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Sima de los Huesos (Sierra de Atapuerca, Spain). The site

In this article a topographical description of the Cueva Mayor–Cueva de Silo cave system is provided, including a more detailed topography of the Sala de los Cíclopes–Sala de las Oseras–Sima de los Huesos sector. The history of the excavations and discoveries of human and carnivore fossils in Sima de los Huesos and adjacent passages is briefly reported, as well as the increase, throughout the succeeding field seasons, of the human collection and changes in the relative representation of the different skeletal elements and major biases. The carnivore assemblage structure is also considered. Examining the characteristics of the bone breccia, and the current and ancient karst topography, different alternative accesses are discussed for the accumulation of carnivores and humans in the Sima de los Huesos. Taking into account all the available information, an anthropic origin for the accumulation of human fossils seems to us to be the most likely explanation.

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The Sima de los Huesos and the Cueva Mayor–Cueva del Silo cave system

The Sima de los Huesos (SH) site is located well inside the Cueva Mayor–Cueva del Silo cave system, in Sierra de Atapuerca (Figure 1). The karst system can be divided into two subsystems with two current openings, namely Cueva Mayor and Cueva del Silo (Figure 2). The Sima del Elefante site, in the railway cutting of the Sierra de Atapuerca (Trinchera del Ferrocarril), belongs to the Cueva Mayor karst subsystem, representing an ancient opening, now completely filled by sediment. The stratigraphic section of Sima del Elefante that was exposed by the railway cutting has been preliminarily sampled and dated by U-series and palaeomagnetism, and includes Lower and Middle Pleistocene layers, some of them rich in macrofauna, stone tools and/or microfauna. Other important sites in the railway cutting, such as the Galería complex or Gran Dolina, are currently not connected to the Cueva Mayor–Cueva del Silo cave system, and could represent separate systems.

The Sima de los Huesos site is around 0·5 km from the Cueva Mayor entrance (Figure 2). This entrance is a rift in the Sierra de Atapuerca southern slope, that becomes a large chamber underneath called El Portalón (or cave portal), with an important Bronze Age occupation site above a probably very deep stratigraphic sequence. F. Jordá excavated a test trench in El Portalón in 1965–1966 and G. H. Clark another in 1971, and finally the site was systematically

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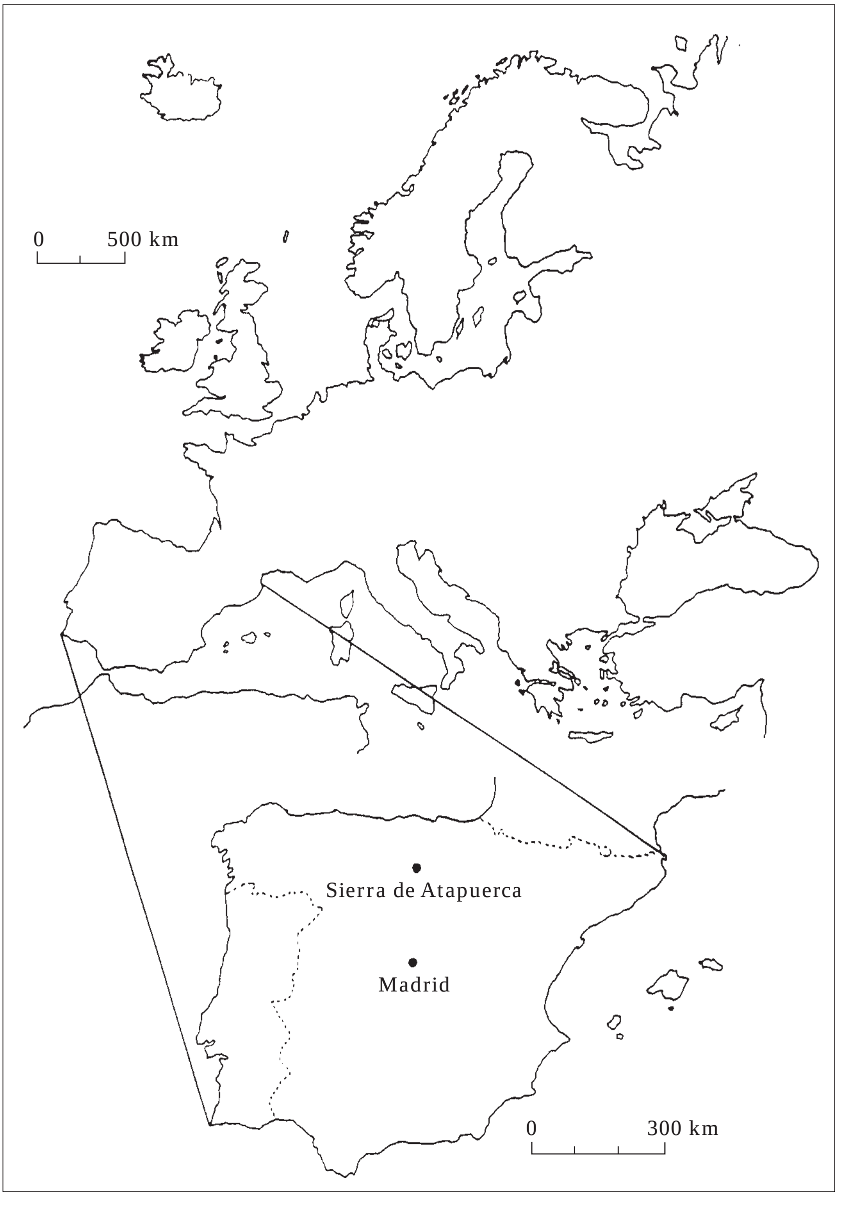

Figure 1. Sierra de Atapuerca location.

excavated by J. M. Apellániz between 1972 and 1983. On the wall is a red painting of a horse's head of problematic age. This painting attracted the attention of ''classic'' prehistorians who visited Cueva Mayor. Carballo (1910, 1921) claimed to be the discoverer of the painting and was the first to publish it. Obermaier (1916) and Breuil (1920), who considered H. Alcalde del Río to be the discoverer, believed the painting palaeolithic, but the palaeontologist Royo y Gómez (1926) thought that the painting was modern.

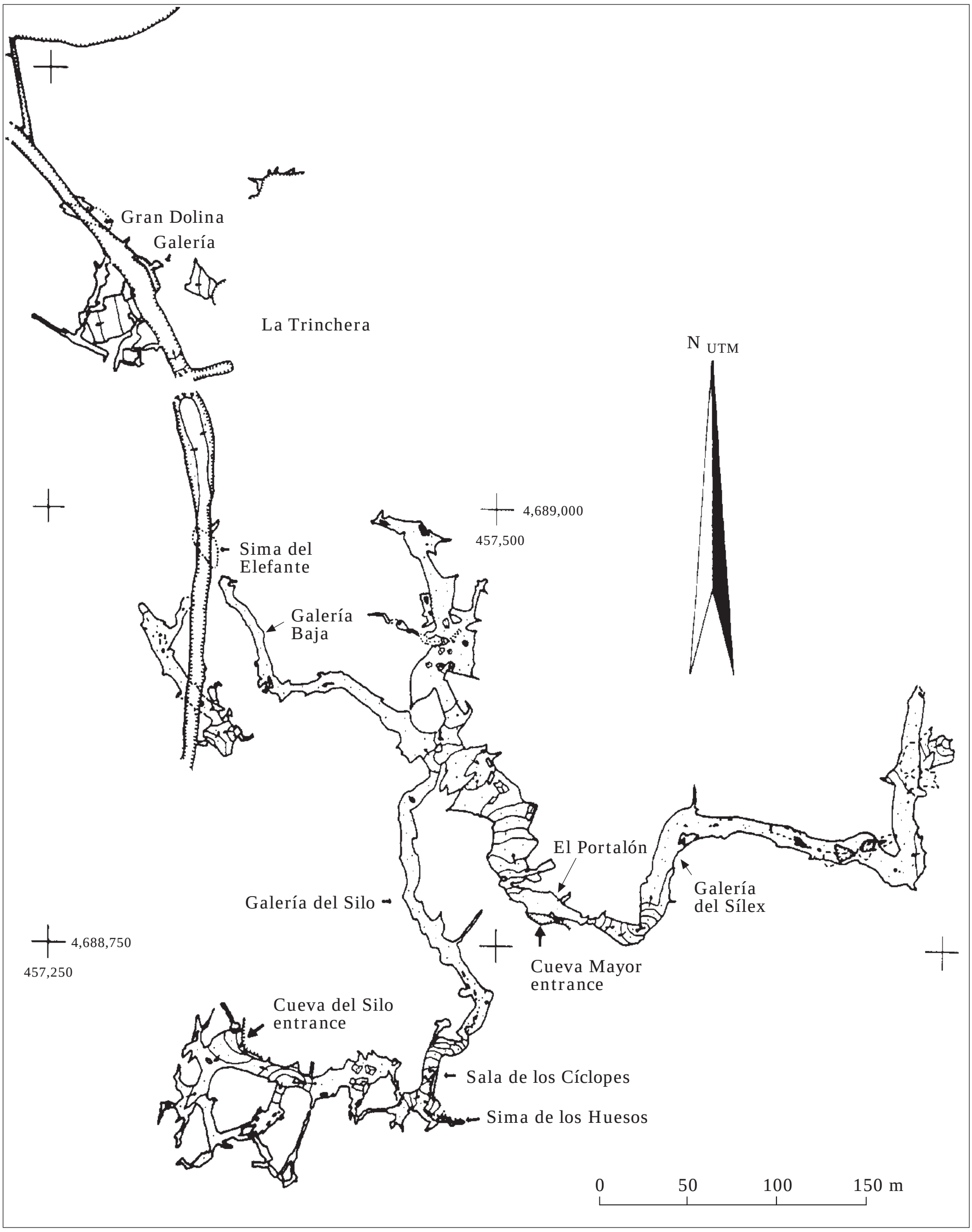

Figure 2. Plan of the Sierra de Atapuerca cave systems (by G. E. Edelweiss).

To the right of the entrance chamber a narrow and sinuous passage between fallen blocks leads to a long and high gallery (Galería del Sílex) (Figure 2). This passage was opened by the Edelweiss Group of Spelaeology in 1972. The gallery contains human skeletons, some faunal remains, pottery, stone tools, engravings and paintings along the walls, and was used as a

Bronze Age funerary chamber. Galería del Sílex once had its own entrance (different from El Portalón) that became filled and obstructed in Bronze Age times.

On the way to the Sima de los Huesos site from El Portalón there is a constriction followed by an extraordinary, large chamber with a very high roof, that leads to a junction with three other galleries. One of these galleries (Galería Baja) ends in the Sima del Elefante site, and another (Galería del Silo), leads to the Sima de los Huesos (Figure 2). Galería del Silo also has Bronze Age engravings and paintings, and ends in a crawling passage that opens into the large chamber called Sala de los Cíclopes. At the opposite end of this chamber there is a narrow and dangerous passage (Tubo de los Vientos in Figure 3) that connects the Cueva Mayor and Cueva del Silo subsystems. This connection was discovered in 1965 by spelaeologists of the Edelweiss Group. It formed a very narrow conduit that was enlarged by the spelaeologists and then sealed by them in 1974, in order to prevent accidents and to restrict the access to the Cueva Mayor subsystem.

The southern half of the Sala de los Cíclopes was completely filled by sediments that were later largely washed out in an erosive phase of the karst history. There are remnant sediments attached to the rock walls as well as to the roof of Sala de los Cíclopes, showing basal thin laminated silts, succeeded by a breccia with angular clasts of limestone supported by a red clayish matrix, another bed of laminated silts, succeeded by coarse sands and, at the top of the section, a new reddish breccia. The laminated silts and coarse sands are deposits from still water and running water, respectively, and the red breccias (of matrix-supported clasts) are interpreted as colluvia (debris-flows) coming from the outside slope of the Atapuerca hill and extending inside the cavity from a low gradient opening (or openings, not apparent at present).

From the bottom of the southern wall of Sala de los Cíclopes, a short passage runs to the southeast (Sala de las Oseras). It is first narrow and low, later becomes larger, and is finally stopped by collapsed large blocks (Figures 3, 4, 5 and 9). Gravimetric and magnetometric studies from the surface suggest an ancient entrance in the collapsed area, that was obstructed by a cave breakdown (Bergamín *et al.*, 1994). Abundant fossils of *Ursus deningeri* (García *et al.*, 1997) were found in test trenches in Sala de los Cíclopes (numbers 2 and 3 in Figures 3 and 4) and in Sala de las Oseras (number 4 in Figures 3 and 4). In the latter passage there are also bear nests in the floor (Figure 4) and bear claw marks on clay patches attached to the walls.

Clearly, the bears used Sala de los Cíclopes and Sala de las Oseras after the disappearance of the sediment that had previously filled the chambers. No other macrofossils or stone tools have been found. Since the bones in the test trenches belong to the species *U. deningeri*, and fossils of its descendant the terminal Middle Pleistocene and Upper Pleistocene *Ursus spelaeus* are lacking, it seems likely that this part of the cave ceased to be accessible before the terminal Middle Pleistocene. The closure was probably due to the collapse or the filling of an ancient entrance, that could correspond (although not necessarily) with the collapse area at the end of Sala de las Oseras or with another collapse close to the Sima de los Huesos shaft (see below). The bear claw marks on the clay walls, and bear nests and skeletons almost on the surface in Sala de las Oseras and Sala de los Cíclopes indicates that the topography of these chambers has not changed much since the last bear used them.

A steep slope of sediment in the southeast corner of Sala de los Cíclopes leads to a flattened terrace (also of sediment) and then to the Sima de los Huesos pit (Figures 3, 4 and 5). Sima de los Huesos means Pit of the Bones. The first plan, profiles and general description of Cueva Mayor was published by Sampayo & Zuaznávar (1868), and the Sima de los Huesos hole named El Silo (storage pit), although the cavity itself was not mapped. From the foot of the 13 m-deep shaft, a passage turns west towards the Sala de las Oseras, but at a lower level. It

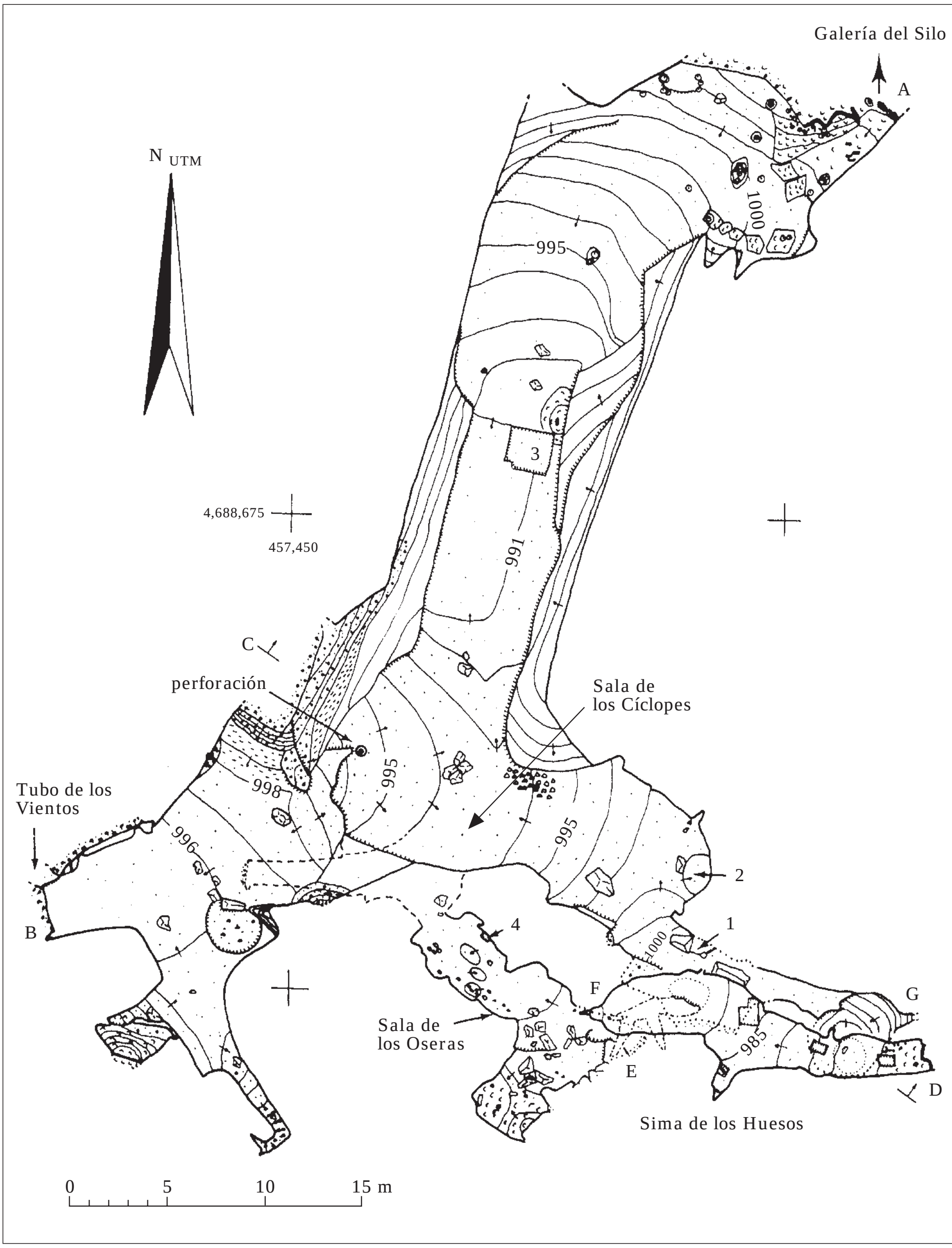

Figure 3. Plan of the Sala de los Cíclopes chamber in Cueva Mayor, its side passage Sala de las Oseras and Sima de los Huesos (by G. E. Edelweiss). Sala de los Cíclopes was connected with Cueva del Silo cave subsystem through the narrow passage of Tubo de los Vientos. Numbers 2, 3 and 4 correspond to test excavations, that have yielded *U. deningeri* fossils. Number 1 indicates the hole where debris from Sima de los Huesos was accumulated in Torres' excavation in 1976. This overburden was excavated in 1990 and 1991, yielding bear and human fossils. For clarity, the plan of Sima de los Huesos has been superimposed onto the Sala de los Cíclopes and Sala de las Oseras plans, although Sima de los Huesos is actually below. ''Perforación'' indicates the shaft drilled from the surface to the ceiling of the Sala de los Cíclopes chamber.

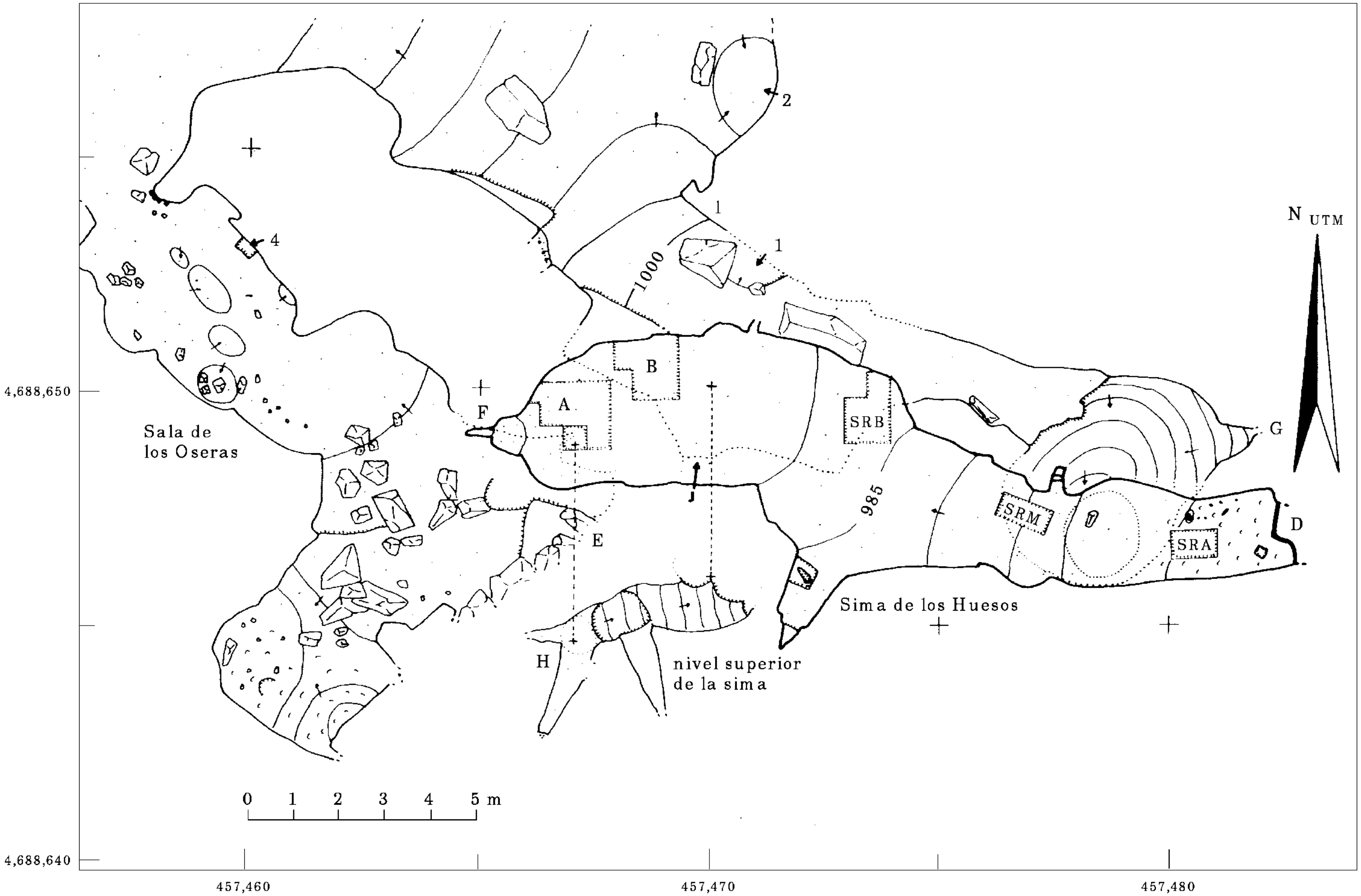

Figure 4. Plan of Sala de las Oseras and Sima de los Huesos (by G. E. Edelweiss, 1992). For clarity, Sima de los Huesos has been superimposed onto the Sala de los Cíclopes and Sala de las Oseras drawings, although it is actually below. The circle and ellipses in the floor of Sala de las Oseras represent bear nests. The plan of the passage leading upwards from the root of Sima de los Huesos has been shifted.

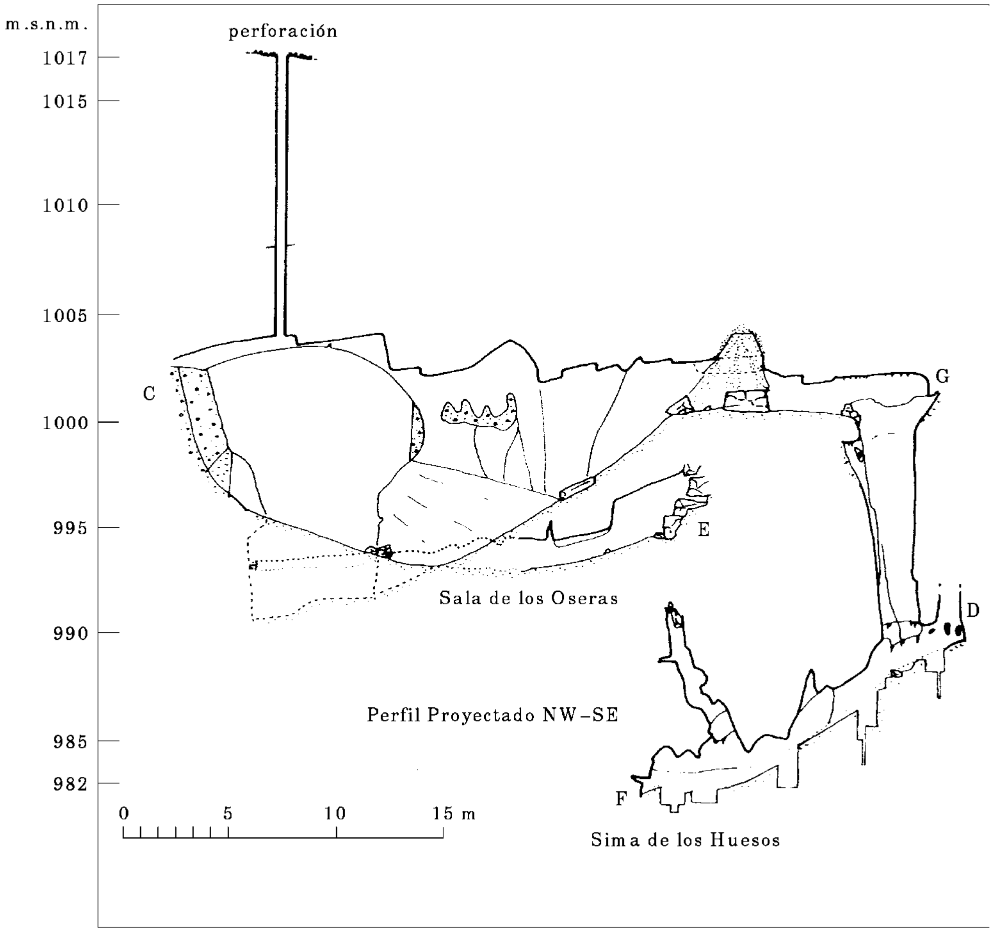

Figure 5. Profile of Sala de los Cíclopes, and projected profiles of Sala de las Oseras and Sima de los Huesos (by G. E. Edelweiss, 1992–1996). Note that the Sala de las Oseras and Sima de los Huesos profiles have been projected on the Sala de los Cíclopes C–D profile (Figure 3), so that actually Sima de los Huesos is not directly below Sala de las Oseras, and the latter is not directly below the passage from the bottom of Sala de los Cíclopes that leads to the top of the shaft. As a consequence of the drain of sediment in Sala de los Cíclopes, the floor of this section of the large chamber is funnel like. In no point of the Cueva Mayor–Cueva del Silo cave system does the floor reach the bedrock. The chimney in Sima de los Huesos behind (to the right of) the shaft, is a blind vertical conduit, and has not been completely drawn.

can be divided in two parts. A first or proximal part (i.e., starting at the foot of the shaft) with a very steep floor, named Sima de los Huesos Ramp, and a second or distal part (the end of the passage) with a more horizontal floor, named Sima de los Huesos Chamber. In the roof of the latter is a vertical conduit that narrows upwards and finally becomes obstructed by limestone blocks (Figures 4, 5 and 9).

History of the discoveries (Table 1)

In 1976, the first human fossils were discovered in Sima de los Huesos by T. Torres while sampling SH sediments for fossil bears. T. Torres had been informed by the Edelweiss

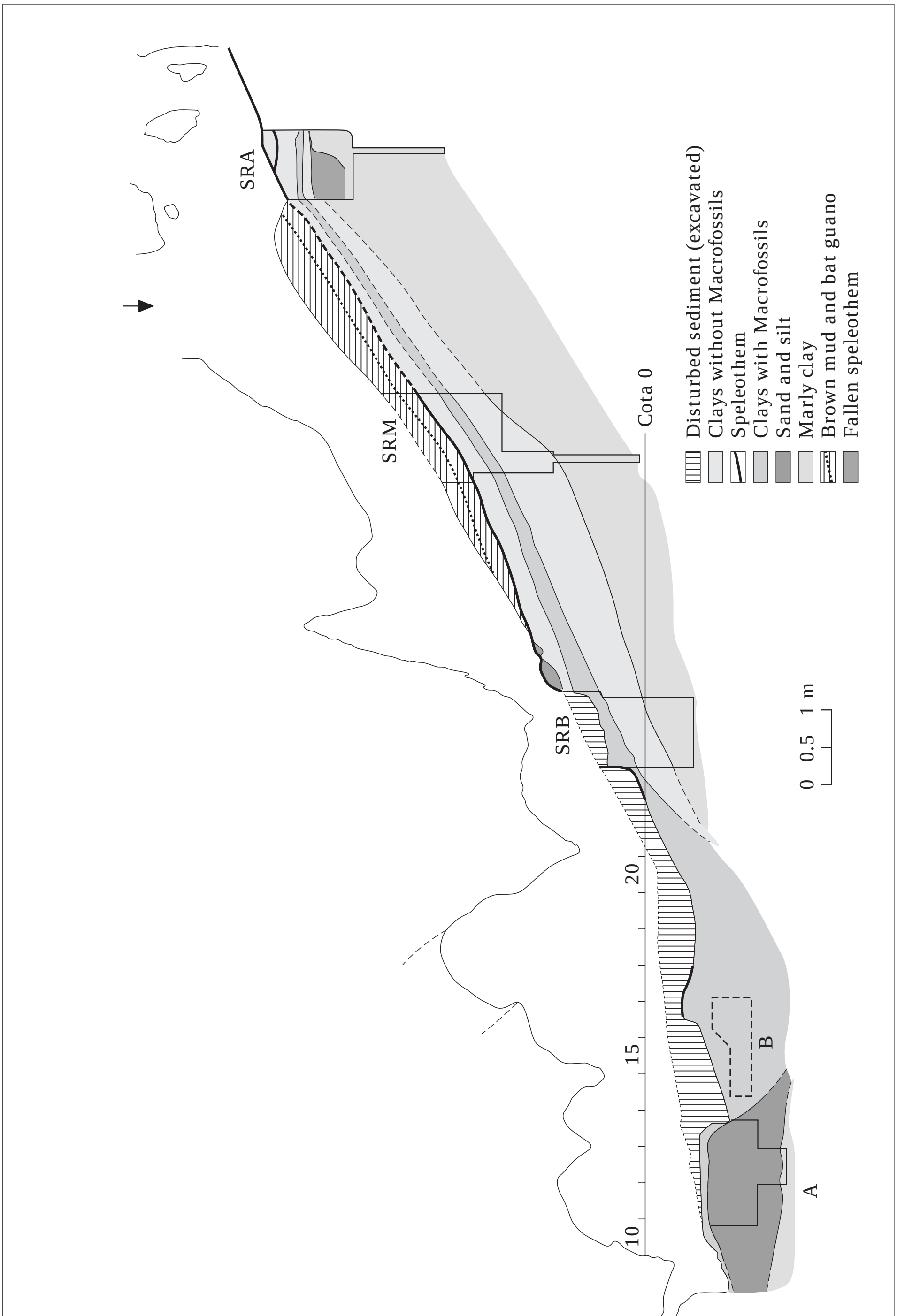

Figure 6. Sima de los Huesos schematic section showing the bone bearing breccia. The sedimentary layers are steeply inclined in the Ramp test pits, but they become horizontal in SRA, making the contact between them abrupt at SRA and the extension upslope of the SRM layers. The arrow indicates the shaft position.

Figure 7. Sima de los Huesos plan showing the excavation grid. In black color speleothems on the site floor or exposed by excavation in the ramp (see Figure 6). Shaded squares in areas A and B have yielded *in situ* human fossils.

Table 1 Number of human fossils found in Sima de los Huesos in different seasons and excavation areas

		SH			SR		
Year	Point 1*	Disturbed sediment	Area A	Area B	SRB	SRM	Total
1976†	—	20	—	—	—	—	20
1983	—	3	—	—	—	—	3
1984‡	—	74	4	—	—	—	78
1985§	—	23	3	—	—	—	26
1986	—	26	—	—	—	—	26
1987	—	22	—	—	—	—	22
1988	—	30	—	—	—	—	30
1989¶	—	30	24	—	—	—	54
1990‖	107	—	23	6	—	—	136
1991**	54	—	—	112	—	—	166
1992††	—	—	—	201	3	5	209
1993‡‡	—	—	—	179	4	2	185
1994§§	—	—	—	316	2	—	318
1995¶¶	—	—	113	299	—	—	412
Total	161	228	167	1113	9	7	1685

*Debris left by T. Torres in 1976 in Sala de los Cíclopes at Point 1 (Figures 3 & 4). †In 1976, 17 human fossils were identified, but later a human tibial fragment, a human humeral fragment and a fragment of human hip bone were identified among the fossils of Torres' campaign. Excavated grid squares: ‡Q-11, Q-12, R-11, R-12. §R-11, R-12. ¶Q-10, R-10. ‖Area A: Q-10, R-10. Area B: S-16, T-16, U-16. **S-16, T-16, U-16. ††T-16, U-15, U-16. ‡‡S-15, S-16, T-15, T-16, U-14, U-15, U-16. §§S-16, T-14, T-15, T-16, U-14, U-15. ¶¶Area A: R-10, R-11, Q-10, Q-11; Area B: S-12, S-13, T-12, T-13, U-12, U-13.

Spelaeological Group of the presence of bear bones at the site. He communicated his finding to his Ph.D. advisor, E. Aguirre, who organized a group to study the Sierra de Atapuerca Pleistocene sites, and directed the research until 1990. Since then, research in the Sierra de Atapuerca Pleistocene sites has been directed jointly by J. L. Arsuaga, J. M. Bermúdez de Castro and E. Carbonell.

In 1983, a small sample of disturbed sediment was collected in a brief visit to the Sima de los Huesos. It yielded three human teeth among many bear remains. The systematic removal of disturbed sediment began during the 1984 season. In that year and in 1985, besides the evacuation of debris, bear and human fossils were found *in situ* in the SH distal excavation squares (area A, Figures 6 and 7). During the 1986–1988 field seasons, the excavation of disturbed sediments from SH continued. The disturbed sediment incorporated a mass of mud and bones (mostly bear's) mixed with many big fallen blocks of limestone. The blocks were pulled out through the shaft and left in Sala de los Cíclopes, although larger blocks were first broken at the foot of the shaft with hammers and chisels. The mud and bone mass was carried out to the Cueva Mayor mouth in back packs and then transported by car to the Arlanzón River, dried and sieved, and finally sorted by taxa in the laboratory. This way, teeth and fragmentary human bones were discovered among thousands of carnivore fragments (almost exclusively bear's). In the 1989 field season, this job was completed and more human fossils were discovered *in situ* in grid squares in area A.

A suspended scaffolding fixed to the walls was installed in 1987 to avoid stepping on the floor. During the same field season, a shaft was drilled from the surface to the roof of Sala de los Cíclopes for the purpose of lowering equipment and pulling out the finds (''perforación'' in

Figures 3 and 5). The shaft also serves to permit oxygen renewal at SH. Before the drilling, oxygen was scarce in Sima de los Huesos.

In 1990, excavation was continued in undisturbed sediments at area A and preliminary excavation was started in area B.

During the 1976 field season, T. Torres' team sorted the SH fossils from Sima de los Huesos close to the top of the shaft, and left the refuse in a hole in the floor (point 1 in Figures 3 and 4). In the 1990 and 1991 field seasons, the debris left by Torres in 1976 was removed, yielding 161 new human fossils, including teeth belonging to the first human discovery, the AT-1 mandible.

From 1991–1994, area B was excavated, and in 1995 both areas were excavated and connected. Test trenches were dug in the Sima de los Huesos Ramp, at SRA and SRM in 1992 and 1993, and at SRB from 1992–1995 (Figures 6, 7 and 9).

The composition of the human collection and the origin of the deposit

The Sima de los Huesos site contains a bone-bearing breccia with clayish matrix (Figure 6) mainly composed of *U. deningeri* (a large minimum number of individuals (MNI = 166), as well as human fossils (more than 32 individuals, Bermúdez de Castro & Nicolás, 1997), *Vulpes vulpes* (MNI = 23) and a few remains of *Panthera leo* cf. *fossilis* (MNI = 3), *Panthera* sp. (MNI = 1), *Lynx pardina spelaea* (MNI = 2), *Felis silvestris* (MNI = 1), *Canis lupus* (MNI = 1), *Martes* sp. (MNI = 3) and a small mustelid (MNI = 2) (García *et al*., 1997). The thickness of the bone breccia (and thus the amount of fossils) increases from the foot of the shaft (a few fossils at SRA test trench) towards the end of the passage. Maximum thickness of the breccia is found at excavation area B, where the bottom of the deposit has not yet been reached, although it becomes very thin at the distal excavation squares in area A (Figure 6).

The relative positions of human and carnivore fossils within the fossil-bearing bed is still being investigated, due to the fact that the undisturbed sediments so far excavated embrace only a small surface and depth, and because the uppermost part of the site was disturbed by cavers. However, there are some very important facts relating to this problem.

First, there is only one human fossil deposit, because human fossils from SRM and SRB fit with fossils from area B, and some of these fit with fossils from area A. AT-724 from SRM belongs to Cranium 8, fragments of which are also found from T-13 (AT-1543, AT-1552), S/T-12/13 (AT-1548, AT-1549, AT-1613, AT-1615), T-16 (AT-433) (all of them from area B) and R-11 (AT-1547) (area A). AT-1192, an occipital fragment from SRB fits with the occipital fragment AT-731 from U-16 (area B). Finally, the hemimandible AT-250 from Q-10 (area A) fits with the other half of the mandible AT-793 from T-15/16 (area B), the incisor AT-1461 from Q-10 (area A) fits with the mandibular fragment AT-950 from U-15 (area B), and Cranium 7 is composed of the fragments AT-240, AT-242, AT-244, AT-245 from Q-10, AT-1542 from Q-11 (all of them from area A), AT-786, AT-804 from U-15, AT-1546 from T/U-12/13 and AT-1541 from T-13 (all of them coming from area B).

The composition of the breccia is almost completely bears in the SH Ramp test pits. At SRA only a few bear fossils have been found, and at SRM and SRB only seven and nine, respectively. Human fossils were discovered among hundreds of bear fossils (specially at SRB) through the 1995 field season. On the other hand, area A has yielded many human fossils and very few bear bones. Actually, not a single bear fossil had yet been found when the human fossil discoveries of the 1989 and 1990 field seasons at area A were published by Arsuaga *et al.* (1990*a*, *b*). At that time we thought that all human fossils found in disturbed sediments came

Figure 8. Human fossils at the Sima de los Huesos. A view of the excavation grid squares U-16 and T-16 (area B) during the July 1992 campaign. All fossils in the picture are human except a bear rib fragment (top center). Among the human fossils, Cranium 5, top, Cranium 4, centre, mandible AT-605 with humeral shaft AT-660 (bottom right), and humeral shaft AT-661 (centre).

from area A. However in the following years many very complete human fossils (Crania 4, 5 and 6, complete hip bones, mandibles, etc) were found in area B, close to the northern wall of the Sima, in a layer containing almost exclusively human fossils (Figure 8).

Finally, the several tons of disturbed sediments (coming from the uppermost part of the site) yielded thousands of carnivore bones and a comparatively small number of human fossils. Furthermore, we suspect that an important number of the human fossils found in disturbed sediments come from a pit dug up by cavers in the end of area A (Arsuaga *et al.*, 1990*a*, *b*).

Our interpretation of this evidence is that there was first an accumulation of human fossils (and probably bear as well) in the Sima de los Huesos, and that there was a later accumulation of bears and other carnivores on top of the human deposit. Some mixture between both deposits could have occurred through geological processes and by the activities of bears at the site.

A sample of human and bear bones from Sima de los Huesos has been directly dated by Bischoff *et al.* (1997), by U-series and electron spin resonance (ESR), indicating a minimum age of about 200 ka, and a probable age >300 ka for the human fossils. These dates are compatible with the faunal content of the site, in terms of both large mammals (García *et al.*, 1997) and micromammals (Cuenca-Bescós *et al.*, 1997).

The human fossils in SH do not show a clear sorting or alignment, although the study of the main orientations of the fossils has yet to be finished.

To clarify the composition and origin of the SH human accumulation, we have published, in previous papers, counts of the number of the different skeletal elements, their relative

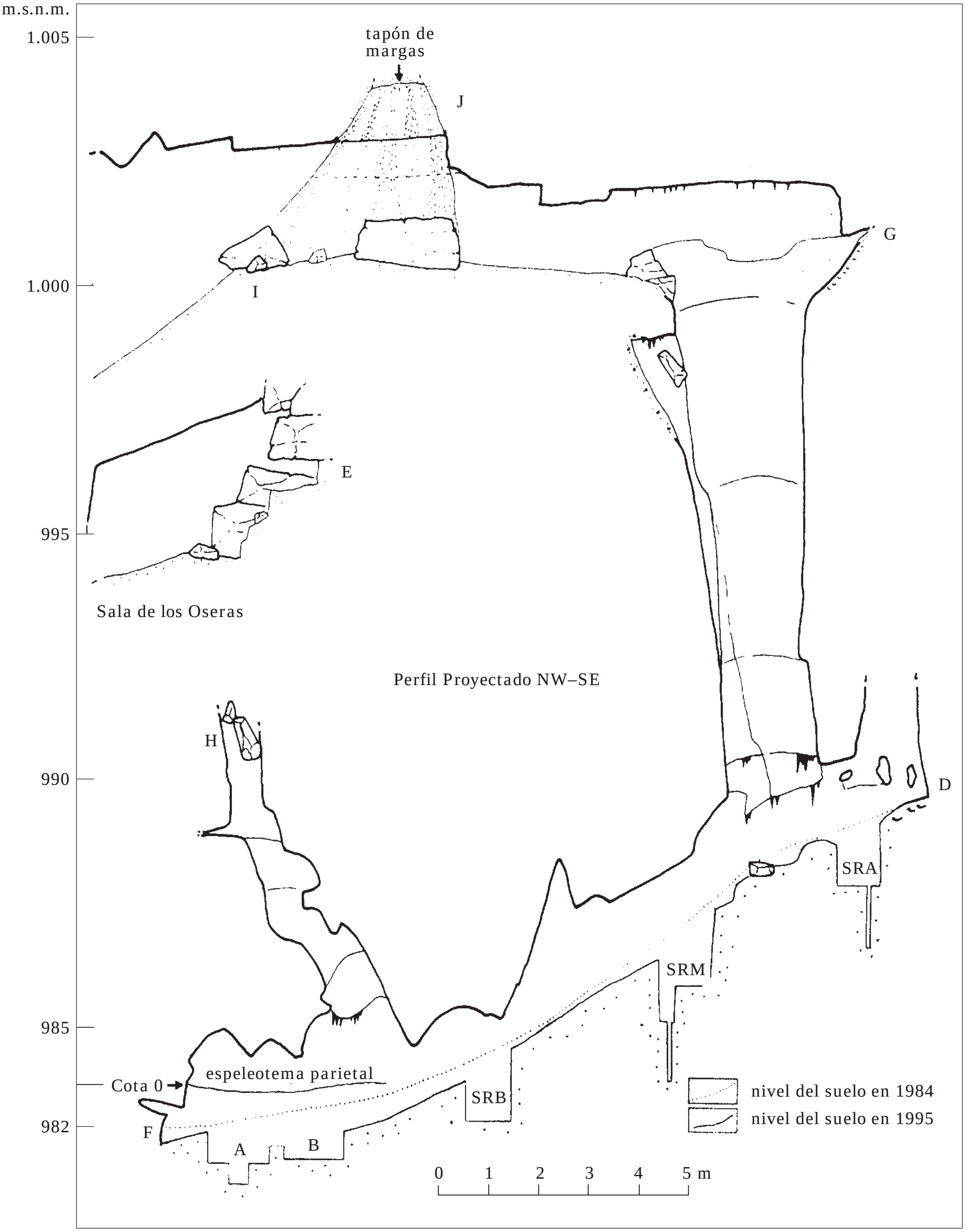

Figure 9. Sima de los Huesos profile (by G. E. Edelweiss, 1992–1996). Projection as in Figure 5. ''Tapón de margas'' indicates a cone of Neogene white marls coming from the outside. The levels of 1984 and 1995 floors are indicated, as well as a wall speleothem. The blind chimney in Sima de los Huesos behind (to the right of) the shaft, has not been completely drawn.

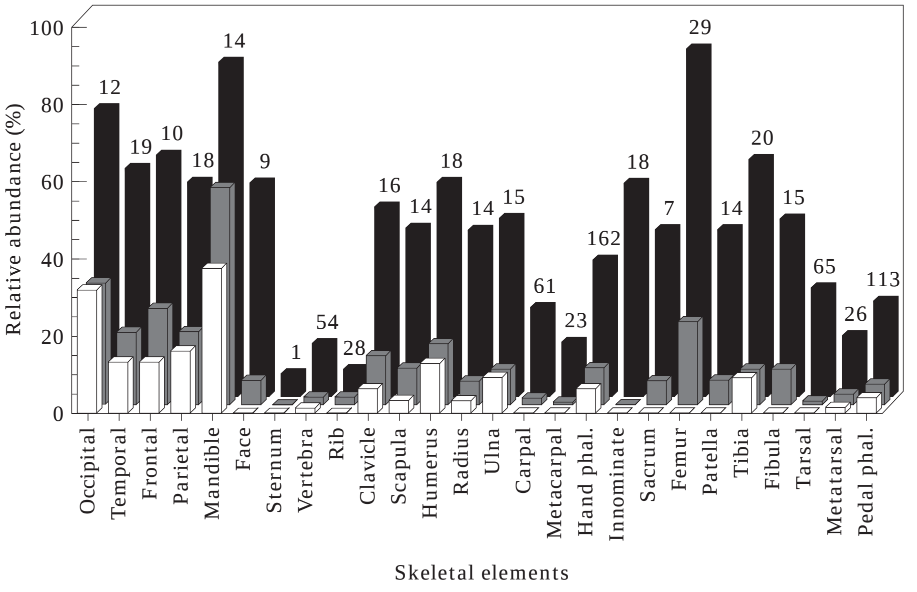

Figure 10. Relative abundance of different skeletal elements recovered up to 1989 (Carretero *et al.*, 1990), 1990 (Arsuaga *et al.*, 1990*b*) and 1995. Percentages are calculated on 16 individuals, which is the minimum number of individuals (based on femora) excluding dental evidence. Numbers above the columns represent the minimum number of skeletal elements through the 1995 field season. (□) SH'89 (Carretero *et al.*, 1990); (▩) SH'90 (Arsuaga *et al.*, 1990*b*); (■) SH'95.

frequencies, or the cumulative percentage graph of minimum number of anatomical units (Arsuaga *et al.*, 1990*a*, *b*, 1995; Carretero *et al.*, 1990). Figure 10 shows the relative abundance of different skeletal elements recovered through the 1995 field season. Figure 11 represents the cumulative percentage of the minimum number of anatomical units. The cumulative graph of Sima de los Huesos is closer to the diagonal representing complete skeletons than that of the Krapina sample and also closer than the graph calculated for SH after the 1990 field season (Arsuaga *et al.*, 1990*b*).

The main biases in skeletal part representation (i.e., relative abundances below 25% of the expectation) are against sterna, vertebrae, ribs, carpal, metacarpal and metatarsal elements. Vertebrae and sterna, having low structural density, are less resistant to post-depositional destructive forces. Ribs are usually found broken into pieces in the Sima de los Huesos and, therefore, it is difficult to distinguish between bear and human rib shafts. In general, the fragmentation of bones decreases the probability that any particular fragment will have an anatomical landmark that is diagnostic (Lyman, 1994).

However, the carpal, metacarpal and metatarsal bones have high structural density and are resistant to destruction. Although there are many of these bones in the Sima de los Huesos collection, they are clearly under-represented. Andrews & Fernández-Jalvo (1997) state that scavenging was responsible for the removal of the small skeletal elements that are missing from the human assemblage. However, hand phalanges are more delicate bones and they are better represented than other hand elements (carpal and metacarpal bones) in the Sima de los Huesos (more than 162 phalanges, representing around 40% of the expectation; Figure 10).

An alternative explanation is that the carpal, metacarpal and metatarsal scarcity could be a sampling artefact, i.e., the excavated surface is a very reduced area and the spatial distribution

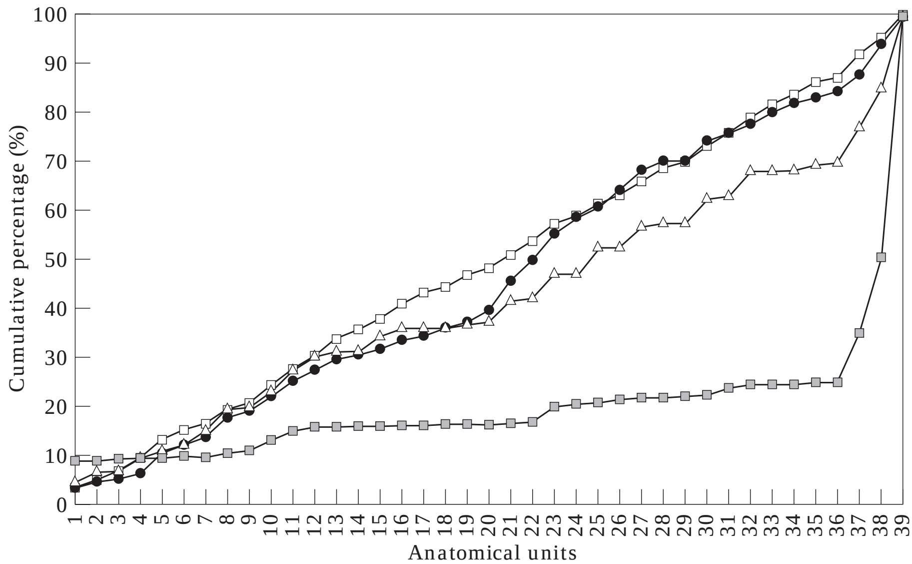

Figure 11. Cumulative percentage of the minimum number of anatomical units (MNAU). MNAU = number of bones or bone portions preserved in a sample divided by number of that bone or bone portion in a complete skeleton (Trinkaus, 1985). Data for ''buried'' and ''non-buried'' Neandertal samples and the Krapina sample from Trinkaus (1985). The anatomical units that were considered have been listed on the horizontal axis and numbered from 1–39: (1) dentition; (2) cervical vertebrae; (3) thoracic vertebrae; (4) lumbar vertebrae; (5) sacra; (6) ribs; (7) clavicles; (8) scapulae; (9) proximal humeri; (10) humeral shafts; (11) distal humeri; (12) proximal ulnae; (13) ulnar shafts; (14) distal ulnae; (15) proximal radii; (16) radial shafts; (17) distal radii; (18) carpals; (19) metacarpals; (20) hand phalanges; (21) hip bones; (22) proximal femora; (23) femoral shafts; (24) distal femora; (25) patellae; (26) proximal tibiae; (27) tibial shafts; (28) distal tibiae; (29) proximal fibulae; (30) fibular shafts; (31) distal fibulae; (32) tali; (33) calcanea; (34) anterior tarsals; (35) metatarsals; (36) pedal phalanges; (37) upper facial; (38) mandibles; (39) neurocrania. The diagonal corresponds to complete skeletons. (△) Krapina; (□) Neandertals buried; (■) Neandertals nonburied, (●) SH'95.

of skeletal elements is not necessarily homogeneous. For instance, 41 carpal bones (67·2% of the total SH sample) and 16 metacarpal bones (69·6%) were discovered in only one field season (1995). There is also a sampling bias against upper teeth compared with lower teeth and maxillae compared with mandibles. Up to the 1990 field season (Arsuaga *et al.*, 1990*b*), the ratio between upper and lower jaws (maxillary alveolar processes *vs.* mandibles) was 0·11 (1:9), and up to the 1995 field season the ratio increased to 0·57 (8:14). The upper teeth/lower teeth ratio increased for the same period from 0·60 (43:71) to 0·71 (123:173, Bermúdez de Castro & Nicolás, 1997). Among the teeth, the isolated upper teeth:lower teeth ratio increased from 0·75 (43:57) to 0·88 (96:109, Bermúdez de Castro, personal communication). Clearly, the major bias affects the teeth in the jaw and is related to the still under-represented maxillae compared with mandibles. It is obvious that the bias against upper jaws and teeth is on the decrease.

How did the carnivore and human fossils come into the Sima de los Huesos? A possible ancient way to the site is the blocked chimney in the roof of the Sima de los Huesos Chamber (Figure 9). This vertical conduit could have led (before it became blocked) to a chamber above the Sima, not accessible today. If there was once such a way, it could represent a natural trap, because it is not possible to climb up the chimney from the site. The possibility that bodies or bones (i.e., not live individuals) got into the Sima de los Huesos through this way seems unlikely, since the bone deposit extends well upslope from the chimney towards the shaft (Figure 6).

Immediately behind the Sima de los Huesos shaft, is a chimney that ends up in a cul-de-sac of bed rock (Figures 5 and 9), with no connections to other cavities. This, therefore, cannot be an ancient entrance. There are bear-claw marks high in the walls of this chimney, probably made by one or more bears that tried to find a way out.

The stratigraphic section of the Sima de los Huesos infilling suggests that it could have continued behind SRA into a passage now completely filled and indiscernible (Figure 6). This hypothetical passage could correspond to an ancient entrance to the Sima de los Huesos for both animals and humans, but it is also possible that the sediment ends in the bed rock (cave wall). In any event, if there was an ancient entrance passage leading to the bottom of the shaft in the Middle Pleistocene (i.e., when the fossils where deposited), it had to be very low, considering the relative positions of the bone-bearing layer and the hypothetical ceiling of the passage (in no case higher than the flowstone that reaches the cave wall behind the shaft's vertical). It is also possible that there was an inclined floor of marls in the Ramp first and that later deposition of clays and bones adapted to it, whatever was its origin (the shaft or another passage). Finally, sediments and bones could have had different sources.

We have also considered the possibility that the Sima de los Huesos site was not a primary deposit and that one or more mud flows carried the fossils to the Sima after primary deposition nearby (Arsuaga *et al.*, 1990*a*; see also Aguirre, 1991/92), maybe through this hypothetical filled passage. Nevertheless, although the human fossils have not been found in anatomical connection in the site, there are significant associations between different bones of the same individual or parts of the same bone, that are not easily compatible with a long transport. For instance, Cranium 5 was found disarticulated (because the neurocranial sutures were open and the face was apart), but all the pieces lay very close to each other at squares U-15/16 (i.e., almost at the end of the cavity) (Figure 8). The mandible of this skull was found below the following year. Also, a complete human pelvis was found in squares U-14/15 (the Sima de los Huesos squares have a 0·5 m side). A short transport along the Ramp with some mixing and dispersal of bones is more likely.

The most obvious ancient way to the Sima de los Huesos site is through the shaft itself, a very old dissolutional conduit and the only extant connection between the site and any other chamber (Figure 9). The upper end of the shaft is located high in the Sala de los Cíclopes, and currently, there is a steep slope from the bottom of this large chamber. *U. deningeri* bears like those found close to the shaft at test trench number 2 (Figures 3 and 4), could have accidentally fallen down, as could other carnivores more rarely (maybe attracted to the odour of the carrion).

On the other hand, near the top of the Sima de los Huesos shaft there is a roof collapse and a small cone of marls (Figures 5 and 9) similar to the Miocene marls that lie on the Cretaceous limestones of Sierra de Atapuerca, and also similar to the marls in the base of the stratigraphic sequence of the Sima de los Huesos site. According to Bartisiokas (1997), the paleoentrance at the top of the shaft of SH, in the place where the white marls are found today, can be regarded as the original entrance of this part of Cueva Mayor. This author interprets the stratigraphy of the Sima de los Huesos Ramp as corresponding to a talus cone and he believes that the bear and hominids came into the Sima de los Huesos site through the shaft. The presence of humans in the cave represents a perimortem mortuary practice, and the presence of bears was accidental as in other caves.

Andrews & Fernández-Jalvo (1997) have demonstrated the occurrence of tooth marks on some bear and human bones. These tooth marks could have been produced by trapped carnivores, including the bears. Since the Middle Pleistocene floor of the Sima de los Huesos Ramp consisted of wet clays and plastic marls (Figure 6), it is very likely that many carnivores could survive the fall through the shaft and would have helped to scatter the remains of those that preceded them, also producing tooth marks and other damages to the bones lying there. According to Andrews & Fernández-Jalvo (1997), tooth marks produced by a large carnivore are on both bear and human fossils. To these authors, large carnivore tooth marks on bear fossils would correspond only to bears and those on human fossils only to big felids. Andrews & Fernández-Jalvo (1997) based their conclusions largely on Haynes' study (1983) of carnivore gnawing, but according to Haynes (1983: p. 164), ''bones that have been only lightly gnawed (which, in our opinion, is the case of Sima de los Huesos) by lions will never be distinguishable from bones that have been lightly gnawed by bears or any other taxon''. In our opinion, the absence of herbivores makes it highly unlikely that the carnivores used the site as a den or that they (big cats in particular) introduced the remains of more than 32 human bodies into the cave in order to eat them while at the same time not one single herbivore, rabbit or bird was ever carried in.

It is more likely that human and bear bodies were already there and that carnivores came into the cave to eat the carrion. However, the large number of foxes (more than 23), and the presence of other carnivores, does not favour the hypothesis that carnivores visited the site only to scavenge and eventually died there by natural causes, and would favour the natural trap hypothesis to explain the carnivore accumulation. This should be considered as the null hypothesis (many instances are known of accumulations of enormous amounts of bear bones of the *U. spelaeus* species in caves where shafts act as natural traps). Moreover, the age-at-death profile of the bear sample in Sima de los Huesos fits better with a catastrophic profile than with an attritional pattern (García *et al.*, 1997). Actually, the Sima de los Huesos has served as a death trap for small carnivores until the present: the carcasses of a recent *Mustela* (with decaying soft tissues) and a recent fox were encountered by us at the site. Small carnivores have been seen by us inside the Cueva Mayor, and their prints and faeces tracked from the entrance to the Sala de los Cíclopes chamber. In the clayey matrix of the human and carnivore fossils, there are few remains of micromammals, namely rodents (NMI = 14), insectivores and bats, but no birds or lagomorphs (two major components of the diet of living Spanish foxes; Blanco, 1988). These microfossils show no signs of having been digested, indicating that they did not accumulate in raptor pellets or small carnivore faeces. This evidence suggests that the site was not adjacent to a cave opening (Cuenca-Bescós *et al.*, 1997).

Considering the biases of the human bone collection and their possible causes, our conclusion is that in the Sima de los Huesos there was an accumulation of human bodies and not isolated skeletal elements (Arsuaga *et al.*, 1990*b*, 1993, 1995; Carretero *et al.*, 1990; Arsuaga, 1993). We think that carnivores were not responsible for the accumulation of the human remains. In the complete absence of herbivores or stone tools, it is clear that humans were not living in the Sima de los Huesos (in the case that it had then an easier access than the shaft). The accumulation of human remains could be either catastrophic or the result of a mortuary practice. For us, the larger the number of human individuals in the accumulation, the more unlikely is the accidental hypothesis. Given the large minimum number of human individuals, the origin of the human accumulation is most likely to be anthropic (Arsuaga *et al.*, 1990*b*, 1993; Arsuaga, 1993) and, in our opinion, this explanation should be considered the null hypothesis for future tests.

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