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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)

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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 $\pm1\sigma$ 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

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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

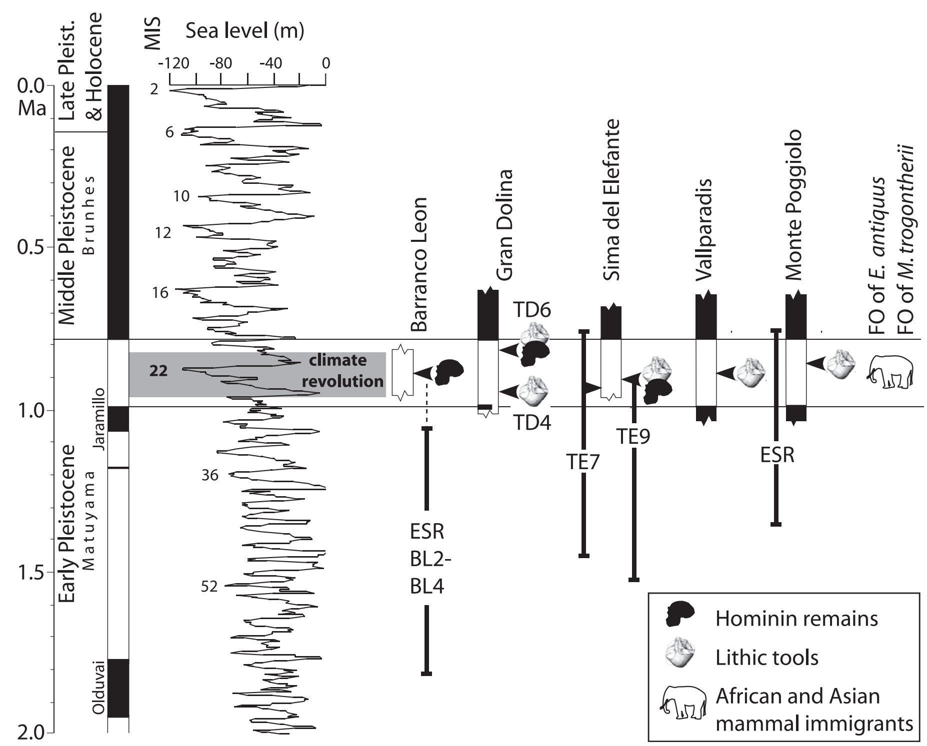

Figure 1. Our preferred interpretation of evidence for the earliest human occupation of southern Europe is during the Matuyama reverse polarity chron between the Jaramillo normal polarity subchron and the Brunhes–Matuyama boundary (0.99–0.78 Ma; Lourens et al., 2004). This was a time of profound climate 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 ± 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 ~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 ($>\sim1$ 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 ~200 kyr (thousands of years) time window encompasses the late Early Pleistocene global climate transition centered on marine isotope stage (MIS) 22 at ~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 ~0.85 Ma immediately after the pronounced cooling that culminated with MIS 22 (Muttoni et al., 2011).

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