

Current events

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**Fuente Nueva-3 (Orce, Granada, Spain)
and the first human occupation of
Europe**

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Introduction

The section of Fuente Nueva (in the Orce region) comprises sediments that form part of the infilling of the intramontane Guadix–Baza Basin, which was isolated in the Betic Chain (Southern Spain). This chain was formed after the collision between the meso-Mediterranean block (Internal Zones of the Betic Chain) and the South Iberian continental margin (External Zones). This collision took place during the Middle Miocene. The sediments infilling the basin are from Upper Miocene, Pliocene and Pleistocene, with abundant outcrops and an excellent paleontological record.

The most recent sediments of the basin infill are continental, with a clear distinction between two domains, marginal and distal. The Guadix formation is the most important among the marginal ones (fluvial sediments), while the Baza formation is the most representative of the distal domain (mainly lacustrine sediments).

The local stratigraphy of the Fuente Nueva sector (Figures 1 and 2) is made up of three members belonging to the Baza Fm: Lower (lacustrine calcareous), Middle (fluvial detrital), and Upper (lacustrine silty-calcareous) (Vera *et al.*, 1985; Soria *et al.*, 1987). Two sections have been studied: FN-1 and FN-3.

In the FN-1 section, all the members are represented (Lower member: from bottom to 3 m; Middle member: from 4 m to 12 m; and Upper member: from 13 m to top), while in the FN-3 section, only the Upper member occurs (Figure 2).

Paleomagnetism

The FN-1 section (see Figures 1 and 2) was chosen for paleomagnetic studies (Oms *et al.*, 1996) because it is the most complete of the area. Along the section, 24 sites were sampled *in situ* with a drilling machine and also by hand using a special device for soft sediments. At least, three cores were collected from each site. Samples were cleaned with thermal demagnetization

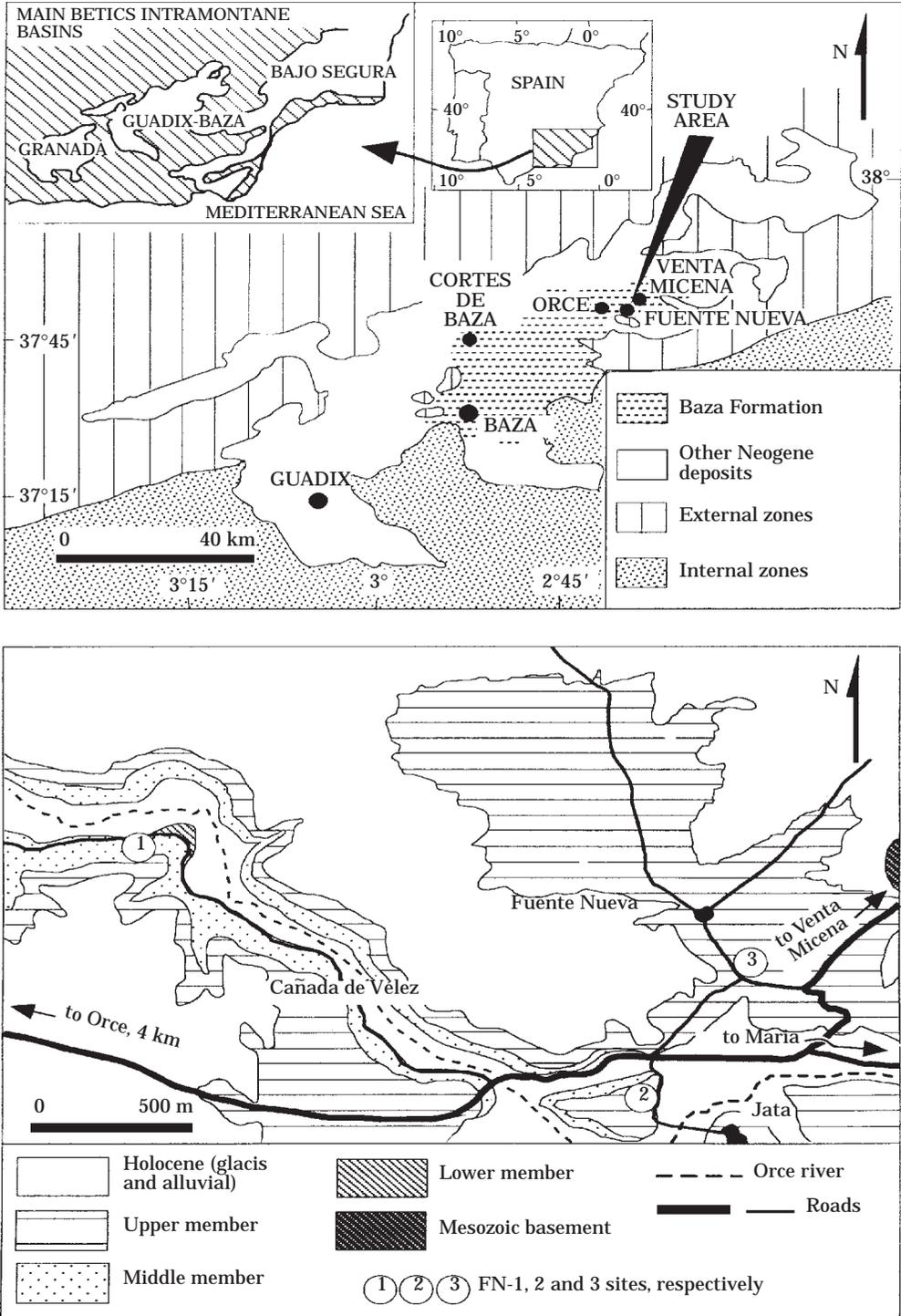


Figure 1. Schematic geological map of the Guadix-Baza basin (top) and location of the studied or referred sections (bottom) (modified from Soria *et al.*, 1987).

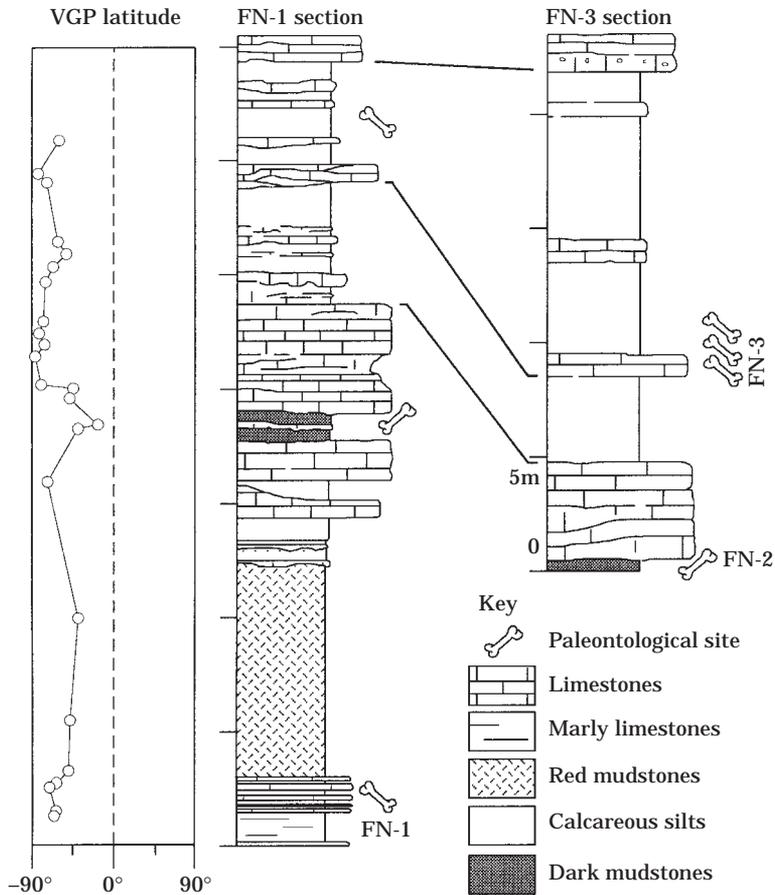


Figure 2. Paleomagnetic results (latitude of the virtual geomagnetic polarities, after Oms *et al.*, 1996) of the Fuente Nueva-1 section (FN-1) and stratigraphic correlation with the Fuente Nueva-3 section (FN-3). Paleolatitudes are always negative, thus indicating a deposition before the Brunhes normal epoch. See location of the sections in Figure 1. The archeological site at Fuente Nueva-3 comprises the span from 9 m to 14 m in the FN-3 section.

and the remanence was measured using a cryogenic magnetometer. Stepwise demagnetization was carried out in up to 13 steps of about 40°C. Demagnetization was always stable enough to derive paleomagnetic field components. The demagnetization of samples is composed of two components (Figure 3). Initially there was a secondary component that generally was removed at maximum temperatures between 150 and 275°C. Next, at higher temperatures between 350–500°C, a primary characteristic remanent magnetization (ChRM) was removed. For each sampling level, the mean virtual geomagnetic pole (VGP) was calculated from the level averaged ChRM direction. Along the section, only a clear succession of reversed paleopoles was observed, although some normal chronozones may not have been sampled or may not be represented because of a hiatus. The studied section must have been deposited before the Brunhes normal polarity chron. According to the correlation on Figure 2, the FN-3 section would be located in the reversed chronozone found at the FN-1 section.

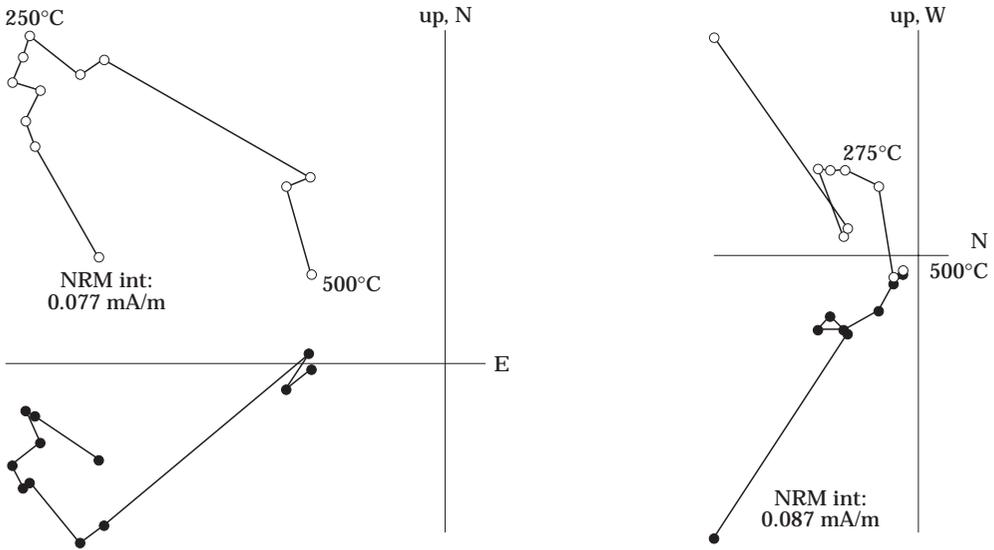


Figure 3. Standard Zijderveld (orthogonal) plots of limestones of the FN-1 section. Note a normal secondary component (attributed to an overprint of the present-day field) and a primary characteristic remanent magnetization (ChRM). Some samples required the use of demagnetization circles to recover the ChRM.

The mean of all the secondary components was attributed to the present-day field direction and may have been caused by recent weathering of rocks. The mean of the characteristic components (Oms *et al.*, 1996) was coincident with those expected for the reversed paleopoles from the stable zone of the Iberian Peninsula.

Stratigraphic synthesis of the archeological site of Fuente Nueva-3

The locality under study is found in carbonatic sediments of the section (see Figure 2). In this area it was possible to conduct a precise geological study of the sedimentary cycle of the paleo-lake of Orce to a depth of some 5 m. From one upper limestone level to another lower limestone and marl level, six geological units have been identified (see Table 1): (I) assemblage of limestones and marls; (II) carbonated clays; (III) clays and silts; (IV) carbonated clays and marls; (V) green clays oxidized at their summit; (VI) marly limestones.

Parallel with this deposit, three archaeological levels with an extension that can be exploited for more than 100 m² have been identified. These are characterized by an accumulation of fauna and the more or less abundant presence of lithic artefacts. The archaeological level 1 is found in the geological unit III, the archaeological level 2 in the geological unit V, and the archaeological level 3 in the geological unit VI. Since deposition, the stratigraphic sequence has not suffered any significant post-depositional modifications.

Faunal assemblage

The assemblage of mammal fauna at Fuente Nueva-3 includes the following species: *Mammuthus meridionalis*, *Hippopotamus antiquus*, *Stephanorhinus etruscus*, *Equus altidens*, *Megaloceros*

Table 1 Fuente Nueva 3: stratigraphic synthesis

Geological stratigraphy	Archaeological stratigraphy
Assemblage I Level 1 hard limestone Level 2 limestone with nodules Level 3 limestone and marls	
Assemblage II Level 4 gray carbonated clays Level 5 darker carbonated clays Level 6 white carbonated clays Level 7 marled carbonated clays	One manuport in level 5
Assemblage III Level 8 gray-green clays Level 9 blue-green silt Level 10 layered clays All possibly with carbonated lenses	Level 1 minor lithic industry, abundant macrofauna (elephant, hippopotamus, rhinoceros, horse, bovids, deer) and microfauna.
Assemblage IV Level 1 carbonated clays passing laterally into limestones and clays with limestone nodules	
Assemblage V Level 12 oxidization of level 13a or 13b Levels 13a and 3b clays (13a) or greenish sands (13b)	Level 2 abundant lithic industry (numerous debitage products, nuclei and "pièces esquillées", and their waste products), and fauna (horse, elephant, bovids, red deer), rare microfauna.
Assemblage VI Level 14 limestone passing into marls with limestone nodules Level 15 hard limestone	Level 3 lithic industry and fauna (horse, rhinoceros).

(*Megaceroides solilhacus*, *Cervus* sp., Bovini cf. *Bos* sp., Bovini gen. et sp. indet., *Hemitragus* sp., *Megantereon whitei*, *Ursus* sp., *Hystrix major*, *Allophaiomys bourgondiae*, *Allophaiomys chalinei*, *Mimomys savini* and *Mimomys oswaldoreigi*).

This faunal assemblage is associated with Lower Pleistocene contexts and is totally distinct from any associated with the Middle Pleistocene, present in the Baza basin at the locality of Cúllar Baza-1 (Ruiz Bustos, 1976), and very different from the Upper Pliocene fauna found in the Lower member at the site of Fuente Nueva-1 (FN-1) (Moyà-Solà *et al.*, 1987). The macromammals of Fuente Nueva-3 correspond to those of Fuente Nueva-2 (FN-2) in the same area and the neighbouring site, Venta Micena, situated some 3 km away in the same basin, where the fossil register is more ample and more widely known (Martínez Navarro, 1991; Palmqvist *et al.*, 1996). In this last deposit there exists evidence of a truly spectacular change of fauna produced in the Lower Pleistocene, as a result of the arrival in Europe of new Asiatic and African immigrants. The former consists mainly of ruminants, and the latter essentially of carnivores such as *Pachycrocuta brevirostris* (Howell & Petter, 1980) and *Megantereon whitei* (Martínez Navarro & Palmqvist, 1995), as well as *Hippopotamus antiquus* and *Equus altidens* (Guerrero *et al.*, 1997). In the latter site the presence of *Homo* sp. has been cited (Gibert *et al.*, 1994; Gibert & Palmqvist, 1995; Martínez Navarro, 1996), but due to continuing problems concerning the taxonomical determination of the piece VM-0 (Agusti & Moyà-Solà, 1987; Palmqvist, 1997; Moyà-Solà & Köhler, 1997) it is impossible, as of yet, to confirm this presence. However, a faunal assemblage similar to that of Venta Micena and Fuente Nueva-3

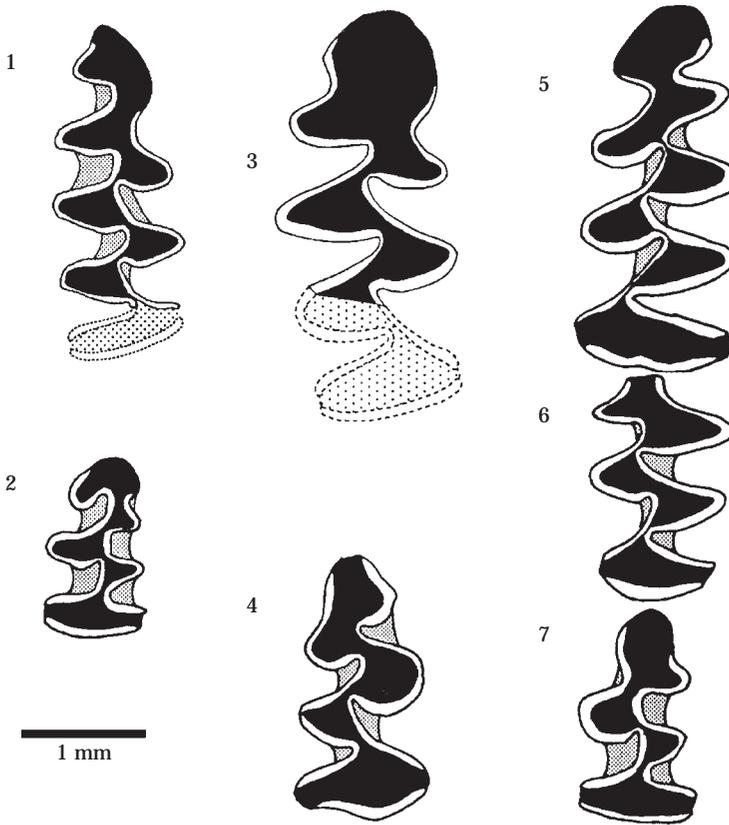


Figure 4. Arvicolids from archaeological level 1 at Fuente Nueva-3: (1) *Allophaiomys bourgondiae*, right lower M1; (2) *A. bourgondiae*, left upper M3; (3) *Mimomys savini*, right lower M1; (4) *M. savini*, right upper M3; (5) *Allophaiomys chalinei*, left lower M1; (6) *A. chalinei*, left lower M2; (7) *A. chalinei*, left upper M3.

has been recorded at the sites of Dmanisi (East Georgia), where there exists evidence of a human presence (Dzparidze *et al.*, 1989; Gabunia & Vekua, 1995), and at Apollonia-1 and Ravin de Voulgarakis (Mygdonia Basin, Macedonia, Greece) (Koufos, 1992; Kostopoulos & Koufos, 1994; Kostopoulos, 1996; Martínez Navarro & Palmqvist, 1996).

Regarding micromammals from the archaeological level 1 (see Figure 4), *Allophaiomys bourgondiae* of Fuente Nueva-3 presents a morphology identical to some examples of species from Monte Peglia B (Italy) (*Allophaiomys* sp. B) (Van der Meulen, 1973). *Allophaiomys chalinei* of Fuente Nueva-3 displays a primitive morphology, with enamel differentiation of the *Mimomys* type, similar to several examples of the type-locality from Cueva Victoria (Spain) (Alcalde *et al.*, 1981). *Mimomys savini* is represented by large-sized specimens similar to those found in other localities of the Gaudix-Baza Basin, such as Loma Quemada-1. *Mimomys oswaldoreigi* is a smaller but more highly evolved form of *Mimomys* that until the present has been recorded only in the southern part of the Iberian Peninsula (Agusti *et al.*, 1993).

The assemblage of large and small mammals and the degree of evolution of *Allophaiomys bourgondiae* (as well as of *Allophaiomys chalinei*) indicates that this locality is older than the lowermost levels of the Gran Dolina of Atapuerca (Spain), which are characterized by the following assemblage of mammals: *Homo* sp., *Ursus* sp., *Felis sylvestris*, *Crocuta* sp., Proboscidea

indet., *Equus caballus*, *Sus scrofa*, *Cervus elaphus* aff. *acoronatus*, *Dama* cf. *clactoniana*, *Capreolus* sp., *Bos* cf. *primigenius*, *Pliomys episcopalis*, *Iberomys huescarensis*, *Stenocranius gregaloides*, *Terricola arvalidens* and others (Carbonell *et al.*, 1995; Cuenca *et al.*, 1995). This assemblage of the Gran Dolina of Atapuerca also includes some examples of *Allophaiomys chalinei*, but these, unlike those of Fuente Nueva-3, have enamel that is undifferentiated, or of the type *Microtus* (Cuenca *et al.*, 1995).

All of this seems to indicate that the site of Fuente Nueva-3 occupies an intermediate biostratigraphical position between the levels with a diversified microfauna of rodents without roots (*Microtus arvalidens* zone) (Van der Meulen, 1973) and the levels with *Allophaiomys pliocaenicus*, such as Venta Micena or Fuente Nueva-2. The lowermost levels of the Gran Dolina of Atapuerca are located in a reverse interval of Matuyama period (chron 1r.1r) while the highest levels are found in the normal period Bruhnes (chron 1n) (Parés & Pérez-González, 1995). Outside the Iberian Peninsula the deposit of Le Vallonet (France) also shows positive polarity, which has been correlated with the short normal period Jaramillo (chron 1r.1n) or with the older Bruhnes (base of the chron 1n) (Bonifay, 1980). As in the case of the Gran Dolina of Atapuerca, this locality contains examples of *Microtus nivaloides* (Chaline, 1985), more highly evolved than *Allophaiomys bourgondiae* of Fuente Nueva-3.

The Fuente Nueva series shows a record from the Upper Villanyan (MN17 zone at the site of FN-1) to the Upper Biharian (*Allophaiomys bourgondiae* zone) but the normal interval Olduvai (chron 2n) has not been localized, probably because of a hiatus. All the section must be included in the Matuyama period, where the FN-1 level must be located in the interval 2r (pre Olduvai), and the FN-2 and FN-3 levels in the interval 1r (post Olduvai) (Oms *et al.*, 1996) probably in the chron 1r.2r. Similar results have been obtained in other parts of the Guadix-Baza basin, the Cortes de Baza section (Oms *et al.*, 1994). Based on this interpretation the Fuente Nueva-3 site is situated below the lowermost levels of the Gran Dolina of Atapuerca, probably one age before the normal interval Jaramillo (chron 1r.1n).

Lithic artefacts

The lithic artefacts of Fuente Nueva-3 are composed of limestone cobbles and knapped flint (Tixier *et al.*, 1995; Turq *et al.*, 1996). The former, around 100 altered objects, show no traces of having been intentionally worked. The diverse types of limestones present certain particularities of the modules, all weighing between 100 g and 2 kg, making it difficult to explain their presence at the site by any natural agent. The flint materials—composed until now of 114 pieces, 60 of them found *in situ* and the other 54 when cleaning the surface—originate from the alluvial formations of the paleo-channels which fed the lake. All display unquestionable signs of having been intentionally worked, and are found essentially in the archaeological level 2 (see Figure 5). All stages of the *chaîne opératoire* (operational/reduction sequence) are represented. The debitage (stone working) was performed with a hard, stone hammer (indicated by double bulbs of percussion and Siret-type accidents). The butts are cortical, plain, inclined, and rarely faceted. The intended use is still unclear, but apparently multiple (debitage products with nearly complete cutting edges, relatively thin flakes, rare cortically-backed flakes). The debitage modes are diverse, with reduction beginning directly from a raw block, or from a large flake (exploiting the inferior surface). The most frequent type consists of short series with relatively frequent changes of the debitage surface. The orientation of detachments can be unipolar, which yields products with a blade-like tendency, or centripetal. These characteristics are more common in the Middle Palaeolithic assemblages than in the more ancient series. In the assemblage from the archaeological level 2 a large

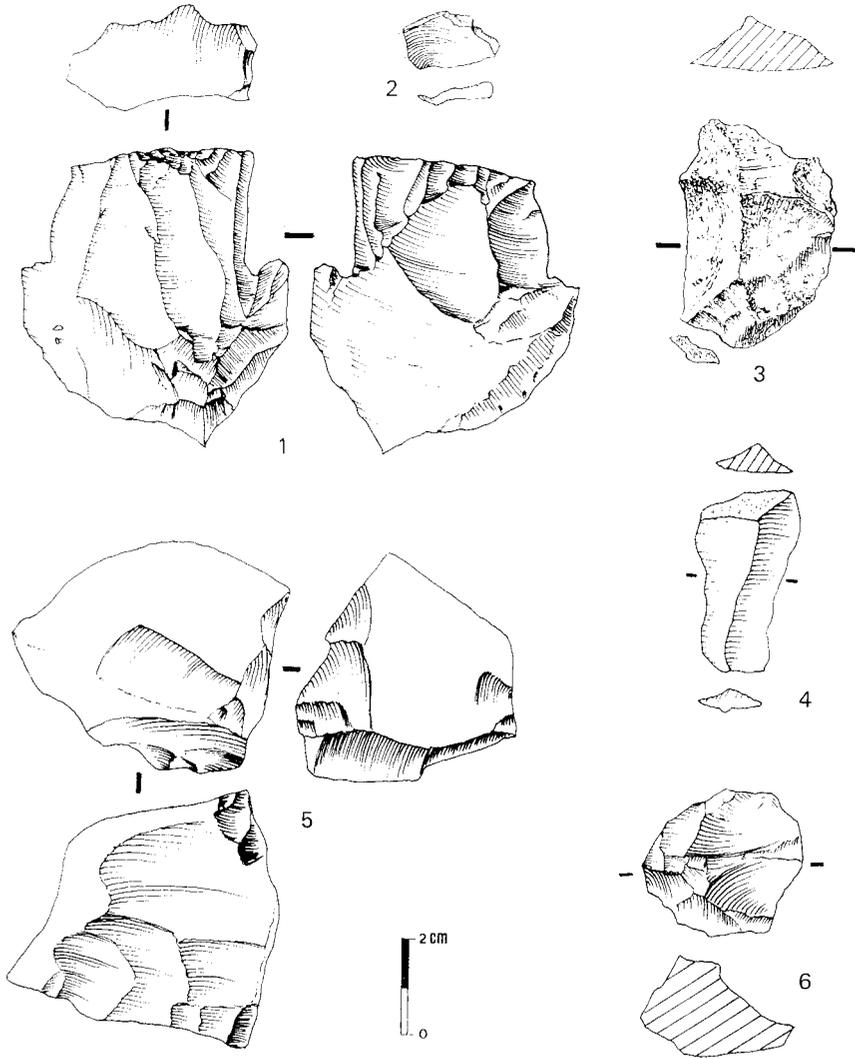


Figure 5. Lithic artefacts from archaeological level 2 at Fuente Nueva-3: (1) core with a blade-like tendency, (2) flake, (3) flakes and (4) core with centripetal orientation of detachments, (5) core with relatively frequent changes of the debitage surface, and (6) "pièce esquillée".

number of flakes are transformed, probably through utilization, into "pièces esquillées". These later, and the "bâtonnets", which are the characteristic fragments, represent by themselves close to 25% of the artefacts. Retouched tools are exceptional but present, represented by scrapers, notches and denticulates.

Conclusions

This lithic sequence, dated to the Lower Pleistocene, as with that of the base of the Gran Dolina of Atapuerca (TD-6) (Carbonell *et al.*, 1995), which may be slightly more recent

confirms the existence in Western Europe of lithic industries older than 0.5 Ma BP (Dennell & Roebroeks, 1996). It represents a lithic assemblage that is original within the context of known Lower Palaeolithic series in Europe, displaying characteristics which more readily evoke those of the evolved Olduvai in East Africa (Roche, 1989), Olduvai (Leakey, 1971, 1975), or of the site, NY 18, Nyabusosi (Texier, 1995), which is dated between 1.5 and 2.0 Ma BP. These industries do not possess for the moment any criterion which would allow them to be included within the Acheulian (absence of bifacial working and of large flake production). The lithic sequences are few in both deposits (Fuente Nueva-3 and TD-6) and proceed from a very limited excavation, and thus do not permit the formation of definite conclusions, but these lithic artefacts are clearly distinct from our present image of the first European tools, which until now we have believed to be essentially composed of modified cobbles.

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References

- Agustí, J., Castillo, C. & Galobart, A. (1993). Heterochronic evolution in the late Pliocene–early Pleistocene Arvicolids of the Mediterranean area. *Quat. Int.* **19**, 51–56. Oxford.
- Agustí, J. & Moyà-Solà, S. (1987). Sobre la identidad del fragmento craneal atribuido a *Homo* sp. en Venta Micena (Orce, Granada). *Estud. Geol.* **43**, 535–538.
- Alcalde, G., Agustí, J. & Villalta, J. F. (1981). Un nuevo *Allophaiomys* (Arvicolidae, Rodentia, Mammalia) en el Pleistoceno inferior de Sur de España. *Acta Geológica Hispánica* **16(4)**, 203–205.
- Bonifay, M. F. (1980). Relations entre donnés isotopiques océanique et l'histoire des grandes faunes européennes plio-pleistocéniques. *Quatern. Res.* **14**, 251–262.
- Carbonell, E., Bermúdez de Castro, J. M., Arsuaga, J. L., Díez, J. C., Rosas, A., Cuenca, G., Sala, R., Mosquera, M. & Rodríguez, X. P. (1995). Lower Pleistocene Hominids and Artifacts from Atapuerca-TD-6 (Spain). *Science* **269**, 826–830.
- Chaline, J. (1985). *Histoire de l'homme et des climats au Quaternaire*. Paris: Doin.
- Cuenca, G., Canudo, J. I. & Laplana, C. (1995). Los arvicólidos de los niveles inferiores de Gran Dolina (Pleistoceno inferior, Atapuerca, España). *Rev. Española Paleontol.* **10**, 202–218.
- Dennell, R. & Roebroeks, W. (1996). The earliest colonization of Europe: the short chronology revisited. *Antiquity* **70**, 535–542.
- Dzaparidze, V., Bosinski, G., Bugianisvili, T., Gabunia, L., Justus, A., Klopotovskaja, N., Kavavadze, E., Lordkipanidze, D., Majsuradze, G., Mgeladze, N., Nioradze, M., Pavlenisvili, E., Schmincke, H-U., Sologasvili, D., Tusabramasvili, D., Tvalcrelidze, M. & Vekua, A. (1989). Der altpaläolithische Fundplatz Dmanisi in Georgien (Kaukasus). *Jahrbuch des Römisch-Germanischen Zentralmuseum Mainz* **36**, 67–116.
- Gabunia, L. & Vekua, A. (1995). A Plio-Pleistocene hominid from Dmanisi, East Georgia, Caucasus. *Nature* **373**, 509–575.
- Gibert, J. & Palmqvist, P. (1995). Fractal Analysis of the Orce skull sutures. *J. hum. Evol.* **28**, 561–575.
- Gibert, J., Sánchez, F., Malgosa, A. & Martínez, B. (1994). Découvertes de restes humains dans les gisements d'Orce (Granada, Espagne). *C.R. Acad. Sci. Paris* **319(II)**, 963–968.
- Guerrero, S., Eisenmann, V., Palmqvist, P. & Martínez-Navarro, B. (1997). Morphometric study of the Venta Micena equid, and its comparison with extant and fossil horses from the New and Old World. (In prep).
- Howell, F. C. & Petter, G. (1980). The *Pachyrocata* and *Hyaena* lineages (Plio-Pleistocene and extant species of the Hyaenidae). Their relationships with Miocene icittheres: *Pallhyaena* and *Hyaenaictitherium*. *Geobios* **13(4)**, 579–623.
- Kostopoulos, D. (1996). The Plio-Pleistocene artiodactyls of Macedonia: systematic, palaeoecology, biochronology, biostratigraphy. Ph.D. Dissertation, University of Thessaloniki, 540 pp+annexe.
- Kostopoulos, D. & Koufos, G. D. (1994). The Plio-Pleistocene artiodactyls of Macedonia (Northern Greece) and their biostratigraphic significance; preliminary report. *C.R. Acad. Sci. Paris* **318(II)**, 1267–1272.

- Koufos, G. D. (1992). The Pleistocene carnivores of the Mygdonia Basin (Macedonia, Greece). *Ann. de Paléont.* **78(4)**, 205–257.
- Leakey, M. D. (1971). *Olduvai Gorge*, 3. Cambridge: Cambridge University Press.
- Leakey, M. D. (1975). Cultural patterns in the Olduvai Sequence. In *After the Australopithecines, mouton*, pp. 476–493.
- Martínez Navarro, B. (1991). Revisión sistemática y estudio cuantitativo de la fauna de macromamíferos del yacimiento de Venta Micena (Orce, Granada). Ph.D. Dissertation, University Autònoma of Barcelona.
- Martínez Navarro, B. (1996). Similarities between skull fragment VM-0 from Orce (Spain) and the *Homo erectus* holotype from Trinil (Java). *Rev. Española Paleont.* **11**, 120–121.
- Martínez Navarro, B. & Palmqvist, P. (1995). Presence of the African Machairodont *Megantereon whitei* (Broom, 1937) (Felidae, Carnivora, Mammalia) in the Lower Pleistocene site of Venta Micena (Orce, Granada, Spain), with some considerations on the Origin, Evolution and Dispersal of the Genus. *J. Archaeol. Sci.* **22**, 569–582.
- Martínez Navarro, B. & Palmqvist, P. (1996). Presence of the African saber-toothed felid *Megantereon whitei* (Broom, 1937) (Mammalia, Carnivora, Machairodontinae) in Apollonia-1 (Mygdonia Basin, Macedonia, Greece). *J. Archaeol. Sci.* **23** in press.
- Moyà-Solà, S., Agustí, J. & Marín, M. (1987). Fuentesnuevas-1: nueva localidad con mamíferos del Plioceno superior de Guadix-Baza (Granada, España). *Paleont. i Evol., Mem. Esp.* **1**, 87–93.
- Moyà-Solà, S. & Köhler, M. (1997). The Orce Skull: Anatomy of a mistake. *J. hum. Evol.* **33**, 91–97.
- Oms, O., Dinarès Turell, J. & Parés, J. M. (1996). Resultados paleomagnéticos iniciales de la sección plio-pleistocena de Fuente Nueva (Cuenca de Guadix-Baza, Cordilleras Béticas). *Rev. Soc. Geol. España* **9**, 89–95.
- Oms, O., Garcés, M., Parés, J. M., Agustí, J., Anadón, P. & Julià, R. (1994). Magnetostratigraphic characterization of a thick Lower Pleistocene lacustrine sequence from the Baza basin (Betic Chain, Southern Spain). *Phys. Earth Planet. Int.* **85**, 173–180.
- Palmqvist, P. (1997). A critical re-evaluation of the evidence for the presence of hominids in Lower Pleistocene times at Venta Micena, Southern Spain. *J. hum. Evol.* **33**, 83–89.
- Palmqvist, P., Martínez Navarro, B. & Arribas, A. (1996). Prey selection by terrestrial carnivores in Lower Pleistocene paleocommunity. *Paleobiology* **22(4)**, 514–534.
- Parés, J. M. & Pérez-González, A. (1995). Paleomagnetic Age for Hominid Fossil at Atapuerca Archaeological Site, Spain. *Science* **269**, 830–832.
- Roche, H. (1989). Pliocene and Pleistocene archeological sites west of the lake Turkana, Kenya. *Oss* **14**, 97–98.
- Ruiz-Bustos, A. (1976). Estudio sistemático y ecológico sobre la fauna del Pleistoceno medio en las depresiones granadinas. El yacimiento de Cúllar de Baza 1. Ph.D. Dissertation, University of Granada.
- Soria, F. J., López-Garrido, A. C. & Vera, J. A. (1987). Análisis estratigráfico y sedimentológico de los depósitos neógeno-cuaternarios en el sector de Orce (depresión de Guadix-Baza). *Paleont. i Evol. Mem. Esp.* **1**, 11–34.
- Texier, P. J. (1995). The Oldowan assemblage from NY 18 site at Nyabusosi (Toro-Uganda). *C.R. Acad. Sci. Paris* **320(IIa)**, 647–653.
- Tixier, J., Roe, D., Turq, A., Gibert, J., Martínez Navarro, B., Arribas, A., Gibert, L., Gaete, R., Maillo, A. & Iglesias, A. (1995). Présence d'industrie lithique dans le Pleistocène de la région d'Orce (Grenada, Espagne): quel est l'état de la question? *C.R. Acad. Sci. Paris* **321(IIa)**, 71–78.
- Turq, A., Martínez Navarro, B., Palmqvist, P., Arribas, A., Agustí, J. & Rodríguez Vidal, J. (1997). Le Plio-Pleistocene de la région d'Orce, province de Grenade, Espagne: Bilan et perspectives de recherche. *Paleo* **8** 161–204.
- Van der Meulen, A. (1973). Middle Pleistocene Smaller Mammals from the Monte Peglia (Italy) with special reference to the phylogeny of *Microtus* (Arvicolidae, Rodentia). *Quaternaria* **17**, 1–144.
- Vera, J. A., Fernández, J., López, A. C. & Rodríguez, J. (1985). Geología y estratigrafía de los materiales Plio-Pleistocenos del sector Orce-Venta Micena (Prov. Granada). *Paleont. i Evol.* **18**, 3–11.