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35,000 years of recurrent visits inside Nerja cave (Andalusia, Spain) based on charcoals and soot micro-layers analyses

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Charcoal and micro-layers of soot trapped in speleothems from the inner galleries of Nerja Cave were analysed through an interdisciplinary study. The absolute dating of the prehistoric subterranean activity of the cave and the identification of different phases of visits to the deep parts are presented and discussed. The charcoal analysis includes anthracological analysis and SEM–EDX. The soot analysis includes optical microscopy, Raman spectroscopy and TEM–EDX, and the microcounting of soot microlayers. The ¹⁴C dating of 53 charcoals identified 12 phases of prehistoric visits to the cave between 41,218 and 3299 cal. BP, putting back the origin of human occupation of this emblematic cave by 10,000 years. The interdisciplinary analysis of the soot microlayers allowed us to perform a high-precision zoom on the last three visitation phases identified by Bayesian analysis (8003–2998 cal. BP.), demonstrating that these phases contain at least 64 distinct incursions, with an average of one visit every 35 years for the Neolithic period. Spatial analysis showed that not all areas of the cave were used in the same periods, highlighting the repetition of visits to certain specific sectors of the Lower Galleries of the cave. Lastly, the anthracological data indicate a cross-cultural and unique use of *Pinus tp. sylvestris-nigra* wood for lighting activities over an extended period between the Gravettian and Upper Magdalenian.

Deep karst visits during the Paleolithic are known by remains such as rock art, fire remains or even human constructions such as the one found at Bruniquel cave¹. It is however difficult to determine if these remains were left by single visits or recurrent ones, as they are often found on the soil surface in caves, devoid of a time-stratigraphic context to provide chronological support. Here, by the ¹⁴C dating of more than 60 samples of lighting and fire remains (charcoals and soot layers) and two abstract rock art representations, we are able to present a robust Bayesian model that constrains the periods of occupation for the internal prehistoric activity in Nerja cave. Using the multi-analytical identification and micro-counting of soot layers trapped in a stalagmite, we also provide the minimum number of visits and their recurrence.

Nerja Cave (Malaga, Andalusia, Spain) is one of the main sites for the study of prehistoric groups in the Western Mediterranean. An extensive archaeological and palaeontological sequence has been recovered in its entrance rooms, including remains from the Gravettian, Solutrean, Magdalenian, Epipalaeolithic, Neolithic and Chalcolithic chrono-cultures. From the discovery of the cave (1959) to the present day, this sedimentary deposit has been examined by different research teams, resulting in extensive scientific and cutting-edge knowledge (including numerous radiocarbon dates) about the prehistoric inhabitants of Southwest Europe^{2–6}.

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