Chapter 17

Prehistoric Human Tracks in Ojo Guareña Cave System (Burgos, Spain): The Sala and Galerías de las Huellas

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Abstract In 1969, members of Grupo Espeleológico Edelweiss discovered the Sala and Galerías de las Huellas in Ojo Guareña Cave system (Burgos, Spain). These contained hundreds of ancient human footprints, preserved in the soft sediment on the floor. These footprints represent the tracks of a small group of people who walked barefoot through these complex passages in the cave. Owing to the difficult compatibility of the documentation and preservation of these prints, it was not possible to study them before the development of new non-invasive remote sensing techniques. However, since 2012 optical laser scanning and digital photogrammetry have been used in Galerías de las Huellas, in combination with GIS techniques, to obtain a model of the cave floor, where the footprints and their internal morphology can be observed in detail. We have identified over 1000 prehistoric human footprints and at least 18 distinct trackways through the passages, which could have been left by around 8–10 individuals. Since 2016, an archaeological field study has been conducted in this sector, in order to determine and explore its surrounding area and find other archaeological evidence that may be directly associated with these tracks. Numerous remains of torches are preserved on the walls and floor in the immediate surroundings of the footprint sites. Some of them have been dated, which has

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revealed the intensive use of this underground landscape from the Upper Palaeolithic to the Mesolithic-Neolithic. However, the remains in Sala and Galerías de las Huellas date solely to the Chalcolithic, around 4300 calBP.

Keywords Human footprints · 3D laser scanner · Ojo Guareña Cave system · Exploration · ^{14}C data · Chalcolithic

Introduction

The Ojo Guareña Cave system, forming one of the most important underground systems in Spain, is located in the Cantabrian Mountains and the Upper Ebro Basin, in the north of the Province of Burgos (Spain) (Fig. 17.1a). This cave system developed in the northern flank of the Mesa-Pereda syncline (del Olmo et al. 1978), in the Coniacian (Late Cretaceous) limestone and dolomite unit. Ojo Guareña is an extensive multilevel cave system, formed by the connection of 14 caves and over 110 km of passages, distributed on 6 main interlinked levels, from a relative height of +70 m to the current level of the River Guareña (Grupo Espeleológico Edelweiss 1986; Ortega et al. 2013: 45–53).

The blind valley of San Bernabé ends at the Guareña sinkhole and contains a series of old fossil entrances perched at different heights above the River Guareña (at 692 m a.s.l.) that, together with the River Trema (karst discharge zone) and the Villamartín stream, has shaped this singular karst landscape listed as Natural and Cultural Heritage of Spain.

This karst complex contains an impressive record of human activities from at least the Upper Pleistocene. The archaeological sites were discovered at the same time as speleological explorations were taking place. The diversity and variety of archaeological remains, in more than 80 sites (Ortega and Martín 1986; Ortega et al. 2013: 164–236), include living areas in cave entrances, rock art, burials, human bones, grave goods or different archaeological objects, which demonstrate the use of this cave landscape from the Middle Palaeolithic to the Middle Ages.

The hundreds of human footprints in the soft sediment on the floor of Sala and Galerías de las Huellas I and II are among the most singular and vulnerable archaeological sites in the cave system. They were found in 1969 by members of the Grupo Espeleológico Edelweiss, during the survey of one of the most labyrinthine sectors of the system, called Dédalo Oeste (Uribarri 1969; Osaba 1969: 305–309; Rubio 2001), which is related to the geomorphologic evolution of the Guareña blind valley and San Bernabé cirque.

Fig. 17.1 (a) Situation of the Ojo Guareña karst in the Iberian Peninsula; (b) location of the Sala and Galería de las Huellas sites in the Ojo Guareña complex, with reference to the main caves; (c) map of Sala and Galería de las Huellas with an orthophoto of the PNOA (IGN, Spain); (d) longitudinal profile, projection N-S, of the Ojo Guareña Cave system in the blind valley of the Guareña River. (Modified from Grupo Espeleológico Edelweiss 1986; Ortega et al. 2013, 2014)

The Site

The Sala and Galerías de las Huellas formed in the third karst level known as Dédalo Oeste. It covers an area of 5652 m² and connects with Laberinto Otilio and Sala Negra in the fourth level. This third level is perched at 40 m above the Guareña River level and comes very close to San Tirso and Bernabé Cave, whose passages belong to the second karst level (Fig. 17.1c). Their western passages descend until they link topographically with the end of Galería de las Huellas I (GH I), although without a physical connection because of the collapse of the cave ceiling and the growth of a

large speleothem (Grupo Espeleológico Edelweiss 1986, Annex mapping 153–3; Martín 1986: 141–147; Ortega and Martín 1986: 342–343). Additionally, sediment on the San Bernabé hillsides has completely silted up the old entrances in this sector, so current access is from Palomera Cave, 1250 m to the west.

Sala de las Huellas is an enormous chamber 80 m long, 50 m wide and more than 5 m high, with large boulders that have collapsed from the ceiling and obstruct transit (Figs. 17.1 and 17.2f). Galerías de las Huellas I and II (GH I and GH II) are located on the south side of this chamber (Figs. 17.1b, 17.2c, g and 17.9a). The first gallery (GH I) consists of a main passage, 60-m-long and a 25-m-long side passage (Figs. 17.2g and 17.3d). The main axis of the second gallery (GH II) is approximately 100 m long. Both galleries are about 5 m wide and 4–5 m high (Fig. 17.3f, g).

The floor of these galleries is characterized by interior cave sediments, with a loamy texture and composition mainly of calcite, quartz, feldspar and to a lesser extent phyllosilicates (Benito-Calvo et al. 2013: 220).

Small channels have incised the floors of both galleries, particularly in the final section of GH II. The entry sections have calcite crusts, which do not register any footprints. On the contrary, the deposition of fine calcite crystals makes it difficult to recognize many of the impressions, especially in the GH I gallery.

The human traces located in these passages are very well preserved in both galleries, thanks to the protection measures that were taken at the time of the discovery, limiting access to the sites and waymarking alternative routes (Fig. 17.3). But unfortunately the difficulty of transit in the large chamber (Sala de las Huellas) led to the destruction of many traces, and only a few footprints have been preserved on large boulders (Figs. 17.2f and 17.3a).

The cave survey in this sector was finished in 1970, and Almagro invited André Leroi-Gourhan to plan a project to study the footprints, including photogrammetric analysis. Unfortunately, it never materialized. Plaster casts of two footprints were made at that time, and a sediment sample from the first passage was sent to León Pales and Michel-Alain García (Ortega et al. 2013: 178–182; 2014: 43–44). In addition, charred wood remains were collected from Laberinto Otilio in the lower level, at the bottom of a shaft from GH I, and interpreted as thrown or fallen from that gallery. They were dated to $15,600 \pm 230$ BP (Delibrias et al. 1974: 53).

New surveying in 1981 (Grupo Espeleológico Edelweiss 1986) achieved an acoustic connection between GH I and the southwestern passage in San Bernabé Cave (Fig. 17.1b). This connection motivated the dating of the speleothem plug that separates the two caves. Rainer Grün, who was visiting Spain to sample caves for his PhD, dated the speleothem to about 175 ka (pers. comm. Adolfo Eraso). This age prompted a new study of the footprints and their superpositions, in order to determine the direction of the prints through photographic and photogrammetric analysis (Galaz et al. 2000). These studies showed that the prints followed an entry and exit route within Sala de las Huellas (Galaz et al. 2000; Ortega et al. 2013: 178–182) and that they were, therefore, not connected with the passage in San Bernabé Cave.

This new study also identified traces of small carnivores (mustelid-type) especially in the eastern gallery (GH I), in whose initial section bear claw scratches are also preserved on the walls. Some charred wood remains have also been observed on

Fig. 17.2 (a) General overview of the Sala Negra; (b) charcoal samples (No 11 and 12) located in the connection shaft between Galería de las Huellas I and Laberinto Otilio; (c) charcoals in the block (No 10) of Laberinto Otilio; (d) block decorated with torch remains and charcoals in the ground (No 14, Laberinto Otilio); (e) torch remains on a block, with charcoals in the floor (No 4), of the Sala de las Huellas; (f) general view of Sala de las Huellas; (g) cross section view of the beginning of Galería de las Huellas II. (Photos (a) P. Carazo-Grupo Espeleológico Edelweiss; (b–f) M.A. Martín-Grupo Espeleológico Edelweiss)

Fig. 17.3 (a) Human footprints on a large block of the Sala de las Huellas; (b) remains of a torch under a block of Sala de las Huellas (No 1); (c) detail of a footprint of Galería de las Huellas II; (d) view of Galería de las Huellas I; (e-g) several views of the traces of the Galería de las Huellas II. (Photos M.A. Martín-Grupo Espeleológico Edelweiss)

the walls and floors of Galerías de las Huellas, although charcoal remains are more numerous in the lower passages (Laberinto Otilio and Sala Negra). In 1999, a charcoal sample from the western Galería de Las Huellas (GH II) provided a date of 3820 ± 50 BP (pers. comm. Juan Luis Arsuaga). This date was very different from the Palaeolithic date mentioned above and showed that the passages had been entered again in recent prehistory.

Access to a Complicated Sector

It was traditionally thought that the access to Galerías de las Huellas during prehistory was from the blind valley of the Guareña River or the San Bernabé cirque, given its obvious proximity (Ortega and Martín 1986: 342–343). Later, the possibility of access from San Bernabé Cave was discarded, because of the age of the collapse now blocking the cave, which is sealed by a thick speleothem (Ortega et al. 2013, 2014). Finally, direct access from outside to the Sala Negra has also been discarded, given that the current blockage of boulders, a consequence of the receding hillside, seems very stable and was already consolidated in the Neolithic, according to the dates obtained in the framework of this project (Table 17.3) (Ortega and Martín 2019).

In contrast, recent investigations into the archaeological evidence inside Palomera Cave, currently the main entrance to the Ojo Guareña Cave system, indicate that transit inside this large cave was much more frequent and intense than previously thought. This is evidenced by the succession of archaeological remains that extend up to almost a kilometre and a half from the current entrance, towards both the east and the west, belonging to different periods from prehistory to the Middle Ages.

On the route from Palomera Cave to the surroundings of Las Huellas (Fig. 17.4), several archaeological remains have been documented in the passages of Museo de Cera, Galería de la Escalada and Galería Macarroni, with confirmed prehistoric dates. The distance from the start of the latter gallery to the Sala del Cacique is barely 100 m; it is very comfortable to walk through and currently included in the tourist route. It is a further 100 m from this point to the first side passage in Galería del Cacique, which leads to Laberinto Otilio. This is the beginning of the sector studied here, where abundant charred wood marks on the walls and pieces of charcoal on the loamy floor and boulders have been identified.

There are several points of access to the Sala and Galerías de las Huellas in this area. One of them starts at the northeast end of Sala Negra, which finishes in an impressive boulder blockage (Figs. 17.2a and 17.9b), where the presence of charcoal confirms the transit, at least in the Early Neolithic (Fig. 17.9b, number 13 and Table 17.3). Another access point, which is a little more comfortable, is through a side passage that ascends gently towards Laberinto Otilio until Sala de las Huellas can be reached by climbing between boulders. As already stated, the entire route is full of charred wood marks and pieces of charcoal (Figs. 17.2b–g and 17.9).

Fig. 17.4 Map of the possible access route to the human footprint site. The *dark green* passages represent the third level of Palomera Cave and the *dark red*, the passages of fourth level. The *greenish* shadings indicate the sites with rock art and the footprint site. The *red marks* refer to other archaeological evidences (habitats, burials, transit, etc.). The *blue dashed line* represents the route of access from Palomera Cave. (Modified from Grupo Espeleológico Edelweiss 1986; Ortega et al. 2013)

This evidence suggests that, after a 1200-m-long route of easy transit through large underground passages, prehistoric humans explored a sector of Palomera Cave that is more complex because of its large size (5652 m²), intricate topography (mazes) and instability (with large embedded boulders that hinder transit). Despite this danger, at least one of the human groups that walked through this sector could have reached the upper level of the Sala and Galerías de las Huellas.

Materials and Methods

Footprint Documentation

Human footprint sites are not very common in the archaeological record because of the special requirements for their formation and preservation, although the number of cases has increased over time (Lockley et al. 2008; Bennett and Morse 2014a). These footprints provide information on human behaviour regarding the environment and on the nature of the sediments, where fine-grained substrates favour the formation and preservation of the prints (Bennett and Morse 2014b). The difficulty in balancing the documentation and conservation of these traces has conditioned their study for many years, and it only became possible with the development of non-invasive digital remote sensing technologies applied to archaeological research and heritage management (Bennett et al. 2013; Ashton et al. 2014; D. Webb et al. 2014; Citton et al. 2017).

The study of the human footprints in Ojo Guareña started in 2012. It focused on accurate three-dimensional reconstruction of Galería de las Huellas I and II, using 3D laser scanner technology and GIS methodologies (Benito-Calvo et al. 2013; Ortega et al. 2014). Sala de las Huellas was excluded from this work because of its topographic irregularity and the difficulty of transit in such a chaotic space.

The three-dimensional mapping of this site was achieved with a ScanStation C10 Leica laser scanner, with a maximum flight range of 300 m, 4 mm accuracy. Seventeen high-resolution scans were performed (5 mm at 10 m), seven in GH I and ten in GH II. The point clouds obtained were joined by a common reference system with reference targets, obtaining a mean error of 1 mm, with final point clouds that reached resolution means of 3 mm in GH I and 4 mm in GH II.

The models of the obtained surfaces were exported to GIS format, generating high-resolution digital elevation models (DEM) that show the topographic relief of the galleries with sufficient resolution to analyse the shape and distribution of the tracks (Benito-Calvo et al. 2013). The terrain roughness index (TRI) model (Riley et al. 1999) allows the irregularities of the floor to be differentiated (white colours) from the softer areas (black colours) by stressing the depressions of the best preserved footprints according to their internal morphology (sole, heel, toes, etc.).

Footprints and Trackways

This precise cartography allows the position of the tracks to be observed in relation to the morphology of the passages by identifying not only the human footprints but also the topographic elements (boulders, rocks, speleothems, crusts, channels, etc.) that form the surface and condition the presence of human footprints. This enables the reconstruction of some of the paths and movements made by these ancient visitors. All the measurements and most of the observations of the footprints have been made over the resulting three-dimensional and cartographic restitution with AutoCAD software, as it is not possible to measure them in situ, owing to the nonconsolidation of the sediment recording the traces.

Once the footprints were scanned, each of the prints was individualized.

The maximum length (FL) was measured parallel to the longitudinal axis of the footprint, while the width of the ball (FW) and the width of the heel (FWH) were measured perpendicular to the FL axis. The longitudinal axis was determined following the technique of D. Webb et al. (2006a).

From the FL and FW measurements, the footprint index (FI) was calculated, which consists of the ratio between foot width and foot length: $FI = FW/FL \times 100$.

The arch index (AI) is a widely used measurement for the purpose of classifying the foot type according to a high ($AI \leq 0.21$), normal ($AI = 0.21-0.26$) and flat ($AI > 0.26$) arch (Cavanagh and Rodgers 1987). AI was measured according to Cavanagh and Rodgers (1987), whereby a perpendicular line to the foot axis was used to divide the toeless area into equal thirds (Fig. 17.5a): rearfoot (A), midfoot (B) and forefoot (C) regions. Then, AI was calculated as the ratio of the area of the midfoot to entire toeless footprint area: $AI = B/(A + B + C)$.

Finally, arch angle (AA) or Clarke angle is defined as the angle between the medial border line of the footprint and the line connecting the most medial point of the metatarsal region of the footprint and the apex of the concavity of the arch of the footprint (Citton et al. 2017) (Fig. 17.5a). AA is a conventional measurement that classifies the internal longitudinal arch between tendency to flatness or pronation ($AA \leq 31^\circ$), normality range ($AA = 31^\circ-45^\circ$) and tendency to cavus foot ($AA > 45^\circ$) (González-Martín et al. 2017).

Estimation of Height and Weight

Many studies support the use of foot length to obtain an individual's range of height, while body mass can be estimated by the correlation between foot width and body weight (D. Webb et al. 2006a; Ukoha et al. 2013; Atamtürk and Duyar 2008; Krishan 2008; Robbins 1986).

Fig. 17.5 (a) Morphological parameters used in the current study, (1) maximum foot length (FL), width of the ball (FW) and width of the heel (FHW), (2) arch index ($AI = B/A + B + C$), (3) arch angle; (b) average and standard deviation of all biometric variables used in the current study for each track

Chronology

Another objective of this project has been to specify the chronology of the tracks in order to contextualize the activities that took place in this sector of the cave, the deep zone over 1 kilometre from the current entrance of Palomera.

To study transit and use in this sector of the system in greater depth, since 2016 we have been conducting a project with the aim of surveying and dating the surroundings of the sector, including Sala and Galerías de las Huellas, on the third level of Ojo Guareña, and Galería del Cacique and its side passages, as well as Laberinto Otilio and Sala Negra, on the fourth level, i.e. lower than Huellas and the main level within the Ojo Guareña Cave system.

Sixteen organic samples were taken for radiocarbon dating. AMS dating of 15 samples was performed at BETA Analytic Inc., between 2017 and 2019. The Gif-1721 sample, dated at the ^{14}C Gif Radiocarbon Laboratory in 1974, completes Table 17.3.

Results

Footprints and Trackways

Although the study has not yet been completed, about 700 footprints have been identified and at least 8–9 entry trackways to GH I and about 10–11 exit trackways (Fig. 17.6). Many superimposed footprints follow an apparently chaotic pattern at the junction with a side passage. This may indicate that some people explored that passage, while the others waited in the main passage.

About 500 human footprints have been identified in GH II, as well as a minimum of 7 entry trackways and 11 exit trackways towards Sala de las Huellas. In addition, the new cartography shows that one of the visitors separated from the group to inspect one of the hidden corners of the gallery (Fig. 17.7).

Fig. 17.6 Plan of the Galería de las Huellas I, from the scanner, with the identification of imprints and trackways

Fig. 17.7 Plan of the Galería de las Huellas II, from the scanner, with the identification of imprints and trackways

A preliminary study of 39 GH I footprints will be described. They are integrated in seven trackways in Galería de las Huellas I: two in an entry direction (trackways 1 and 2) and the remaining five in the exit direction towards Sala de las Huellas (Fig. 17.8 and Table 17.1). All these footprints are located on the sides of the passage and correspond to 22 right feet and 17 left feet. They are in an excellent state of preservation, with the identification of complete footprints with clear anatomical features (toes, balls, heels, etc.) in the form of a low relief in the soft loam sediment.

The measurements of the maximum lengths and widths of the footprints are given in Table 17.1.

The sample of footprints is characterized by a certain uniformity in foot length, with measurements ranging between 250 and 290 mm, resulting in average estimated heights of between 173 and 188 cm (Tables 17.1 and 17.2). This suggests that the footprints correspond to adult individuals, probably males. The foot width range shown in Table 17.2 varies from narrower traces, about 123 mm wide, to prints about

Fig. 17.8 Identification of the trackways and imprints analysed in this study. Galería de las Huellas I, Ojo Guareña Cave system

Table 17.1 Main measurements of the 39 footprints (grouped in 7 trackways) selected for this study, from Galería de las Huellas I (mm)

ID_Foot	L/R	FL	FW	FHW
1	R	251	112	79
2	L	247	129	84
3	R	247	111	81
4	L	263	128	76
5	R	259	118	88
6	L	256	134	76
7	R	266	122	80
9	R	247	106	77
10	R	257	139	109
11	R	226	121	84
12	L	255	138	11
13	R	273	112	100
14	L	258	119	82
28	R	272	155	113
29	L	245	147	72
101	R	249	117	75
102	L	264	131	100
103	R	258	134	123
104	L	272	129	92
105	R	272	139	105
106	L	256	145	97
67	L	269	124	97
70	R	274	126	104
97	L	267	148	118
98	R	292	137	90
99	L	266	123	102
100	R	271	143	106
68	R	254	124	94
76	R	271	143	82
89	L	259	136	88
90	R	267	144	106
74	R	288	132	120
85	L	290	150	108
93	R	287	150	104
108	L	257	140	103
30	R	249	116	91
31	L	264	125	108
33	L	281	156	86
34	R	273	135	105

L/R left or right, *FL* foot length, *FW* foot width, *FHW* foot heel width

Table 17.2 Estimated stature and body mass of seven trackways of Galería de las Huellas I, using different height calculation equations (mm)

Trackway	Direction	FL *	FW *	FHW *	Atamtürk (2003)	Ukoha (2013)	Krishan (2008)	Atamtürk (2003) ^a	Atamtürk (2003) ^b	Krishan (2008) ^a	Krishan (2008) ^b
1	Inlet	252 ± 10.9	123 ± 11.2	77 ± 23.9	173.34	172.627	175.63	91.95	82.18	72.92	69.85
2	Inlet	262 ± 13.2	133 ± 21.1	92 ± 18.3	178.46	175.769	179.21	99.25	89.84	75.67	75.62
100	Outlet	262 ± 8.8	132 ± 9.5	99 ± 15.6	178.26	175.646	179.07	98.79	93.52	75.50	78.40
200	Outlet	273 ± 9.5	133 ± 10.7	103 ± 9.2	183.87	179.095	183.00	99.48	95.77	75.75	80.09
230	Outlet	263 ± 7.4	137 ± 9.1	92 ± 10.3	178.76	175.954	179.42	102.06	90.29	76.73	75.96
240	Outlet	280 ± 15.6	143 ± 8.8	109 ± 7.5	187.63	181.405	185.63	106.62	98.75	78.44	82.34
300	Outlet	267 ± 13.6	133 ± 17.2	97 ± 10.7	180.81	177.216	180.86	99.25	92.79	75.67	77.85

FL foot length, FW foot width, FHW foot heel width, * median/standard deviation

^aBody mass from footprint width

^bBody mass from footprint heel width

133, 137 and 144 mm wide (Tables 17.1 and 17.2). These values stress the presence of strong individuals.

Despite the uniformity in foot size among the trackways analysed, the AI and the AA reveal some morphological differences. The AA shows a tendency to flatness or pronation in all trackways ($AA \leq 31^\circ$), except in trackway 230, which corresponds to a normal range (Fig. 17.5b). Furthermore, the AI suggests a normal arch range for all trackways, except for trackway 230, which displays a slightly high arch, and for trackway 2 and trackway 300, which display a flat arch. These flat arches according to the AI are commonly a consequence of weight-bearing activities, so it may suggest that some individuals were carrying an additional weight.

The analysed footprints belong to seven trackways, which represent a minimum of five individuals according to the direction of the trackways (two entry trackways and five return trackways) (Fig. 17.8). The length and width measurements of trackways 2 and 100 are similar, which suggests that these may belong to the round-trip trackway of the same individual, whose estimated height is about 175–179 cm. The weight calculations are more disparate, however. Depending on the chosen equations and markers, the weight could be either about 76–78 kg or 90–99 kg (Table 17.2).

Chronology

The chronology of the trackways has been determined in order to contextualize the activities that took place in this part of the cave, over 1 kilometre from the current entrance of Palomera Cave.

Delibrias et al. (1974: 53) published four radiocarbon dates from Ojo Guareña, and Sample Gif-1720 (OG2), from the footprint site, provided an age of $15,600 \pm 230$ BP, in the Upper Palaeolithic. This sample, collected in 1970, was taken from the charred remains of a torch at the bottom of a pit that connects Laberinto Otilio (lower level) with Galerías de las Huellas (upper level). In 1999, a new date of charcoal on a footprint in Galería de las Huellas II was more recent, 3820 ± 50 BP (pers. comm. Juan Luis Arsuaga), which suggests that both Palaeolithic hunter-gatherers and Chalcolithic farmers transited this sector of the cave (Ortega et al. 2013: 182).

The new survey has identified a significant amount of evidence of visits, totalling 60 records: 6 remains in Sala Negra, 23 in Laberinto Otilio and side passages of Galería del Cacique, 22 in Sala de las Huellas and another 9 in Galerías de las Huellas I and II, different from the footprints (Fig. 17.9).

In all these passages we have documented scattered remains of charred wood as well as small concentrations of charcoal and charred wood marks on the walls and boulders, to mark the rock or rekindle the torches. Several panels of bear claw scratches on the walls and abundant mustelid imprints have been documented at the beginning of Galería de las Huellas I and also in the initial section of Laberinto Otilio.

Fig. 17.9 Map of sector of the Sala and Galería de las Huellas site, separated in the different levels; (a) third level, Sala de las Huellas and Galería de las Huellas I-II; (b) fourth level, Laberinto Otilio and Sala Negra. The *black points* represent the archaeological evidences and the *red numbers* the dated samples, referred to in Table 17.3. (Modified from Grupo Espeleológico Edelweiss 1986; Ortega et al. 2014)

This survey has also documented the deterioration of the human footprints in Sala de las Huellas, in which only three areas with prints are preserved, all of them in the southern section of the great hall, on the irregular surface of the large inclined blocks covered with loam in which a few human footprints can be observed (Fig. 17.3a).

This study thus presents the results of 15 AMS radiocarbon determinations for samples from different pieces of charcoal and torches in the Otilio-Negra-Huellas sector (Figs. 17.2b-e, 17.3b and 17.9). They were selected from 55 points with charcoal identified in the archaeological surveying.

Table 17.3 reflects all the ages of the samples in the different sectors. The number refers to the identification of the sample on the maps in Fig. 17.9. The table has been divided into two groups, the upper one corresponds to the third level, with three dates from Sala de las Huellas, two from Galería de las Huellas II and one from Galería de las Huellas I. Additionally, it should be noted that we have been able to identify the 1999 sample in the field, which corresponds to sample 17.OG17.GH2.C2 (Fig. 17.9, number 3).

Regarding the fourth level of the karst, the survey of the northeast end of this sector could indicate a possible access from the San Bernabé blind valley (Figs. 17.1b, c and 17.2a), and one sample of the five identified in the blockage in

Sala Negra has been dated (Fig. 17.9b, number 13). Eight samples from Laberinto Otilio have been dated, to add to Sample GIF-1721 OG2 published in Delibrias et al. (1974: 33) (Fig. 17.9b, numbers 7–12 and 14–16).

The distribution map and chronological table of the remains (Fig. 17.9 and Table 17.3) reveal the wide chronological range from the Upper Palaeolithic to the Chalcolithic in the Laberinto Otilio-Sala Negra sector and the concentration of dates in the third level.

The Palaeolithic sample (GIF-1721 OG2) was collected by members of the Grupo Espeleológico Edelweiss at the base of the pit that separates the two Galerías de las Huellas and connects with Laberinto Otilio (Figs. 17.2b and 17.9b, number 7). The new dates from this section of the maze are concentrated in the Late Mesolithic and Initial Neolithic (Fig. 17.9b and Table 17.3). A third period corresponds to the Chalcolithic, with two dates from the upper part of Laberinto Otilio, in areas with difficult access to Sala de las Huellas.

The spatial layout of archaeological evidence in Sala de las Huellas displays a clear perimeter distribution towards Galerías de las Huellas II and I. This southern part of the hall is next to a connection between boulders with the lower Otilio maze, and several charcoal fragments are observed in both levels. The charcoal identified as number 1 from Sala de las Huellas was dated to 4080 ± 30 BP, and the charcoal from the upper part of Laberinto Otilio, number 16, was dated to 3850 ± 30 BP (Fig. 17.9 and Table 17.3).

In turn, the six samples from the Huellas Sector in the third level have ages between those two dates (Fig. 17.9a and Table 17.3). This suggests that the Huellas sector was explored in approximately 4300 calBP.

In contrast, visits in the immediately lower Otilio Sector took place in a wide chronological range from the Upper Palaeolithic to the Chalcolithic.

Table 17.3 Summary of the human footprint site ^{14}C data from charcoal, all unpublished and AMS except Gif-1721 (Delibrias et al. 1974)

No	Site	Lab-no	Sample	^{14}C BP	calBP*	calBP* (m)	Period
1	SH (floor, under block)	Beta- 518405	141.OG18.SH14	4080 ± 30	4648-4514 (68%)	4606	CH
					4806-4760 (15.8%)		
					4481-4445 (7.9%)		
2	SH (floor)	Beta- 518404	124.OG18.SH3.2	3910 ± 30	4422-4248 (95.4%)	4335	CH
3	GH-II (floor)	Beta- 463838	6.GH1	3870 ± 30	4414-4227 (89.7%)	4314	CH
					4200-4178 (4.3%)		
4	SH (floor)	Beta- 518406	144.OG18.SH21	3860 ± 30	4410-4225 (84.0%)	4301	CH
					4203-4158 (11.4%)		

(continued)

Table 17.3 (continued)

No	Site	Lab-no	Sample	^{14}C BP	calBP*	calBP* (m)	Period
5	GH-II (floor)	Beta-473662	17.OG17.GH2.C2	3820 ± 30	4299-4142 (84.9%)	4214	CH
					4126-4093 (5.3%)		
6	GH-I (floor)	Beta-473661	16.OG17.GH1.C4	3780 ± 30	4245-4081 (82.9%)	4159	CH
					4031-4009 (2.5%)		
7	LO (shaft area, connection with GH I)	Gif-1721	GOG2	$15,600 \pm 230$	19,392-18,446 (95.4%)	18,919	UP
8	LO (floor)	Beta-463837	5.LO1	6940 ± 30	7839-7689 (95.4%)	7764	ME
9	LO (hearth)	Beta-473663	18.OG17.LO1	6920 ± 30	7826-7680 (95.4%)	7753	ME
10	LO (floor, close to torch)	Beta-498596	104.OG18.LO9	6840 ± 30	7732-7610 (95.4%)	7671	ME
11	LO (wall, shaft, connection with GH I)	Beta-463836	4.LO2	5800 ± 30	6670-6503 (95.4%)	6587	EN
12	LO (wall, shaft, connection with GH I)	Beta-473664	19.OG17.LO2	5780 ± 30	6656-6499 (95.4%)	6578	EN
13	SN (floor)	Beta-518403	119.OG18.SN4	5760 ± 30	6650-6484 (95.4%)	6567	EN
14	LO (torch)	Beta-498597	105.OG18.LO15	5410 ± 30	6289-6181 (94.0%)	6234	EN
					6139-6129 (1.4%)		
15	LO (upper level)	Beta-518402	145.OG18.LO20	3860 ± 30	4410-4225 (84%)	4301	CH
					4203-4158 (11.4%)		
16	LO (upper level)	Beta-498598	106.OG18.LO19	3850 ± 30	4407-4218 (75.7%)	4286	CH
					4209-4156 (19.7%)		

SH Sala de las Huellas, GH Galería de las Huellas, LO Laberinto Otilio, SN Sala Negra, CH Chalcolithic, UP Upper Palaeolithic, ME Mesolithic, EN Early Neolithic, * calibrated with OxCal 4.2 using Intcal 13 (Bronk Ramsey 2009), m median

Discussion

An increasing number of sites with prehistoric human footprints are becoming known (Aldhouse-Green et al. 1992; Bell and Neuman 1997, 1999; Ambert et al. 2000; Facorellis et al. 2001; Onac et al. 2005; Bennett et al. 2010; Bennett and Morse 2014b; Citton et al. 2017; Ashton et al. 2014; S. Webb et al. 2006b; D. Webb et al. 2014; Atamtürk et al. 2018; Roach et al. 2016). Recent research approaching this type of site through different disciplines is contributing new knowledge of interaction between humans, the land and the environment in painted caves as special places (Pastoors et al. 2015, 2017).

The Sala and Galería de las Huellas can be framed within those sites that provide information on the use and transit of the dark zone of caves, where the tracks of old paths are preserved, but whose specific relationship with the concept of the natural, social and cultural environment is unknown (Mlekuž 2012; Moyes 2012).

In the case of the tracks in Ojo Guareña, their singularity lies in the fact that they are a long way from the possible entrance point and without a direct relationship with symbolic spaces (rock art, burials, etc.), although these exist in other parts of the cave system. The large number of traces is unique, with over 1200 footprints of a minimum of 6 individuals but probably of between 9 and 11, according to the trackways that have been counted.

The superimposition of the footprints, in opposite directions, is indicative of round-trips, which suggests a single inspection of these passages, during which some members approached the recesses of the walls or entered the side passage in GH I. These preliminary observations are visible in both of the Galerías de las Huellas passages.

It can therefore be proposed that the human footprints in the Sala and Galerías de las Huellas correspond to a single visit, possibly to explore this deep sector of the cave.

However, the human visits or tours that have been documented at different times in the Laberinto Otilio-Sala Negra sector are more difficult to comprehend. This sector is characterized by the absence of archaeological record and the isolation of the sector from places of symbolic activity. Nevertheless, this space was visited on at least four occasions in prehistory: the first about 19,000 calBP, the second moment around 7700 calBP, the third about 6500 calBP and the last time in relation with the exploration of the Huellas sector about 4300 calBP.

The results of this project show that the first significant explorations in Laberinto Otilio, a relatively comfortable maze in its initial section, took place in the Mesolithic and Early Neolithic, the times of which the first remains are preserved in Sala Negra. During more intense explorations in the Chalcolithic, the unstable final ramp of large boulders was first accessed in order to reach the upper level where their footprints have been preserved in the Sala and Galerías de las Huellas. The challenges involved in access to this sector, combined with the spaciousness of its passages and the chaotic boulders on the floor, do not facilitate an understanding

of the specific activities that took place, although they must be linked with the exploration and knowledge of the underground world.

The characteristics of this site mean that it cannot be compared with most human footprint sites, which are generally linked with the zones of habitats, or sacred or rock art sites, both in the open air and in caves (Bennett and Morse 2014b; Ashton et al. 2014; Westaway et al. 2013; Atamtürk et al. 2018). Ciur-Izbuc Cave, Romania (D. Webb et al. 2014); Bàsura Cave, Italy (Citton et al. 2017); Aldène Cave (Ambert et al. 2000); and Foissac Cave, France (García and Duday 1983), dated in the Middle Palaeolithic, Upper Palaeolithic, Mesolithic and Chalcolithic, respectively, are not associated with symbolic elements. Foissac Cave was quarried for clay in the Chalcolithic. The deep zone of Mammoth Cave (United States) was also used for mining activities (Kennedy and Watson 1997; Willey et al. 2009). However, the prehistoric traces in Jaguar Cave (Tennessee, USA) are more interesting for our case study. Watson et al. (2005) documented a single visit by a group of nine individuals about 4500 BP. The cave was never used for any specific purpose, so the tracks represent an isolated event.

The footprint site in Sala and Galerías de las Huellas similarly represents a single event, a simple exploration, but its surroundings, Laberinto Otilio, Sala Negra and Galería del Cacique, were explored earlier several times. They are in the eastern part of Palomera Cave, where different types of evidence and human activities have been identified over a distance of more than a kilometre in length. They show that during prehistory, the inhabitants of this karst transited and explored the cave until they met the sediment plug in the San Bernabé cirque, leaving marks in the underground landscape, small hearths, torches, stones or rock art, graves, etc.

This indicates that the exploration of the interior of this cave system was an activity that was carried out with certain normality. This exploration must have represented an initial contact of the underground world that they wanted to conquer and then select at a later time the different symbolic places that have contributed to the singularity of this site, which has been designated as Spanish Cultural Heritage since 1972.

Conclusion

The human footprint site of Sala and Galerías de las Huellas is one of the most important sites in the Ojo Guareña Cave system, located about 1200 m from Palomera Cave. It is dated in about 4600–4200 calBP, a range that suggests a use of the dark area of the cave in the Chalcolithic, although intensive human traffic in the immediate environment (Laberinto Otilio-Sala Negra-Sala del Cacique) is documented during the Upper Palaeolithic, Mesolithic and Neolithic.

The analyses suggest that a group of between 8 and 10 adults explored several passages in the Dédalo Oeste sector of this large cave, leaving more than 1200 footprints in the soft sediment on the floor of Galería de las Huellas. The exceptionality of this incursion is due to the complexity of access. This survey of the route taken by the explorers and their trackways is improving our knowledge of the use of

the underground world in prehistory. The analyses of the numerous evidences of transit in this big cave are helping us to understand the intensity of cave use in prehistory and especially the use of the dark zone as a symbolic and social landscape.

The research also proves the value of optical laser scanning and photogrammetry in the collection of data, analysis and preservation of the fragile footprints.

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