CORE
Metadata, citation and similar papers at core.ac.uk
Provided by Columbia University Academic Commons

Journal of Human Evolution 65 (2013) 746–749

Contents lists available at ScienceDirect

Journal of Human Evolution

journal homepage: www.elsevier.com/locate/jhevol

News and Views

A critique of evidence for human occupation of Europe older than the Jaramillo subchron (~1 Ma): Comment on 'The oldest human fossil in Europe from Orce (Spain)' by Toro-Moyano et al. (2013)

Giovanni Muttoni [a,d,*], Giancarlo Scardia [b], Dennis V. Kent [c,e]

[a] Department of Earth Sciences, University of Milan, via Mangiagalli 34, I-20133 Milan, Italy
[b] CNR Istituto di Geologia Ambientale e Geoingegneria, via Salaria km 29.300, I-00016 Monterotondo Scalo, Roma, Italy
[c] Department of Earth and Planetary Sciences, Rutgers University, Piscataway, NJ 08854, USA
[d] ALP, Alpine Laboratory of Paleomagnetism, via Madonna dei Boschi 76, I-12016 Peveragno, CN, Italy
[e] Lamont-Doherty Earth Observatory, Palisades, NY 10964, USA

ARTICLE INFO

Article history:
Received 17 June 2013
Accepted 25 August 2013
Available online 17 October 2013

Keywords:
Pleistocene
Magnetostratigraphy
Electron spin resonance
Hominin fossils

The recently dated human tooth from Barranco León, Spain, would seem to indicate that hominins were present in southern Europe as early as ~1.4 Ma (millions of years ago) based on electron spin resonance (ESR) ages on quartz grains coupled with magnetostratigraphic and biochronologic correlations (Toro-Moyano et al., 2013). We suggest that the evidence for human occupation of Europe prior to 1 Ma is highly equivocal.

The ESR ages and associated analytical errors (as quoted at the $\pm 1\sigma$ level) are as follows: (I) 1.73 ± 0.17 Ma from sample BL-1 from a layer located 1.5 m below the paleontological (human tooth) layer (level D); (II) 1.46 ± 0.17 Ma from sample BL-2 from the paleontological layer; (III) 1.88 ± 0.19 Ma and 1.23 ± 0.12 Ma from samples BL-3 and BL-4, respectively, both from the same layer located just above the paleontological layer; (IV) 1.02 ± 0.09 Ma from sample BL-5 from a layer located ~1 m above the paleontological layer (Toro-Moyano et al., 2013). Toro-Moyano et al. (2013) calculated a weighted mean age of 1.43 ± 0.38 Ma based on the ages of samples BL-2–BL-4 to represent the age of the hominin fossil. A simple linear regression of this weighted mean age for samples BL-2–BL-4 (1.43 Ma) combined with the 1.73 Ma age of underlying sample BL-1 and the 1.02 Ma age of overlying sample BL-5 would imply that the ~4 m of sampled section across the paleontological layer spans a duration of ~0.7 Ma.

This age distribution makes Toro-Moyano et al.'s (2013) interpretation of the magnetostratigraphic data highly problematic. The authors presented a new paleomagnetic study that confirmed previous results (Oms et al., 2000): the entire 30 m-thick section bears only reverse magnetic polarity. Based on the ESR chronology, Toro-Moyano et al. (2013) asserted that the deposits could be correlated to the reverse polarity Matuyama chron between the normal polarity Olduvai and Jaramillo subchrons (although neither was found). However, this part of the Matuyama chron lasts for about 0.7 Ma (Cande and Kent, 1995; Lourens et al., 2004), which corresponds to just the amount of time supposedly captured by the ESR dates in only 4 m of the section. If the section extends far beyond 0.7 Ma in duration, as the ESR dates in the absence of evidence or even discussion of abrupt sedimentation rate variations would seem to suggest, it is unexplained why the Jaramillo and the Olduvai were not found anywhere in this densely re-sampled section (Oms et al., 2000; Toro-Moyano et al., 2013).

These observations raise the possibility that the ESR dates are inaccurate and overestimate the age of deposition of the section. For example, ESR dates on quartz grains are based on the assumption of a complete resetting during transport of the bleachable ESR signal prior to sediment deposition, otherwise the ESR dates would overestimate the true age of deposition. Toro-Moyano et al. (2013: SOM) emphasize that this complete bleaching may occur within a short distance of transport, within 1 km according to bleaching experiments on quartz grains from modern river sediments (Voinchet et al., 2007). However, the sandstone layers that yielded the ESR dates at Barranco León are not traceable laterally anywhere close to distances of 1 km. Therefore, the transport distance of quartz grains from the source area may not have been adequately long to reset the ESR signal prior to deposition. Oms et al. (2011: 41) stated: "The main process in the

* Corresponding author.
E-mail address: giovanni.muttoni1@unimi.it (G. Muttoni).

0047-2484/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jhevol.2013.08.005

formation of the Barranco León 5 paleontological-archeological site (level D1) is related to a sudden event of high-energy currents entering a lacustrine – palustrine domain. These currents transported gravels, bones and lithic industries from a short distance (maximum, hundreds of meters)". There is thus the strong possibility that there was insufficient bleaching of quartz grains during such high-energy sheet-flood events to preclude that the ESR-dated hominin layer is younger than the Jaramillo (~<1 Ma). It seems that the proposed ESR dates (as well as the previously reported U-series/ESR dates on fossil teeth from the same paleontological layer (Duval et al., 2012a,b)) are too inexact to usefully differentiate between pre- and post-Jaramillo.

Regarding the chronological interpretation of the microfauna from Barranco León, much relevance is given to the rodent *Allophaiomys* aff. *lavocati*. Toro-Moyano et al. (2013: 7) reported that "An age younger than the Olduvai subchron (1.95–1.77 Ma) is inferred from the more derived morphology of *Allophaiomys* aff. *lavocati* compared with *A.* cf. *deucalion* from the site of Kryzhanovka (Tesakov, 1998), which is associated with the Olduvai subchron (Pevzner et al., 1998)". However, neither Kryzhanovka nor the supposedly coeval locality of Tizdar from Sinyaya Balka contains any evidence of the Olduvai subchron. The ~33 m-thick Kryzhanovka section starts with sands and clays of reverse polarity (Pevzner, 1989; Pevzner et al., 1998) and ends at the top with a loess-paleosol sequence reported to contain an upper normal-lower reverse magnetic polarity stratigraphy, which was originally interpreted as the Brunhes–Matuyama boundary (Pevzner, 1989). Pevzner et al. (1998) assumed a hiatus between the upper loess-paleosol sequence and the underlying sands and clays; the latter were assigned a pre-Olduvai Matuyama age because they contain mollusks and small mammals attributed to the late Kujalnik marine stage of the Eastern Paratethys. The Kujalnik stage was interpreted to span from the end of the Gauss normal chron to within the Olduvai subchron (Pevzner, 1989; Pevzner et al., 1998). Hence, the attribution of Kryzhanovka to the pre-Olduvai Matuyama is indirect (i.e., no Olduvai subchron found) and based on correlations of distant and discontinuous sections the details of which are difficult to reconstruct (Pevzner et al., 1998). Finally, we point out that *Allophaiomys lavocati* was found at Sima del Elefante in levels TE7–TE14, which were tentatively correlated with the Waalian (1.5–1.3 Ma) (Cuenca-Bescós et al., 2010), roughly in agreement with the chronology of Carbonell et al. (2008), but could as well be younger than the Jaramillo (i.e., <1 Ma) (Muttoni et al., 2010).

Toro-Moyano et al. (2013: 7) also claimed that "*Allophaiomys* aff. *lavocati* is, in turn, more archaic than the microtine species present at Vallonnet (France) and Untermassfeld (Germany), two localities dated to the Jaramillo subchron (0.99–1.07 Ma; Yokoyama et al., 1988; Wiegank, 1997)". We notice that the fossiliferous strata of Untermassfeld showed a transition from normal to reverse magnetic polarity (Wiegank, 1997) that could well represent the Brunhes–Matuyama boundary as already pointed out by van Kolfschoten and Markova (2005). The attribution of Vallonnet to the Jaramillo is also unclear. Yokoyama et al. (1988) reported normal polarity directions from Level III of the cave stratigraphy that they interpreted as pertaining to either the Brunhes or the Jaramillo or the Olduvai, without illustrating any data or providing any information on the experimental procedure used to obtain the polarity stratigraphy. Gagnepain (1996) provided inconclusive

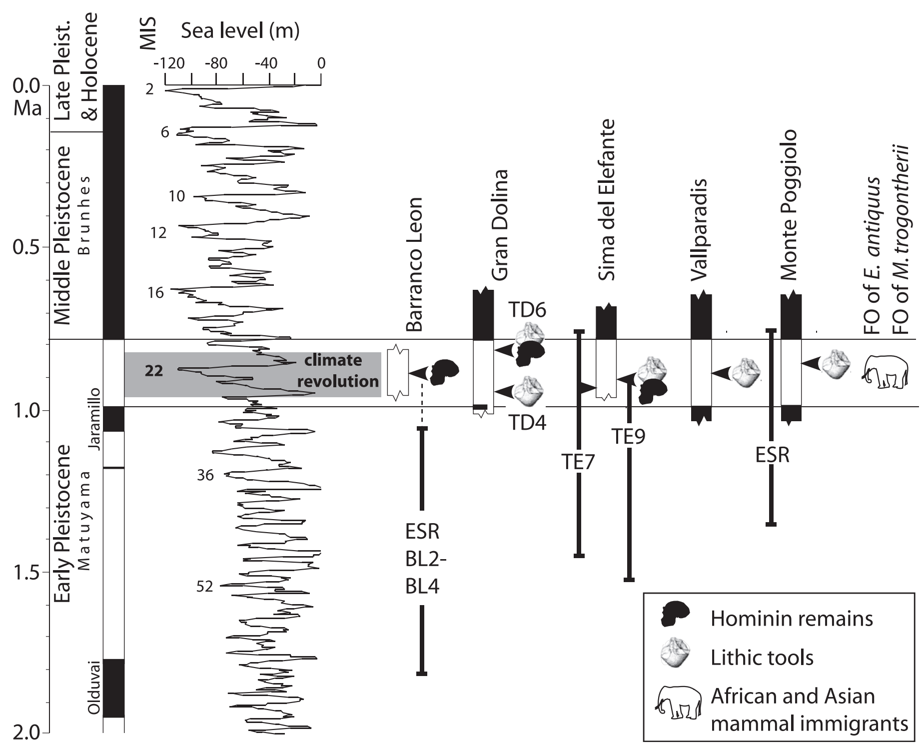

Figure 1. Our preferred interpretation of evidence for the earliest human occupation of southern Europe is during the Matuyama reverse polarity chron between the Jaramillo normal polarity subchron and the Brunhes–Matuyama boundary (0.99–0.78 Ma; Lourens et al., 2004). This was a time of profound climate change centered on marine isotope stage (MIS) 22 at ~0.87 Ma, as revealed by benthic oxygen isotope data (Shackleton, 1995) scaled to the glacio-eustatic drop at the last glacial maximum time (Fairbanks, 1989). Key hominin sites with reliable magnetostratigraphy straddle this time interval: Gran Dolina (Pares and Perez-Gonzalez, 1999; Pares et al., 2013), Sima del Elefante (Carbonell et al., 2008) (with cosmogenic burial ages TE7 and TE9 reported here at 2σ level), Vallparadis (Martinez et al., 2010), and Monte Poggiolo (with indication of previous, and superseded, ESR mean age; Muttoni et al., 2011 and references therein). The Barranco León site may also straddle this time interval if the reported ESR weighted mean age from levels BL-2 to BL-4 (Toro-Moyano et al., 2013) is considered a maximum age estimate. Hominins may have migrated from stressed environments in Africa and Asia to southern European refugia at this time, together with African and Asian mammals, such as *Elepas antiquus* and *Mammuthus trogontherii* (FO is first occurrence datum).

paleomagnetic data from Vallonnet, which did not allow to establish a clear magnetic polarity for the succession: "Naturellement, de nombreux points restent à confirmer ou à completer, comme les polarités magnétiques obtenues..." (Gagnepain, 1996; page 146 and figure 122).

Finally, Toro-Moyano et al. (2013: 7) claimed that "…a recent dating of the level TE9 from Sima del Elefante, in the Atapuerca karstic complex (Cuenca-Bescós et al., 2001), contains a more evolved *Allophaiomys* than *A.* aff. *lavocati* from Barranco León D. The age of this level has been established at 1.22 $\pm$ 0.16 Ma, based on cosmogenic nuclides (Carbonell et al., 2008). Therefore, the age of the level BL-D can be constrained between 1.77 Ma (top of Olduvai subchron) and $\sim$1.2 Ma (age of Sima del Elefante)". As previously noted (Muttoni et al., 2010), the statistical errors on the cosmogenic burial age estimates at Sima del Elefante were quoted at the 1σ level (only 68% confidence), whereas at a more rigorous 2σ level (95% confidence) these data would suggest that the uncertainty in the age range of hominin level TE9 is more like 0.90–1.54 Ma (and 0.77–1.49 Ma in TE7 level below). This would not preclude that hominin occupation at Sima del Elefante occurred between the Brunhes–Matuyama boundary, which was found a few meters above level TE9, and the Jaramillo, which was not found in the section (Pares et al., 2006; Carbonell et al., 2008).

In summary, we suggest that the chronologic constraints on the Barranco León human tooth should be treated more cautiously. All that can be said with any acceptable degree of confidence about the age of the layer that yielded the human tooth at Barranco León is that the reverse polarity shows it is older than 0.78 Ma, the age of the Brunhes–Matuyama boundary. However, evidence of hominin presence in Europe before the Jaramillo ($>\sim$1 Ma), or even during the Jaramillo (Garcia et al., in press), is in our opinion very tenuous (see also Muttoni et al., 2010, 2011) and frequently based on problematic ESR dating (e.g., Barranco León), disputable magnetostratigraphic interpretations (e.g., Untermassfeld, Vallonnet), and biostratigraphic correlations to distant, poorly dated, and frequently discontinuous continental sections (e.g., Kryzhanovka).

A recent critical assessment of the available magnetostratigraphic and/or radiometric age constraints on key sites bearing hominin remains and/or lithic industries from Italy, France, and Spain led us (Muttoni et al., 2010) to propose that the first occurrence of hominins in southern Europe took place between the Jaramillo subchron and the Brunhes–Matuyama boundary (0.99–0.78 Ma). This $\sim$200 kyr (thousands of years) time window encompasses the late Early Pleistocene global climate transition centered on marine isotope stage (MIS) 22 at $\sim$0.87 Ma, the first prominent cold stage of the Pleistocene (e.g., Berger et al., 1993; Shackleton, 1995) (Fig. 1). We suggested that aridification in North Africa and eastern Europe, particularly harsh during MIS 22 times, triggered migration pulses of large mammals (e.g., elephants) as well as hominins from these environmentally stressed regions into more equable circum-Mediterranean refugia, including southern Europe. This post-Jaramillo follow-the-herd hypothesis is substantially consistent with – or does not openly violate – the ages of earliest hominin sites in southern Europe including key sites in Spain with reliable magnetostratigraphy such as Gran Dolina (Pares and Perez-Gonzalez, 1999; Pares et al., 2013), Sima del Elefante (Carbonell et al., 2008; see also above), Vallparadis (Martinez et al., 2010), and (we surmise) also Barranco León (Fig. 1). This hypothesis was also tested and supported by a recent study at the tool-bearing site of Monte Poggiolo, northern Italy, where a sequence of stable normal and reverse polarities in a regional lithostratigraphic context indicated that the site demonstrably post-dates the Jaramillo and pre-dates the Brunhes, most probably occurring at $\sim$0.85 Ma immediately after the pronounced cooling that culminated with MIS 22 (Muttoni et al., 2011).

Acknowledgments

We thank Rainer Grün and an anonymous reviewer for insightful comments, and Christopher Lepre for discussion on an earlier version of this manuscript.

References

Berger, W.H., Bickert, T., Schmidt, H., Wefer, G., 1993. 22. Quaternary oxygen isotope record of pelagic foraminifers: site 806, Ontong Java Plateau. Proc. Ocean Drill. Program Sci. Results 130, 381–395.

Cande, S.C., Kent, D.V., 1995. Revised calibration of the geomagnetic polarity timescale for the Late Cretaceous and Cenozoic. J. Geophys. Res. 100, 6093–6095.

Carbonell, E., Bermúdez de Castro, J.M., Parés, J.M., Pérez-González, A., Cuenca-Bescós, G., Ollé, A., Mosquera, M., Huguet, R., Made, J. van der, Rosas, A., Sala, R., Vallverdú, J., García, N., Granger, D.E., Martinón-Torres, M., Rodríguez, X.P., Stock, G.M., Vergès, J.M., Allué, E., Burjachs, F., Cáceres, I., Canals, A., Benito, A., Díez, C., Lozano, M., Mateos, A., Navazo, M., Rodríguez, J., Rosell, J., Arsuaga, J.L., 2008. The first hominin of Europe. Nature 452, 465–470.

Cuenca-Bescós, G., Canudo, J.I., Laplana, C., 2001. La séquence des rongeurs (Mammalia) des sites du Pléistocène inférieur et moyen d'Atapuerca (Burgos, Espagne). L'Anthropologie 105, 115–130.

Cuenca-Bescós, G., Rofes, J., Lopez-Garcia, J.M., Blain, H.-A., De Marfa, R.J., Galindo-Pellicena, M.A., Bennasar-Serra, M.L., Melero-Rubio, M., Arsuaga, J.L., Bermúdez de Castro, J.M., Carbonell, E., 2010. Biochronology of Spanish Quaternary small vertebrate faunas. Quatern. Int. 212, 109–119.

Duval, M., Falgueres, C., Bahain, J.-J., 2012a. Age of the oldest hominin settlements in Spain: contribution of the combined U-series/ESR dating method applied to fossil teeth. Quatern. Geochronol. 10, 412–417.

Duval, M., Falgueres, C., Bahain, J.-J., Grün, R., Shao, Q., Aubert, M., Dolo, J.-M., Agustí, J., Martinez-Navarro, B., Palmqvist, P., 2012b. On the limits of using combined U-series/ESR method to date fossil teeth from two Early Pleistocene archaeological sites of the Orce area (Guadix-Baza basin, Spain). Quatern. Res. 77, 482–491.

Fairbanks, R.G., 1989. A 17,000-year glacio-eustatic sea level record: influence of glacial melting rates on the Younger Dryas event and deep-ocean circulation. Nature 342, 637–642.

Gagnepain, J., 1996. Etude Magnetostratigraphique de Sites du Pleistocene Inferieur et Moyen des Alpes-Maritimes et d'Italie: Grotte du Vallonnet, Marina Airport, Ca' Belvedere di Monte Poggiolo, Isernia La Pineta, Venosa, Loreto. Museum National d'Histoire Naturelle, Paris.

Garcia, J., Landeck, G., Martinez, K., Carbonell, E. Hominin dispersals from the Jaramillo subchron in central and south-western Europe: Untermassfeld (Germany) and Vallparadís (Spain). Quatern. Int., in press, http://dx.doi.org/10.1016/j.quaint.2013.03.005.

Lourens, L., Hilgen, F., Shackleton, N.J., Laskar, J., Wilson, D., 2004. The Neogene period. In: Gradstein, F., Ogg, J., Smith, A. (Eds.), A Geologic Time Scale. Cambridge University Press, Cambridge, pp. 409–440.

Martinez, K., Garcia, J., Carbonell, E., Agustí, J., Bahain, J.-J., Blain, H.-A., Burjachs, F., Caceres, I., Duval, M., Falgueres, C., Gomez, M., Huguet, R., 2010. A new lower Pleistocene archeological site in Europe (Vallparadis, Barcelona, Spain). Proc. Natl. Acad. Sci. 107, 5762–5767.

Muttoni, G., Scardia, G., Kent, D.V., 2010. Human migration into Europe during the late Early Pleistocene climate transition. Palaeogeogr. Palaeoclimatol. Palaeoecol. 296, 79–93.

Muttoni, G., Scardia, G., Kent, D.V., Morsiani, E., Tremolada, F., Cremaschi, M., Peretto, C., 2011. First dated human occupation of Italy at $\sim$0.85 Ma during the late Early Pleistocene climate transition. Earth Planet. Sci. Lett. 307, 241–252.

Oms, O., Pares, J.M., Martínez-Navarro, B., Agustí, J., Toro-Moyano, I., Martinez-Fernandez, G., Turq, A., 2000. Early human occupation of Western Europe: paleomagnetic dates for two paleolithic sites in Spain. Proc. Natl. Acad. Sci. 97, 10666–10670.

Oms, O., Anadon, P., Agustí, J., Julià, R., 2011. Geology and chronology of the continental Pleistocene archeological and paleontological sites of the Orce area (Baza basin, Spain). Quatern. Int. 243, 33–43.

Pares, J.M., Perez-Gonzalez, A., 1999. Magnetochronology and stratigraphy at Gran Dolina section, Atapuerca (Burgos, Spain). J. Hum. Evol. 37, 325–342.

Pares, J.M., Perez-Gonzalez, A., Rosas, A., Benito, A., Bermúdez de Castro, J.M., Carbonell, E., Huguet, R., 2006. Matuyama-age lithic tools from the Sima del Elefante site, Atapuerca (northern Spain). J. Hum. Evol. 50, 163–169.

Pares, J.M., Arnold, L., Duval, M., Demuro, M., Perez-Gonzalez, A., Bermudez de Castro, J.M., Carbonell, E., Arsuaga, J.L., 2013. Reassessing the age of Atapuerca-TD6 (Spain): new paleomagnetic results. J. Archaeol. Sci. 40, 4586–4595.

Pevzner, M., 1989. Magnetic polarity of the Kujalnikian deposits and their position in the magnetochronological scale. Bull. Comm. Study Quat. 58, 117–124.

Pevzner, M., Tesakov, A.S., Vangengeim, E., 1998. The position of the Tizdar locality (Taman Peninsula, Russia) in the magnetochronological scale. Paludicola 2, 95–97.

Shackleton, N.J., 1995. New data on the evolution of Pliocene climate variability. In: Vrba, E., Denton, G.H., Partridge, T.C., Burckle, L.H. (Eds.), Palaeoclimate and

Evolution, with Emphasis on Human Origins. Yale University Press, New Haven, pp. 242–248.
Tesakov, A.S., 1998. Early stage of *Allophaiomys* evolution in Eastern Europe. Paludicola 2, 98–105.
Toro-Moyano, I., Martínez-Navarro, B., Agustí, J., Souday, C., Bermúdez de Castro, J.M., Martinón-Torres, M., Fajardo, B., Duval, M., Falguères, C., Oms, O., Parés, J.M., Anadón, P., Julià, R., García-Aguilar, J.M., Moigne, A.-M., Espigares, M.P., Ros-Montoya, S., Palmqvist, P., 2013. The oldest human fossil in Europe dated to ca. 1.4 Ma at Orce (Spain). J. Hum. Evol. 65, 1–9.
van Kolfschoten, T., Markova, A.K., 2005. Response of the European mammalian fauna to the mid-Pleistocene transition. In: Head, M.J., Gibbard, P.L. (Eds.), Early-middle Pleistocene Transitions: The Land-ocean Evidence, Geol. Soc. Lond. Spec. Publ., vol. 247, pp. 221–229.
Voinchet, P., Falgueres, C., Tissoux, H., Bahain, J.-J., Despriee, J., Pirouelle, F., 2007. ESR dating of fluvial quartz: estimate of the minimal distance transport required for getting a maximum optical bleaching. Quatern. Geochronol. 2, 363–366.
Wiegank, F., 1997. Paläomagnetische Charakteristik des Unterpleistozäns von Untermassfeld, in Das Plesitozän von Untermassfeld bei Meiningen (Thüringen). In: Kahlke, R.-D. (Ed.), Das Plesitozän von Untermassfeld bei Meiningen (Thüringen). Romisch-Germanisches Zentralmuseum, Mainz, pp. 63–69.
Yokoyama, Y., Bibron, R., Falguères, C., 1988. Datation absolue des planchers stalagmitiques de la grotte du Vallonnet à Roquebrune-Cap-Martin (Alpes-Maritimes, France), par la résonance de spin électronique (ESR). L'Anthropologie 92, 429–436.