

A new Lower Pleistocene archeological site in Europe (Vallparadís, Barcelona, Spain)

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Here we report the discovery of a new late Lower Pleistocene site named Vallparadís (Barcelona, Spain) that produced a rich archeological and paleontological sequence dated from the upper boundary of the Jaramillo subchron to the early Middle Pleistocene. This deposit contained a main archeological layer with numerous artifacts and a rich macromammalian assemblage, some of which bore cut marks, that could indicate that hominins had access to carcasses. Paleomagnetic analysis, electron spin resonance-uranium series (ESR-US), and the biostratigraphic chronological position of the macro- and micromammal and lithic assemblages of this layer reinforce the proposal that hominins inhabited Europe during the Lower Pleistocene. The archeological sequence provides key information on the successful adaptation of European hominins that preceded the well-known fossil population from Atapuerca and succeeded the finds from Orce basin. Hence, this discovery enables us to close a major chronological gap in the early prehistory of Iberia. According to the information in this paper and the available data from these other sites, we propose that Mediterranean Western Europe was repeatedly and perhaps continuously occupied during the late Matuyama chron.

During the early Pleistocene, hominins moved into new environments outside of Africa to the Euroasian continent in one or several migratory waves (1). By developing strategies and technologies to adapt to new environments, hominins succeeded in the next several hundreds of millennia in occupying diverse habitats from eastern to western Eurasia. The pace and causes of this early colonization are still the source of intense scientific debate (2–6). According to some authorities, the first human colonization of Europe would have been episodic or intermittent, at least until the early Middle Pleistocene, and of little demographic importance (7). However, there is increasingly solid data from Spain (8–13) that clearly indicate that Europe was occupied for the first time over a million years ago, and which thus supports the “Mature Europe” hypothesis (14). In addition, paleoanthropological interpretations of the first hominins’ morphotypes suggest that there is sufficient evidence for biological continuity within the Eurasian fossil record (8, 15, 16).

Vallparadís is a recently discovered Lower Pleistocene site in the Mediterranean Iberian Peninsula, which provides sound information concerning both the ecological adaptation and the lithic technology of the hominins, and which suggests that this region has been continually settled for at least 1 million years.

Geomorphology and Sedimentology. The site is located in a sequence of intermittent fluvial and alluvial sediments on the banks of Vallparadís River at the location where it flows through the city of Terrassa (Fig. 1B). Large Quaternary fossiliferous Pleistocene deposits were discovered in this river valley during excavations in 1997 at the neighboring site of Cal Guardiola (17). From 2005 to 2007, an ≈20-m thick deposit was exposed in this area during the building of a new train station. The deposits were part of the alluvial fan of a tributary in the town of Terrassa. The sedimentary sequence was divided into two parts, separated by an erosional surface (unit 5), and is formed by a series of

interspersed layers of fluvial and alluvial origin (Fig. 1A). The fluvial layers are lutites deposited within the flood plain, weak developed river bars, and travertine formations; the alluvial layers are lutites and alluvial/colluvial conglomerates. There is also a lake-marsh layer rich in macromammals and fossil wood remains (at the bottom of unit 4). Archeological and/or paleontological remains have been found in practically all of the stratigraphic units (Fig. S1). The archeological excavation has been limited to the richest unit of the sequence (unit 7).

Unit 7 is made up of two archeological layers: the upper layer 10 and the lower layer 10c. Layer 10 has a maximum thickness of 2 m. The sediment is formed by gray-green clays and mud with angular and subangular clasts of quartz, lydite, and metamorphic rock, ranging in size from 1 mm to 1 cm in a matrix supported fabric. Layer 10c is made up of gravel and conglomerates dominated by large-scale rounded blocks (up to 40 cm thick) in a matrix supported fabric. In the NE sector of the excavation, a carbonate layer, formed of oncolithics (oncolithic rudstone), covers layer 10 and descends at a slope of 15°; the seasonal circulation of water would have created this carbonated platform through the shoaling of conglomerates. Layer 10c was probably formed by the accumulation of transported massive debris flow and to a lesser extent by sheet flows with erosive capabilities. Layer 10 was formed on layer 10c when clay was deposited as a result of dense mudflows moving in a NE-SW direction. These mudflows were caused by successive seasonal river level rises and were rapidly colonized by vegetation.

Chronological Data. Paleomagnetic analysis and electron spin resonance-uranium series (ESR-US) readings were used to date. The Vallparadís sequence shows three magnetozones: (i) an initial normal magnetozone N1 (units 8 and below), (ii) a reverse magnetozone R1 (units 4–7, inclusive), and (iii) a second normal magnetozone N2 (unit 3 and above). Stone tools have been recorded in the N2 and R1 magnetozones, the latter of which contains layers 10 and 10c (unit 7). The rodent assemblage of these layers (see below) shows that they are below the Matuyama-Brunhes boundary of 0.78 Ma. Furthermore, this rodent association is younger than that of Sima del Elefante in Atapuerca (8), which indicates that the paleomagnetic sequence as a whole is younger than the Olduvai subchron. Between units 3/4 we identify the paleomagnetic transition between the Lower and the Middle Pleistocene. Consequently, the normal magnetozone at the base of the Vallparadís section should correspond to the Jaramillo sub-

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materials were also employed, such as lydite, flint, quartzite, and metamorphic rock. All these small clasts were transported by natural processes to the site. It seems likely that the small clasts were selected intentionally and that this choice was as culturally determined and not conditioned by the kinds of raw material available (22, 23). This observation is reinforced by the fact that the conglomerates in the immediate vicinity of the site were not used to provide large blocks of raw material. All of the elements of the *chaîne opératoire* are represented and we believe that this is because the mudflows have moved the archeological record in its entirety regardless of the size and density of the lithic elements. This in turn means that the integrity of the archeological record is ensured (Fig. 2).

The flakes show the systematic use of orthogonal core reduction, mainly bipolar on anvil. This method is common at other European Lower and Middle Pleistocene sites (24–27). This knapping technique results in flakes with two opposing butts. The flakes often bear cortical surfaces, both on the butts and on the dorsal face. The bipolar flakes also tend to show trimming, or marginal retouches with a denticulate delineation on the distal extremity produced accidentally during knapping when the core was struck on the anvil with a hammerstone.

When flake detachment was extended to a new knapping plan, polyhedral and cubical forms were generated. There are a few examples of centripetal cores and *débordant* flakes. Low quantities of these centripetal elements are also present in the other Lower Pleistocene sites (24–27). The recovered anvils are flint, quartzite, and metamorphic rock. They are between 10 and 15 cm long and are flat rolled boulders upon which percussion traces and depressions can be seen. Large-size objects on cobbles (e.g., a chopper in a metamorphic rock) were found in layer 10c.

Retouched tools such as denticulates and notches were abundant. There are flakes that combine a denticulate retouch on a long side and a notch on the transversal distal end, which in many

cases forms the trihedral shape of a *bec*. This repeated retouching is the same habit that has been recorded at other sites (24, 28, 29) and is a recurrent morphotype among the assemblages produced by the first hominin populations outside of Africa.

The characteristics of the lithic record are comparable to those of other mode 1 technology (Oldowan-like) sites (1). These characteristics can be summarized as (i) the use of local raw materials in knapping processes; (ii) the mastery of orthogonal methods of core exploitation and, at this site, bipolar on anvil; (iii) the small size of the objects; (iv) short and not very intensive knapping processes; (v) the presence of large objects on cobbles (choppers); and (vi) the presence of denticulates, notches, and *becs* as morphotypes of retouched tools.

Macromammalian Fauna, Taphonomy, and Paleocological Reconstruction.

The taxonomic identification of the mammalian species indicates that they belong to the Epivillafranchian biochron (30, 31). These are: *Pseudodama vallonensis*, *Sus cf. scrofa*, *Equus altidens*, *Przemegaceros verticornis*, *Bison* sp., *Stephanorhinus hundsheimensis*, *Hippopotamus antiquus*, *Elephas antiquus*, *Lynx* sp., *Canis mosbachensis*, *Ursus deningeri*, and *Panthera gombasgoeensis*. In layer 10c, an almost complete adult cranium and other anatomically semiconnected appendicular remains of *Pachycrocuta brevirostris* were recovered. Likewise, dental and maxillary remains of *Macaca sylvanus cf. florentina* have also been recorded (32). This faunal association indicates that ecologically the site was located on an ecotone, near a river with an abundant and regular water flow.

The faunal record is dominated by cranial remains, isolated dental elements, and appendicular long bones. The skeletons are dismembered and there is an overlaying of large animal remains, which could be attributed to the differential preservation of the taphocenosis after the intense activity of scavengers. Rolling and polishing caused by water abrasion affected only 12.1% of the bones analyzed (334 bones) and always at the lowest stages of



Fig. 2. Lithic tools and faunal remains with cut marks. (1) Chopper of metamorphic rock from layer 10c, (2) cubical core of flint knapped using the bipolar on anvil method, (3) denticulate on a small cobble of lydite, (4) *bec* of quartz, (5) *bec* of flint, (6) anvil stone of flint, (7) notched of quartz, (8) denticulate of flint, (9) denticulate of flint, (10) denticulate of quartz, (11) mandible of Rhinocerotidae with several isolated short and deep cut marks in the tongue side, and (12) dorsal vertebra with two parallel short and deep cut marks in the apophysis and carnivore marks beside them.

and astragal). The absence of the rest of the skeleton probably means that the other elements were destroyed by hyenas (33, 34).

The cranial and appendicular skeleton is also better represented among the larger species. The entire sequence of scavengers' activities can be seen in the long bones, which were abandoned in the form of diaphyseal cylinders. Coprolites are abundantly represented in the deposit and the final composition of the bone collection was determined by the scavengers' activities. It is especially important to note that no hyena infant remains have been found. These would be common in a hyena den given the ethology of this species (34, 35).

The sample also shows the impact of humans on animal skeletons. Twelve elements (i.e., 5% of the sample) bear cut marks, including dismembering and defleshing, and five elements show fractures of anthropic origin (Table S6). The diversity of taxa, the skeletal elements, and the age of the individuals consumed by the hominins are consistent with a general predator strategy. The percentage of cut marks in Vallparadís is significantly higher than in other sites of the same age such as Orce, Dmanisi, and 'Ubeidiya (36, 37). The low percentage of cut marks in these sites contrasts with remains from cave sites such as TD6, where cut marks reach 25%. This high percentage in TD6 is directly related to a low incidence of scavenger activity (38).

Half of the bones with cut marks also show bite marks, which would indicate competition between hominins and large predators for the same prey (2, 39). No overlaid marks have yet been found that would enable us to determine the sequence of these actions. However, in a diaphyseal cylinder (a rhinoceros tibia), a large incision covers the whole length of the long bone. We deduced that hominins defleshed the tibia before the hyenas could consume the epiphysis and turn it into a cylinder (40). Also interesting is the low representation of bones with anthropic fractures. The possible lack of interest in bone marrow has also been observed at other sites in Eurasia and Africa and was interpreted as evidence that hominins did not act as scavengers (37).

To determine the environment of layer 10, a combination of pollen records and amphibian remains was used. At the Vallparadís site, pollen was only found at the bottom of unit 4, a lake-marsh deposit (chronologically on the Matuyama-Brunhes boundary). These data suggest that during this period, the landscape was forested with more than 60% arboreal pollen (AP), above all *Pinus*, *Quercus ilex-coccifera*, and *Corylus*. However, to gain a better insight into the environment of layer 10, we had to use a palynological analysis of the richest fossil layer (D2) at the neighboring Cal Guardiola site, which is located in the same sedimentary deposit as Vallparadís and is separated from it by less than 100 m. The Cal Guardiola site is geochronologically and biostratigraphically dated to the lower boundary of the Jaramillo subchron (41). Here, the analysis shows an open landscape with only 12% AP, including 1% of riverbank tree species. The key characteristic of this landscape is that it experienced seasonal rainfall, which would have enabled the development of megaforb meadows during the rainy seasons. This flora suggests a temperate, subarid, Mediterranean climate, with a seasonal distribution of rainfall (Fig. 3). In contrast, layer 10 has no similar pollen record; however, it does have amphibian and squamate reptile fossil remains such as the western spadefoot toad (*Pelobates cf. cultripes*), one indeterminate anuran, one indeterminate lacertid, and two colubrine snakes (*Natrix natrix* and cf. *Rhinechis* sp.). The overall association may characterize a Mediterranean landscape (meso and thermo-

Mediterranean bioclimatic levels) with sunny open-dry areas with few or no vegetation and rocky soils and laterally more humid areas with presence of water and open Mediterranean woodlands.

Conclusions

The sedimentary sequence of Vallparadís dates from the Jaramillo subchron to the early Brunhes. Lithic remains and cut marks on animal bones show that hominins were present in the area. Therefore, we hypothesize that the region was repeatedly and perhaps continuously occupied between the late Lower and early Middle Pleistocene periods. Consequently, the first European hominins were capable of reproducing and surviving for generations in the Mediterranean regions of the Iberian Peninsula. This situation continued at Vallparadís until the early Brunhes period (unit 4), when changes in the archeological record show the arrival of an arboreal landscape, the presence of a fully Galerian species such as *Cervus elaphus*, and larger lithic artifacts than those which are found in the preceding layers.

The first hominins began to expand from their original gallery forests in East Africa into other habitats, and their diet became increasingly carnivorous. This migration into other ecosystems indicates that behaviorally and technologically these early hominins were not limited to a specific distribution of resources or climatic conditions. At Vallparadís, paleoenvironmental analyses show that the local environmental conditions varied, especially in terms of rainfall. This evidence is supported by the climate models obtained from the marine, continental, and palynological records (42, 43). Nevertheless, the hominin populations of Vallparadís faced these changing climatic conditions and their effect on the prehistoric landscapes and fauna (44). The most decisive factor regarding the expansion and adaptation of hominins outside Africa was probably their carnivorous diet rather than any cultural, ecological, and even physical features (36). In the Mediterranean temperate ecosystems, hominins must have depended on animal resources for subsistence at certain times of the year. This would have led to direct competition between hominins and other large European predators and scavengers of the time (45). The hominin groups that occupied Vallparadís exploited a rich biological environment and adapted in a way that shows they were not at all selective in terms of either the prey they consumed or the raw material they used in their knapping processes. This broad adaptive strategy meant that the hominins would not have required great technological skills to exploit the resources available. Therefore, we propose that these first European hominins would have been a cohesive group of general predators that would have taken advantage of the best parts of the carcasses that they found in the areas along river banks. We also hypothesize that they had primary access to prey and, along with large predators, occupied a position near and possibly at the top of the food chain.

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