** edge-damaged, patinated, and/or abraded items; **h-i** items in good surface condition (**h**. bifacial foliate point; **i**. straight dihedral burin; **j**. blade with two continuously retouched edges)

such a component represents stone tools discarded at the site in the framework of the human occupation defined by the G1 split-based bone point. But the data also indicate that the stratigraphic position of these Aurignacian lithics is ambiguous, the most diagnostic items having been found in the G/F unit, i.e., in mixed deposits of, or the at the interface between, G and F. Such an ambiguity, plus the significant edge damage apparent on many artifacts—indicating that they were either washed or in situ turbated—suggests considerable disturbance of the deposits found at that interface, in at least some areas of the cave. Given the evidence, it is in any case clear that the level of uncertainty surrounding the provenience of the most diagnostic lithic elements recovered in the basal F and upper G levels is a byproduct of true stratigraphic problems rather than of excavation error.

The typology and provenience of the bone tools corroborate a diagnosis of inhomogeneity for the G1 assemblage (Table 2; Fig. 5). In fact, alongside the well-known split-based point fragment, the level also yielded a few fragments (Vi-2610, Vi-3438, Vi-3439, Vi-3440, Vi-3441) of the same Mladeč point types more abundantly found in overlying levels Fd/d and F/d. The evidence from western Europe is that split-based and Mladeč points belong in different, successive culture-stratigraphic units (Early Aurignacian or Aurignacian I and Evolved Aurignacian or Aurignacian II, respectively), and the same applies to Vindija's immediate regional context.

In adjacent Slovenia, for instance, no other putative "Olschewian" occupation associates split-based and Mladeč points in the same find horizon. The site of Potočka Zijalka (Brodar and Brodar 1983;

Fig. 4 The ensemble of G/F lithic artifacts kept at the Croatian Academy of Sciences, Zagreb, with the indication "retouched tools" (as of April 2004) and that presenting a good surface condition: **a**. prismatic bladelet core; **b**. unretouched blade (with a bit of edge damage); **c**. unretouched blade (partial retouch near the broken base); **d**. unretouched blade; **e**. sidescraper on laminar flake; **f**. proximal fragment of blade with lipped platform with Aurignacian retouch on the left side; **g**. mesial fragment of blade with bilateral Aurignacian retouch; **h**. blade with bilateral Aurignacian retouch; **i**. endscraper on blade with continuous bilateral retouch; **j**. mesial fragment of blade with bilateral retouch

Pacher et al. 2004) produced a rich assemblage of Mladeč points (128 from the 1920s to 1930s extensive excavation work, plus two from the restricted areas investigated in 1997–2000), but not a single example of a split-based point (occasionally—e.g., Karavanić 2000—one particular bone tool from this cave has been referred to the split-based type, but that find is in fact a naturally fissured object where, as Brodar and Brodar point out, no osseous material is missing on the inner side of both lips, as would have to be the case if the split resulted from intentional manufacture). Conversely, at the cave site of Mokriška Jama (Brodar 1985), not one of the nine bone points recovered was of the Mladeč variety: one preserved a proximal portion sufficiently large for a split base to be observed, while at least two other medial and distal fragments (and possibly three smaller ones too) could well have been of the same type. The evidence from the cave of Divje Babe I (Turk 1997), where one split-based point, but none of the Mladeč type, was recovered in level 2, is consistent with this pattern.

Site Formation Process

It seems fair to conclude, therefore, that, even though the Vindija succession may well feature a significant level of stratigraphic integrity above and below the F/G interface, major problems exist at exactly that interface, causing the apparent association in the uppermost G unit (i.e., level G1) of a mix of items that normally would have been stratigraphically differentiated. One possibility is that only the Szeletian bifacial foliate lithic point is in situ, and that the split-based bone point is a later intrusion, since it is most certainly related to an

Table 2 Upper Paleolithic sagaie bone points from Vindija kept at the Croatian Academy of Sciences, Zagreb (as of April 2004)

Inventory #	Year of excavation	Level	Cultural horizon (Karavanić 1995)	Cultural horizon (Zilhão, this paper)	Fragmentation	Base	Cross-section	Mladečtype
Vi-3471	–	D/g	Epigravettian	Epigravettian	Mesial	–	Circular	
Vi-3465	–	D			Proximal	double-bevelled	Circular	
Vi-3466	–	D			Mesial	–	Circular	
Vi-3467	–	D			Mesial	–	Circular	
Vi-3468	1979	D			Mesial	–	Circular	
Vi-3469	1977	D			Mesial	–	Circular	
Vi-3470	–	D			Proximal	Double-bevelled	Circular	
Vi-2508	1983	E + F	Gravettian	Aurignacian II or III/IV	Proximal and mesial	Massive	Oval	*
Vi-3460	1975	E/F			Proximal and mesial	Massive	Oval	*
Vi-3461	–	E/F			Mesial	–	Circular	
Vi-3456	1979	F/s	Gravettian	Aurignacian II or III/IV	Proximal	Massive	Flat	*
Vi-3457	1978	F/s			Mesial	–	Flat	*
Vi-3458	1978	F/s			Distal, with apical fracture	–	Flat	*
Vi-3459	1978	F/s			Mesial	–	Flat	*
Vi-3465	1979	Fd/s			Mesial and distal with apical fracture	–	Flat	*
Vi-3451	–	F/d	Unknown	Aurignacian II or III/IV	Mesial	–	Flat	*
Vi-3452	1979	F/d			Distal with apical fracture	–	Flat	*
Vi-3453	1978	F/d			Distal with apical fracture	–	Flat	*
Vi-3454	1978	F/d			Mesial	–	Flat	*
Vi-3449	–	Fd/d	Aurignacian	Aurignacian II or III/IV	Proximal and mesial	Massive	Flat	*
Vi-3450	–	Fd/d			Proximal and mesial	Massive	Oval	*
Vi-3445	1984	Fd/d + G1	Mixed	Mixed	Proximal to distal with apical fracture	Massive	Flat	*
Vi-3446	1984	Fd/d + G1			Proximal to distal with apical fracture	Massive	Flat	*
Vi-2512	1983	Fd/d + G1? G1?			Mesial	–	Flat	*
Vi-2509	1983	G1	Olschewian	Mix of	Mesial	–	Flat	*
Vi-2510	1983	G1		Szeletian +	Proximal	Massive	Flat	*

Table 2 (continued)

Inventory #	Year of excavation	Level	Cultural horizon (Karavanić 1995)	Cultural horizon (Zilhão, this paper)	Fragmentation	Base	Cross-section	Mladečtype
Vi-3437	–	G1		Aurignacian I+ Aurignacian II	Proximal and mesial	Split	Wide, very flat	
Vi-3438	–	G1			Proximal and mesial	Massive	Flat	*
Vi-3439	–	G1			Proximal to distal with apical and lateral fractures	Massive	Flat	*
Vi-3440	1983	G1			Mesial	–	Flat	*
Vi-3442	1979	G1			Mesial, split longitudinally	–	Flat	*

The following items included in Karavanić's (1994) bone tool inventory were excluded because they are either intrusive or not sagaie points: in levels D and D/g, Vi-1977, a pendant, Vi-3474 and Vi-3475, awls, all of which feature a lack of fossilization indicating provenience from the overlying Neolithic; in level E, Vi-3462, an awl; in level G, Vi-3436, an awl; in level G1, a (penian?) bone with marks associated with a note saying "green layer," i.e., G3. Also excluded were Vi-2111 and Vi-3463, which are not artifacts, as well as the Vi-3464, Vi-3447, Vi-3449 and Vi-3464 "buttons," which are in fact carnivore-broken bones.

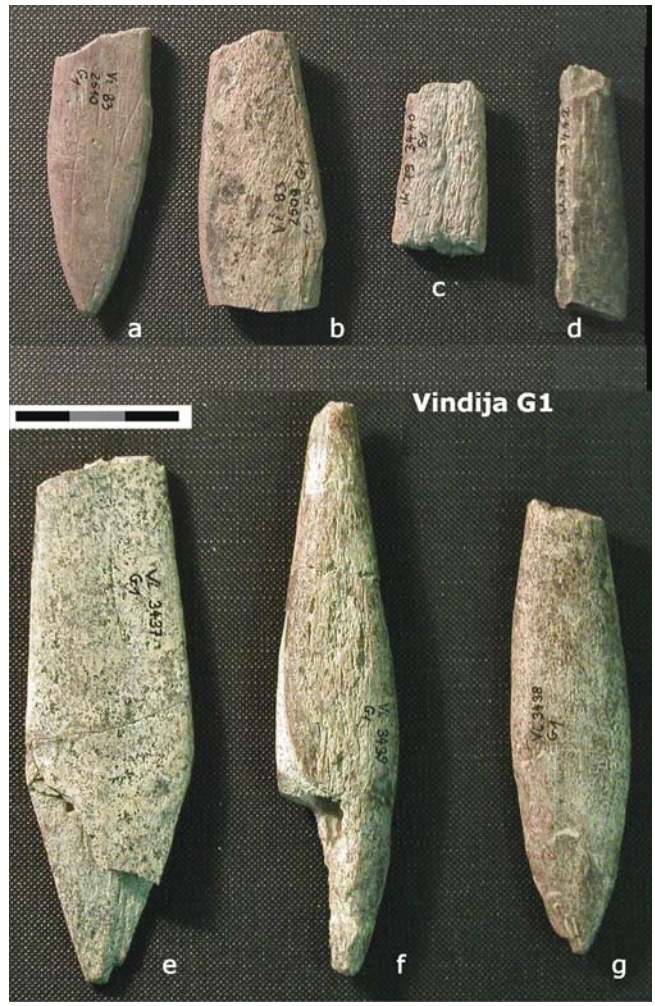

Fig. 5 Split-based (**e**) and Mladeč (**a-f**, **f-g**) points from the G1 unit (cf. Table 2): **a**. Vi-3440; **b**. Vi-3441; **c**. Vi-3437; **d**. Vi-3439; **e**. Vi-3438; **f**. Vi-2610; **g**. Vi-3442

Aurignacian I occupation of the site, also reflected in the retouched blades found in the mixed G/F unit. In such a scenario, the G1 Mladeč point fragments, a type that is represented in the overlying levels by a significant number of finds (Table 2), would likewise be intrusive too.

This view is consistent with the sedimentological nature of G1 as described, for instance, by Karavanić (1995): a red-brown clay sandwiched between two series of sandy sediments with abundant limestone rubble, G3 below (G2 only occurs in restricted portions of the site), and F and E above. The pattern suggests pedogenesis, i.e., that, as the excavators thought, the formation of G1 occurred during a period of warming climatic conditions (Malez et al. 1980). In the regional geological and paleoenvironmental setting, one would expect such conditions to translate into a marked slowdown in the rate of sedimentation, favoring the creation of archeological palimpsests via the intrusion into previously accumulated deposits of material from occupations taking place on long-standing, stabilized surfaces. Coupled with subsequent post-depositional disturbance (e.g., cryoturbation), such well-known and purely geological processes parsimoniously explain the utterly exceptional association in G1 of tool-types that elsewhere always occur separately, effectively dispensing with the need to christen a new cultural-stratigraphic category (the "Olschewian") to account for it.

If we consider the evidence from G1 in light of the site's wider geographical context, both regional and continental (Teyssandier 2003; Teyssandier et al. 2006; Liolios 2006; Zilhão 2007), it is also

clear that the association in that level of find categories that, elsewhere, are of Aurignacian II, Aurignacian I, or Szeletian affinities, would represent (if taken as meaning strict contemporaneity) the survival, reappearance, or first appearance of those items several millennia beyond their documented chronological range. For the sake of the argument, let us assume, for instance, that the Mladeč bone points are good indicators of the level's formation age. In that case, the deposition of its contents would have taken place c. 30–32 ka ^{14}C BP (c. 34–35 ka cal BP), i.e., within the interval defined by the dates for six such points from the Potočka Zijalka (Rabeder and Pohar 2004), and in agreement with the fact that, elsewhere in Europe, no other specimen of unambiguous assignment to this type has ever yielded a direct date older than c. 32 ka ^{14}C BP (Jacobi and Pettitt 2000; Charles et al. 2003; Bolus and Conard 2006; Higham et al. 2006b). However, if G1 is homogenous and formed c. 30–32 ka ^{14}C BP, then the split-based bone point would be two to three thousand years later than the most recent occurrences of the type elsewhere in Eurasia, where it is found from Asturias (northern Spain) in the west to the northern Levant in the east, only during the time interval of c. 32–35 ka ^{14}C BP (c. 37–40 ka cal BP); and, in the case of the Szeletian- or Altmühlian-type bifacial foliates from central Europe, whose distribution, spatially, covers Moravia, Germany, Hungary, and southern Poland and, temporally, the interval of c. 37–40 ka ^{14}C BP (c. 41–44 ka cal BP), the difference in the expected age would be some ten thousand years.

Obviously, the contradictions above are reversed in their terms, but not eliminated, if we consider that the true age of deposition of G1 is that given by the temporal distribution of Szeletian foliates or of Aurignacian I split-based bone points. In contrast, in the framework of a palimpsest model, the co-occurrence of "index-fossils" of such distinct chronology is easy to understand, since it implies that the contents of G1 mix remains from different, chronologically widely separated and very episodic human visits to the cave.

Chronology of the Succession

The palimpsest *cum* disturbance model is also the only interpretation of G1 that can accommodate without any form of special pleading the actual dating results available for the Vindija sequence itself (Wild et al. 2001) (Table 3). Where G1 is concerned, the earliest date is that of 46,800/ +2300/–1800 ^{14}C BP (VERA-1428) (c. 50.4 ka cal BP), obtained for a cave bear bone. A second cave bear bone yielded a date of 33,000±400 ^{14}C BP (c. 37.3 ka cal BP), and the U-Th ages obtained for two other samples were c. 27.9 and 33.1 ka cal BP. Even if the latter are rejected due to the issues of uncertainty concerning uptake assumptions discussed by Wild et al., the two radiocarbon results confirm that the contents of G1 do sample an extended period of time—in fact, broadly the same ten millennia obtained when, as in the preceding section, the level's formation process is assessed on the basis of chronological estimates derived from cultural-stratigraphic patterns of regional and continental validity.

Moreover, since the G1 deposits are 8–20 cm thick only, both the relative and the absolute chronological timescales further imply a sedimentation rate in the range of 5–15 mm per thousand years. This is five to fifteen times less than can be estimated for the site's Upper Pleistocene succession as a whole (levels D–K): being c. 7.25 m thick, it accumulated at an overall rate of some 72.5 mm per thousand years. Such a slowdown of sedimentation rates at the F/G interface perfectly fits the expectations of the palimpsest *cum* disturbance model.

Immediately underlying G1, level G3 is 10–20 cm thick and is dated by two AMS results on samples of Neandertal bones (Krings et al. 2000; Serre et al. 2004). One is a minimum age only: >42 ka ^{14}C BP (Ua-13873) (>45 ka cal BP). The other is a finite result of 38,310±2130 ^{14}C BP (Ua-19009) (c. 42.3 ka cal BP); given its large standard deviation, this date probably is simply a minimum age too. Combined, the results indicate a chronology securely in excess of 42 ka cal BP for the deposition of G3, in good agreement with the U-Th result of c. 41 ka cal BP obtained for a cave bear bone from that level.

While fully consistent with the palimpsest interpretation for G1, the chronology of the G3 deposit further leaves open the possibility that a marked hiatus existed at the interface between G1 and G3, implying significant erosion and, possibly, redeposition. Such a hiatus would provide yet another conceivable explanation, via the presence in G1 of

Table 3 Radiometric dates for the Transition in Croatia and Slovenia, after Karavanić (1995, 2003), Turk et al. (1997), Smith et al. (1999), Krings et al. (2000), Wild et al. (2001), Rabeder and Pohar (2004), Serre et al. (2004) and Higham et al. (2006a). Calibration uses the 2007 Hulu version of the CalPal software (Weninger and Jöris 2004). Following Zilhão and d'Errico (1999) and Wild et al. (2001), conventional dates on bone were excluded

Country	Site	Level	Culture	Material	Method	Lab no.	Age ^{14}C BP	Age cal BP	cal BP 2σ range
Croatia	Sandalja II	G	Aurignacian II	Charcoal	^{14}C	Z-536	27,800±800	32,500±690	31,120–33,880
	Velika Pećina	G	Aurignacian II	Charcoal	^{14}C	Z-189	27,300±1200	31,940±1120	29,700–34,180
		I	Aurignacian I	Charcoal	^{14}C	GrN-4979	33,850±520	38,930±1480	35,970–41,890
		J	Intrusive	Modern human frontal	AMS ^{14}C	OxA-8294	5045±40	–	–
	Vindija	F	Aurignacian II and/or III/IV	Charcoal	^{14}C	Z-612	24,000±3300	28,050±3470	21,110–34,990
		F		Charcoal	^{14}C	Z-613	29,700±2000	34,360±1990	30,380–38,340
		F/d, or F/d -F/d/d		Charcoal	^{14}C	Z-551	27,000±600	31,630±540	30,550–32,710
		G1	Mixed	Cave bear bone	U-Th	–	–	27,900±1000	25,900–29,900
				Cave bear bone	U-Th	–	–	33,100±800	31,500–34,700
				Cave bear bone	AMS ^{14}C	ETH-12714	33,000±400	37,300±820	35,660–38,940
				Cave bear bone	AMS ^{14}C	VERA-1428	46,800/ +2300/–1800	50,390±2700	44,990–55,790
				Neandertal parietal (Vi-208)	AMS ^{14}C	OxA-8295	28020±360	32,540±370	31,800–33,280
					AMS ^{14}C	OxA-X-2089-07	32,400±1800	37,360±2240	32,880–41,840
				Neandertal mandible (Vi-207)	AMS ^{14}C	OxA-8296	29,080±400	33,500±430	32,640–34,360
					AMS ^{14}C	OxA-X-2089-06	32,400±800	36,860±1150	34,560–39,160
		G3	Mousterian	Cave bear bone	U-Th	–	–	41,000/ +1000/–900	39,100–42,900

Table 3 (continued)

Country	Site	Level	Culture	Material	Method	Lab no.	Age ^{14}C BP	Age cal BP	cal BP 2σ range
				Neandertal bone (Vi-80/33.16) (a)	AMS ^{14}C	Ua-19009	38,310±2130	42,340±1770	38,800–45,880
				Neandertal bone (Vi-75-G3/h-203)	AMS ^{14}C	Ua-13873	>42,000	>45,000	–
		H/I	Mousterian	Cave bear bone	U-Th	–	–	88,200±2300	83,600–92,800
		I	Mousterian	Cave bear bone	AMS ^{14}C	VERA-0109	37,000±600	–	–
		J	Mousterian	Cave bear bone	AMS ^{14}C	VERA-0105	34,700±500	–	–
Slovenia	Divje Babe I	2	Aurignacian I	Bone	AMS ^{14}C	RIDDL-734	35,300±700	40,210±1020	38,170–42,250
	Potočka Zijalka	Layer 5, NW sector, Brodar excavations	Aurignacian II	Bone point PZ59, #806	AMS ^{14}C	VERA-2522	30,140/+330/–310	34,370±250	33,870–34,870
				Bone point PZ54, #802	AMS ^{14}C	VERA-2521	31,080/+370/–360	35,090±370	34,350–35,830
		Layer 7, W sector, Brodar excavations	Aurignacian II	Bone point PZ128, #831a	AMS ^{14}C	VERA-2526	29,560±270	33,910±300	33,310–34,510
				Bone point PZ126, #830a	AMS ^{14}C	VERA-2525	29,740/+330/–310	34,040±300	33,440–34,640
				Bone point PZ121	AMS ^{14}C	VERA-2524	29,760/+330/–310	34,060±290	33,480–34,640
				Bone point PZ112, #847	AMS ^{14}C	VERA-2523	31,490/+350/–340	35,370±390	34,590–36,150

(a) The bone is a piece of human tibia originally put in the fauna. The label Vi-80 was written on the bone to identify the level and area from which it came, and it still bears this label. When the bone was recognized as human, it was given the hominid catalog number Vi-33.16 (Hawks, personal communication)

material derived from G3, for the mix of items with very different chronology that characterizes the G1 bone and stone tool assemblage. In a hiatus scenario, one might think, for instance, that the split-based bone point was in situ, while the Szeletian foliate (plus the cave bear bone dated to c. 50.4 ka cal BP) derived from G3, and, as in the palimpsest scenario, the fragments of Mladeč points intruded from Fd or Fd/d.

The chronometric evidence, therefore, concurs with the typological indications in favoring "palimpsest *cum* post-depositional disturbance" and "hiatus with erosion and redeposition" views of level G1, or any combination of the two. Whichever model is preferred, it is in any case clear that such ordinary site formation processes need to be rejected before cultural factors (such as the putative Olschewian) can be accepted for consideration as a viable explanation for the anomalous find association that characterizes the level.

Where the chronology of the E and F complexes is concerned, Karavanić (1994, 1995) and Janković et al. (2006) propose a Gravettian to Late Gravettian age on the basis of their stratigraphic position (between Aurignacian and Epigravettian) and of a date for level E of 18,500±300 ^{14}C BP (Z-2447). However, the latter is a conventional result on bone that must be a minimum age only, as are all the other conventional bone results for the Pleistocene succession of the site, which appear systematically rejuvenated by comparison with those obtained for the same levels by AMS ^{14}C or U-series methods. On the other hand, all the bone points from the different E-F levels (Fd/d, F/d, Fd/s, Fs, Fg and E) feature shapes and cross-sections that fall fully within the range documented in the large, chronologically homogeneous collection from the Potočka Zijalka, indicating that they all belong to the Mladeč type (Fig. 6). Such an exclusive representation, combined with the lack of any stone tools that can be considered either as exclusive of the Gravettian or as incompatible with the Aurignacian, suggests that these E-F deposits in fact date to Aurignacian times in their entirety.

The relative abundance of burins reported by Karavanić (1994, 1995) for the retouched pieces found in E and F replicates the pattern observed in the few well-described post-Aurignacian II lithic assemblages of western Europe, better examplified by level 6 of the Abri Pataud (Chiotti 1999), assigned to the Aurignacian III/IV. At Vindija, attribution of the E-F assemblages to such latest manifestations of the technocomplex is fully consistent with the conventional charcoal dates obtained for associated samples (Table 3). The large standard deviations indicate that the results may simply represent minimum ages; but even so, at the 95% confidence level, there is significant overlap with the chronological range of that latest Aurignacian (c. 28–30 ka ^{14}C BP, i.e., c. 32.5–34.2 ka cal BP).

The chronostratigraphic reassignment of the E-F units implies that the succession features a significant hiatus at the Aurignacian/Epigravettian interface, with no preservation at the site of deposits dating to the Last Glacial Maximum (LGM). Whether this pattern denotes that sediments ceased to accumulate at Vindija as the LGM approached, or that pre-Epigravettian erosive processes removed any deposits accumulated during the Gravettian, is something that remains to be clarified. The significant cryoturbation features reported by Karavanić (1995) for level E, however, are in all likelihood of LGM age, suggesting that we are dealing with a sedimentation hiatus indeed.

A rapid accumulation of sediments during Aurignacian II and later Aurignacian times, leading to the formation of rather thick deposits, rich in cave bear bones and containing traces of human incursions, followed by a hiatus and by erosion and redeposition at the time of the LGM, is exactly what we have at the Potočka Zijalka (Rabeder and Pohar 2004, 243), and one would expect to see the same pattern replicated at nearby sites in a similar setting. The regional evidence thus corroborates that the Vindija succession should not be seen as a continuous record, and that the formation processes proposed here for level G1 are in no way exceptional.

Age of the G1 Neandertals

A separate but related issue is that raised by the presence of Neandertal remains in G1. Their direct dating initially suggested a surprisingly recent chronology, in the range of c. 28–29 ka ^{14}C BP (c. 32.5–33.5 ka cal BP; Smith et al. 1999). Such an age could conceivably support the reality of the Olschewian

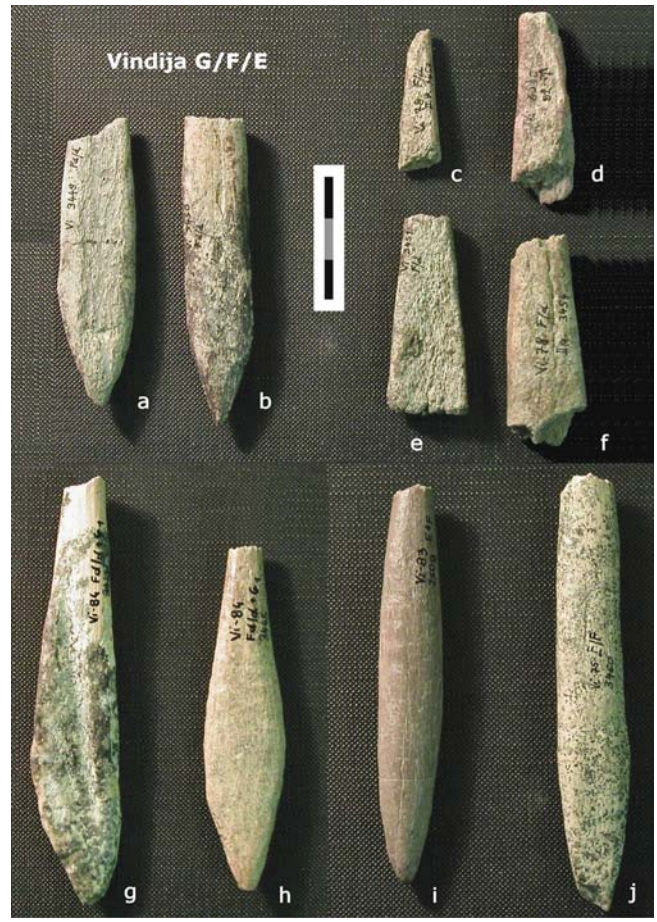

Fig. 6 Mladeč points from the E, F, and G units, as well as from contact or mixed levels at the E/F and F/G interfaces (cf. Table 2): **a**. Vi-3449; **b**. 3450; **c**. Vi-3453; **d**. Vi-3452; **e**. Vi-3451; **f**. Vi-3454; **g**. Vi-3446; **h**. Vi-3445; **i**. Vi-2508; **j**.Vi-3460.

and of its specific combination of split-based bone and bifacial foliate lithic points. For instance, assigning a Neandertal authorship to the technocomplex, one might speculate, following Svoboda's (2001, 2005) line of reasoning, that the Olschewian represented the incorporation into a long-standing Neandertal stone-tool tradition (e.g., the Szeletian) of innovations (the different types of bone points) acquired via independent development or via diffusion from, or exchange with, neighboring modern human populations. Alternatively, if the Olschewian model is rejected, palimpsest views of G1 are accepted, and the fact is duly considered that the very recent results for the G1 Neandertals postdate by one or two millennia the most recent direct date for the Mladeč points of the Potočka Zijalka, then such results might be taken instead to indicate a Neandertal (Late Szeletian?) reoccupation of the site (and the region?) during a brief time period between the Aurignacian II and the Gravettian.

The recent revision of the age of the two G1 Neandertal samples to c. 32.4 ka ^{14}C BP (c. 37.1 ka cal BP) (Higham et al. 2006a) means that such speculations can no longer be entertained, while at the same time opening up a new possibility: since the revised age falls within the time range of the Aurignacian I, the level legitimately can be viewed, even in the framework of a palimpsest interpretation, as sufficient evidence that the split-based bone point found therein (and, conceivably, the regional Aurignacian I as a whole) was manufactured by anatomically Neandertal populations. Where issues of formation process are concerned, however, the new age estimates do not change the fact that the G1 Neandertals would still be of a very different chronology from that of the associated Mladeč bone and Szeletian lithic points. Put another way: if correct, they simply provide additional corroboration of the notion that the level features a mix of finds of rather disparate age and therefore that,

where Vindija G1 is concerned, co-occurrence is no sufficient proof of contemporaneity.

In all probability, however, these revised dates are still underestimated, as Higham et al. (2006a, 555) also explicitly caution: "the results should not be used to infer more than that the level G1 human remains and associated archeological debris date in the vicinity of 32,000–34,000 B.P. *and perhaps somewhat earlier*" [present author's emphasis]. Personal observation of the dated specimens (the mandible Vi-207 and the parietal Vi-208) indicates that there is good reason to be cautious indeed: the dates were obtained on very small samples—229 and 233 mg, respectively, according to Smith et al. (1999)—of cancellous bone extracted from inside the mandibular ramus and from the inner wall of the cranial fragment. The nature of the material, and the fact that the specimens were coated with consolidants, make it only reasonable to suspect that even the older results reported by Higham et al. (2006a) may well be no more than minimum ages. This inference is supported by Wild et al.'s (2005) report of rejuvenated results for human long bones from Mladeč that had been consolidated, yielding dates that are several thousands of years younger than those obtained on noncontaminated collagen extracted from the dentine of human teeth from the same collection.

The fact that the radiocarbon dating of bone samples from Vindija is a technically challenging issue is further corroborated by the fact that Smith et al. (1999) report only two successful determinations out of the seven Vindija samples that they took. The failed ones include two other Neandertal specimens, and all three bone points sampled, including the split-based piece from G1. Wild et al. (2001) encountered the same problem with attempts at dating cave bear bones from this level. Based on the determination of their nitrogen content, only one out of eleven, that which yielded the c. 50.4 ka cal BP result, was found suitable for analysis. That even bones so judged may in fact yield minimum ages only is further proven by the fact that, given the overall site stratigraphic patterns, the 37,000±600 ^{14}C BP (VERA-0109) and 34,700±500 ^{14}C BP (VERA-0105) results obtained, respectively, for cave bear bones from levels I and J, much deeper in the sequence, are vast underestimations of their true age, as cautioned by Wild et al. (2001) and confirmed by their U-Th dating of a cave bear bone sample at the H/I interface to c. 88.2 ka cal BP. These I and J results illustrate well the potentially problematic nature of the radiocarbon dating of bone in this time range (Zilhão and d'Errico 1999b; Jöris et al. 2003), particularly prior to the recent development of the ultrafiltration technique (Higham et al. 2006b).

Discussion

In this context, one is thus forced to ask the key question concerning the samples from levels G1 and G3 of Vindija that supporters of the validity of the direct dates obtained on the site's Neandertals have so far failed to address: how can one explain a success rate of 67% for the dated human bones (four out of six: two out of the four submitted to Oxford, plus two out of the two submitted to Uppsala), compared to 9% (one out of eleven) for the cave bear bone dated at Vienna, and 0% (zero out of three) for the bone tools whose dating Oxford also attempted? Taken at face value, such success rates would lead us to believe that small samples of cancellous bone from human remains treated with consolidants are a better dating material than larger samples of compact, cortical bone from cave bear remains, when, obviously, the opposite must be true. Thus, the null hypothesis in this case can only be that the finite results reported for the Vindija Neandertals reflect a residual presence of contaminants in the dated samples, not their true radiocarbon age.

Direct dating problems such as those encountered at Vindija are in no way exceptional for human remains from the Transition, and affect as well, for instance, the chronology of the Neandertal infant skeleton from the cave of Mezmaiskaya, in the northern Caucasus. Directly dated to c. 29 ka ^{14}C BP (Ovchinnikov et al. 2000), this skeleton was found below intact Mousterian deposits with an age clearly in excess of c. 36 ka ^{14}C BP, as established by several reliable radiocarbon results (Golovanova et al. 1999), and as independently corroborated by ESR dating of animal teeth from the same levels (Skinner et al. 2005). A further and perhaps more

pertinent example from a geographically closer region is the failure, after three attempts, in obtaining a finite date from samples collected, as with Vi-208, from the inner side of a human parietal—in this case, the Romanian cranium Oase 2, otherwise contextually dated to c. 35 ka ^{14}C BP (c. 39.9 ka cal BP) (Rougier et al. 2007).

Although completely sorting out the situation at Vindija is clearly a difficult task, and the real age of the Neandertal material in G1 remains an open issue, it can at least be concluded that the evidence does not support the notion of "Olschewian" Neandertals living in Croatia until c. 33–28 ka ^{14}C BP (c. 37.3–32.5 ka cal BP). The arguments presented above show that the data in fact easily fit the normal central European patterns of (1) Mousterian and Szeletian Neandertals inhabiting the site prior to c. 43 ka cal BP, and (2) the split-based bone points characteristic of the Early Aurignacian being stratigraphically and chronometrically earlier than the Mladeč bone points characteristic of the Evolved Aurignacian.

The interpretation of the Vindija sequence presented here is also in complete agreement with the stratigraphic patterns displayed by the three other cave sequences with Aurignacian I material known in Croatia and Slovenia, all of which neatly fit into the overall regional and continental chronostratigraphy of the Transition. At the Šandalja II cave, on the Adriatic coast, basal layer H yielded a split-based bone point associated with undiagnostic lithic elements; and the overlying layer G, featuring a small lithic assemblage with atypical carinated scrapers and a pierced tooth pendant, yielded a conventional charcoal date of 27,800±800 ^{14}C BP (Z-536) (Karavanić 2003). At c. 32.5 ka cal BP, this charcoal date is fully consistent with the *terminus ante quem* provided by the results obtained on similar samples for the Vindija F complex. At Velika Pećina (where the modern human partial frontal bone in Aurignacian level J was shown to be intrusive through direct radiocarbon dating to the mid-Holocene; Smith et al. [1999]), split-based bone points were recovered in levels H and I, the latter conventionally dated on charcoal to 33,850±520 ^{14}C BP (GrN-4979), i.e., c. 38.9 ka cal BP. Conversely, no such items were present in overlying levels F and G, which feature other types of bone points and for which a conventional date on charcoal—27,300±1200 ^{14}C BP (Z-189), i.e., c. 31.9 ka cal BP—is available for level G (Karavanić 1995). And finally, at the Slovenian site of Divje Babe I, the split-based bone point comes from level 2, AMS dated on bone to 35,300±700 ^{14}C BP (RIDDL-734), i.e., c. 40.2 ka cal BP.

The lack of diagnostic human remains in association with Protoaurignacian and Aurignacian I assemblages makes it impossible completely to reject the notion that the Aurignacian I occupation of Vindija signaled by the split-based point from G1 is related to Neandertals. However, despite their purely paleontological context, the human fossils from the cave of Oase, in the Romanian Banat, prove that modern humans were present in the region during the time range of concern here. In fact, as the crow flies, the distance between Oase and Vindija is less than 500 km, with the two sites being found at broadly the same latitude in the eastern and western boundaries, respectively, of a vast expanse of unimpeded plains where the Danube and its tributaries provide easy communication routes between the foothills of the Alps (where Vindija is located) and the foothills of the southwestern Carpathians (where Oase is located; Fig. 1).

Given this geographical setting, it is difficult to support the notion that some sort of long-lasting, stable biocultural frontier—such as, for instance, the "Ebro frontier" of Iberia (Zilhão 1993, 2006)—existed between western Romania and eastern Croatia at the time of the Transition, making for separate demographical and human biological regional trajectories throughout the interval of the putative frontier's duration. Moreover, there is no indication in the paleonvironmental records that such a frontier ever existed at the purely biogeographical, noncultural level. Finally, for supporters of the Olschewian concept, a further obstacle to any frontier hypotheses is the fact that Oase falls squarely within the postulated geographic range of the entity—"around the Alps and Carpathians" (Karavanić 2000, 159).

Conclusion

Under the assumptions of the Assimilation model (Smith et al. 2005; Trinkaus 2005, 2007), the few Neandertal features apparent in the Oase individuals (Trinkaus et al. 2003; Rougier et al. 2007) carry the implication that, in eastern and central Europe, the

absorption of European Neandertals into the larger modern human gene pool was already far advanced in Aurignacian I times, thus making it unlikely that diagnostically Neandertal populations, such as those represented by the Vindija G1 fossils, survived at that time anywhere in this part of the world. Put another way, if you accept the premises of that model, then you cannot have, in the same space (the Pannonian basin) and at the same time (34 ka ^{14}C BP; 39 ka cal BP), "moderns with Neandertal traits" at Oase and "pure Neandertals" at Vindija. If the model is right, the Vindija fossils must be of an earlier age; if the Oase and Vindija fossils are of the same age, the model is falsified, and the rival view of replacement after long-term contemporaneity is strengthened. One cannot have both the model and the dates.

Given the regional archeological context and the site formation and dating arguments reviewed here, the parsimonious reading of the Vindija situation is that the artifact assemblage from level G1 corresponds to a mix of items discarded at the site in the framework of (1) Neandertal-related Szeletian occupation(s) taking place during the 40–50 ka cal BP interval, and (2) modern human-related Aurignacian I and Aurignacian II occupations taking place during the 30–40 ka cal BP interval. Bearing in mind the uncertainties concerning the direct dating of the Vindija Neandertals, a corollary of these conclusions is that the fossils in question represent the makers of the site's Szeletian, not those of the site's Aurignacian. These conclusions are fully consistent with the paleontological arguments suggesting admixture at the time of Neandertal/modern human contact in eastern Europe, arguments derived from the analysis of the c. 40,000-calendar-year-old Oase fossils. The Vindija evidence is thus effectively reconciled with the Assimilation model.

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