

# A Middle Palaeolithic origin of music? Using cave-bear bone accumulations to assess the Divje Babe I bone 'flute'

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*The discovery of a perforated cave-bear femur from the Neanderthal levels at Divje Babe has been interpreted as the oldest musical instrument in Europe. Here we present the current discussion on the 'flute' and its implications for other similar bone finds from early prehistory.*

No Stradivarius ever attracted such a large audience as the recent discovery of the Divje Babe I perforated cave-bear femur, described by the finders as possibly the oldest musical instrument found in Europe (Turk *et al.* 1995; 1996; 1997; Lau *et al.* 1996). The use of the object as a flute by Neanderthals has quickly become a fact in media coverage (Wilford 1996; Garrigues 1997; Hawkes 1997; Anon. 1997; Wong 1997). The piece has been reported as potential evidence for early music by some scholars (Bednarik 1996; Jelínek 1997). Reconstructions have been proposed suggesting that the bear bone is a segment of a flute about 37 cm long and capable of playing the entire seven-note scale on which Western music is based (Fink 1997).

An extensive monograph (224 pages, 110 figures with line drawings and colour photos) on the site and the object has been recently published in Slovene and English (Turk 1997). This book includes several chapters on the stratigraphy, dating and archaeological context of the object, the faunal assemblage and the taphonomy, a detailed description and interpretation of the bone flute with colour micrographs, results from replicative manufacturing,

playing experiments, and comparative data from Upper Palaeolithic and younger flutes and pipes.

In spite of this extensive documentation there seems to be no full agreement among archaeologists (Wong 1997) about the nature and significance of this object. If this piece were to be accepted as the oldest musical instrument, manufactured and used by Neanderthals, this would have important implications for our understanding of the evolution of the human brain.

The publication of this piece takes place in the context of ongoing debates about the cognitive abilities of the Neanderthals and the explanatory value of the evolution *versus* revolution models for the origin of symbolic behaviours (d'Errico & Villa 1997). In the last few years, and in spite of robust opposition by the partisans of a symbolic explosion coinciding with the Middle to Upper Palaeolithic transition (Chase & Dibble 1987; 1992; Davidson & Noble 1989; White 1992; Stringer & Gamble 1993; Mellars 1989; 1996; Byers 1994), the proponents of a gradual acquisition of modern cognitive abilities (Marshack 1976; 1988; 1991; 1995; Simek 1992; Hayden 1993; Bednarik 1992; 1994; 1996; Bahn 1996) have succeeded in pre-

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senting viable challenges to the revolution model, still the dominant paradigm. These authors have generally based their argument on such evidence as collections of fossils and crystals, putatively perforated and engraved objects of stone and bone, use of ochre, and bone fragments interpreted as musical instruments.

Numerous perforated animal phalanges, often interpreted as whistles, have been reported from Middle Palaeolithic sites (e.g. La Quina, Combe Grenal, Bocksteinschmiede, Prolom II; Martin 1907–1910; Wetzell & Bosinski 1969; Stepanchuk 1993). Chase (1990), however, has convincingly shown, using actualistic data, that these perforations should be interpreted as carnivore punctures, a hypothesis previously put forward by Martin (1907–10) for the majority of perforated phalanges at La Quina. According to Martin, at least one reindeer phalanx, presenting two symmetrical perforations on the posterior and anterior faces, was human-made. Recent examination of this object by Taborin (1990) has shown that the edges of the perforations are sharp and angular, as in carnivore punctures, and carry no traces of human manufacture.

A long-bone shaft with a single perforation, found in the Middle Palaeolithic levels of Haua Fteah, Libya, was published as a broken whistle by McBurney (1969). One of the shaft's broken edges is concave and has been interpreted as the remnant of a second hole, aligned with the first. The hole on this object is interpreted as a carnivore puncture by Davidson (1991) who points out the absence of stone-tool marks and the morphology of the hole walls, which exhibit depressed margins, a common feature of carnivore punctures.

A mammoth long-bone fragment from Schulen, Belgium, found in association with a Mousterian industry and an Upper Pleistocene cold fauna, and showing a set of deep sub-parallel grooves, was interpreted by Huyge (1990) as a scraped idiophone, i.e. a musical instrument with a corrugated surface that is scraped rhythmically by a non-sonorous object to produce sounds. In contrast with this interpretation, d'Errico (1991) suggested that the morphology of the

grooves documented by Huyge, and the rounded polished appearance of the bone surface, increasing toward the end of the fragment, were compatible with an interpretation of these features as the result of a severe carnivore gnawing associated with salivary rounding of break edges.

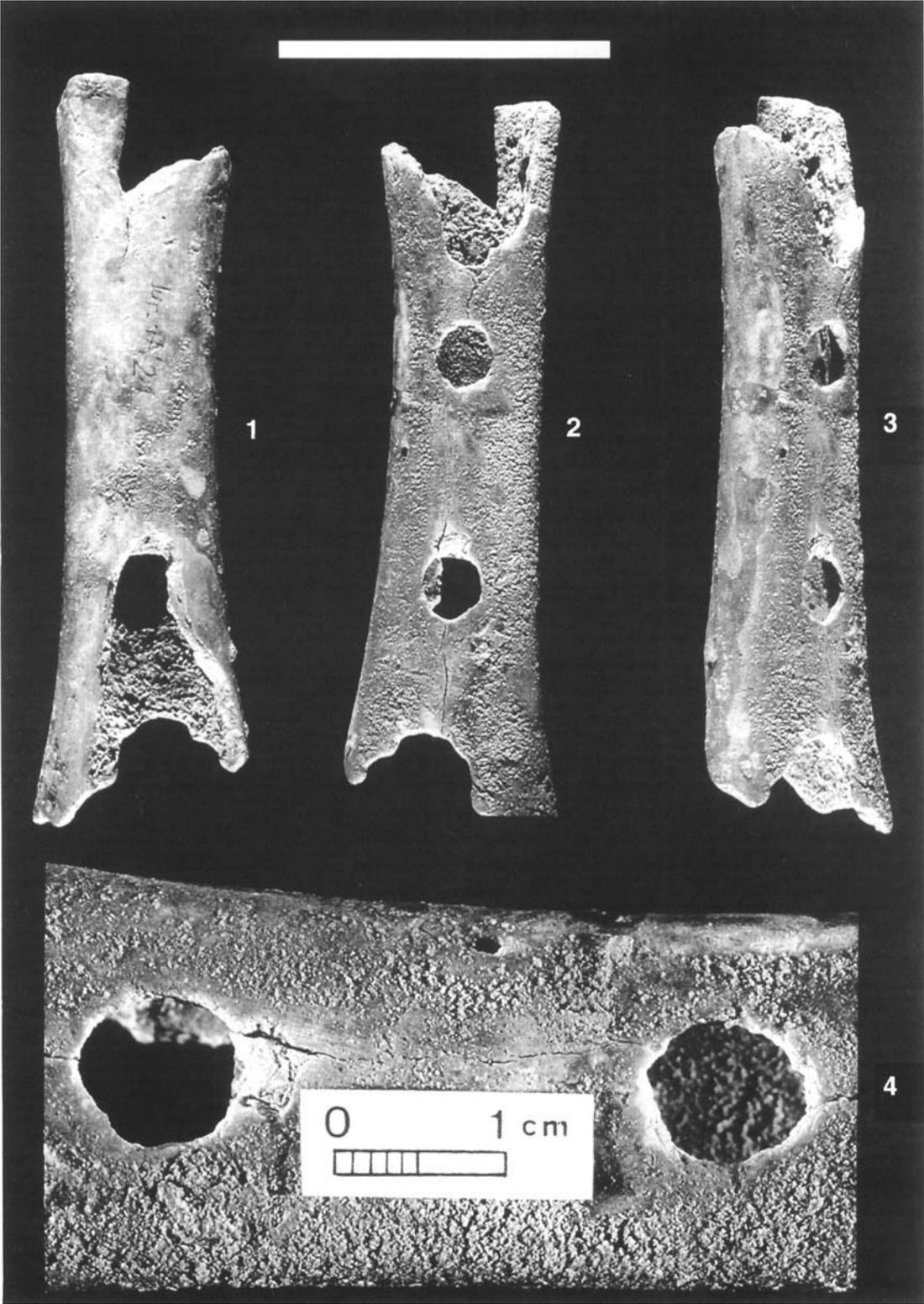
Is the Divje Babe perforated femur the first Neanderthals' proof of a musical tradition among Neanderthals? Does current knowledge on the distinction between man-made and animal traces suggest alternative interpretations of this object, a possibility already mentioned by the discoverers (Turk *et al.* 1995; 1996; Turk 1997: 175)?

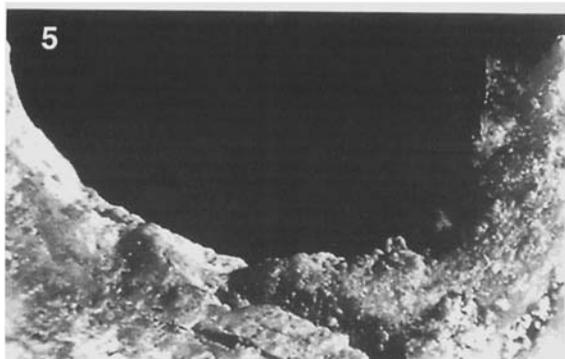
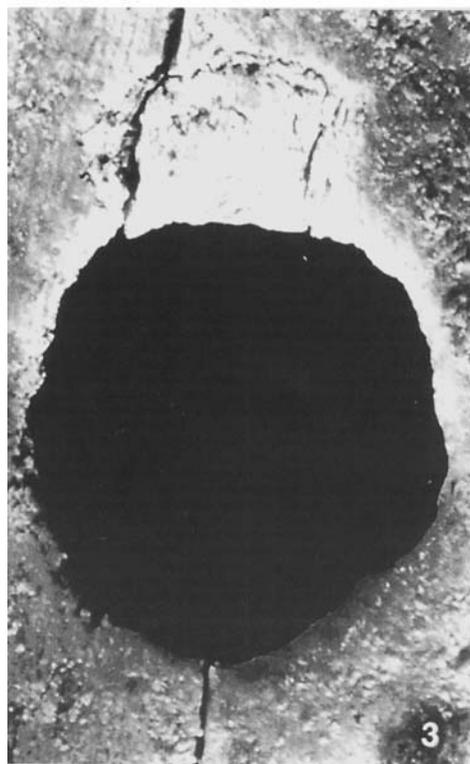
### The site and the object

Divje Babe I is a cave in western Slovenia, near the village of Reka, containing a 12-m thick Upper Pleistocene sequence under excavation since 1980. An Aurignacian bone industry was found in layers 2–3; layers 4–8 and older contain rare Mousterian artefacts. Traces of fireplaces were found in layers 5, 6 and 8. Cave-bear remains dominate the faunal assemblage of all layers with more than the 99% of all finds (Turk *et al.* 1997). The remaining 1% is represented by more than 50 species, mostly consisting of carnivores (mainly wolf) and small mammals. Layer 2 has been dated by AMS at  $35.3 \pm 0.7$  ka (RIDDL 734), layer 6 at  $43.4 - 1.4 + 1.2$  (RIDDL 735). Layer 8 has provided four AMS dates ranging from  $49.2 - 3.2 + 2.3$  (RIDDL 750) to  $40.3 \pm 1.0$  (RIDDL 745) (Turk 1997: table 4.2). More recently ESR dating of layer 8 based on bear teeth has indicated an age between  $67 \pm 10$  and  $82 \pm 11$  ka (Lau *et al.* 1996).

According to Turk *et al.* (1995; 1996) the Divje Babe I putative flute is the left femur of a young 2-year-old cave bear with two artificial holes on the posterior face and remnants of two more (FIGURE 1). In the 1997 monograph, the description has been slightly modified in that the distal incomplete hole is now interpreted as a possible opening for the mouth-piece modified by carnivore gnawing. The object was found in layer 8, not far from a fireplace. The polishing and rounding affecting the fracture edges is described as being a common feature of bone fragments in layer 8 as well as in the other layers of the cave.

FIGURE 1. *The Divje Babe I perforated cave-bear femur.* 1 anterior face; 2 posterior face; 3 lateral face. Scale at top = 5 cm. 4 close-up view of the two holes (after Turk 1997).





According to the excavators (Turk 1997: 160), traces of working with a stone tool are not present on the edges of the complete holes nor on the edges of the suspected broken holes at the distal and proximal end. This is clearly documented by several macrophotos published in the monograph (FIGURE 2).

By comparison with musical instruments found in Upper Palaeolithic sites, Turk *et al.* (1995) suggest that this object may be the oldest known musical instrument. At various points in the monograph (1997) they caution that the interpretation of these features as carnivore punctures cannot be definitely dismissed. They point out, however, that the pierced femur is the only example amongst 600 femurs of juvenile cave bear found at the site to present these particular features and that it could have been used as a flute by Neanderthals.

The reasons that would suggest an anthropic origin for the perforations and the use of the object as a musical instrument can be summarised as follows:

- 1 the unusual number of holes, two clearly visible, four according to the first reconstructions (Turk *et al.* 1995) and three in the newest publication (Turk 1997);
- 2 their unusual position, at the centre of a long-bone shaft;
- 3 their regular round shape, interpreted as an index of human manufacture;
- 4 the dimensions of the two complete holes (their minimum diameter is 8.1 and 8.7 mm), compatible with their use as flute's finger holes;
- 5 the supposed similarity of this object with Upper Palaeolithic musical instruments made on long-bone shafts with holes aligned on the major axis of the diaphysis;
- 6 the absence of spongy bone inside the marrow cavity allowing the use of the shaft as a wind instrument;
- 7 the apparent absence of gnawing marks;
- 8 the fact that they were able to replicate the 'flute' holes by piercing a bear bone using a stone tool and a wood hammer;
- 9 the presence of stone borers and other piercing implements in the stone tool assemblage;

10 the possible association of the object with a fireplace found nearby.

Our purpose here is to evaluate the relevance of these different reasons by comparing features observed on the Divje Babe object with data provided by taphonomic studies of cave-bear bone accumulations in Spanish and Italian caves. While Divje Babe I appears to represent a record of alternating occupations by hominids and cave bears, two of the sites considered here are clearly natural accumulations providing no evidence of human occupation nor clues indicating that humans had a possible influence in the bone accumulation process. Morphological and metrical analyses of bone modifications from these sites show strong similarity to those described at Divje Babe.

As a result of these comparisons, we argue that when tested against data from bear bone accumulations, none of the reasons listed above provide material support for an interpretation of the Divje Babe object as a human artefact and a musical instrument.

### Methodology

Our comparative sample consists of materials from the caves of Arrikutz and Troskaeta, in the Basque region of Spain. Excavations at Arrikutz were carried out in 1966 by Altuna (1972) and in 1975, 1986 and 1994 by Torres (Altuna *et al.* 1982). Faunal remains from this site, attributed to the Upper Pleistocene, are dominated by *Ursus spelaeus* (Torres 1988; Perez *et al.* 1986) but also include *Coelodonta antiquitatis*, *Canis lupus*, *Capra pyrenaica*, *Crocota crocota spelaea*, *Panthera spelaea* and *Marmota marmota*.

Excavations by Llopis Llado & Elosegui (1954) at Troskaeta have yielded an important cave-bear collection (Kurtén 1955). A new systematic excavation was carried out in 1987–88 by Torres (Torres *et al.* 1991) in the chamber called 'Sima de los Osos'. This has provided an assemblage of 3987 bones of which only 4 specimens (three bat bones and one attributed to *Capra* sp.) do not belong to *Ursus spelaeus parvilatipedis* n.ssp.

FIGURE 2. Micrographs of the holes and notches of the Divje Babe I femur. 1 proximal hole; 2 right edge of the proximal hole showing micro-indentations; 3 distal hole; 4 distal notch; 5 proximal notch. (Modified after Turk 1997.) Scale not provided in original publication.

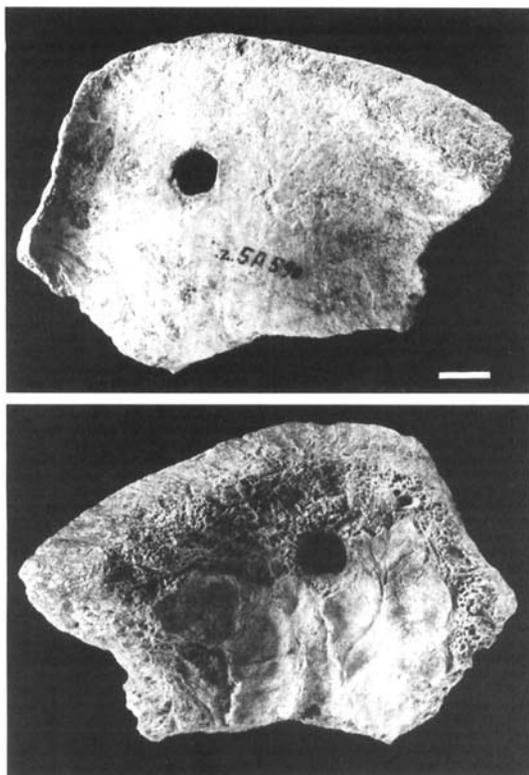


FIGURE 3. Fragment of cave-bear parietal from Lezetxiki with a large sub-circular hole. Scale = 1 cm.

None of the bones from Arrikruz and Troskaeta are burned, have unambiguous cut-marks or other possible traces of human intervention. Excavations of the two sites have never

revealed artefacts or other traces of hominid activities. Examinations by one of us (ACPL) of all the cave-bear bones from Arrikruz and of one-third of those found by Torres at Troskaeta has allowed the identification of a variety of surface modifications suggestive of carnivore actions, in particular 99 fragments showing holes corresponding to large punctures produced by carnivores, as described in the literature (Binford 1981; Haynes 1983; Lyman 1994; Fisher 1995). It is well-known that when most species of carnivores bite down hard on bone, the teeth leave impressions as pits or holes on the bone surface.

The following variables were recorded for each site: skeletal element, type of carnivore damage (gnawing, scoring, tooth notches, spiral breaks, punctures), and their anatomical position. The number of punctures present on each bone, their minimum diameter and whether they occurred in opposition on both sides of the bone was also recorded. Punctures were examined under a reflected light microscope; a selected sample was replicated with Provil L elastomer (Bayer, Leverkusen, Germany). Positive casts, made in RBS resin (T2L Chimie, Chalabre, France), were mounted on metal supports, coated with gold-palladium and observed with a SEM 840A Jeol.

We have also included in our analysis a bear skull fragment (FIGURE 3) from the cave of Lezetxiki (Basque region), a site presenting a 10-m thick Middle–Upper Pleistocene sequence with a record of alternating occupations by

skeletal element	Arrikruz			Troskaeta		
	NISP	NISP with puncture marks	% of element with punctures	NISP	NISP with puncture marks	% of element with punctures
skull bone	164	2	1.2	67	4	6
vertebra	320	22	6.9	27	12	44.4
rib	136	1	0.7	33	5	15.2
scapula	25	0	0	19	5	26.3
pelvis	16	0	0	15	7	46.6
limb bone	300	20	6.7	82	8	9.7
patella	6	0	0	15	1	6.7
carpal/tarsal	95	1	1.0	194	2	1.0
metapodial	120	8	6.7	141	1	0.7
phalange	96	0	0	353	0	0
<i>total</i>	<i>1278</i>	<i>54</i>		<i>946</i>	<i>45</i>	

TABLE 1. Cave-bear bones with tooth punctures from two caves in the Basque region (Spain). Isolated teeth are excluded from both samples.

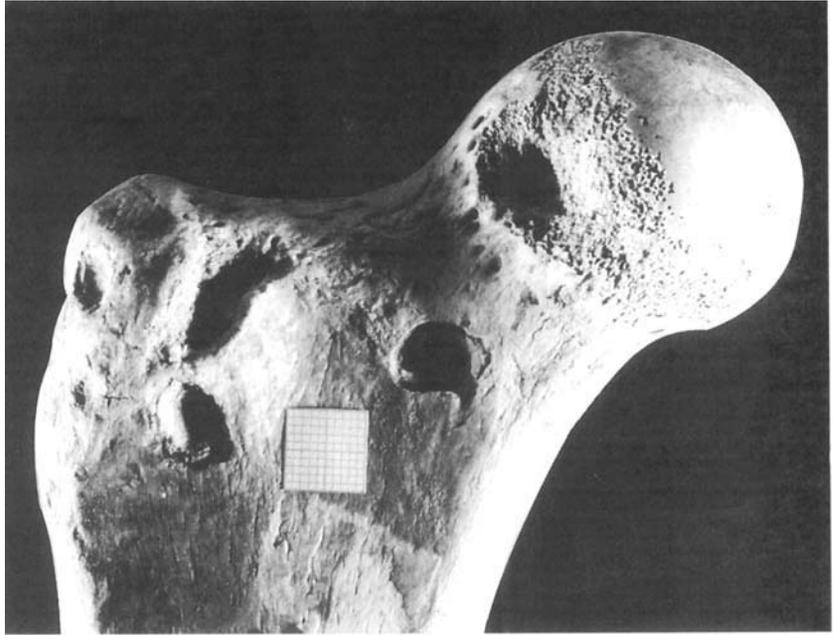


FIGURE 4. Large punctures on a proximal cave-bear femur from Troškaeta.

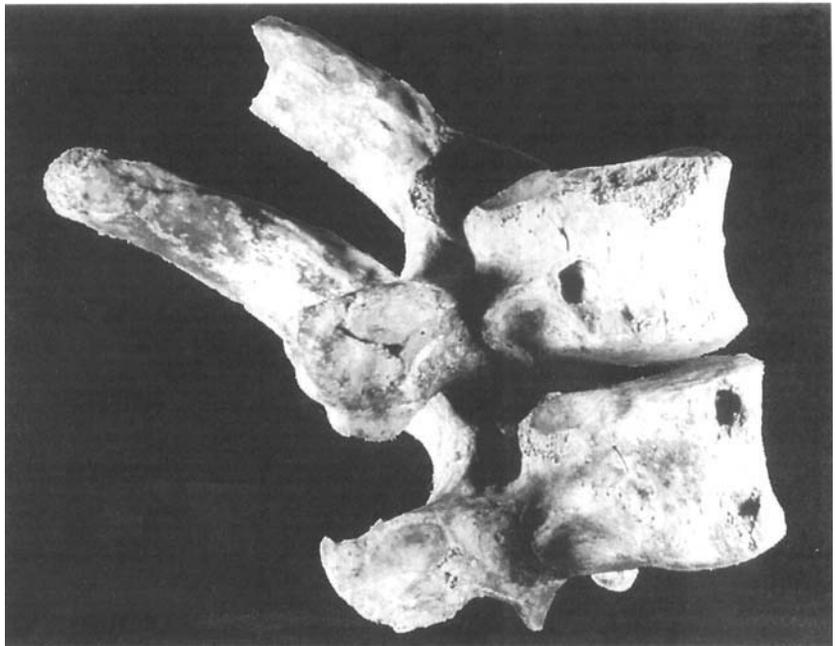


FIGURE 5. Large punctures on vertebral bodies from Arrikruz.

hominids and cave bears. This fragment comes from a level (VI) which has yielded a Typical Mousterian assemblage and is currently attributed to the Last Interglacial or to one warm phase of the Middle Pleistocene (Sanchez Goñi 1993). Bear bones from this level are attributed to *Ursus deningeri* by Altuna (1972). The skull fragment

presents a round perforation described as humanly drilled by Baldéon (1993), a diagnosis accepted by Bednarik (1997), and very similar in size and shape to those on the Divje Babe I bone (FIGURE 2). The perforation was studied with optical and scanning electron microscope following the same procedures described above

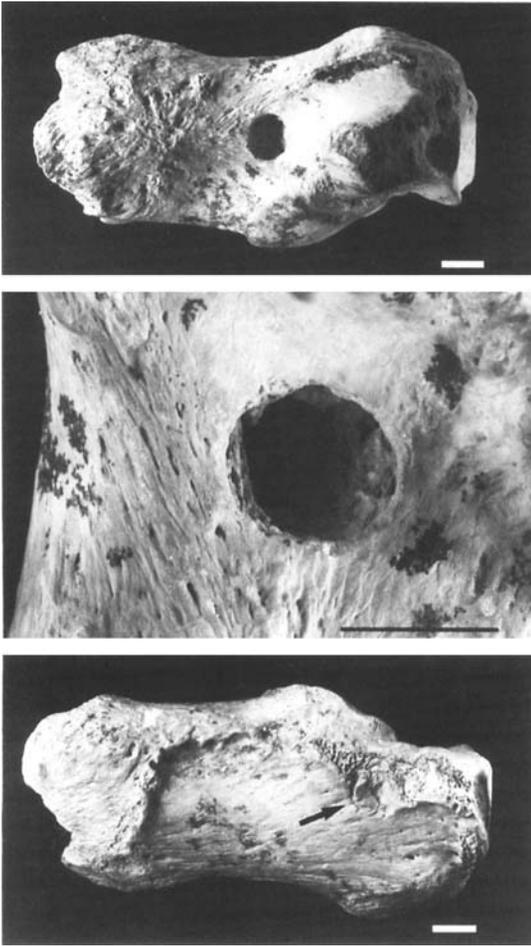


FIGURE 6. *Top: cave-bear calcaneum from Arrikruz with a large circular puncture; centre: macrophotograph of the hole showing marginal microbreakage; bottom: puncture on the opposite side of the bone. Scales = 1 cm.*

for the bones with punctures from Arrikruz and Troskaeta.

## Results

Arguments put forward to suggest an anthropic origin of the Divje Babe holes, and their possible use to produce harmonic sounds, lose a large part of their convincing power when seen in the light of taphonomic analyses of natural cave-bear accumulations. Deep punctures occur on the 4.2 and 4.8% of the examined remains from Arrikruz and Troskaeta (TABLE 1). They are present on many types of bone and are noticeably abundant on long bones. Most of the punctures show distinctive features (FIGURES 4–5)

consisting of irregular edges, depressed margins and flaking of the outer wall of the bone pushed into the depression (Lyman 1994). In a few cases, however, when the cortical bone overlying spongy bone is thin, the teeth penetrate the bone leaving circular or slightly elliptical holes, with regular edges (compare FIGURES 6 and 5 with FIGURE 2). At microscopic scale, the edges of these regular holes often present micro-indentations with occasional microscars corresponding to the local detachment of the first bone lamellae.

The number of holes present on the Divje Babe femur, their anatomical position and their large size cannot be considered as elements suggesting the anthropic origin of the perforations. In our comparative collection, the sum of the bones with two or more punctures exceeds, in both samples, those with a single puncture (FIGURE 7) and, among the former, those with two punctures are, as at Divje Babe, the most common. Puncture diameters vary between 1 and 12 mm at Arrikruz, and between 3 and 11 mm at Troskaeta, where small punctures are less common. In both samples, however, the large majority of the values range between 4 and 10 mm, a range which includes the diameter of the two holes on the Divje Babe femur (8.1 and 8.7 mm).

Similarly, the apparent absence of carnivore traces does not necessarily support the hypothesis of an anthropic origin of the perforations. Large isolated or multiple punctures occur at Troskaeta and Arrikruz on bones which do not show matching tooth marks on the other side of the specimens or other clear traces of carnivore damage (TABLE 2).

The hole on the Lezetxiki bear skull, which is very similar to those on the Divje Babe 'flute', is attributed by Baldéon and Bednarik to human drilling. First-hand examination of the Lezetxiki perforated object reveals traces of extensive carnivore gnawing in the form of pitting and scoring affecting the exocranial surface, and chipped-back edges (Binford 1981). Grooves produced by scoring meet the fracture edges indicating that gnawing occurred on the broken fragment. Scoring (FIGURE 8) can be distinguished from the many impressions of vascular grooves crossing the exocranial surface since the former presents frayed edges, an irregular internal morphology and compact zones crossed by parallel striations while the latter have regular U-shaped sections, clean edges and

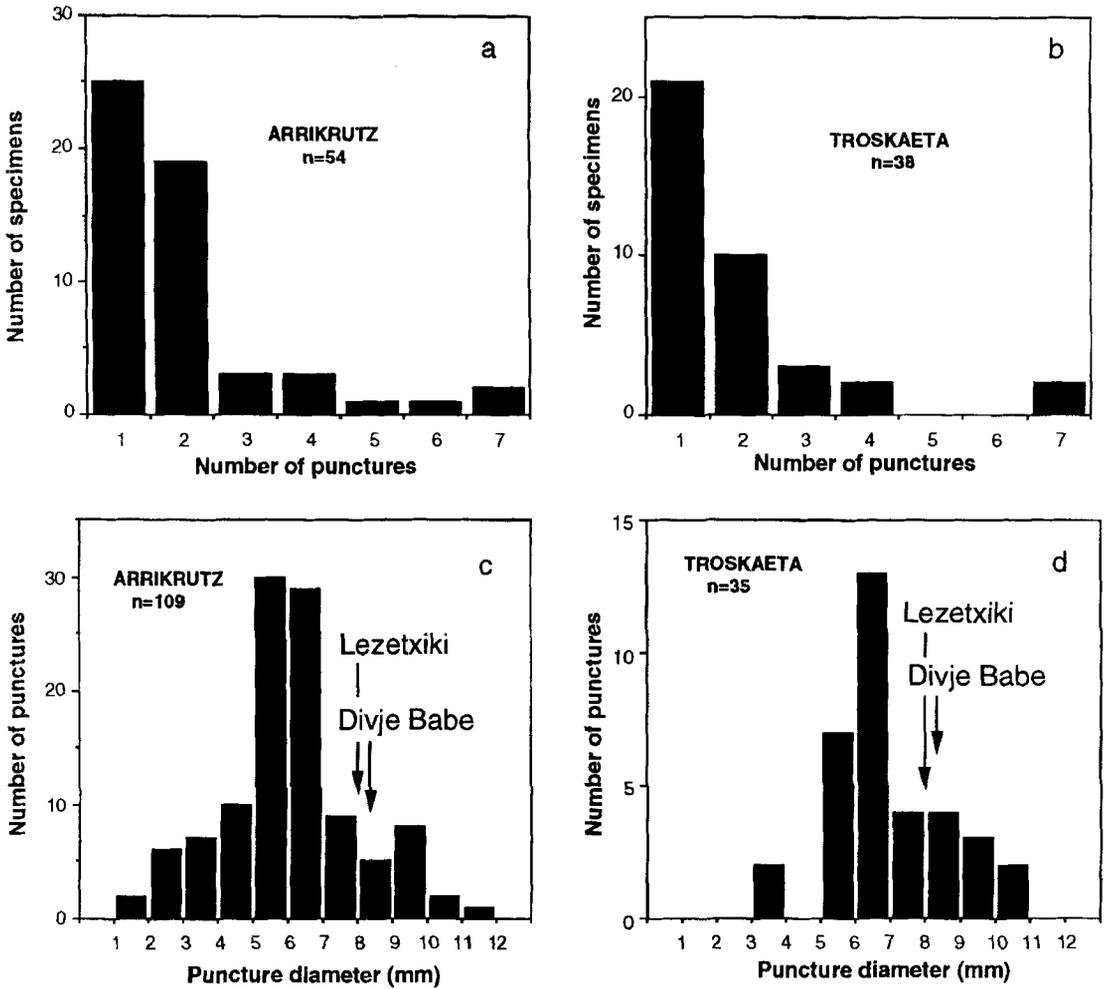


FIGURE 7. Frequency distributions of selected variables in Arrikruz and Troskaeta samples. a-b: number of punctures, c-d: puncture diameter.

number of punctures on single specimens	number of specimens	with opposing tooth marks	with tooth notches	with gnawing on shaft	with gnawing on articular or broken shaft end
1	25	8	3	1	3
2	19	12	1	-	2
3	3	2	-	-	-
4	3	3	1	1	-
5	1	1	-	-	-
6	1	1	-	2	-
7	2	2	2	-	-
<i>total</i>	54	29	7	4	5

TABLE 2. Association of puncture marks with other types of carnivore damage on cave-bear bones from Arrikruz cave.

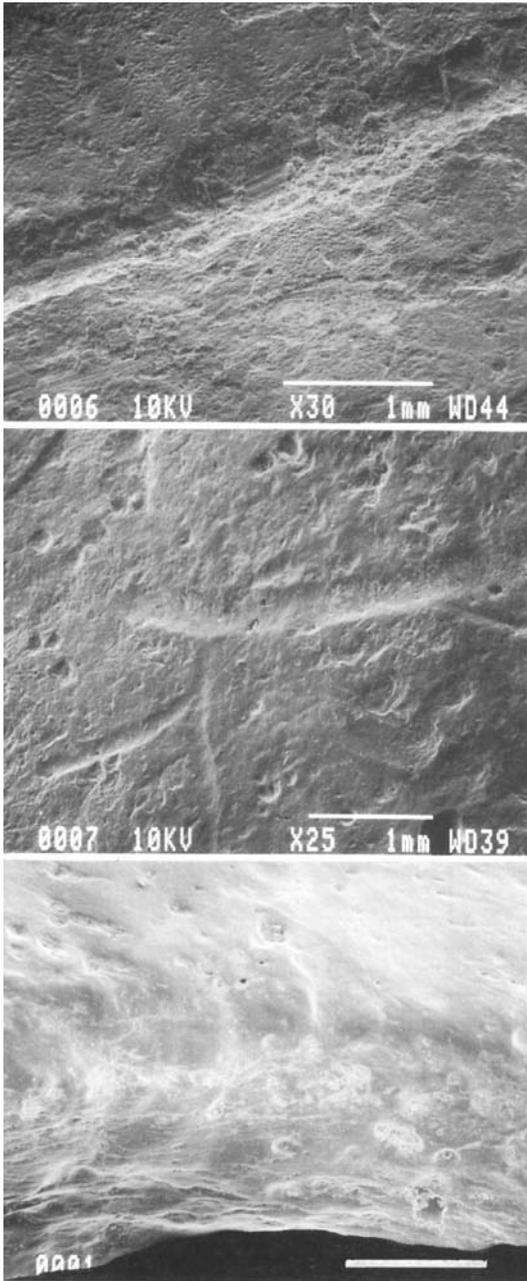


FIGURE 8. SEM micrographs of the Lezetxiki parietal. Top: scoring produced by carnivore gnawing on the exocranial surface; centre: surfacial impressions of vascular grooves; bottom: exocranial view of the hole edge.

often show branching patterns (d'Errico & Villa 1997).

The exocranial aspect of the hole (FIGURE 9) shows the same features observed at Arrikrutz

and Troskaeta (subcircular shape, slight indentations, local removal of the first lamella). The endocranial aspect presents continuous flaking, giving the hole walls a funnel-like shape. This suggests that the hole was produced by a canine attacking the exocranial surface of the skull and thus producing the extensive breakage visible on the endocranial side. Microscopic analysis (FIGURE 8) reveals a slight smoothing of the edge but no striations or scraping marks associated with the use of stone tools, as documented experimentally (d'Errico 1993) and by Upper Palaeolithic perforated objects (Stordeur 1979).

### Final remarks

A number of natural agents may produce holes on bones. Mushroom and bacteria produce perforations too small (1–10 mm) to be relevant here (Baud 1986). Beetles in their larval state bore large holes in long bones to use the inner cavity as a pupation chamber. The genus *Dermestes* produce holes up to 6 mm in diameter (Jodry & Stanford 1992); according to Kitching (1980), carrion beetles can bore even larger holes, up to 8–10 mm (d'Errico & Villa 1997). Unfortunately detailed descriptions or visual documentation of reference material is lacking. We cannot test this hypothesis but, as we suggest below, several reasons incite us to develop the carnivore hypothesis.

Sutcliffe (1970) has shown that circular holes are a common feature of bone fragments regurgitated by modern spotted hyenas. These bones show surface modifications (scalloped surfaces, micropits, knife-sharp edges) which make the agent of the modification rather easy to identify. Morphometric and microscopic analysis of a large sample of regurgitated bones from modern and Pleistocene hyena dens (d'Errico & Villa 1997) shows that the length of these fragments is generally smaller than 6 cm and, with only one exception, it never exceeds 9 cm. About 90% of the hole diameters range between 0.5 and 4 mm; holes up to 9.5 mm were found only exceptionally.

The Divje Babe I perforated bear femur cannot be interpreted as a hyena-regurgitated bone due to its large size (113 mm), the absence of diagnostic features of bones swallowed by hyenas and the large hole diameters. Instead, many converging reasons suggest that the holes were produced by the teeth of a large-sized carnivore. The dimensions, the morphology, and the number

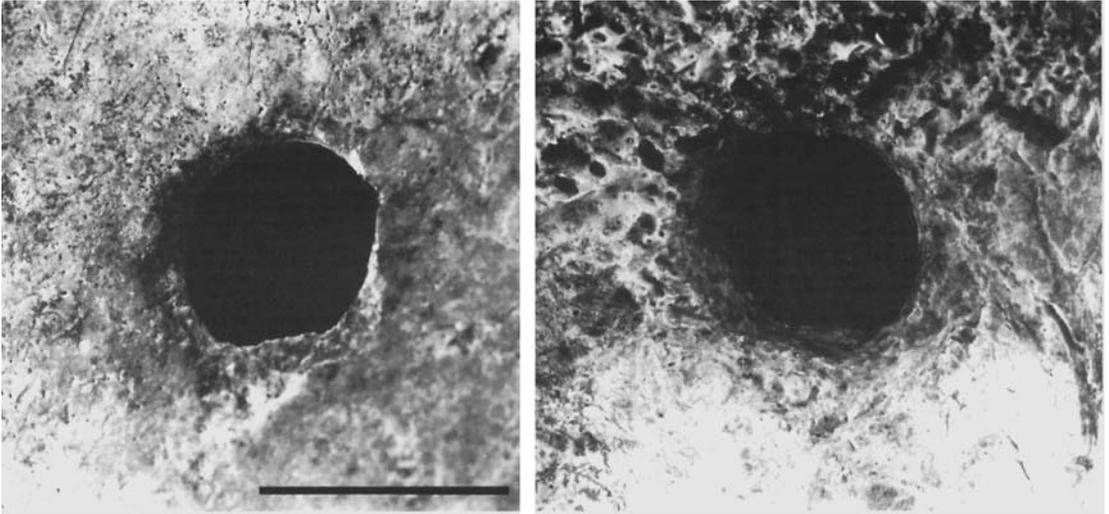


FIGURE 9. *Exocranial (left) and endocranial view (right) of the Lezetxiki hole. Scale = 1 cm.*

of Divje Babe holes are compatible with those observed in cave-bear bone accumulations with no human intervention (FIGURE 6).

To firmly identify the species responsible for the holes, however, is not an easy task. Although carnivore punctures are a well-known and widely described type of carnivore damage (*cf.* Binford 1981; Haynes 1983; Morlan 1983; Fisher 1995), we still have limited information on the size range of punctures produced by different carnivore species. According to experimental and field observations by Haynes (1983), modern hyenas and wolves produce punctures around 3–5 mm wide. Bears too leave 'tooth cusp impressions . . . consisting of single, nearly flat bottomed holes entering the cancellous tissue'. Measurements of tooth marks taken by Selvaggio (1994) show that lions and spotted hyenas teeth can leave punctures as wide as 5 and 6 mm respectively. However modern samples may not be appropriate for assessing the range of puncture diameters left by Pleistocene carnivores which may be larger than the correlative modern species. Stiner (1995) provides the range and the mean values of puncture diameters found in trabecular bone from five Middle and Upper Palaeolithic Italian sites (FIGURE 10). As several different carnivores, including leopard, brown bear, hyena and wolf are present among the faunal remains of these sites, the punctures found on the bones are likely a mixture of damages produced by different species and cannot be used as a criterion to identify a particular taxon.

Large punctures on bear-cub bones, around 7–8 mm in diameter, interpreted as suggesting cannibalism by adult bears, were recently described at Yarimbuzgaz Cave (Stiner *et al.* 1996). However, as with the Italian samples, damage produced by other carnivores, primarily canids and other larger carnivores such as *Panthera*, and perhaps hyena, are present at the site. Data from Troskaeta, a site where only bears were present, strongly suggest, in contrast with Gargett's opinion (1996: 42, 140), that cave bears often inflicted heavy damage to bones and that cave-bear puncture diameters are among the largest produced by carnivores.

This hypothesis is supported by evidence from another site, the Grotta d'Ernesto, a small cave site in the Italian Alps, dated to the Mesolithic. This site contains only sporadic traces of human presence and a faunal assemblage dominated by brown bear, virtually the only carnivore (Cavallo *et al.* 1991). Large punctures, up to 10 mm wide, were observed on red-deer and brown-bear bones from this site. The distance between two large punctures on a red-deer skull from this site is identical to that measured between the tips of canines on a brown-bear mandible from the same site, suggesting that this species was responsible for much of the gnawing (Cavallo *et al.* 1991: figure 6).

Although the hypothesis that the 'flute' perforations were made by carnivores is considered by the excavators (Turk 1997), they do not consider cave bear as the possible perpetrators

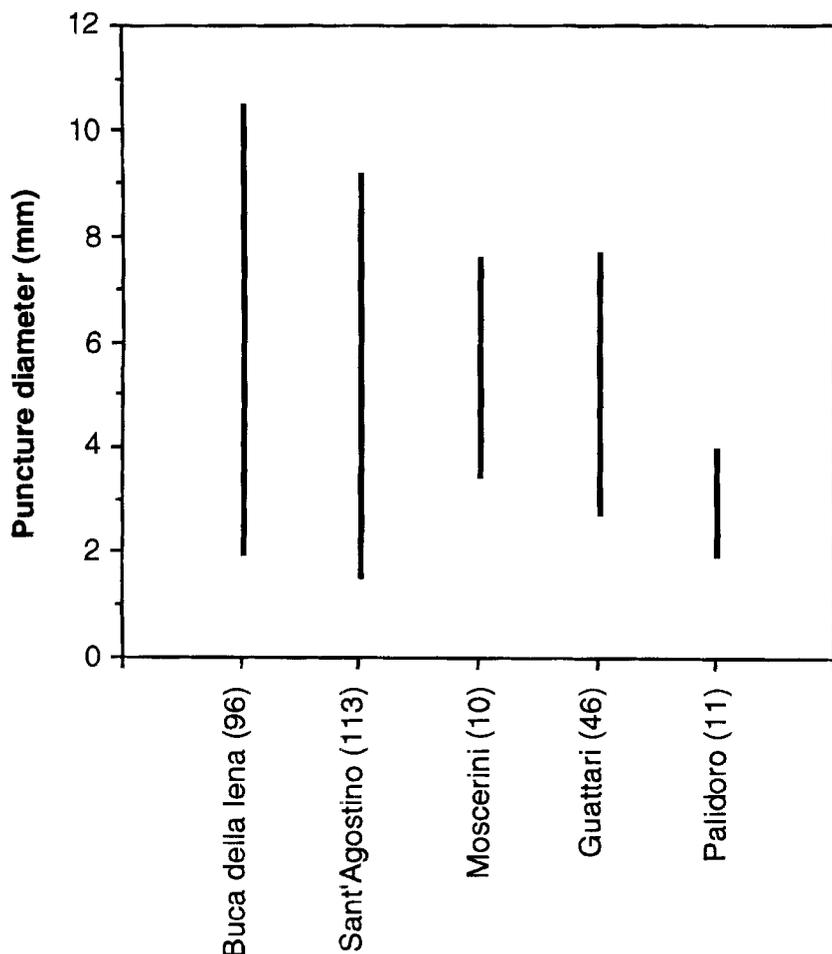


FIGURE 10. Range of puncture diameters in ungulate and carnivore bones from several Middle Palaeolithic Italian sites (adapted from Stiner 1994: table 5.19).

concentrating instead on dismissing the role of wolves and hyenas (1997: 173–4).

The alignment and identical shape and size of the two Divje Babe holes might suggest that they were produced simultaneously by carnivore teeth biting the bone surface perpendicularly. This could have been done by canines or by carnassials.

In the first case, however, the punctures could not have been done in just one bite by an adult cave bear. The distance between the centres of the two perforations (35.4 mm) is less than half the distance between the canine tips of this species and smaller than that of most large-sized carnivores, including adult hyenas, lions and wolves. They might have been produced simultaneously by the canines of a juvenile carnivore or they might be the product of repeated bites.

In the second case, the holes could have been made by the paracone of the upper carnassials or by the protoconid of the lower carnassials

of a large carnivore with strong jaws and very pointed carnassials. This second mechanism seems more probable if the holes were produced by carnivores other than cave bears since the morphology of cave-bear carnassials cannot produce such round, large holes. An action by cave-bear canines, however, cannot be excluded since, as seen above, large punctures are found in sites where only bears are present.

Whatever the gnawing mechanism responsible for creating the two holes, why was no other carnivore damage recorded on the femur? We have already shown (TABLE 2) that in cave-bear-dominated bone assemblages, large isolated or multiple punctures can occur on bones lacking any other traces of carnivore gnawing. Moreover, the absence of gnaw-marks on the Divje Babe femur is an assertion that needs verification.

In fact, the femur carries on its anterior face a semi-circular notch associated to a diverging

fracture (FIGURE 1.1), which could be interpreted as a bite-mark opposite to the distal hole. The origin of this feature is not explained by the excavators, who state that no traces of counter-bites are present on the bone (1997: 175).

The proximal and distal notches that Turk (1997: 160) describes respectively as a broken hole and a possible man-made mouthpiece opening of the presumed flute could also be interpreted as the effect of a carnivore gnawing the two shaft ends. These notches show the same crenulated morphology of bones with thin cortical walls such as palates and mandibles gnawed by carnivores (Binford 1981: figures 3.25 and 3.27). Their interpretation as gnaw-marks is compatible with the rounding of the broken bone edges. It is known that when carnivore gnaw long-bone shafts their rough tongues are capable of rounding bone surfaces.

The lack of spongy bone inside the shaft is not proof of deliberate cleaning-out since no traces of this action are visible on the bone internal surface. Many shafts from the site, carrying no holes, appear completely or partially without spongy bone. Yet no traces of working are visible on them (1997: 174).

Before attributing the presence of perforations on the juvenile cave-bear femur to the deliberate intention of choosing a bone suitable to make a musical instrument one should consider the frequency of juvenile bones in cave bear assemblages. It is known that newborn and juvenile individuals can represent a large portion of faunal remains found in cave-bear accumulations (Kurtén 1955; 1976; Andrews & Turner 1992; Torres *et al.* 1991). This appears to be the consequence of high mortality of young cave bears during the hibernation period. Thus the presence of large punctures on the long bone of a juvenile cave bear need not be interpreted as the deliberate choice of a Neanderthal craftsman, and should more likely be attributed to the large number of juvenile bones in this type of site. At Divje Babe (1997: 102–10), all layers show a high percentage of juvenile bones, and of juvenile and deciduous teeth. The interpretation of the holes and the semi-circular notches on the 'flute' as damage produced by carnivores is consistent with the high percentage of gnawed bones found at the site. Gnawed bones figured in the monograph (1997: 117, figure 9.2 and 173: 11.19) present, among other typical traces, large multiple punctures and notches very similar to those on the 'flute'. The percentage of

gnawed limb bones is considerably greater among juveniles than among adults. Among the former, the bone with the highest percentage of punctured holes is the femur, i.e. the bone on which the presumed flute was made.

That carnivores had a dominant role in creating and modifying the Divje Babe bone assemblage is also confirmed by the fact that spiral fractures associated with percussion notches are, by the excavators' own admission, very rare, and only 8 possible cut-marks were found on the 200,000 bone fragments recovered from the cave. This result is compatible with the relatively low number of stone artefacts found at the site, and in the lower Mousterian layers, where the flute was discovered. Layers 7–8 combined have yielded only 127 stone artefacts.

In sum, the extremely high frequency of cave-bear bones in the Divje Babe assemblage (99% of the total number of bones) clearly shows that humans had only a negligible role in the accumulations of these bones, that hibernating bears were an important factor contributing to the accumulation of the faunal assemblage and that the Divje Babe cave assemblages represent 'palimpsests' (Bordes *et al.* 1972; Villa 1982) of alternate occupations by carnivores and humans.

The proximity of the 'flute' to a fireplace cannot be considered, by itself, proof that they are contemporaneous. Recurrent human and carnivore occupation of the same site and accumulations of temporally separated materials on the same surface are a common feature of the archaeological record in sites with low sedimentation rates, such as caves. Estimates of sedimentation rates in Stone Age caves often indicate low values. One cm of deposit may represent 5–167 years with an average of 14 years (Speth & Johnson 1976). Thus materials now aggregated in a single layer may have been discarded during separate phases of occupation and possibly different modes of site use (Villa & Courtin 1983: 270). Refitting links between lithics or bone fragments might suggest the contemporaneous use of the same excavated surface but this kind of analysis remains to be performed at Divje Babe. Even so, refitting would only suggest, but could not provide absolute proof of contemporaneity. The problem is even more cogent in a site like Divje Babe since we know that cave bears (Kurtén 1976), like modern black bears (Rogers 1981), displaced consistent amounts of sediment in order to prepare comfortable beds for hibernation.

The available data from Divje Babe shows that no living floors have been identified at the site (Turk 1997: 119–21). No pattern is observed in the spatial and stratigraphic distribution of finds suggesting a contemporaneity of objects. Bones and stone artefacts are scattered throughout all layers with no evidence of concentration. An increase in the density of stone artefacts and bone remains near the fireplaces might indicate that objects nearest to them were deposited at the same time, but no such increase are observed in the stratigraphy.

The occurrence of borers among the stone tools found at the site proves opportunity, but not the origin of the holes, since no diagnostic traces of stone-tool use on the hole walls and edges were found. The excavators suggest that constant use or natural abrasion might obliterate such traces. This, however, cannot be con-

sidered in any way as supporting the hypothesis of human manufacture.

We must conclude that by far the most likely explanation for the modifications observed on the Divje Babe femur is that of damage produced by carnivore teeth and that, as a consequence, the most ancient musical instruments known to date are still the Aurignacian flutes discovered in the French cave of Isturitz (Buisson 1991) and those recently discovered by Jochim Hahn (1996) at Geissenklösterle in Germany.

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