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# DATING AND CORRELATION OF EARLY HUMAN OCCUPATION IN THE BAZA FORMATION (GUADIX-BAZA BASIN, SE SPAIN)

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**Abstract**
The magnetostratigraphic and paleontologic studies carried out in the sections of Fuente Nueva and Cortes de Baza-Cúllar in the Guadix-Baza Basin (SE Spain) have enabled an accurate calibration of the early-middle Pleistocene sites of this basin and their correlation with other early Paleolithic localities in the Mediterranean area (Atapuerca, Le Vallonet, Isernia, Ubeidiya). The paleontological record (rodents) in the Cortes de Baza section indicates an age ranging from the earliest Pleistocene (latest Villanyian or early Biharian) to the late early Pleistocene (late Biharian). The whole Cortes de Baza Section is placed in a reverse magnetic interval identified as the upper part of the Matuyama chron. This datum confirms an upper Matuyama, pre-Bruhnes age for the archaeological site of Fuente Nueva 3. Also in the Guadix-Baza Basin, the section of Cúllar Baza, where the Middle Pleistocene (early Toringian) paleontologiucal and archaeological site of Cúllar-Baza 1 is placed, has been extended to the early Pleistocene (late Biharian). Thus, the locality of Cúllar-Baza B is placed in a reversed magnetozone correlated with the uppermost Matuyama, while the locality of Cúllar-Baza C is placed in a normal magnetozone correlated to the lower Bruhnes epoch. Therefore, the site of Cúllar Baza 1 falls well within the Bruhnes epoch. This result is consistent with what is found in other early-middle Pleistocene sections of Spain (Atapuerca Gran Dolina) but is in contrast with the upper Matuyama age initially given for the Paleolithic site of Isernia.

**Keywords**
Early Paleolithic, paleomagnetic dating, Early Pleistocene, Guadix-Baza Basin.

## Introduction

Study of earliest human occupation in Europe is usually hampered by the absence of an accurate chronostratigraphic background ("dating") of the early to early-middle Pleistocene sites (Roebroeks and Kolfshoten, 1995). This is best exemplified in the Iberian peninsula, where uncertainities on the age of several early Paleolithic localities such as El Aculadero or Puig d´en Roca remain as a main topic of discussion (Raposo and Santonja, 1995). In spite of the existence of several mammal sites, the interpretation of this record is often confused because of the absence of long terrestrial sections with reference localities, suitable for an accurate biostratigraphic and magnetostratigraphic correlation. In this context, a noticeable exception is the Guadix-Baza Basin (SE Spain), where a number of fossiliferous levels are located in long sections which have being calibrated magnetobiostratigraphically (Agustí, 1986; Oms *et al*., 1994; Garcés *et al*., 1996; Agustí *et al*., 1997). After years of dubious and controversial findings (Gibert and Palmqvist, 1995; Moyà-Solà and Köhler, 1997; Palmqvist, 1997), the paleoanthropological interest of this basin has been raised again after the description of lithic artefacts at Fuente Nueva-3, a well calibrated stratigraphic site of early Pleistocene age (Martínez-Navarro *et al*., 1997). Besides Fuente Nueva-3, other previously described early Paleolithic sites such as Cúllar Baza-1, in the Baza Formation, deserve interest for the question of the first settlement of the basin (Vega-Toscano, 1989; Raposo and Santonja, 1995). Recent magnetobiostragraphical work undertaken in some sections of the Baza Formation enable the authors to calibrate these previous findings and correlate them with other Mediterranean sites. Several paleomagnetic studies have been carried out in different sections in the Baza Formation (Oms *et al*., 1994, Oms *et al*., 1996, Garcés *et al*., 1996) with the aim of constraining the Pliocene and Pleistocene continental biozonations.

Concerning the two studied sections in the present work, the paleomagnetism of the Cortes de Baza section has been previously discussed by Oms *et al.* (1994) and has furnished a sucession of 43 sites with continuous reversed polarities. Thus, here we only report the paleomagnetic results concerning the Cúllar Baza section.

## Geological setting

The Guadix-Baza Basin is an intramontane basin located in the Alpine Betic chain, south of the Iberian Peninsula (fig. 1). This chain has a

complex structure of fold and thrust sheets that can be grouped in two areas: the Internal zone (basically made up of Paleozoic and Triassic basement units) and the External zone (made up of Cenozoic and Tertiary cover units). Such areas belong to the mesomediterranean block and the southiberian margin, respectively. They collided during the Middle Miocene and raised the chain (Sanz de Galdeano and Vera, 1992). The Guadix-Baza Basin sediments were deposited in a depression spread over the two zones and the contact between them (fig. 1). Such sediments are Upper Miocene, Pliocene and Pleistocene in age and provide excellent exposures of terrestrial flat rocks that host a large number of Pliocene and Pleistocene paleontological sites (Agustí, 1986).

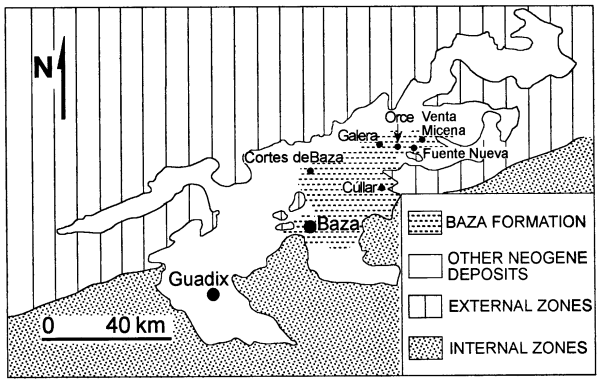



Figure 1. Geological sketch map of the Guadix-Baza Basin and extension of the Baza Formation.

The paleogeography of the basin depicts two main environments: a distal and a marginal one (Vera, 1970). The first one is mainly alluvial and is basically represented by the conglomeratic Guadix Formation and the second one is mainly made up of rocks belonguing to the Baza Formation (Vera, 1970). The Baza Formation is widely spread in the central area of the basin and records a deposition in a slightly saline lake (Anadón *et al*., 1986). Vera *et al*. (1985) provided a clear and useful characterization of the main stratigraphic features of the Orce - Fuente Nueva - Venta Micena area. Three members were differentiated in the Baza formation: (1) a lower "calcareous member", (2) a middle "red detrital member", and (3) an upper "silty calcareous member" (hereafter abridged as lower, middle and upper members, respectively). Above all these materials a topmost level was also distinguished.

The lower member is mainly built up by limestones that were deposited in a shallow lacustrine environment with occasional subaerial exposure and terrigenous supply. The middle member is formed by reddish mudstones and sandstones that resulted from the deposition in an alluvial plain with small channels and palustrine areas. The upper member was built up by limestones (calcretes and others), carbonate silts and dark mudstones, all of them deposited in a lacustrine environment with a thin water lake level where episodes of vegetation expansion occurred. The topmost level was interpreted as piedmont and alluvial fan deposits located at the margins of the basin that evolved to a glacis towards the center of the basin. In general, all these deposits are considered to record a lake flanked by minor fluvial currents that formed small coarse grained deltas.

The age of the Baza Formation ranges from the late early Pliocene (MN15, Upper Ruscinian; Agustí, 1986; Garcés *et al*., 1997) to the middle Pleistocene (Torinagian; Agustí *et al*., 1987b). Numerous paleontological sites are described in several studies (Agustí, 1986; Agustí *et al*., 1987a and b) and most of them are restricted to the triangle defined by the villages of Orce, Cortes de Baza and Cúllar Baza where excellent exposures of flat lying materials occur. The sites here reported belong to the most recent outcrops of the Baza formation and are located in a similar latitude in the basin.

## The Fuente Nueva section

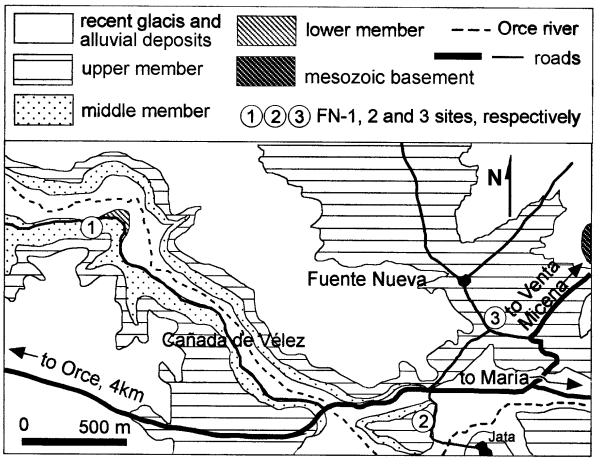



Figure 2. Geological map (after Vera *et al*., 1985 and Soria *et al*., 1987) of the Fuente Nueva sector and location of the three main sites.

The Fuente Nueva sector hosts a number of fossiliferous localities (fig. 2 and 3) which are included in three main sections. The Fuente Nueva-1 section displays the lower, middle and upper members of the Baza Formation (see the former paragraph). The lower member is mainly build up of whitish limestones that host the Fuente Nueva 1 site (see later). They can be observed in

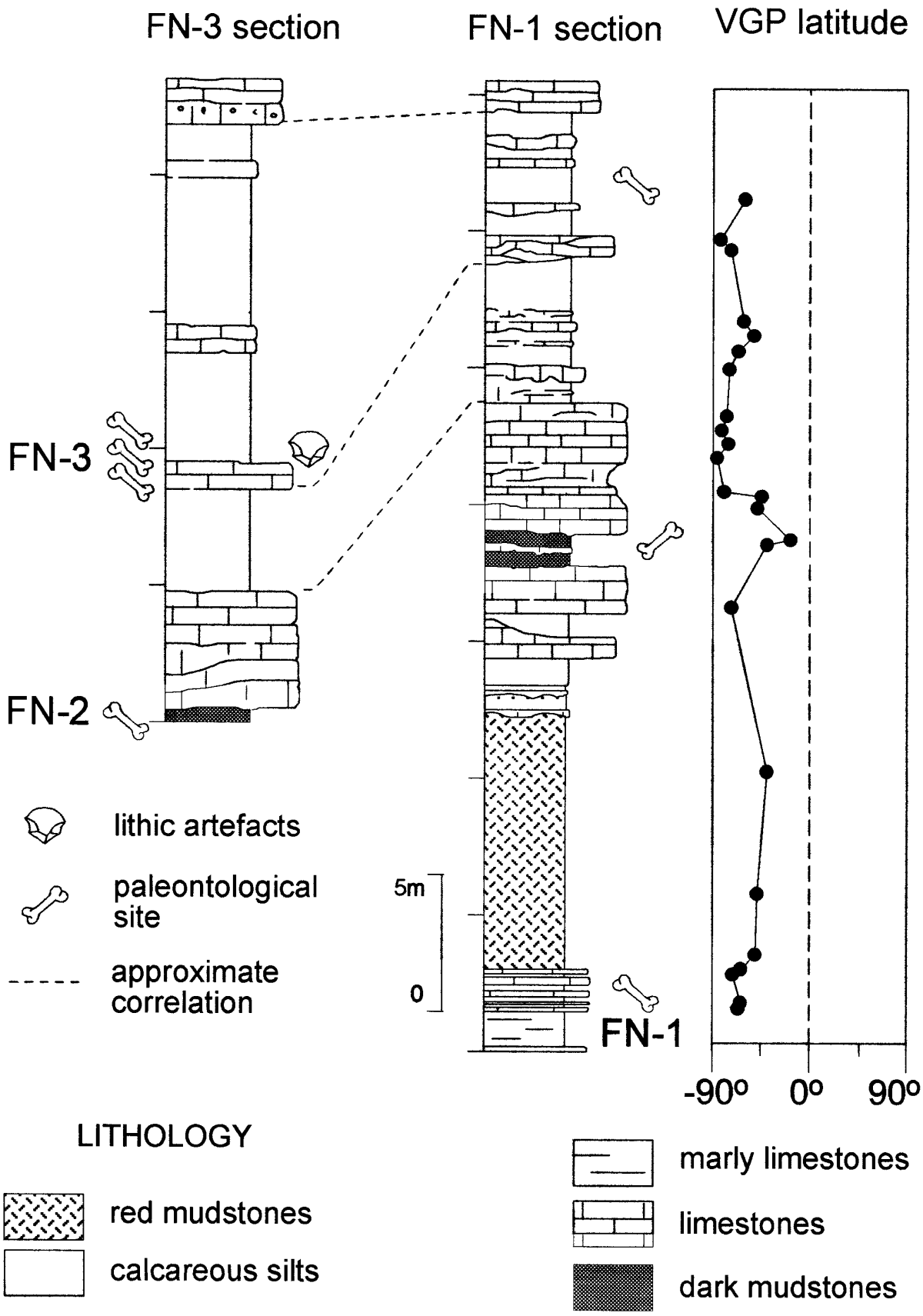



Figure 3. The Fuente Nueva-1 section (redrawn from Martínez-Navarro *et al*., 1997) and tentative correlation to the Fuente Nueva-3 section. Paleomagnetic results by Oms *et al*., 1996.

the road bend where large flint nodules are found. The middle member is built up of soft materials (mostly reddish mudstones) that are generally covered. On the other hand, the upper member is pretty well exposed as spectacular limestone cliffs, although other lithologies are found.

Fuente Nueva-1 is the oldest mammalian paleontological site at the Orce - Fuente Nueva area. It was discovered during the construction of the road that follows the south lowermost side of the Cañada de Vélez, between Fuente Nueva and the town of Orce. The site is placed in the lacustrine calcareous lower member of the Baza Fm, just below the middle fluviatile member (Vera *et al.* 1985). A first field-campaign by a joint team of the Institut of Paleontology M. Crusafont (Sabadell) and the Department of Paleontology of the University of Granada (1982-1985) led to the recovery of several remains of a typical late Pliocene (MN 17) association with *Gazella borbonica, Equus stenonis vireti, Mimomys* sp. (aff. *medasensis*), *Castillomys crusafonti ssp.* and *Apodemus dominans* (Moyà-Solà *et al.* 1987, Marín, 1987). This association can be correlated with other late Pliocene (MN 17) localities in Spain such as La Puebla de Valverde, Valdeganga 1-2 and Rincón 1, and is younger than the MN 16 site of Villarroya.

The Fuente Nueva 2 site, placed between Fuente Nueva 1 and 3, delivered an early Biharian mammal association including *Allophaiomys pliocaenicus, Apodemus* aff. *mystacinus, Castillomys crusafonti, Hystrix major* and *Equus stenonis granatensis* (Agustí *et al*., 1987a; Marín, 1987). *Allophaiomys pliocaenicus* from Fuente Nueva 2 coincides in size and morphology with the specimens from Venta Micena 1 and 2 and suggests a similar age. The other faunal elements in Fuente Nueva 2 are also present at the famous site near Orce, thus confirming the isochrony of both localities. The main interest of this locality comes from its intermediate position between the two other large mammals sites in the section, Fuente Nueva 1 and Fuente Nueva 3.

The site at Fuente Nueva-3 was found on May the 5th, 1991 by the amateur archeologist Mr. Alain Bocquet, who in the same day reported the finding to one of us (BMN). The locality is found in carbonate sediments of the Fuente Nueva section in the Upper lacustrine silty-calcareous member of the Baza Fm (Vera *et al.*, 1985). In this area during the excavations made the last week of April of 1994 and all August of 1995, it was possible to conduct a precise geological study of the sedimentary cycle of the paleo-lake of Orce to the depth of some 5 m. From one upper limestone level to another lower limestone and marl level, six geological units have been identified:

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

The assemblage of mammal fauna at Fuente Nueva-3 includes the following species (Martínez-Navarro *et al*., 1997): *Mammuthus meridionalis, Hippopotamus antiquus, Stephanorhinus etruscus, Equus altidens, Megaloceros (Megaceroides) solilhacus, Cervus sp.,* Bovini *cf. Bos sp.,* Bovini gen. et sp. indet., *Hemitragus sp., Megantereon whitei, Ursus sp., Hystrix major, Allophaiomys burgondiae, Allophaiomys chalinei, Mimomys savini, Mimomys oswaldoreigi* and *Castillomys crusafonti.* The assemblage of small and large mammals at Fuente Nueva-3 and the degree of evolution of *Allophaiomys bourgondiae* and *A. chalinei* shows that this locality is older than the lowermost levels of the Gran Dolina of Atapuerca. In accordance with these biostratigraphic and paleomagnetic data (Oms *et al.* 1996; Martínez Navarro *et al.* 1997), this site is located in the reverse Chron 1r.2r, below the Jaramillo normal event (Chron 1r.1n).

The lithic artefacts from Fuente Nueva 3 are composed of limestone cobbles and knapped flint (Tixier *et al.* 1995; Turq *et al.* 1997; Martínez Navarro *et al.* 1997). 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, make 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. All the 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 facetted. 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 interior 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 Paleolithic assemblages than in the more ancient series. A large number of flakes are transformed, probably through utilization, into "pièces esquillées" in the assemblage from the archeological level 2. These layer, 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.

This lithic sequence, together with that of the base of the Gran Dolina of Atapuerca (TD-6) (Carbonell *et al.* 1995), confirms the existence in Western Europe of lithic industries older than 0.5 Ma (Dennell and Roebroeks, 1996). It represents a lithic assemblage different from the typical Lower Paleolithic series in Europe, displaying characteristics which more readily evoke those of the evolved Oldowan in East Africa.

**The Cortes de Baza-Cúllar composite section**.

The Cortes de Baza section (see figs. 1 and 5) is located in the western area of the Baza Formation and has been reported in some previous works (Peña *et al*., 1977; Oms *et al*., 1994). The studied outcrop (road cut east of the Cortes de Baza village; see fig. 1) displays 135 m of yellowish silts and silty sandstones, limestones, silty mudstones and a few dark mudstones. Sometimes levels with gypsum occur and are known as Benamaurel Evaporites. Most of the sediments are laminated and fine-grained. Sediments (both clastics and carbonates) may have a laminated appearance. Limestones never record palaeosoils as happens in all the marginal areas of the Baza Formation (Orce and Cúllar areas). In general, all the sedimentary record account for sediments being deposited in the depocenter of a relatively shallow lake where wave reworking can be recognized.

The Cortes de Baza section includes at least three fossiliferous levels which have yielded significant remains of micromammals. These levels are called CB 1, CB 41 and CB 88. The level of CB 1, at the base of the series, has delivered an abundant microfauna including *Mimomys* cf. *blanci*, *Mimomys* sp., *Castillomys crusafonti* and *Apodemus* aff. *sylvaticus*. *Mimomys* cf. *blanci* is a small, advanced *Mimomys* species probably related to *Mimomys oswaldoreigi* from the locality of Gilena 2 (Agustí *et al*., 1993). The anteroconid cap is short and the anteroconid complex presents a straight neck. An enamel island is present in the third upper molars. Together with these species, a second larger *Mimomys* is represented by few teeth. It could represent a member of the *M. tornensis-M. malezi* lineage. The CB 1 assemblage, with its advanced *Mimomys* species is typical of the latest Villanyian-earliest Biharian localities such as Schambach (Koenigswald, 1977). Above the CB 1 level, *Mimomys* cf. *blanci* is still present in the level CB 18 of the Cortes de Baza section.

The most significant level above the lower levels of the section is CB 41, characterized by the presence of a more evolved *Allophaiomys* species assigned to *Allophaiomys* cf. *vandermeuleni.* This form is represented by large sized molars with abundant cement and bearing undifferentiated or slightly *Mimomys*-like enamel. In the first lower molars the anteroconid cap is very simple and T1, T2 and T3 (*sensu* Meulen, 1973) are communicated. *Allophaiomys vandermeuleni* is a typically Iberian arvicolid species, previously defined in the early Biharian site of Barranco Conejos, in the Guadix-Baza Basin (Agustí, 1991).

Above the level CB 41, no significant assemblages of rodents have been found. However, the level CB 88 delivered fragments of a rootless arvicolid bearing *Microtus*-type enamel. In spite of their scarcity, this material indicates that at least a *Microtus* (s.s.) species was already present at this level in the Cortes de Baza section.

The palaeontological record (rodents) in the Cortes de Baza section indicates an age ranging from the earliest Pleistocene (latest Villanyian or early Biharian) to the late Early Pleistocene (late Biharian). In the Guadix-Baza Basin, the Middle Pleistocene (early Toringian) was already known at the locality of Cúllar-Baza I, but new studies in the area enabled also the recognition of Early Pleistocene deposits in the lower part of the section.

The Cúllar area (fig. 4) is classically known because of the occurrence of the Cúllar-Baza 1 palaeontological and archaeological site, which delivered an abundant early Middle Pleistocene (early Toringian) fauna including small and large mammals associated with an early Paleolithic industry (Vega-Toscano, 1989). This fauna includes *Arvicola cantiana, Iberomys brecciensis, Allocricetus bursae duranciensis, Apodemus* aff. *sylvaticus, Eliomys quercinus helleri, Lepus* cf. *granatensis, Canis etruscus, Crocuta crocuta, Mammuthus trogontherii, Equus altidens, Equus sussenbornensis, Stephanorhinus hundsheimensis, Sus* cf. *scropha, Bison* sp., *Capra* sp. and *Megaceros savini (*Ruiz-Bustos and Michaux, 1976; Alberdi *et al*., 1989). On the other hand, stratigraphically below the Cúllar-Baza-1 site there are other localities (levels of Cúllar B and C), as seen in figure 5.

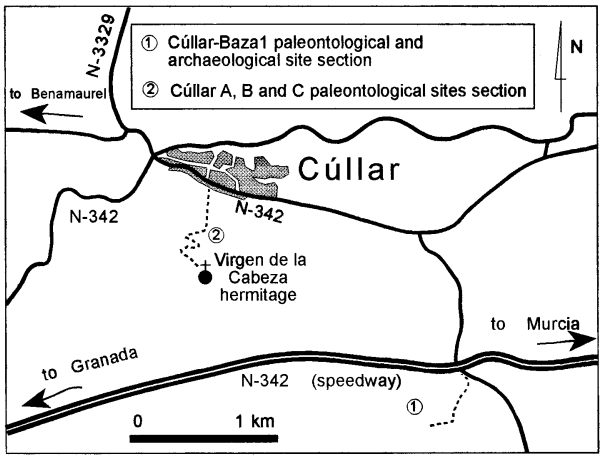



Figure 4. Location of the Cúllar Baza 1 and Cúllar A, B and C sites. 1. lower Cúllar section; 2. upper Cúllar section.

The lower Cúllar section (Cullar B and C fossiliferous levels) belongs to a set of outcrops adjacents to the village, in the south rim of the Cúllar river. The section is located in the eastern boundary of the Baza formation and also the edge of the basin and includes the locality of Cúllar-Baza 1 as well as the ones resulting from the new samplings in the area. The Cullar B and C localities resemble the Cortes de Baza area depositional environment (sandy distal lake with few evidences of subaerial exposition).

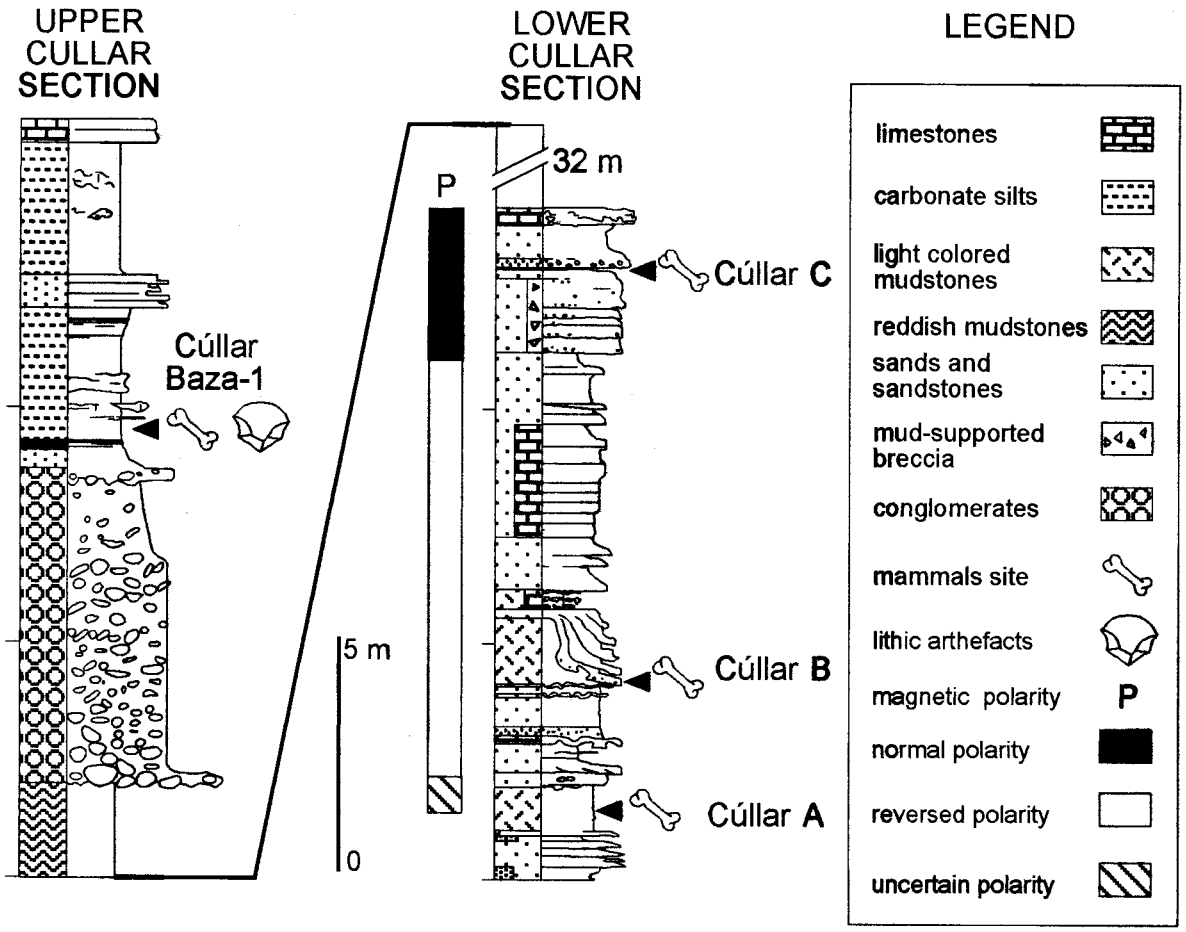
The most significant faunal element at the level Cu -C is *Terricola arvalidens*. 10 m below this level, the level of Cu-B still delivered some remains of *Castillomys crusafonti*, a relictual murid that became extinct before the beginning of the Middle Pleistocene and which is already absent in the lowermost levels of Atapuerca TD (uppermost Biharian).

**Calibration of Early to Middle Pleistocene sites in the Baza Formation and correlation with the Mediterranean record**

The magnebiostratigraphic calibration of the Cortes de Baza and Cúllar sections sheds light on some of the previously existing datings of early to middle Pleistocene sites with lithic artefacts in Europe. The whole Cortes de Baza section presents a long reverse interval that has been identified as the upper Matuyama chron (Oms *et al*., 1994). The level of CB-41 is characterized by the presence of advanced specimens of species *Allophaiomys vandermeuleni* and can be therefore ascribed to the early Biharian. *Allophaiomys vandermeuleni* appears as the most plausible ancestor for *Terricola jordanica* from Ubeidiya (Agustí, 1992), a conclusion which is reinforced by the morphology and morphometrics of the specimens from Cortes de Baza.

The presence of an evolved microtine with *Microtus* enamel differentiation in the level of CB 88 indicates that the boundary between the early Biharian (*Allophaiomys pliocaenicus* Zone) and the late Biharian (characterized by advanced *Allophaiomys* species with *Microtus* enamel differentiation; *Allophaiomys burgondiae* Zone) is placed within the upper part of the Matuyama chron.

The lower part of the Cúllar section which contains the level of Cu-B with *Castillomys crusafonti* is still in a reverse magnetized interval. On the contrary, the level of Cu-C, with *Terricola arvalidens*, is placed in the normal interval at the top of the series. The Cúllar section is in a stratigraphic position above the Cortes de Baza section (fig. 5 and 6), although it is difficult to exactly quantify the vertical span between the two areas. This means that the short reversed interval at the base of the Cúllar section, where the level of Cu-B is placed, still belongs, as the whole Cortes



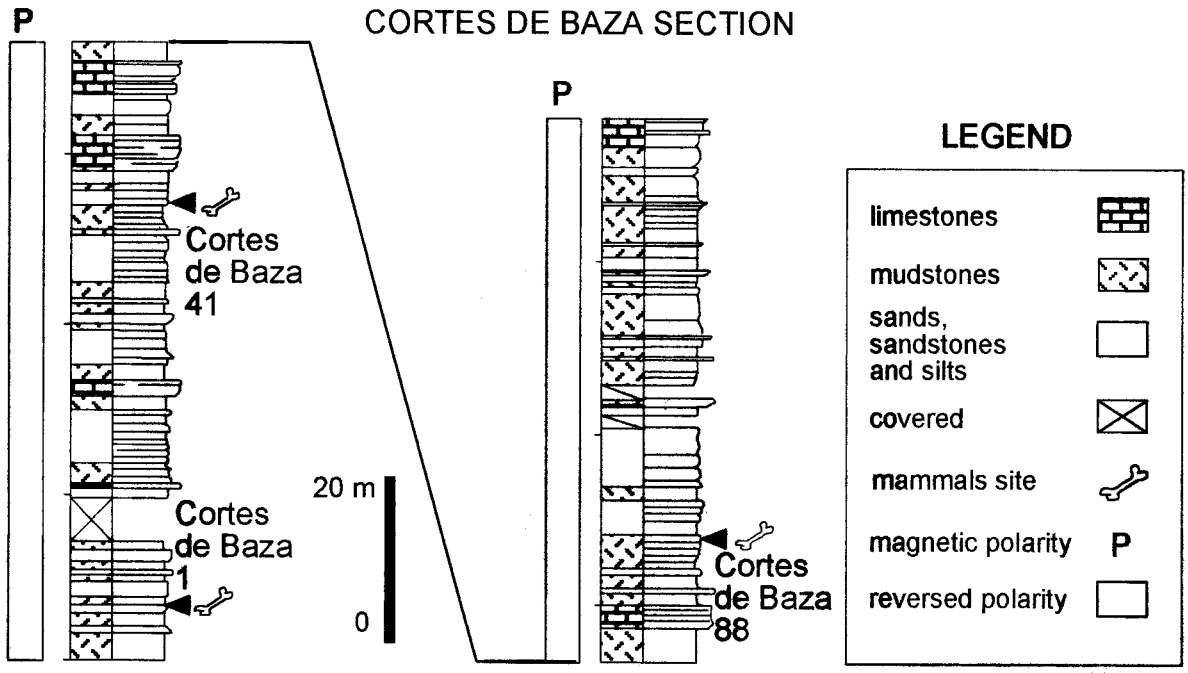




Figure 5. The Cortes de Baza and Cúllar sections. Top: composite Cúllar section (see Agusti *et al.*, 1999 for further details). Bottom: Cortes de Baza section (modified from Oms *et al.*, 1994). Note that the Cortes de Baza and Cúllar sections have different scales.

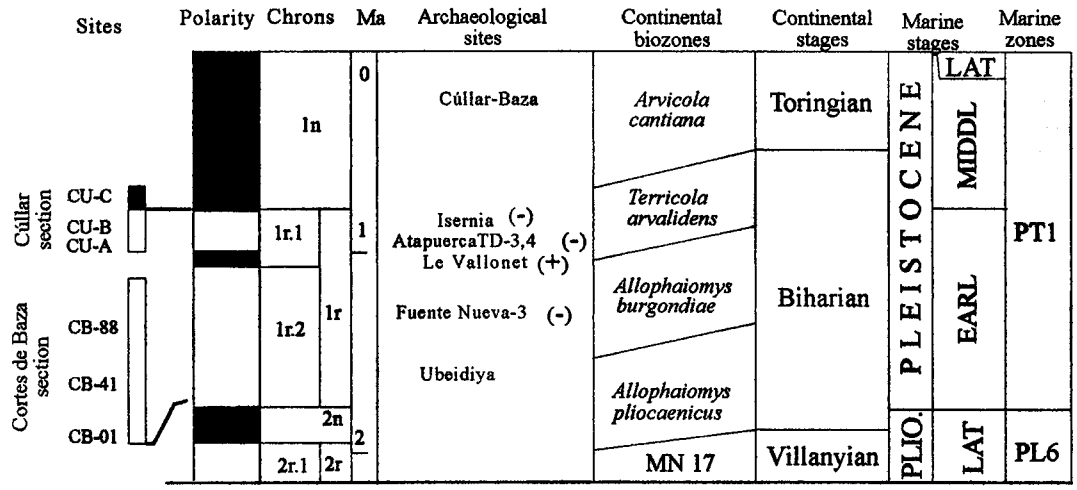



Figure 6. Correlation of the main early and middle Pleistocene archaeological sites and coeval rodent biozones to the Geomagnetic Polarity Time Scale, as established in the Guadix-Baza Basin.

de Baza Section, to the upper Matuyama chron. Therefore, the normal interval where the Cu-C level is placed could represent either the Jaramillo or the Bruhnes chrons. However, the presence of *Terricola arvalidens* indicates a close correlation with the lower levels of Atapuerca TD, which contains a typical association with *Mimomys savini*, *Terricola arvalidens* and *Stenocranius gregaloides* and where the Bruhnes-Matuyama boundary has been identified according to the data by Parés and Pérez-González (1995).

Also, the presence of *Terricola arvalidens* in Cu-C indicates an age younger than the locality of Le Vallonet (France), a normally magnetized early Paleolithic site which has been placed within the Jaramillo chron (Lumley, 1976; Gagnepain *et al*., 1995 a and b). Le Vallonet presents an advanced *Allophaiomys* species (Cf. *"Microtus nivaloides"* in Chaline, 1985) and can be correlated with the *Allophaiomys burgondiae* Zone of the Guadix-Baza Basin. All these data reinforce the identification of the reverse-normal interval in the Cúllar Section as the Matuyama-Bruhnes boundary and place the limit between the *Allophaiomys burgondiae* Zone and the *Terricola arvalidens* Zone (= *"Pitymys" gregaloides* Zone in Agustí *et al*., 1987b) still within the upper Matuyama epoch. Moreover, this confirms the Upper Matuyama age established for the archaeological site of Fuente Nueva-3, which presents a rodent association still belonging to the *Allophaiomys burgondiae* Zone.

On the other hand, the paleomagnetic analysis carried out in the Cúllar Section indicates that the upper part of the *Terricola arvalidens* Zone (latest Biharian) is already included in the lowermost part of the Bruhnes chron. Therefore, the middle Pleistocene (early Toringian) locality of Cúllar-Baza 1, more than 50 m above the level of Cu-C, is clearly placed within this Bruhnes chron. This result is in contrast with previous analysis developed in another early Paleolithic site in the Mediterranean, the locality of Isernia la Pineta (Italy), where a fauna including *Arvicola cantiana, Terricola* cf. *arvaloides* and *Microtus arvalinus* was intially found to be included in a reverse interval immediately overlained by a tuff dated at 0.73 Ma and which placed the earliest *Arvicola* faunas in the uppermost part of the Matuyama chron (Coltori *et al*., 1982). However, recent analysis of the section inidicates that the fossiliferous locality is placed within a normally margnetized chron identified as the Bruhnes chron (McPherron *et al*., in Peretto, 1983; Gagnepain *et al*., 1995 a and b). Besides the Cúllar Section, this interpretation is also supported by the results in the section of Kärlich (Germany), where a similar fauna with *Arvicola cantiana* is also placed in a normal interval correlated to the lower part of the Bruhnes chron (Brunnacker *et al*., 1976; Kolfshoten,1990). The analysis carried out in the Guadix-Baza Basin strongly supports the placement of the Biharian-Toringian boundary (early-middle Pleistocene boundary) in the lower part of the Bruhnes chron.

**Summary**

According to the magnetobiostratigraphical dating

of the Cortes-Cúllar composite section, the Cúllar Baza-1 early Paleolithic site can be placed in the early part of the Bruhnes chron. This result also suggest an early Bruhnes age for the Italian site of Isernia La Pineta, in contrast with the first datings of this site (but see also Gagnepain *et al*., 1995 a and b). On the other hand, the levels belonging to the *Allophaiomys burgondiae* Zone are included in the upper part of the Matuyama epoch. This results confirms an upper Matuyama, pre-Bruhnes age for the site of Fuentenueva-3, older than the Atapuerca TD levels. A post-Olduvai, upper Matuyama age of the early site of Ubeidiya is supported by the magnetobiostratigraphical results in the Cortes de baza section, on the basis of the assumed ancestor-descendent relationship established between *Allophaiomys vandermeuleni* (CB-1) and *Tibericola jordanica* (Ubeidiya).

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## References

AGUSTÍ J., 1986. Synthèse biostratigraphique du Plio-Pleistocène de Guadix-Baza (province de Granada, sud-est de l'Espagne). *Geobios* 19(4):505-510.

AGUSTÍ J., 1991. The *Allophaiomys* complex in Southern Europe. *Geobios* 25(1):133-144.

AGUSTÍ J., CASTILLO C. and GALOBART A., 1993. Heterochronic evolution in the Late Pliocene-Early Pleistocene Arvicolids of the Mediterranean area. *Quaternary International* 19:51-56.

AGUSTÍ J., MOYÀ-SOLÀ S., MARTÍN-SUÁREZ E. and MARÍN M., 1987a. Faunas de mamíferos en el Pleistoceno inferior de la región de Orce (Granada, España). *Paleontologia i Evolució*, Mem. Esp. 1:73-86.

AGUSTÍ J., MOYÀ-SOLÀ S. and PONS-MOYÀ J., 1987b. La sucesión de Mamíferos en el Pleistoceno inferior de Europa: proposición de una nueva escala bioestratigráfica. *Paleontologia i Evolucio*, Mem. Esp. 1:287-295.

AGUSTÍ J., OMS O., GARCÉS M. and PARÉS J.M., 1997. Calibration of the late Pliocene-early Pleistocene transition in the continental beds of the Guadix-Baza Basin (South-Eastern Spain). *Quaternary International* 40:93-100.

ALBERDI M., ALCALÁ L., AZANZA B., CERDEÑO E., MAZO A.V., MORALES J. and SESÉ C., 1989. Consideraciones bioestratigráficas sobre la fauna de Vertebrados fósiles de la cuenca de Guadix-Baza (Granada, españa). *Trabajos Neógeno-Cuaternario* 11:347-355.

ANADÓN P., de DECKKER P. And JULIÀ R., 1986. Paleoclimatic inferences from the Plio-Pleistocene continental sequence of the Guadix-Baza basin (Spain): salinity variations and ostracod succession. *Hydrobiologia* 143:199-208.

BRUNNACKER K., BOENIGK W., KOCI A. and TILLMANS W., 1976. Die Matuyama-Bruhnes Grenze am Rhein und an der Donau. *Neue Jarhbuch Geologie und Paläontologie Abhandlungen* 151(3):358-378.

CARBONELL E., BERMÚDEZ DE CASTRO J.M., ARSUAGA J.L., DIEZ J.C., ROSAS A., CUENCA G., SALA R., MOSQUERA M. And RODRIGUEZ 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.* Doin eds., 366 pp. Paris.

COLTORI M., CREMASCHI M., DELITALA C., ESU D., FORNASERI M., MCPHERRON A., NICOLETTO M., van OTTERLOO R., PERETTO C., SALA B., SCHMIDT V. and SEVINK J., 1982. Reversal magnetic polarity at Isernia La Pineta, a new lower palaeolithic site in Central Italy. *Nature* 3000, 5888:173-176.

DENNELL R. And ROEBROEKS W., 1996. The earliest colonization of Europe: the short chronology revisited. *Antiquity* 70: 535-542.

GAGNEPAIN J., HEDLEY J., BAHAIN J.J., LUMLEY H. de, PERETTO C., PIPERNO M. And WAGNER J.I., 1995a. Elaboration d´un cadre magnétostratigraphique dans le Pliocène inférieur et moyen en Italie et en France méridionale d´après l´étude paléomagnetique des sites du Vallonet (Alpes maritimes, France), Ca Belvedere di Monte Poggiolo (Emilia Romagna, Italie), Isernia La Pineta (Italie) et Loreto (Basilicata, Italie). *XIII Congresso Internazionale delle Scienze Prehistoriche e Protohistoriche.* Forli.

GAGNEPAIN J., HEDLEY J., BAHAIN J.J., PERETTO C. And WAGNER J.I., 1995b. L´apport du paléomagnetisme pour la connaissance du cadre chronostratigraphique des sites d´Isernia La Pineta (Molise), Ca Belvedere di Monte Poggiolo (Emilia Romagna,), et la grotte du Vallonet (Alpes maritimes, France). *XI Congresso degli Antropologi Italiani.* Isernia.

GARCÉS M., AGUSTÍ J. and PARÉS J.M., 1996. Late Pliocene continental magnetochronology in the Guadix-Baza Basin (Betic Ranges, Spain). *Earth Planetary Science Letters* 146(3-4):677-688.

GIBERT J. and PALMQVIST P., 1997. Fractal Analysis of the Orce skull sutures. *J. hum. Evol.* 28:561-575.

KOENIGSWALD W., 1977. *Mimomys* cf. *Reidi* aus der villefranchischen Spattenfüllung Schamback bei Treuchtlingen. *Mitt. Bayer. Staat. Palëont*. 17:197-212.

KOLFSHOTEN T., 1990. The Evolution of the mammal fauna in the Netherlands and the middle Rhine area (Western Germany) during the late middle Pleistocene. *Mededelingen Rijks Geologische Dienst* 43(3):1-69.

LUMLEY H. de, 1976. Les premières industries humaines en Provence. *In: La Prehistoire française* 1-2:765-776. Ed. du C.N.R.S.

MARIN J., 1987. *Equus stenonis granatensis* en el Pleistoceno inferior de Venta Micena (Granada, Espana). *Paleontologia i Evolucio Mem. Esp*. 1:255-282.

MARTINEZ NAVARRO B., TURQ A., AGUSTI BALLESTER J. And OMS M., 1997. Fuente Nueva-3 (Orce, Granada, Spain) and the first human occupation of Europe. Journal of Human Evolution 33:611-620.

MEULEN A. van der, 1973. Middle Pleistocene smaller mammals from the Monte Peglia (Orvieto, Italy) with special reference to the phylogeny of Microtus (Arvicolidae, Rodentia). *Quaternaria* 17:1-144.

MOYÀ-SOLÀ S., AGUSTI J. And MARIN M., 1987. Fuentesnuevas-1: nueva localidad con mamiferos del Plioceno superior de Guadix-Baza (Granada, Espana). *Paleontologia i Evolucio Mem. Esp*. 1:87-93.

MOYÀ-SOLÀ S. and KÖHLER M., 1997. The Orce skull: anatomy of a mistake. *Journal of human Evolution* 33:91-97.

OMS O., GARCÉS M., PARÉS J.M., AGUSTÍ J., ANADÓN P. and JULIÀ R., 1994. Magnetostratigraphic characterization of a thick Lower Pleistocene section from the Baza Basin (Betic Chain, Southern Spain). *Physics of Earth and Planetary Interiors* 85:173-180.

OMS O., DINARÈS TURELL J. and PARÉS J.M., 1996. Resultados paleomagnéticos iniciales de la sección Plio-Pleistocena de Fuente Nueva (Cuenca de Guadix-Baza, Cordilleras Béticas). *Revista de la Sociedad Geológica de España* 9(1-2):89-95.

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.

PARÉS J.M. and PÉREZ-GONZÁLEZ A., 1996. Paleomagnetic Age for Hominid Fossils at Atapuerca Archaeological Site, Spain. *Science* 269:830-832.

PEÑA J.A., RODRIGUEZ FERNÁNDEZ J. and RUIZ-BUSTOS A., 1977. El yacimiento de vertebrados de Cortes de Baza 1 (Depresión de Guadix-Baza). Nota preliminar. *Acta Geológica Hispanica* 12:42-45.

RAPOSO L. and SANTONJA M., 1995. The earliest occupation of Europe: the Iberian peninsula. *In*: Roebroeks, W. and Kolfshoten, T. (eds.): *The earliest Occupation of Europe*. Univ. of Leiden, 7-25.

ROEBROEKS W. and KOLFSHOTEN T., (eds.). *The earliest Occupation of Europe*. Univ. of Leiden, 1-6.

RUIZ-BUSTOS A. and MICHAUX J., 1976. Le site préhistorique nouveau de Cúllar de Baza-I (Grenade, Espagne) d´âge pléistocène moyen. *Géologie méditerranéenne* 3:173-182.

SANZ de GALDEANO C. and VERA J.A., 1992. Stratigraphic record and palaeogeographical context of the neogen basins in the Betic Cordillera, Spain. *Basin Research* 4:21-36.

TIXIER J., ROE D., TURQ A., GIBERT J., MARTINEZ NAVARRO B., ARRIBAS A., GIBERT L., GAETE R., MAILLO A. and IGLESIAS A., 1995. Présence d'industrie lithique dans le Pleistocène de la région d'Orce (Granada, Espagne): quel est l'état de la question? *Comptes Rendus de l'Académie des Sciences de Paris* 321(Iia):71-78.

TURQ A., MARTINEZ NAVARRO B., PALMQVIST P., ARRIBAS A., AJUSTI J. and RODRIGUEZ VIDAL J., 1997. Le Plio-Pleistocène de la région d'Orce, province de Grenade, Espagne: bilan et perspectives de recherche. *Paleo* 8:161-204.

VEGA TOSCANO L.G., 1989. Ocupaciones humanas en el Pleistoceno de la Depresión Guadix-Baza: elementos de discusión. *In*: Alberdi, M.T. y Bonadona (eds.): Geología y Paleontología de la Cuenca Guadix-Baza. *Trabajos Neógeno-Cuaternario* 11:327-345.

VERA J.A., 1970. Estudio Estratigráfico de la Depresión de Guadix-Baza. *Boletín del Instituto Geológico y Minero* 84:429-462.

VERA J.A., FERNÁNDEZ J., LÓPEZ-GARRIDO A.C. and RODRÍGUEZ-FERNÁNDEZ J., 1985. Geología y estratigrafia de los materiales plio-pleistocenos del sector Orce-Venta Micena (Prov. Granada). *Paleontologia i Evolució* 18:3-11.