

December 2008

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# Late Neandertals in Southeastern Iberia: Sima de las Palomas del Cabezo Gordo, Murcia, Spain

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Contributed by Erik Trinkaus, November 7, 2008 (sent for review October 17, 2008)

**Middle Paleolithic fossil human remains from the Sima de las Palomas in southeastern Iberia (dated to  $\leq 43,000$ – $40,000$  calendar years before present) present a suite of derived Neandertal and/or retained ancestral morphological features in the mandibular symphysis, mandibular ramus, dental occlusal morphology, and distal hand phalanx. These traits are combined with variation in the mandibular corpus, discrete dental morphology, tooth root lengths, and anterior dental size that indicate a frequency difference with earlier Iberian and more northern European Neandertals. The Palomas Neandertals therefore confirm the late presence of Neandertals associated with the Iberian persistence of the Middle Paleolithic, but suggest microevolutionary processes and/or population contact with contemporaneous modern humans to the north.**

dentition | mandible | Middle Paleolithic | postcrania

It has become apparent that the transition from a Europe populated by Neandertals to one occupied by early modern humans during marine (oxygen) isotope stage (MIS) 3 consisted of a westward spread of modern humans, variably absorbing at least some local Neandertal populations (1, 2). However, the detailed aspects of this population process remain obscure as a result of the scarcity of well-dated late Neandertals and early modern humans, despite the recent direct dating of several specimens from both samples (3–9). If we are to understand the paleobiogeography of this process, and hence the potential patterns of interactions between these two morphologically defined human groups, then it is essential to document the biology of both the earliest modern humans and the latest Neandertals.

It has been recognized for some time that the Middle Paleolithic, generally presumed in Europe to have been the product of Neandertals, persisted substantially longer in Iberia south of the Pyrenees (south of the "Ebro Frontier") than elsewhere in Europe, to  $\approx 34,000$  ( $\approx 34$  ka) calendar years before present (cal BP) ( $\approx 30$  ka radiocarbon years before present ( $^{14}\text{C}$  BP)] (10; supporting information (SI) Appendix, Fig. 1). Even though there are Iberian Neandertal remains that have been referred to this age (11), their purported late age has been placed in doubt (12). At present, the most recent, securely dated, diagnostic Neandertal fossil from the region is the Oliveira 1 middle manual phalanx at  $\approx 43,500$  cal BP ( $\approx 39$  ka  $^{14}\text{C}$  BP) (13), about the same age as the northern Spain El Sidrón remains (7). It is in this context that we present a series of Neandertal remains from the upper levels of the Sima de las Palomas in southeastern Spain.

## Results

**Context of the Palomas Human Remains.** The Sima de las Palomas (Rock-Dove Hole) is a karstic shaft ( $37^{\circ} 47' 59''$  N,  $0^{\circ} 53' 45''$  W) in the Permo-Triassic marble of a hill (Cabezo Gordo) in Torre Pacheco township, Murcia, reaching 312 m a.s.l., overlooking the Mar Menor coastal lagoon of the Mediterranean Sea (SI Ap-

pendix, Figs. 1 and 2). The main shaft is 18 m deep, opening beneath overhanging rock at  $\approx 123$  m a.s.l. (SI Appendix, Figs. 3 and 4). The shaft's brecciated contents were largely emptied by 19th century miners, who left a sediment column down one side and scattered fossiliferous rubble on the hillside. Systematic collection of disturbed remains and excavation of the upper breccia deposits were begun by M.J.W. and the late J. Gibert after discovery of a crushed facial skeleton (Palomas 1) from the uppermost breccia by J. C. Blanco in 1991 (14, 15). Fossil human remains have been collected from the mine rubble (1992–1999) and excavated in situ (1994–present) (SI Appendix, Table 1).

A number of the in situ human remains come from above, within, and slightly below a fusiform lens of dark-gray sediment (burnt, according to X-ray diffraction and fluorescence analyses). It attained a maximum thickness of  $\approx 20$  cm in the angle of an L-shaped excavation area in the Upper Cutting, covering a thin, oblong marble slab ( $\approx 40 \times 30 \times 10$  cm) between levels 2k and 2m. The lens petered out, both near the open shaft and below the entrance where it covered part of the foot of a downward and inwardly steeply sloping ( $30^{\circ}$ – $40^{\circ}$ ) éboulis or scree of marble blocks  $\leq 50$  kg. A more consistent and widespread lower layer of dark-gray sediment lies beneath level 2l, fading away beside the open shaft (Fig. 1; SI Appendix, Figs. 5 and 6).

Only human bones and teeth from sediments postdating the éboulis (from levels no deeper than 2l) are dealt with here. Although these later sediments contain few large rocks and were laid down horizontally, they often have a coarse texture implying that they were washed from the hillside into the cave and down the steep interior scree slope; the slope had developed neither an eroded surface nor a calcrete crust, in contrast to the thin calcite deposit on the hillside that eventually sealed off the éboulis. These later sediments contained Middle Paleolithic artifacts, animal bones (some of which are burnt), and pollen indicative of mild climatic conditions (14, 16, 17). Because of carbonate precipitation, the éboulis is in part cemented into irregular brecciated conglomerate masses, in which there are Middle Paleolithic artifacts, faunal remains, and variably articulated and crushed human remains. The human fossils include the Palomas 92 and 96 partial skeletons, the Palomas 93 to 95 teeth, and the remains of at least 2 more individuals, including crania with mandibles.

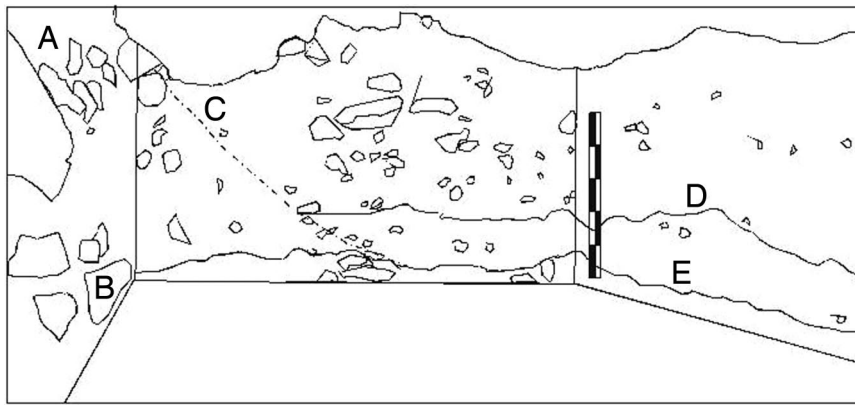
Author contributions: M.J.W., J.G., and E.T. designed research; M.J.W., J.G., M.V.L., A.V.L., A.P.-P., J. Zapata, J.O., T.H., A.P., J.-L.S., J. Zilhão, and E.T. performed research; M.J.W., M.V.L., J. Zapata, J.O., T.H., A.P., J.-L.S., and E.T. analyzed data; and M.J.W., T.H., A.P., J.-L.S., J. Zilhão, and E.T. wrote the paper.

The authors declare no conflict of interest.

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This article contains supporting information online at [www.pnas.org/cgi/content/full/0811213106/DCSupplemental](http://www.pnas.org/cgi/content/full/0811213106/DCSupplemental).

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**Fig. 1.** Schematic drawing of the current profiles of the Upper Cutting (see *SI Appendix*, Figs. 5 and 6). (A) The *éboulis* above northwestern corner of the excavated cutting. (B) Levels 2m-2o breccia containing human bones. (C) Projection of the *éboulis* scree slope, which is less perceptible in this profile than it had been in now removed sections parallel to it in the foreground. (D) Uppermost limit (levels  $\approx$ 2h-2i) of lens of burnt sediment mainly in the northeastern area of the cutting. (E) Lower limit of burnt ash sediment (levels 2m-2o) in the northern and eastern area of the cutting.

**Chronological Age of the Palomas Human Remains.** The age of the human fossils of concern here is primary, because the issue is the morphology of the latest Neandertals in Europe. The Palomas artifacts are all Middle Paleolithic, made on retouched flakes of flint, quartz, rock crystal, and marble (14–16, 18). Given current reliable dates for Iberian Middle Paleolithic assemblages (10, 19), this indicates an age of  $\geq 34$  ka cal BP ( $\geq 30$  ka  $^{14}\text{C}$  BP) for the deposits.

Collagen preservation is poor in the Palomas human remains, and direct  $^{14}\text{C}$  dating of the human bones has not been possible. However, a combination of dating techniques permits chronological control of the Upper Cutting (see *SI Appendix*, Figs. 7 and 8, for the stratigraphic positions of the samples).

A burnt faunal bone directly adhering to the Palomas 59 mandible in level 2f provided a date of  $34,450 \pm 600$   $^{14}\text{C}$  BP (OxA-10666) [95% CI: 40,950–37,622 cal BP using the Cariaco06  $^{14}\text{C}$  curve (20)]. A burnt lagomorph bone from the deeper level 2l provided a statistically identical age of  $35,030 \pm 270$   $^{14}\text{C}$  BP (OxA-15423) (95% CI: 40,986–38,850 cal BP). Given the natures of the dating specimens and the moderately high C:N atomic ratios for these samples (albeit an expected elevation given the burning), it is likely that these ages fall closer to the upper limits of the 95% confidence intervals for these dates (*SI Appendix*, Section III). This interpretation of these dates from the upper sediment fill is supported by the associated palynology (17), which shows relatively temperate conditions, probably during GIS9 and therefore slightly before the onset of the severely cold Heinrich 4 oscillation  $\approx 40$  ka cal BP (21).

To assess further the ages of these deposits and the stratigraphically older *éboulis* deposits, U-series (LA-ICP-MS) dates were obtained from 3 bones (*SI Appendix*, Section IV). A date of  $43,800 \pm 750$  cal BP (APSLP4) is from a faunal specimen from level 2i; it is slightly earlier than the likely  $^{14}\text{C}$  calibrated ranges from levels 2f and 2l. Two much older and statistically similar U-series dates come from the stratigraphically deeper, steeply sloping *éboulis*: one on a Palomas 96 metacarpal from level 2e of  $54,000 \pm 3,850$  cal BP (APSLP1) and the other on a faunal bone from level 2l of  $51,000 \pm 1,250$  cal BP (APSLP6). These U-series estimates presume that the samples were closed systems, which cannot be verified. They should therefore be regarded only as corroborating the  $^{14}\text{C}$  and paleoclimatological assessments of the age of the upper sediment fill and the earlier age of the *éboulis* level, including some mixed material in the burnt dark-gray sediment horizon.

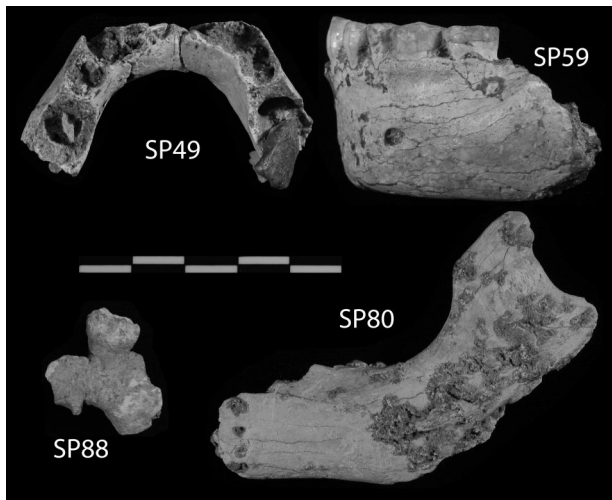
In addition, a sediment sample (X2509) from the top of level 2k directly overlying the marble slab and hence below the

dark-gray sediment level in the northeastern corner of the Upper Cutting was dated by using optically stimulated luminescence (OSL) (*SI Appendix*, Section V). The sample provided an age estimate of  $54,700 \pm 4,700$  cal BP for these sediments. This determination increases confidence in the U-series dates for stratigraphically similar specimens and hence in the age of the stratigraphically younger deposits dated by  $^{14}\text{C}$ .

These dating assessments therefore combine to indicate an age for the upper sediment fill  $\approx 40$  ka cal BP but possibly slightly older (i.e.,  $\approx 43$  ka cal BP). The subsample of the Palomas human remains from this portion of the sediment includes 63 elements, 54 or 85.7% of which are isolated teeth or tooth fragments. They make these Palomas Neandertals the most recent, and largest, sample of southern Iberian late Neandertals currently known. The other Neandertals close in age are the Initial Upper Paleolithic ones from Spy (9), and probably Saint-Césaire, Arcy-Renne, and Vindija G<sub>1</sub> (22–24). These Palomas fossils are also approximately the same age as the earliest modern humans in Europe (4, 25), albeit at the other end of Europe. If the earliest phases of the Aurignacian were indeed made by modern humans (26, 27), then the Palomas remains should overlap in time with modern humans as close as the northern Pyrenees (10).

**The Palomas Human Remains.** The Palomas fossil human remains therefore consist of 3 samples. There are the undated and isolated remains discovered in the miners' rubble. There are the partial face, partial skeletons, and isolated remains from the brecciated *éboulis*. And there are the 63 isolated remains from the excavated deposits at or above the levels dated to  $\approx 40$ –43 ka cal BP.

The diagnostic remains from the first 2 samples can all be attributed to Late Pleistocene Neandertals. For the remains out of context, the relevant aspects include supraorbital torus presence (Palomas 11, 12, and 62), retreating mandibular symphyses and lateral corpus thickness (Palomas 6 and 23), incisor and molar occlusal morphology and incisor root length (Palomas 24 and 50), manual middle phalanx breadth (Palomas 65), and femoral diaphyseal shape (Palomas 52). For the brecciated remains, the isolated teeth appear undiagnostic, and Palomas 96 and the other associated skeletons are still largely in breccia. Yet, the Palomas 1 mandible has a retreating symphysis, a retromolar space, a prominent coronoid process, and an asymmetrical mandibular notch. The Palomas 92 partial skeleton aligns with the Neandertals in distal humeral, proximal ulnar and femoral diaphyseal morphology, as well as inferred body proportions. Although many of the isolated remains from Palomas are



**Fig. 2.** Occlusal view of the immature Palomas (SP) 49 mandibular corpus and lateral views of the Palomas 59, 80 and 88 mandibles. Palomas 59 is in *norma lateralis*, and Palomas 80 and 88 are in the planes of their lateral corpora. Scale in centimeters.

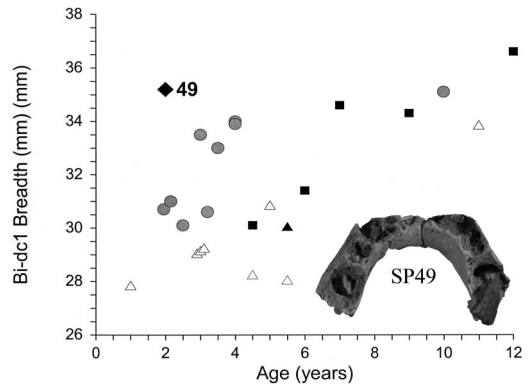
undiagnostic as to human group in a Late Pleistocene context, there are sufficient indicators to align these remains with the Neandertals. In no case do any of the remains exhibit uniquely derived characteristics of modern humans (cf., ref. 28).

Given the concern with late Neandertal paleobiology, the considerations here are limited to the remains found in situ at or above the 40–43 ka cal BP levels. The comparative samples consist of MIS 5–3 western Eurasian Neandertals, MIS 5 Middle Paleolithic early modern humans (MPMH), circum-Mediterranean Early Upper Paleolithic modern humans (EUP) (>33 ka cal BP), and western Eurasian Middle Upper Paleolithic modern humans (MUP) (≈33–24 ka cal BP).

**The Mandibles.** Four partial mandibles were found in situ in the younger levels (Palomas 49, 59, 80, and 88) (Fig. 2). Palomas 59 is a left corpus lacking the full symphysis, and the others are variably complete immature specimens.

The preserved bone of Palomas 59 indicates that it had a relatively vertical symphysis but no prominent development of either a tuber symphyseos or lateral tubercles [probably mentum osseum rank 3 (29)]. The immature Palomas 49 has a similar or more retreating symphyseal profile. The dental arcade is only intact for Palomas 49, and as with other very young Neandertals (30), its bi-dc<sub>1</sub> external arcade diameter (35.2 mm) is beyond those of similarly aged early modern humans (Fig. 3), including that of the earlier Aurignacian La Quina-Aval 4 mandible (≈30.0 mm). Palomas 59 had a retromolar space, and Palomas 80 has a prominent coronoid process and an asymmetrical mandibular notch, but an open mandibular foramen. Most of these features align them principally with the Neandertals among MIS 5–3 humans (8).

At the same time, the mental foramina of the adult Palomas 59 (at P<sub>4</sub>M<sub>1</sub>) and the infant Palomas 49 and 88 (at dm<sub>1</sub>) are moderately mesial (8, 31), but the juvenile Palomas 80 mandible has an unusually mesial mental foramen, because it was distinctly mesial of the P<sub>3</sub>P<sub>4</sub> break. There is little difference in lateral mandibular corpus height between Neandertals and early modern humans (Kruskal–Wallis  $P = 0.251$ ), but there is a significant ( $P = 0.0002$ ) difference in breadth (SI Appendix, Table 4). The other Palomas mandibles (1, 6, and 23) are with other Neandertals in corpus breadth (Fig. 4). Palomas 59, however, is among the EUP and MUP modern humans; its corpus breadth is 2.21 standard deviations from the Neandertal mean (with the Kebara

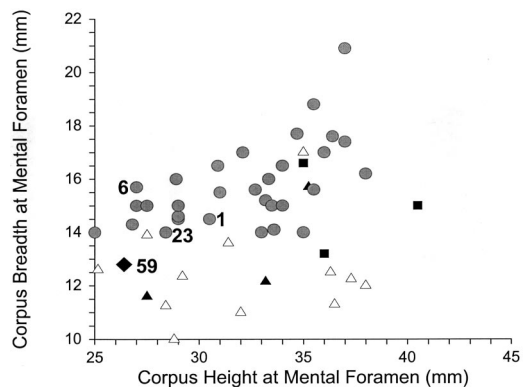


**Fig. 3.** Bivariate plot of external bi-deciduous canine (dc<sub>1</sub>) dental arcade breadth versus developmental age for immature Late Pleistocene human mandibles. Symbols: black diamond, Palomas 49; gray circles, Neandertals; black squares, MPMH; black triangle, EUP modern human (La Quina-Aval 4); open triangles, MUP modern humans. Ages are based on dental calcification relative to extant humans.

2 high outlier trimmed, 1.97 standard deviations with Kebara 2 included).

**The Dentitions.** The abundance of isolated teeth, plus those in Palomas 59 and 80, make several observations possible. All four of the maxillary central incisors (I<sub>1</sub>'s: Palomas 34, 73, 79, and 90) exhibit moderate to marked labial convexity, and the 3 lingually preserved ones have large marginal ridges and lingual tubercles (Fig. 5). The 2 maxillary canines (C<sub>1</sub>'s: Palomas 35 and 74) have very small lingual tubercles, and Palomas 35 has little if any shoveling (Fig. 5). Of the 4 P<sub>4</sub>s (Palomas 57, 59, 78, and 87), 3 each exhibit a transverse crest even though only the Palomas 59 crest is pronounced (Fig. 6). All of them have a mesially displaced metaconid, and 3 have extra lingual cusps. Only one of the P<sub>4</sub>s, Palomas 59, has lingual asymmetry, but it probably lacked extra lingual cusps. Yet, there are no consistent associations between these traits across the 4 Palomas P<sub>4</sub>s. Of the 5 first and second lower molars (M<sub>1</sub>s and M<sub>2</sub>s: Palomas 29, 80, and 84, with one each from Palomas 59), all exhibit anterior fovea but 3 lack midtrigonid crests (Fig. 7). The one M<sup>2</sup> (Palomas 36) has a skewed profile and centrally placed cusps.

Most of these dental occlusal traits occur in both the Neandertals and other Pleistocene (and recent) human samples, and



**Fig. 4.** Bivariate plot of mandibular corpus breadth versus height at the mental foramen, for Late Pleistocene mature mandibles. Symbols as in Fig. 2; numbered symbols are for Palomas 1, 6, 23, and 59, the first 3 of which are geologically older than Palomas 59 or undated. The early modern humans with high corpus breadths are Qafzeh 9 and Skhul 4 (MPMH), Nazlet Khater 2 (EUP), and Cro-Magnon 1 (MUP); the high Neandertal outlier is Kebara 2.

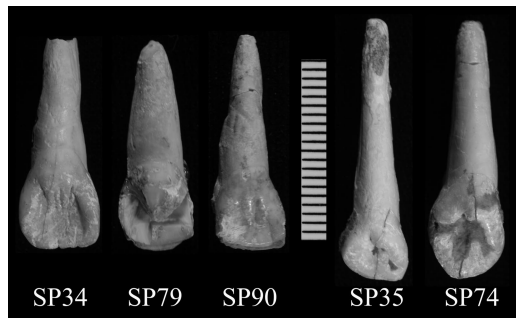


Fig. 5. Lingual views of Palomas (SP) maxillary central incisors ( $I_1$ s) (SP 34, 79 and 90) and maxillary canines ( $C_1$ s) (SP 35 and 74). Scale in millimeters.

not all Neandertals exhibit all of them (32). However, these are all traits that occur in high frequencies among the Neandertals, and Neandertals in particular have high frequencies, compared with other Pleistocene samples, of these traits occurring in combination. Of these Palomas teeth, only the  $I_1$ s and the  $M^2$  exhibit the full suite of features increasingly considered characteristic of the Neandertals.

Root lengths, especially of anterior teeth, have been shown to largely differentiate Neandertals and Upper Paleolithic humans (33); additional data (SI Appendix, Table 5) indicate a significant comparative sample difference in root lengths for all but the  $I^2$ . Of the 13 Palomas anterior teeth providing root lengths, 4 are below the Neandertal ranges, 4 are  $>2\sigma$  from the Neandertal means, and 77% are below the Neandertal means.

The Palomas 59  $M_1$  exhibits supradicular taurodontism, and the  $M_2$  has pronounced radicular endotaurodontism, the latter especially being characteristic of the Neandertals (34). Yet, the Palomas 29  $M_2$  lacks any pulp chamber expansion.

Neandertals and early modern humans have similar postcanine dental dimensions (35), but the former have greater  $I_1$  and  $I_2$  labiolingual crown diameters (Kruskal–Wallis  $P < 10^{-6}$  for each) but contrast less in  $C_1$  breadths (Kruskal–Wallis  $P = 0.025$ ) (SI Appendix, Table 6). One of the in situ Palomas  $I_1$ s (Palomas 21) and 3 of the 5  $C_1$ s (Palomas 26, 54, 59) are below the Neandertal range, and the remainder of the Palomas anterior mandibular teeth are at or below the Neandertal means [2-tailed Wilcoxon  $P = 0.047$  ( $I_1$ ), 0.312 ( $I_2$ ), 0.013 ( $C_1$ )].

**The Postcrania.** In the postcrania, despite multiple elements (SI Appendix, Table 1), only 1 diagnostic bone is stratigraphically secure in the more recent deposits, the Palomas 28 distal hand

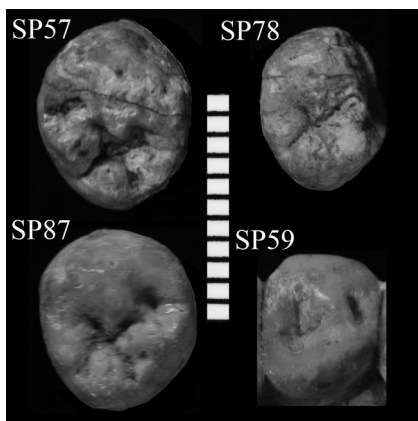


Fig. 6. Occlusal views of Palomas (SP) mandibular second premolars ( $P_4$ s). Scale in millimeters.

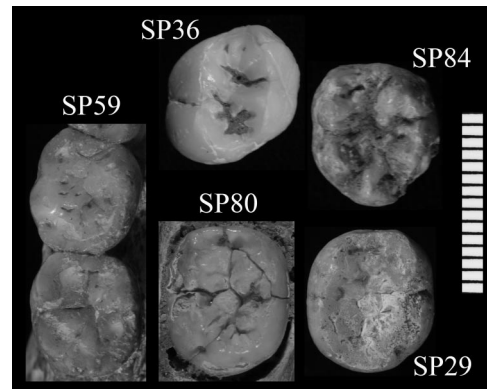


Fig. 7. Occlusal views of Palomas (SP) molars. SP 36, maxillary  $M^2$ ; SP 59, mandibular  $M_1$  and  $M_2$ ; SP 80, mandibular  $M_2$ ; SP 29, mandibular  $M_2$ ; SP 84, mandibular  $M_1$ . Scale in millimeters.

phalanx. It has a broad, rounded apical tuberosity lacking unguis spines (Fig. 8), an archaic *Homo* configuration (36, 37). Neandertal distal phalangeal breadths are significantly absolutely broader than those of almost all early modern humans (Fig. 8; Kruskal–Wallis  $P = 0.00003$ ) (SI Appendix, Table 7), and most of them are broader relative to phalangeal length despite the relatively longer distal phalanges of the Neandertals (38). The distal breadth of the Palomas 28 phalanx (9.7 mm) falls absolutely and relatively among those archaic humans (Fig. 8 and SI Appendix, Table 7).

## Discussion

**Neandertal Affinities.** These considerations of the in situ human remains from the upper levels of the Sima de las Palomas confirm that they are best seen as late southwestern European Neandertals. There is a suite of features, including mandibular symphyseal configuration, ramal shape, dental occlusal morphology, and manual distal phalanx shape, that places them with archaic *Homo* and separate from early modern humans. Moreover, the  $I_1$ s and the  $P_4$ s,  $M^2$ ,  $M_1$ s and  $M_2$ s exhibit apparently derived Neandertal occlusal traits or combinations of traits. Other retained plesiomorphous aspects lost among early modern humans or autapomorphous traits of the Neandertals (28) are not preserved or evident only on undated or older Palomas fossils. These considerations should nonetheless be sufficient to

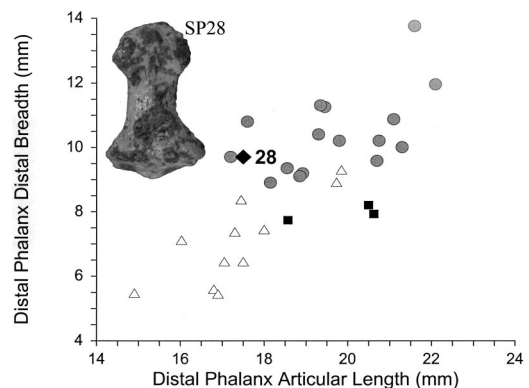


Fig. 8. Bivariate plot of distal phalangeal breadth versus articular length for Palomas 28 and Late Pleistocene samples. Symbols as in Fig. 2. Given uncertainties in digit assignment for isolated ray 2–4 distal phalanges, values are averaged for those individual preserving multiple distal phalanges to provide an individual value.

confirm that at  $\approx 40\text{--}43$  ka cal BP, in southeastern Iberia, the Middle Paleolithic population consisted of Neandertals.

**Morphological Variability.** At the same time, it is evident that the late Palomas Neandertals exhibit a complex mix of Neandertal and more “modern” features. Three of the mandibles have mental foramina that are moderately mesial for Neandertals, but one is unusually so. Distinctive dental features such as large  $C^1$  lingual tubercles,  $M_1$  and  $M_2$  midtrigonid crest,  $P_4$  transverse crest, lingual tubercles, mesial metaconid and lingual asymmetry, long anterior tooth roots, anterior crown dimensions, and lower molar taurodontism are reduced or variably present in the sample. None of the  $P_4$ s has all 4 of the “Neandertal” configurations.

It is possible to find individual Neandertal teeth or mandibles that exhibit one or more of most these “non-Neandertal” aspects, and biological variation across the Neandertals (including trends through time and clinal variation in space) has been noted (7, 39–42). However, the level of variation in these features in the Palomas late Middle Paleolithic sample is unusual for a group of Neandertals. It is possible that these contrasts with other Neandertals represent: (i) late Neandertal genetic drift in the direction of modern human morphology through isolation-by-distance in the cul-de-sac of southern Iberia, (ii) an adaptive shift to local environmental constraints in some of these features, and/or (iii) the product of gene flow from early modern human populations to the immediate north.

The first explanation would emphasize regional (perhaps clinal) variation among the Neandertals (*cf.*, refs. 7 and 40). Securely dated earlier MIS 4–3 Neandertals from south of the Pyrenees [e.g., Banyoles (43, 44), Cova Negra (45), Gegant (46), Valdegoba (47), Zafarraya (48), plus the earlier Palomas remains] exhibit the Neandertal pattern in comparable elements (wide lateral mandibular corpora, relatively posterior mental foramina, large anterior teeth, anterior foveae and midtrigonid crests on  $M_1\text{--}M_3$ , and asymmetrical  $P_4$ s with mesial metaconids and lingual tubercles) with minor variation in mental foramen position and a couple of the dental traits. These fossils thus imply that the Palomas variation is not merely the result of long-term isolation of Iberian Neandertals through the earlier Late Pleistocene. Moreover, such isolation would not necessarily explain

the presence of autapomorphous modern human traits (e.g., a narrow mandibular corpus, reduced  $C^1$  lingual tubercles, short anterior tooth roots, or small anterior dental crowns) in a Neandertal population. The second explanation would imply that some of these mandibular and dental features confer an advantage on these populations, although variation in some of the features may well be selectively neutral. The third consideration would require that the earliest Aurignacian of the northern Pyrenees and elsewhere be the product of modern humans, to provide a geographically proximate source for gene flow. It would also invoke human biological contact across the “Ebri Frontier” during a time when there is little evidence for cultural diffusion (10). In this scenario, the cultural contrasts across the “Ebri Frontier” would be due to behavioral choices, possibly ecologically driven, rather than isolation of the southern Iberian populations.

## Conclusion

The human remains from the Sima de la Palomas in southeastern Iberia therefore document the presence of Neandertals, relatively late in the Middle Paleolithic. They help to substantiate that the Middle Paleolithic of the region was the product of Neandertals, even though diagnostic human remains associated with the very latest phases of this technocomplex in Europe remain elusive. At the same time that the Palomas humans exhibit a suite of derived Neandertal features and archaic *Homo* configurations long since lost among early modern humans, their morphological variation indicates that they deviate from the expected Neandertal ranges of variation. This pattern may be result of genetic drift in relative isolation, directional change or, perhaps more likely, population contact to the north.

**ACKNOWLEDGMENTS.** We thank the landowners of Cabezo Gordo and the management of the Cabezo Gordo S.A. quarry for allowing the excavations to occur, T. Rodríguez and J. L. Polo for providing X-ray diffraction and fluorescence analyses, and the many colleagues and volunteers over the years for enthusiastically providing assistance and expertise. This work was supported by the Spanish government (CGL2005/02410/BTE; BOS/2002/02375; PB/98/0405; PB/92/0971), the Murcia government (PSH93/52; 05584/ARQ/07; CTC/DGC/SPH/063/2001; CCE/DGC/IPH/SAR/1998; CCE/DGC/IPH/SAR/1997; CCE/DGC/IPH/SAR/011/1996; CCE/DGC/IPH/SAR/1995; CCE/DGC/IPH/SAR/1994; PSH/93/52), the municipality of Torre Pacheco, and the Earthwatch Institute (1994–2001). Analysis of the human remains was supported by the Spanish government (CGL2007–60802/BTE) (A.P.-P.) and Washington University (E.T.).

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