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Dating the hominin footprints from Matalascañas (Spain): taxonomic and paleoanthropological implications



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INTRODUCTION

The dating of archeological or paleoanthropological material is essential since it provides information on the spatio-temporal distribution of hominin populations and by extension on their migration. Footprint dating is even more important because in most cases it is thanks to the chronological context that a hominin species can be attributed to footprints. For example, the footprints found at Matalascañas in 2021 were attributed to Neandertals (Mayoral et al., 2021) since the surface in which they were left had been dated to 106 ± 19 ka (Zazo et al., 2005).

We report here new OSL dates for these footprints, benefiting from the latest methodological advances, and discuss the impact of these new dates for the taxonomic attribution of this ichnological assemblage.



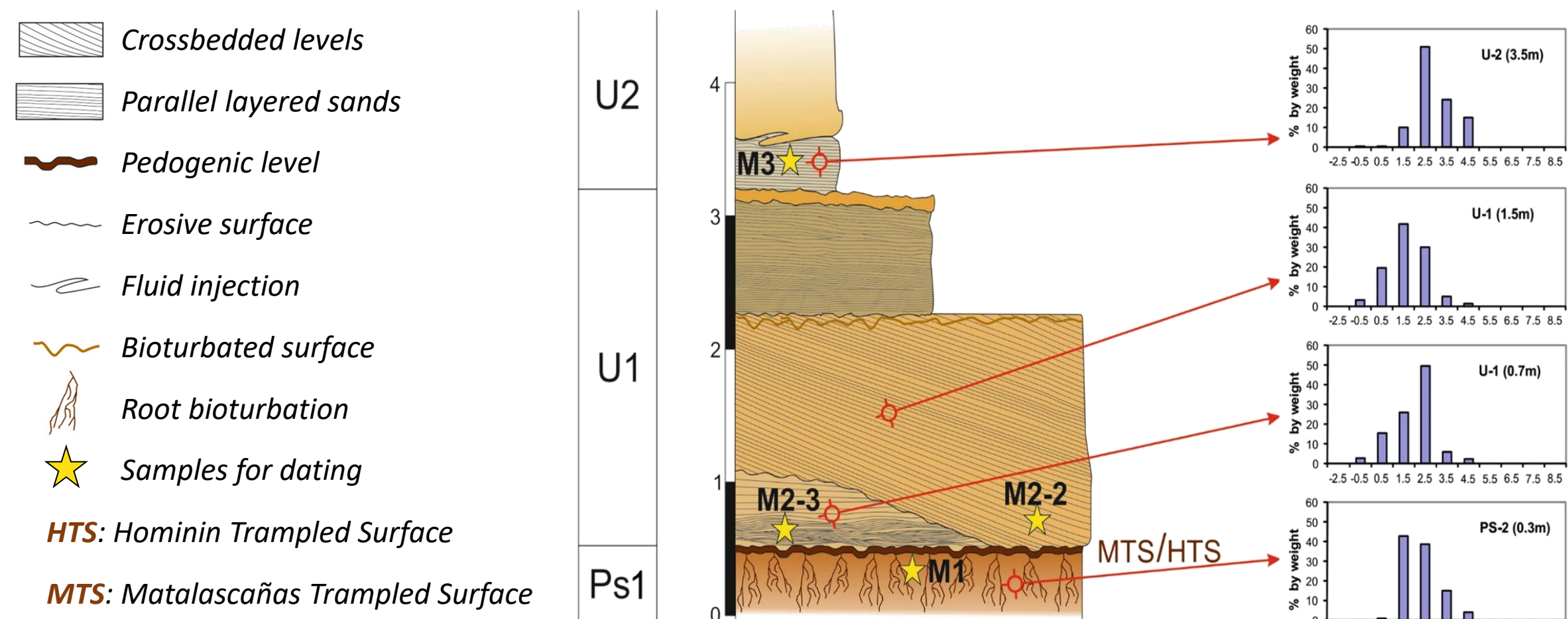
The site of Matalascañas



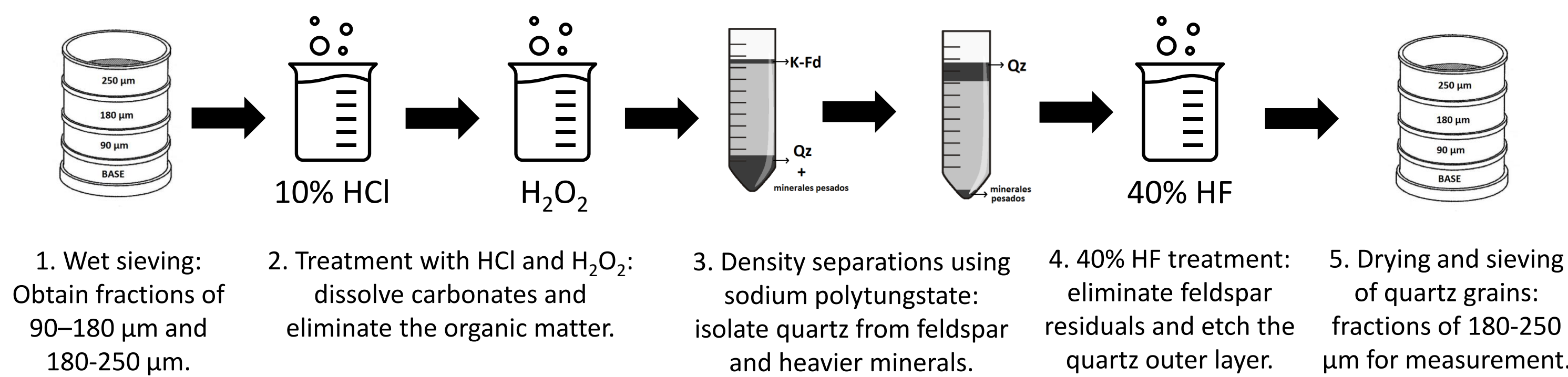
Location of the Matalascañas site

SAMPLING AND PREPARATION

Sampling from 4 sedimentary units located above and below the Hominin Track Surface (HTS).

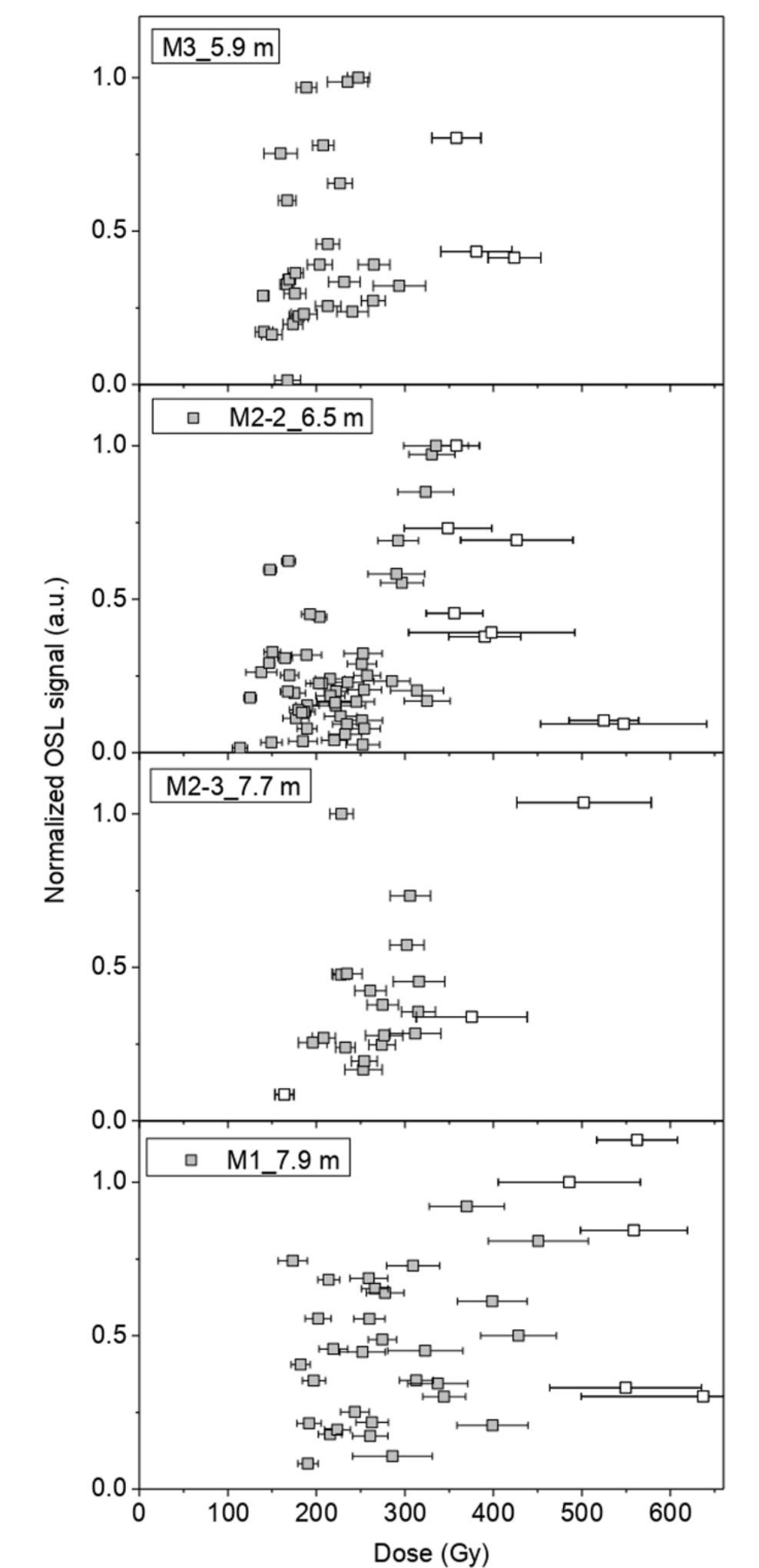


SAMPLE PREPARATION



OSL MEASUREMENTS AND ANALYSES

- OSL measured using Risø OSL/TL readers (TL-DA 20) with a calibrated ⁹⁰Sr/⁹⁰Y beta source delivering ~0.10 Gy/s at the sample disc location.
- The OSL signal from 30-60 small quartz multi-grain aliquots (1 and 2 mm diameter) was measured from each aliquot. 30 aliquots were measured by default. Measurements were extended to 60 aliquots when the overdispersion was higher than 35%.
- The OSL signal was measured for 40 s at 0.1 s per data point, giving 400 data points. OSL signal was measured using a blue LED as the light source. The reading temperature for OSL was 125 °C.
- The fast component dominated the signal, and the first 5 data points (0.5 s) were considered for measurement. Grain-size analysis was developed using a normalized base 2 logarithmic Udden-Wentworth scales.
- Derived dose distributions have been reduced by removing individual outliers, identified as those values out of 1.5 times the interquartile range. The resulting populations are normally distributed with over dispersion values <25%.
- The Central Age Model (CAM) has been applied to calculate the equivalent dose (i.e. the accumulated dose due to the ionising radiation received by the quartz grains over the period they have been buried) of each sample.



Dose distributions derived from OSL measurements. The normalised OSL signal is plotted as a function of the individual dose values.

DOSE RATE CALCULATIONS

- Total dose rates were calculated from the activity concentrations of ⁴⁰K, ²³²Th and ²³⁸U, measured by high-resolution low-level gamma spectrometry.
- The contribution of the cosmic radiation to the total dose rate were calculated as a function of the latitude, altitude, burial depth and the average overburden density.
- Dose rate calculations were determined using the Dose Rate and Age Calculator (DRAC).
- Water content is representative of the burial period.

Sample	Lab code	Water content (%)	⁴⁰ K (Bq/kg)	²³² Th (Bq/kg)	²³⁸ U (Bq/kg)
M3	LM20139-07	15 ± 5	231 ± 10	5.11 ± 0.38	3.8 ± 1.2
M2-2	LM20139-05	20 ± 5	263 ± 12	8.07 ± 0.38	5.6 ± 1.3
M2-3	LM20139-06	25 ± 5	239 ± 11	6.88 ± 0.48	4.7 ± 1.5
M1	RDI-4233	25 ± 5	259 ± 5	11.9 ± 0.35	6.8 ± 0.7

Water content and gamma spectrometry results

Sample	Lab code	⁴⁰ K (%)	²³² Th (ppm)	²³⁸ U (ppm)
M3	LM20139-07	0.682 ± 0.059	1.26 ± 0.19	0.29 ± 0.19
M2-2	LM20139-05	0.776 ± 0.071	1.99 ± 0.19	0.43 ± 0.20
M2-3	LM20139-06	0.705 ± 0.032	1.70 ± 0.24	0.36 ± 0.23
M1	RDI-4233	0.764 ± 0.016	2.93 ± 0.09	0.53 ± 0.06

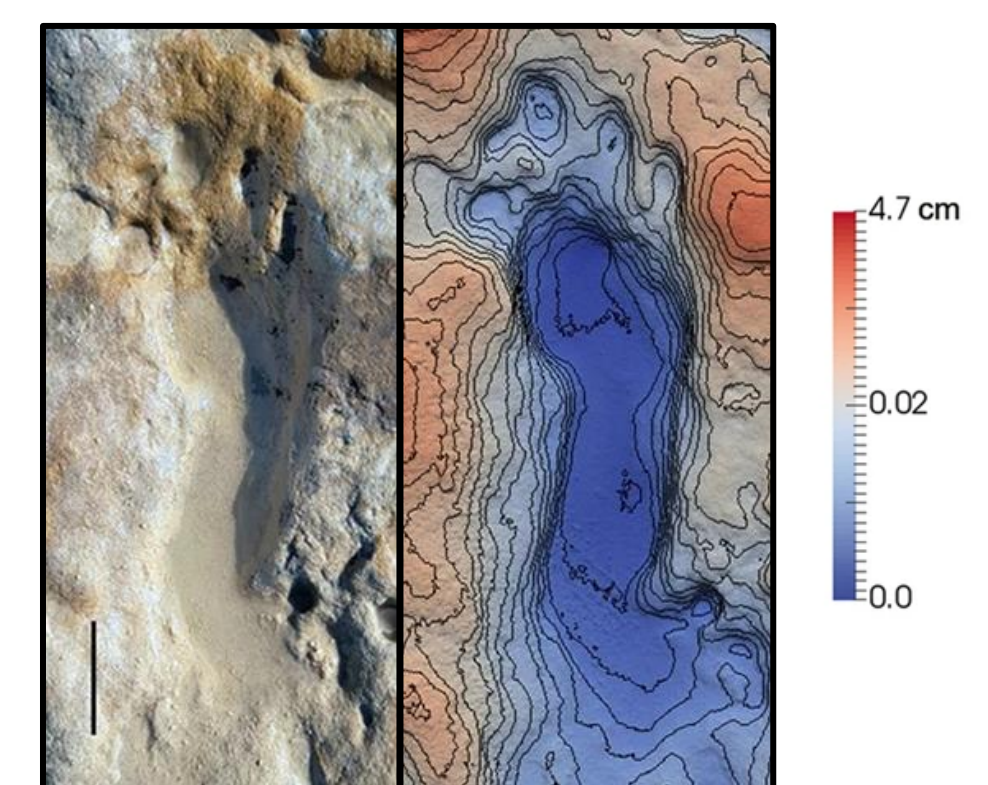
Gamma spectrometry results.

Sample	Lab code	Grain size (mm)	Latitude (DD)	Longitude (DD)	Altitude (m)
M3	LM20139-07	180 - 250	37.0157	-6.5834	3.5
M2-2	LM20139-05	180 - 250	37.0157	-6.5834	0.7
M2-3	LM20139-06	180 - 250	37.0157	-6.5834	0.7
M1	RDI-4233	180 - 250	37.0157	-6.5834	0.3

Additional parameters considered in DRAC.

RESULTS

- The dating of the samples from the 4 stratigraphic units range from **204,000 to 296,000 years**.
- These new dates indicate that the Hominin Track Surface surface is between **274,000 and 296,000 years old**, probably closer to 296,000 years because of its stratigraphic position within the PS1 paleosol.



Depth map of one of the Matalascañas footprints (black scale bar: 5 cm)

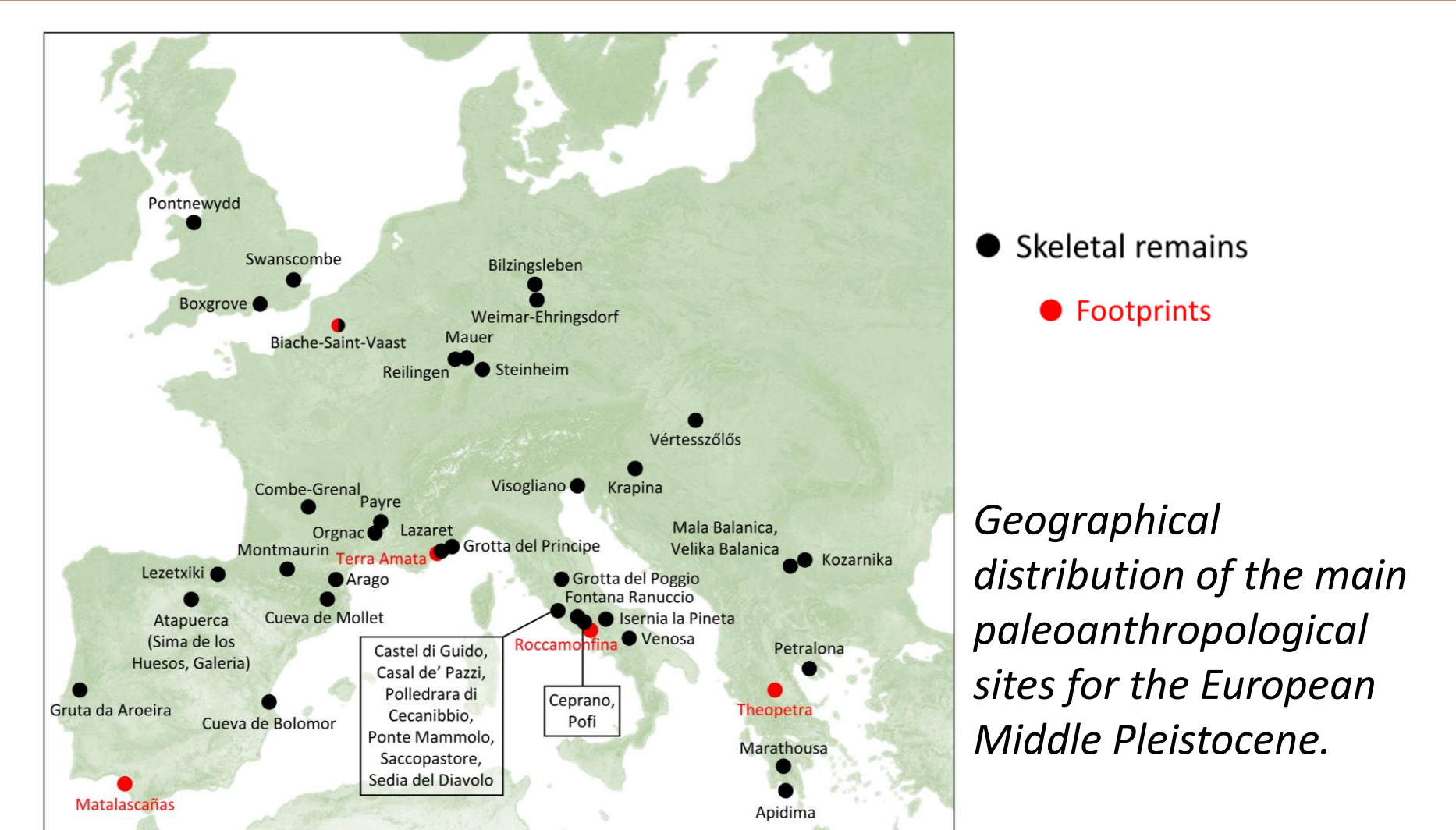
Sample	Lab code	Depth (m)	Dose rate (Gy/ka)	Burial dose (Gy)	Age (ka)
M3	LM20139-07	5.9	0.97 ± 0.05	197.3 ± 7.6	203.8 ± 12.7
M2-2	LM20139-05	6.5	0.91 ± 0.04	211.2 ± 7.4	232.8 ± 13.1
M2-3	LM20139-06	7.7	0.95 ± 0.04	259.3 ± 8.8	274.0 ± 15.8
M1	RDI-4233	7.9	0.91 ± 0.03	269.9 ± 13.0	295.8 ± 17.8

Summary of results from OSL dating. Including the estimated burial dose, the calculated dose rates and the derived ages. LM: Centro Nacional de Investigación sobre la Evolución Humana - CENIEH. RDI: Radioisotope Laboratory of the University of Seville.

TAXONOMIC IMPLICATIONS

- The new chronology at Matalascañas indicates that the hominin footprints would have been made nearly 200,000 years prior to the time established in their initial study. This chronological shift places these new footprints during the Middle Pleistocene, and more specifically at the transition between MIS 9 and MIS 8.
- Evidence of human occurrences dating to MIS 9 and MIS 8 is extremely rare. From this period, European paleoanthropological remains (hominin skeletons and footprints) are much more scarce than archaeological material. Footprints are generally scarce in the entire European Middle Pleistocene since only four sites have delivered footprints from this period.

→ Based on the current knowledge of the human fossil record in Western Europe and in the Iberian Peninsula in particular, we consider that individuals belonging to the Neandertal lineage are still the most likely track-makers of the Matalascañas footprints.



Geographical distribution of the main paleoanthropological sites for the European Middle Pleistocene.

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Mayoral, E., et al., (2021). Tracking late Pleistocene Neandertals on the Iberian coast. *Sci. Rep.* 11, 4103.
Zazo, C., et al., 2005. Landscape evolution and geodynamic controls in the Gulf of Cadiz (Huelva coast, SW Spain) during the Late Quaternary. *Geomorphology*, 68(3-4), 269-290.

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