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ESR and AMS-based ^{14}C Dating of Mousterian Levels at Mujina Pećina, Dalmatia, Croatia

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This paper presents the first chronometric dates for sediments that contain a Mousterian industry in Dalmatia (south Croatia). Electron spin resonance (ESR) dating was conducted on two teeth from the Mousterian level E1 at the site of Mujina Pećina. Additionally five bone and one charcoal sample from five different strata of origin at this site were dated by accelerator mass spectrometry (AMS). Assuming 30% moisture for both the gamma and beta dose rate calculations, the mean LU ESR age estimate is 44 ± 5 ka for level E1, which is statistically indistinguishable from the mean EU ESR age estimate of 40 ± 7 ka. A single, uncalibrated ^{14}C age from the E1/E2 interface yielded an age estimate of 45,170 $+2780/-2060$ years BP while the mean of the five samples from overlying Mousterian levels is 39 ± 3 ka. The true (calibrated) age of this mean is about 42 ka, which means that the entire stratigraphic profile in Mujina Pećina apparently was very rapidly deposited, and that the ESR age, regardless of uptake model is in good agreement with the calibrated ^{14}C mean age. Temporally, Mujina Pećina overlaps with Pontinian Mousterian sites in west-central Italy and Vindija level G3 from northwestern Croatia. However, there are notable differences between the Mousterian industry from Mujina Pećina and these other sites. Collectively, the Croatian sites yield important evidence on the adaptation of European Mousterian people.

Keywords: ELECTRON SPIN RESONANCE, ^{14}C ACCELERATOR MASS SPECTROMETRY, ARCHAEOMETRY, MIDDLE PALEOLITHIC, MUJINA PEĆINA, DALMATIA, CROATIA.

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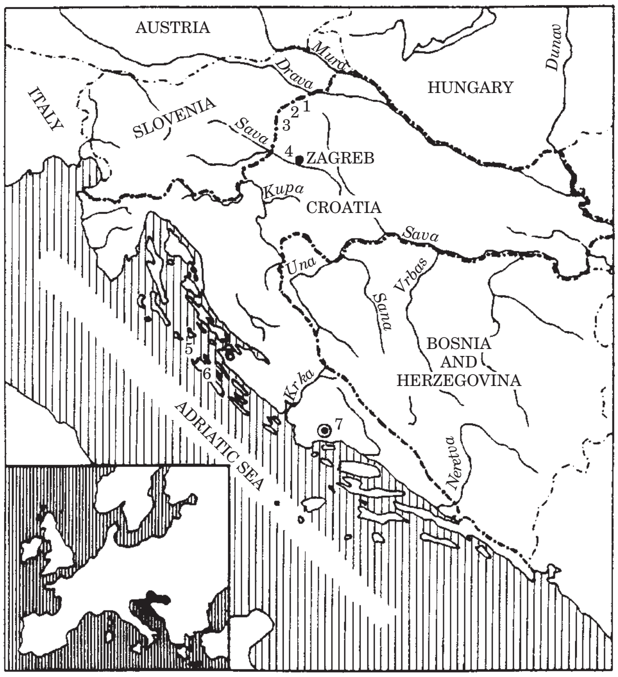

Figure 1. Important Middle Paleolithic sites of Croatia: 1. Vindija, 2. Velika Pećina, 3. Krapina, 4. Veternica, 5. Panđerovica, 6. Ražanac, 7. Mujina Pećina.

Introduction

In Croatia, the well-known Paleolithic sites of Krapina and Vindija in the Hrvatsko Zagorje (northwestern Croatia) have been chronometrically dated by several methods (Rink *et al.*, 1995; Krings *et al.*, 2000; Smith *et al.*, 1999). However, until recently, no Paleolithic site in southern Croatia (see Figure 1) has been chronometrically dated. Furthermore, because few sites in this region have been excavated using scientific standards, little is known about cultural and environmental features during the Middle Paleolithic period of the eastern Adriatic coast, including Dalmatia. Most Mousterian finds from Dalmatia were collected on the surface of open-air sites and were often found in mixed cultural contexts (Batović, 1988). The only systematically excavated site from this region, with an unequivocally homogenous Mousterian stratigraphic sequence suitable for chronometric dating, is Mujina Pećina, a cave located in the rugged hilly area north of Trogir and northwest of Split. The cave is approximately 10 m long and 8 m wide (Figure 2) and its mouth is located at about 280 m above sea level. The initial finds were collected in 1977 from the surface of the cave and deposits in front of its entrance (Malez, 1979), and the first test excavation was undertaken in 1978 (Petrić, 1979). In 1995 a joint project of the Department of Archaeology at the University of Zagreb and Kaštela City Museum launched systematic excavations which are still in progress.

The trench position from these excavations is presented in Figure 2. Excavation followed the natural stratigraphy in the cave. All artifacts and ecofacts with dimensions of 2 cm or more in size have been entered in three dimensions on site plans, and all sediments were sieved. Samples for electron spin resonance (ESR) and accelerator mass spectrometry (AMS) dating were taken in the course of these excavations. Two teeth from level E1 were dated by the ESR method, while AMS dates were obtained for the bone collagen from five samples (levels B, C, D1, D2 and E1/E2 interface) and one charcoal sample from a single level (D2). The purpose of this paper is to establish the chronological position of the Mujina Pećina Mousterian industry, to provide a brief preliminary assessment of that industry, and to discuss the results of ESR and AMS-based ^{14}C dating at the site.

Site Characteristics

Stratigraphy

Sediment samples from square F9 (levels B, C, D1 and E1/E2 interface) have been preliminarily analysed. They comprise poorly sorted sediments, with similar granulometric content throughout but with different percentages of individual fractions in different levels. The sediments are composed of angular and subangular large fragments of carbonate rock (debris), small subrounded and rounded sand grains, silt (rarely), and some clay (M. Sarkotić, pers. comm.). All stratigraphic profiles suggest a short period of deposition because they represent a short stratigraphic sequence without significant breaks or hiatuses in deposition process or due to erosion or nondeposition.

Description of the levels is based on the North profile "A". This profile was exposed during the first season of systematic excavations in 1995 (Karavanić & Bilich-Kamenjarin, 1997). The following year, the excavation area was widened (1 m towards the north, west and south and 3 m towards east—see Figure 2), thus forming the wider northern profile. However, the interpretation of Mujina Pećina stratigraphy presented here is based here on the original northern profile "A" (Figure 3), because it contains level C, which is lacking on later northern profile. The features of other levels described in the paper are mostly the same in all of the excavation area, except for the varying layer thicknesses. The only exception is that level E3 mostly appears above the cave floor at the entrance but cannot be seen in northern profiles.

The colours of the sediments were established in humid conditions according to the "Munsell Soil Colour Charts".

Level E3

Very dark brown (10YR2/2) sandy clay sediment with some stone debris, these sediments fills a number of cracks in the bedrock of the cave. It forms

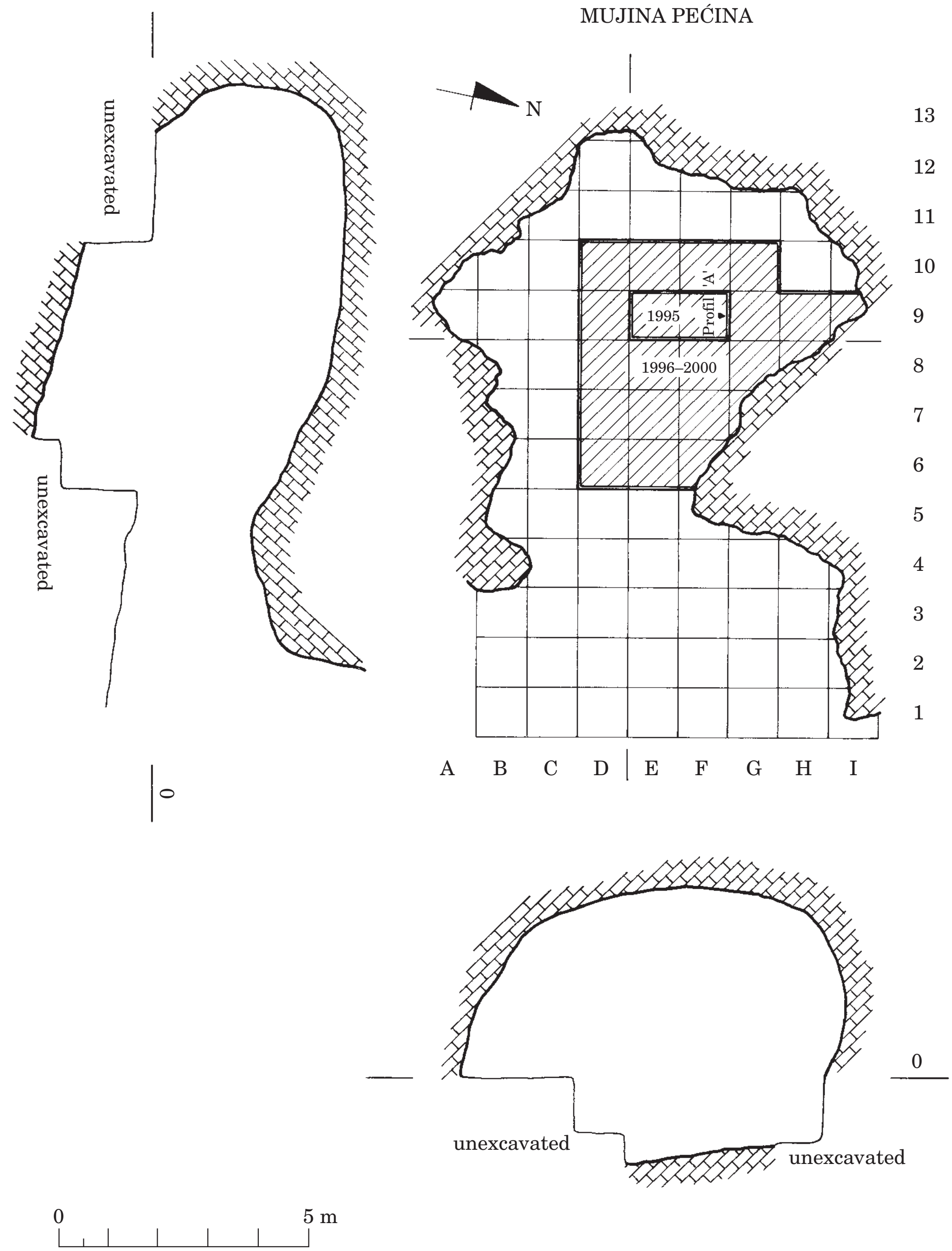

Figure 2. Plan and sections of the excavated zone in Mujina Pećina.

a full stratigraphic unit at the entrance of the cave with thickness between 1 and 50 cm. It indicates a presence of considerable organic material.

Level E2
This level is characterized by dark reddish brown (5Y3/3) 12–18 cm thick sandy clay sediment with stone debris, also exhibiting considerable organic material.

Level E1
Reddish brown (5Y4/3) 8–12 cm thick sandy sediment comprises this sediment, which contains a large amount of rock debris. This sediment also suggests presence of considerable organic material.

Level D2
Cryoclastic stone debris with gravel and yellowish red (5YR4/6) sandy sediment, 25–28 cm thick, define

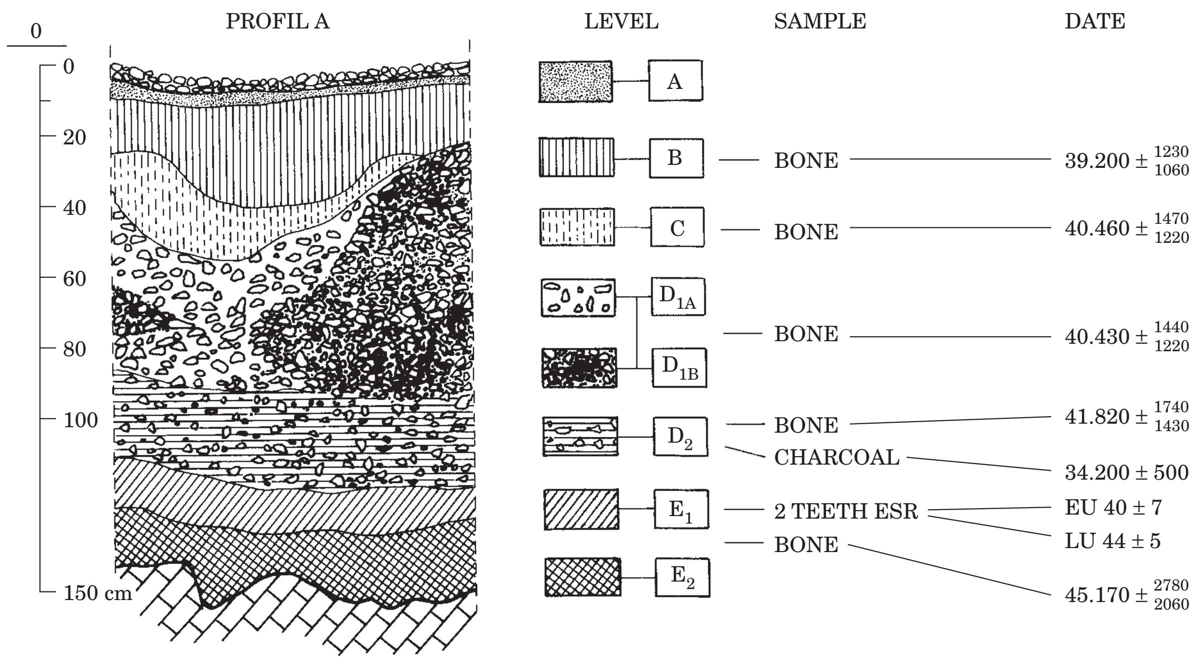

Figure 3. Stratigraphic profile of Mujina Pećina (drawing: M. Bezić, modified after Karavanić & Bilich-Kamenjarin, 1997). Level E2—dark reddish brown sandy clay sediment; Level E1—reddish brown sandy sediment; Level D2—cryoclastic stone debris with gravel and yellowish red sandy sediment; Level D1, stratigraphic unit D1A—cryoclastic stone debris with some gravel and yellowish red sandy sediment; Level D1-stratigraphic unit D1B—cryoclastic stone debris sporadically calcified with little or no fine sediment; Level C—strong brown sandy sediment with stone debris; Level B—strong brown sandy sediment with stone debris; Level A—dark brown humus.

this level. It contains more stone debris than the level E1 and suggests cold climate.

Level D1
(a) Stratigraphic unit D1A
Cryoclastic stone debris with some gravel and yellowish red sandy sediment (5YR5/6).
The level is 1–38 cm thick and indicates a period of cold climate. In some places the cryoclastic stone debris has been calcified.
(b) Stratigraphic unit D1B
Cryoclastic stone debris sporadically calcified with little or no fine sediment, 1–71 cm thick, suggests a cold period.

The only minor difference between D1A and D1B in profile "A" (Figure 3) as described above is the amount of scarcely present gravel and sandy sediment in these levels. Given that the difference could not be established during excavation in almost any part of the cave (with the exception of the northern niche that contained only stone debris along the cave wall), stratigraphic units D1A and D1B were considered to be the same archaeological level, level D1.

Level C
Strong brown (7.5YR4/6) sandy sediment, 1–26 cm thick, with stone debris.
The presence of the debris is significantly lower than in the layers D1 and D2.
This level is present only in squares E9, E10, F9, F10, G9 and G10. It indicates relatively warm climate.

Level B
Strong brown (7.5YR5/6) sandy sediment, 12–31 cm thick, with stone debris indicating relatively warm climate.

Level A
Dark brown (7.5YR3/3) humus, 2-4 cm thick.

Archaeological content

The concentration of archaeological finds in oldest levels (E3, E2 and E1), deposited during relatively warm periods, is much higher than in levels D2 and D1, which were deposited during cold periods. Two localized areas of burning have been discovered in level D2 that probably represent open, unconstructed and unpaved Mousterian hearths. Debitage items in all levels indicate the production of tools *in situ*, rarely with the use of Levallois technology. Small tools (similar to those of so called Micromousterian) have been found in these levels along with "typical" Mousterian tools. Levels C and B (Figure 4, nos. 1–7) are dominated by small tools that are made on local chert. Small tool size can be explained by the size of local raw material used for tool production. One

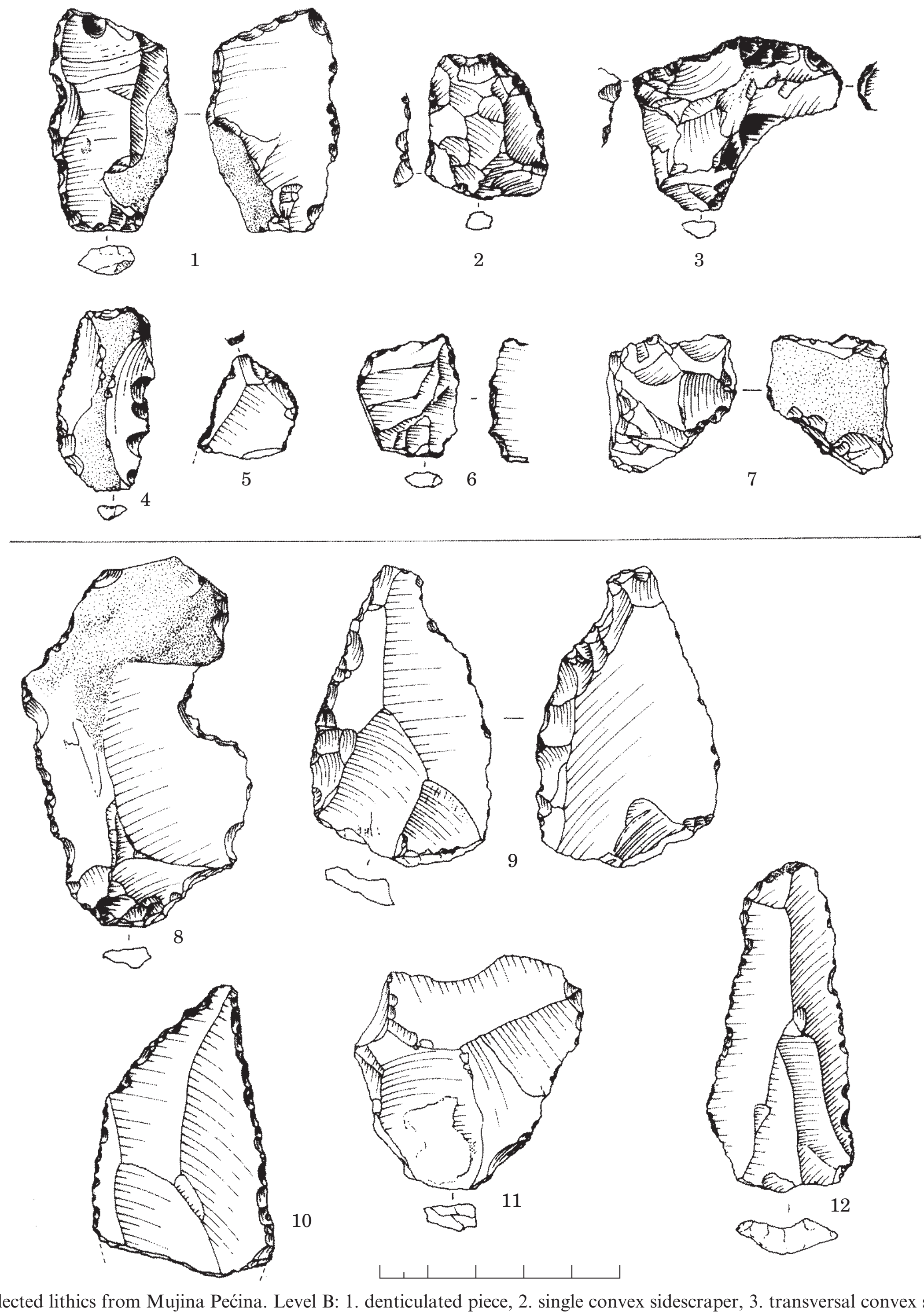

Figure 4. Selected lithics from Mujina Pećina. Level B: 1. denticulated piece, 2. single convex sidescraper, 3. transversal convex sidescraper, 4. notch, 5. alternate retouched bec, 6. drill 7. flake core. Level D1: 8. denticulated piece, 9. alternate scraper, 10. Mousterian point, 11. Levallois flake, 12. Levallois blade. Scale is in cm. Drawing: M. Bezić.

reflection of this is that cortex on tools (Figure 4, nos. 1 and 4) and cores (Figure 4, no. 7) could not be completely removed due to the small dimensions of the chert pebbles and nodules. Another limit to tool size is the structure of some local cherts. Specifically, lithic experiments by IK on local raw materials have demonstrated that it is rarely possible to produce large and regular flakes on this raw material even if a large piece is used. Moreover, some of larger flakes produced experimentally broke during retouching. However,

Table 1. Analytical data for teeth and sediments from Level E1

Sample	Type	Square	x	y	z	U (ppm)		Th (ppm)	K (wt %)	Enamel geometry (in micrometers)	
97140A	Bovid tooth	G9	67	79	− 117·3	Enam	<0·1	—	—	Thickness	1643 ± 72
	Cusp 1					Den	6·19			Outer removed	57 ± 28
										Inner removed	65 ± 33
97140B	Bovid tooth	G9	67	79	− 117·3	Enam	<0·1	—	—	Thickness	1598 ± 98
	Cusp 2					Den	6·26			Outer removed	54 ± 27
										Inner removed	61 ± 32
97140	Attached sediment	G9	67	79	− 117·3	Sed	2·3	1·1	0·14		
97141AB	Caprid tooth combined cusps	G10	54	70	− 129·9	Enam	<0·1	—	—	Thickness	596 ± 94
						Den	15·3			Outer removed	17 ± 9
										Inner removed	50 ± 24
97141	Attached sediment	G10	54	70	− 129·9	Sed	4·9	3·5	0·37		
97212	Gamma dose sediment+rock	F9	20	100	− 125	Sed	1·7	0·9	0·10		

along with these small tools, as mentioned above, standard size Mousterian tools have been found in Mujina Pećina lithic assemblages, especially in levels D2 and D1 (Figure 4, nos. 8–10) where Levallois debitage items are present (Figure 4, nos. 11 and 12).

Overall, the tool assemblage is dominated by denticulates, notched pieces, retouched flakes, scrapers and pseudo-tools. It seems that the significant presence of denticulates and notched pieces is a universal characteristic of the late Mousterian in the Eastern Adriatic region (Basler, 1983).

The lithic industry is associated with significantly more numerous faunal remains. Most of these finds are indeterminable bone fragments. Faunal material from levels D1 and D2 has been preliminary analysed. The dominant animal species represented is red deer, followed by chamois/ibex, birds and large bovids while equids and carnivores are very rare (preliminary analysis by P. T. Miracle). Only a single bear canine (probable from *Ursus spelaeus*) has been found in level D2 (Karavani & Bilich-Kamenjarin, 1997: Figure 5). More detailed analyses of the fauna and lithic industry are underway.

Preliminary results suggest much longer occupation and intensive activity of humans in the oldest levels (E3, E2, E1) than in the more recent levels (D2 and D1) deposited during cold periods (Karavanić, 2000).

Samples and Methodology

ESR dating

ESR dating was conducted on two teeth from level E1 using the method described in Rink (1997). The gamma dose rate was reconstructed using a large mass (about 1 kg) whole rock plus sediment sample from the same level as the teeth. The cosmic dose rate was reconstructed using a half-thickness (6·5 m) of the present day total overburden of limestone and sediment (about 13 m). The beta dose rates were calculated using the fine-grained sediment removed from the teeth themselves, which had considerably higher levels of radioelements (uranium, thorium and potassium) than the fine grained sediment plus rock sample (Table 1).The ages were calculated using the program ROSY Version.1·41 (Brennan *et al.*, 1999).

AMS-based ^{14}C dating

Six samples were dated by the AMS method. Five indeterminable bone fragments from the levels B, C, D1, D2 and the E1/E2 interface were analysed at the AMS facility of Gröningen University. The organic bone matrix, collagen, was extracted following the pretreatment procedure of Longin (1970). After cleaning of the surface, the bone is placed in a HCI solution (4%, 20°C) so that the collagen is decomposed into soluble amino acids. Thoroughly washed with demineralized water, the insoluble humic contamination is removed by centrifuging; and finally dried by evaporation at 120°C (Mook & Streurman, 1983). Next, the collagen is combusted into CO_2, employing an automated Combustion/Mass-Spectrometer/Sampling system. An Elemental Analyser (EA) consists of a combustion furnace and purification traps. The EA is coupled on-line to a continuous-flow Mass Spectrometer (MS), enabling $\delta^{13}C$ measurements. The EA/MS combination in turn is connected to a cryogenic CO_2 trapping system (van der Plicht *et al.*, 2000). The CO_2 is reduced to graphite by reduction under hydrogen gas excess, using iron powder as a catalyst. The graphite is then pressed into a target which fits into the ion source of the Groningen AMS (Gottdang, Mous & van der Plicht, 1995). The following criteria are used for estimating the reliability of the collagen quality:

(1) the %C should be 40–50%,
(2) the $\delta^{13}C$ should be in the range − 18 to − 22 per mil,
(3) the ash fraction after combustion should be low,
(4) the insoluble fraction should be below 10%.

Charcoal fragments from the second localized area of burning from level D2 (square G9), determined to

Table 2. ESR ages for tooth enamel from Level E1

		ESR age (ka)		ESR age (ka)	
Sample	Square	EU (10% moisture)	LU (10% moisture)	EU (30% moisture)	LU (30% moisture)
97140A	G9	36 ± 6	39 ± 7	41 ± 7	44 ± 8
97140B	G9	40 ± 7	43 ± 8	46 ± 8	49 ± 9
97141AB	G10	29 ± 3	34 ± 4	32 ± 4	39 ± 5
Mean		35 ± 6	39 ± 5	40 ± 7	44 ± 5

Table 3. Analytical data and AMS 14C ages from Mujina Pećina

Level	Lab. number	Material	Square	x	y	z	δ^{13}C	%C	Date
B	GrA-9633	Bone	F9	63	96	− 23·5	− 18·69	40·1	39·200 $\pm^{1230}_{1060}$
C	GrA-9634	Bone	F9	41	75	− 47·7	− 18·68	35·5	40·460 $\pm^{1470}_{1220}$
D1	GrA-9636	Bone	F9	13	72	− 87·4	− 19·91	26·9	40·430 $\pm^{1440}_{1220}$
D2	GrA-9639	Bone	F9	29	33	− 125·4	− 19·07	46·0	41·820 $\pm^{1740}_{1430}$
D2	OxA-8150	Charcoal, *Juniperus* sp.	G9	30	100	− 105·4	− 22·3	—	34·200 ± 500
E1/E2	GrA-9635	Bone	F9	76	94	− 136·8	− 19·43	46·9	45·170 $\pm^{2780}_{2060}$

be from *Juniperus sp.* (M. Culiberg, pers. comm.), were dated at Oxford University. The samples were prepared using the standard Oxford pretreatment for charcoal, which is aimed at extracting carbon from cellulose. The dating of such material is routine at Oxford. The sample was treated in mild acid to remove carbonates, after which it was given a caustic wash to break up remaining material and release contaminants such as humic acids and resins trapped in the sample's fibrous structure. Finally, the sample was given a further acid wash to purify the remaining cellulose. Following this the sample was freeze-dried for combustion. The radiocarbon dates (both GrA and OxA) obtained from the Mujina Pećina samples are reported in uncalibrated radiocarbon years BP (Table 3).

Results

The analytical data (for teeth and sediments) and ESR ages for tooth enamel from level E1 are given in Tables 1 and 2. There has been considerable uranium uptake in the dentine of the teeth, but the enamel is essentially uranium free (Table 1). This results in a considerable spread in the individual early (EU) and linear uptake (LU) ages (Table 2), although the mean EU and LU ages are statistically indistinguishable at $\pm 1\sigma$. Since the moisture history of the sediment in the cave is unknown, we have calculated the ages using two assumed, but geologically reasonable, moisture content values of 10 and 30 wt.%. Better constraints on the correct uptake model for the ESR ages will only be known after future work on the uranium series age determinations on the dentine.

For level E1, mean ESR age estimates of 40 ± 7 ka (EU) and 44 ± 5 ka (LU) have been obtained. These assume a 30% moisture for both the gamma and beta dose rate calculations. The corresponding mean age estimates for an assumed moisture content of 10% are 35 ± 6 (EU) and 39 ± 5 (LU). An overall error in the gamma plus cosmic dose rate of ± 20% is assumed, while the error in moisture content used to calculate the beta doses was ± 100% in the case of the 10% moisture (10 ± 10%) and ± 33% in the case of the 30% moisture calculation (30 ± 10%). Error propagation on individual tooth ages is explained in Brennan *et al.* (1999), and the $\pm 1\sigma$ values are given for the mean ages (n=3).

At the current time there is only a single uncalibrated ^{14}C age of 45,170 +2780/ − 2060 years BP on bone from the interface of the same level (E1) with underlying level E2 and five radiocarbon dates for overlying levels (Table 3). Four of these five dates, obtained from bone samples, are consistent with each other while charcoal date is much younger and chronologically does not fit into the sequence. However, contamination of the sample was not observed and we included the result on charcoal sample in the calculation of the age as the mean of five dates from overlying levels (D2, D1, C and B). The age of these levels, calculated as the mean of 5 dates from these levels is 39,222 ± 2956 BP. This mean suggests that the true age of the overlying levels is about 42 ka, some 3000 years older, based on the calibration curves of

Bard *et al.* (1990). These results are in closer agreement with the ESR ages calculated at 30% moisture.

Discussion

The mean LU ESR age estimate of 44 ± 5 ka for level E1 at Mujina Pećina overlaps with ESR (LU) dates from two Pontinian Mousterian sites in west-central Italy, Grotte Breuil and Sant' Agostino (Schwarcz *et al.*, 1990–91). Strata 3 and 4 from the former site have been dated to 36.600 ± 2700 BP, while there are several dates for the later site: level 0—a mixed level (32,000 ± 7000), level 1 (43,000 ± 9000), level 2 (53,000 ± 7000) and level 3 (54,000 ± 11,000) (Schwarcz *et al.*, 1990–91; Kuhn, 1995: Table 3.8). However, the ESR LU ages at Grotte Breuil and Sant' Agostino must be viewed as minimum LU age estimates, since subsequent developments in the beta attenuation calculations in ESR dating (Yang, Rink & Brennan, 1998) have shown that age underestimation ranging from 1–20% can occur when older beta attenuation models were used. These and other Mousterian Pontinian sites from west-central Italy, as well as several Mousterian sites from Eastern Adriatic Region (including Mujina Pećina) and, for example, some levels of Asprochalico site in Epirus (northwestern Greece) are characterized by small tools, typical for so-called Micromousterian (Basler, 1983; Kuhn, 1995; Papaconstantinou, 1988). The typically small tools of Eastern Adriatic and Pontinian sites can be explained as the use of local small-pebble raw material (Basler, 1983; Kuhn, 1995). However, there are notable differences in tool typology between these two (Eastern Adriatic and Tyrrhenian) Mediterranean regions. Notched pieces and denticulates are frequent at many late Mousterian sites in the Eastern Adriatic (Basler, 1983), while they are significantly less frequent at Pontinian sites, where scrapers dominate (Kuhn, 1995: Table 3.3b). It is possible that these differences resulted from different functions of the sites in these regions.

Besides the ESR dates for Mujina Pećina, we obtained six radiocarbon dates from five different strata of origin at the site (Table 3). A sample from E1/E2 interface was dated to 45 ka, while the mean of overlying levels is 39 ka. The true (calibrated) age of this mean is about 42 ka (Bard *et al.*, 1990), though calibration data in this time range is very sparse. Bard (1998) reported new data on a coral sample from New Guinea, in which four radiocarbon age estimates yielded a weighted mean of 35,6000 ± 920 years BP and a U/Th age of 41,100 ± 500 (± 2σ) ka (but cautioned that the wide spread in ^{14}C ages might suggest contamination by modern carbon). Nonetheless, this new date confirms the earlier trends of Bard *et al.* (1990) that show underestimation in uncalibrated ^{14}C ages, but it does not allow more meaningful estimates in the uncertainty of attempted calibrations of ^{14}C ages in this time range relative to the earlier work of Bard *et al.* (1990).

Our best estimates using both ^{14}C and ESR suggest that the entire stratigraphic profile was very rapidly deposited, and may only cover a few thousand years. However, the date obtained on the charcoal sample is considerably younger than the bone ^{14}C dates. Disparity between bone and charcoal ^{14}C dates has already been reported for some Spanish sites (see Zilhão & d'Errico, 1999 and references therein). Charcoal dates for El Castillo dated the earliest Aurignacian in northern Spain around to 39,000 BP (which was also confirmed by ESR on tooth enamel in the Notes in Proof section of an article by Rink *et al.*, 1996) while the bone dates are no older than 35,000 BP (Zilhão & d'Errico, 1999: 21). The charcoal dates (between 37 and 41 ka BP) are also older than the bone date (about 35 ka BP) for the basal Aurignacian of L'Arbreda (Bischoff *et al.*, 1989; Zilhão & d'Errico, 1999). In contrast, at Mujina Pećina the bone dates are older than the date from the charcoal sample. The dated charcoal fragments were collected from the second localized area of burning (square G9) that probably represents an open Mousterian hearth, suggesting that it is unlikely that these fragments came from one of the overlying levels. According to the ages obtained on bone samples (Table 3) we are close to the limits of the radiocarbon method. A very small amount of contamination with modern carbon (1%) of such old samples produces much younger results than the true age (see Aitken, 1990: 85–86), and this might be the reason while the date on the charcoal does not fit chronologically into the sequence. Nonetheless, pretreatment procedures should have removed any contamination with younger carbon, so we have included the result on the charcoal sample in the calculation of the mean of five dates from four levels (D2, D1, C, B).

Some levels from Mujina Pećina could be contemporary with level G3 of Vindija cave in northwestern Croatia, which contains a late Mousterian industry and Neanderthal remains (Karavanić & Smith, 1998). This level recently has been dated by AMS (Ua-13873) to over 42,000 ka BP (Krings *et al.*, 2000). The industry of this level at Vindija is characterized by a high frequency of notched and denticulate pieces (36%) as is also the case at Mujina Pećina level B (38%). However, this also includes becs, which are not present in Vindija. Sidescrapers are more frequent at Vindija (26%) than in Mujina Pećina level B (13%). On the other hand, Upper Paleolithic tool types are more frequent at Mujina Pećina (18%) than at Vindija (14%). Besides typologically defined tools, about 26% of the tool assemblage are simple retouched pieces in Mujina Pećina level B and about 5% more in level D1. However, levels D1 and D2 in Mujina Pećina contain too few formal tools to allow for statistical comparison with other levels from the same or different sites. Levallois debitage items have been found in the D levels (Figure 4, nos. 11 and 12) while there are no such finds in level G3 at Vindija. The data for the Mujina

Pećina tool assemblage (level B), presented above, are based on preliminary analysis and are subject to alteration after detail lithic analysis is complete.

It is important to note that the industry from level B in Mujina Pećina is very similar, if not identical, to other Mousterian sites in the Eastern Adriatic region. These include two open air sites from Dalmatia—Panđerovica and Ražanac (Figure 1, nos. 5 and 6), and level XIII from Crvena Stijena in Montenegro. Mousterian tool assemblages from all of these sites and Mujina Pećina are characterized by a significant presence of denticulates and notched pieces. The claim that this manifestation is typical for chronologically late Mousterian industry in the Eastern Adriatic region (Basler, 1983) is now supported by the chronometric dates for the Mujina Pećina industry presented here.

Mousterian sites in Croatia provide considerable insight into the adaptational flexibility of Mousterian people in south central Europe. Stable isotope analyses on Neandertal remains from Vindija have demonstrated that these Mousterian people obtained the vast majority of their dietary protein from meat and that this meat must have been obtained largely by hunting (Richards *et al.*, 2000). This finding supports the indication that the much earlier Krapina Neandertals were efficient hunters of large game, including Merck's rhinoceros (Miracle, 1999). The Mujina Pećina people, presumably (although not demonstrably) also Neandertals, appear to have been successful hunters in quite a different environmental regime than the Hrvatsko Zagorje Neandertals. Furthermore, like at Krapina (Simek & Smith, 1997), the Mujina Pećina people modify their lithic technology to effectively exploit local raw material sources. Thus Mujina Pećina, in addition to providing a chronological anchor for the Mousterian in the eastern Adriatic, also provides further evidence of the diversity of Mousterian adaptation in Europe.

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