Quaternary International 771 (2026) 110312

Contents lists available at ScienceDirect

Quaternary International

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

Variations in human ecodynamics in the southern Pyrenees: chert procurement and use at Cova Gran de Santa Linya during the Upper Paleolithic

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ARTICLE INFO

Keywords:
Upper paleolithic
Pre-pyrenees
Procurement strategies
Mobility
Chert

ABSTRACT

The southern slope of the Pyrenees is rich in siliceous resources, particularly chert. This material, widely distributed across the region, was the primary raw material exploited by anatomically modern humans (AMH) during the Upper Paleolithic. However, it remains unclear whether the procurement strategies employed during this period—marked by multiple climatic fluctuations and chrono-cultural phases remained consistent or changed over time. To address this question, an archaeopetrological characterization of chert was conducted on the core and retouched tool assemblages from the Upper Paleolithic sequence at Cova Gran de Santa Linya. This analysis aims to identify the sedimentary origins of the silicifications and infer potential procurement zones to detect variations in lithic organization and procurement strategies over time.

The study distinguishes two main types of silicifications: cherts formed in a continental hypersaline (evaporitic) sedimentary environment, likely associated with the Garumnian facies of the Tremp Formation, and cherts derived from a continental lacustrine environment, available in various geological formations within the Pre-Pyrenean Marginal Ranges and the Ebro Valley. Additionally, marine-origin cherts were identified, in formations located both on the southern and northern foothills of the Pyrenees. This preliminary approach suggests a primary procurement strategy in the transverse valleys of the southern Pyrenees and the Ebro Depression. The presence of marine-origin cherts, whose outcrops are located at a greater distance, suggests a certain permeability towards northern territories within the Pyrenean range.

Furthermore, we detected a shift in raw material use and management throughout the Upper Paleolithic, particularly from the Last Glacial Maximum (LGM) onwards, where evaporitic chert varieties decrease in favor of lacustrine varieties. This progressive changes in raw material use coincides with parallel re-organisation of technology during the Magdalenian. Long-distance tracers are mainly identified on the onset of the LGM, likely indicating broader mobility and procurement strategies as a resilient response to harsh climate conditions and resources availability.

This article is part of a special issue entitled: Pleistocene Human Ecodynamics in Valley Ecotones published in Quaternary International.

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https://doi.org/10.1016/j.quaint.2026.110312
Received 24 December 2025; Received in revised form 27 April 2026; Accepted 4 May 2026
Available online 8 May 2026

1. Introduction

The southern slopes of the Pyrenees constitute a region with significant potential for reconstructing Late Pleistocene human activity in the Iberian Peninsula. Unlike the northern face of the Pyrenees, which was extensively studied throughout the 20th century, the southern region has remained archaeologically latent until recent years. The discovery of new Middle and Upper Palaeolithic archaeological sites in the last decades has shifted this trend, providing new data to which analyse human ecodynamics in one of the most relevant areas to understand cultural transmission process and the dispersion of human groups into Iberia.

The central Pre-Pyrenean zone concentrates a rich Middle Palaeolithic record at sites such as Roca San Miguel (Montes Ramírez et al., 2021), Gabasa (Montes et al., 2001), Fuentes de San Cristóbal (Menéndez et al., 2009), Estret del Tragó (Casanova i Martí et al., 2014), Abric Pizarro (Samper Carro et al., 2024), Roca dels Bous (Martínez-Moreno et al., 2010a), and Cova Gran de Santa Linya (Mora et al., 2011) among other, extending from Marine Isotope Stage 5 to 3. The Upper Palaeolithic evidence is more geographically dispersed but recently discovered sites has promoted a more cohesive perspective of human settlement, especially after the Last Glacial Maximum (LGM). Early Upper Palaeolithic (EUP) occupations have been identified at Cova Gran de Santa Linya (Martínez-Moreno et al., 2010b; Mora et al., 2011; Sánchez-Martínez et al., 2021) and the caves of Serinyà (Ortega et al., 2018; Wood et al., 2014). By the onset of the Last Glacial Maximum (LGM), human presence in the southern Pyrenees is attested at sites such as Montlleó (Sánchez de la Torre et al., 2025), and later at Cova Gran de Santa Linya (Sánchez-Martínez et al., 2022a), Parco (Fullola i Pericot and Soler, 1997), and others including Chaves, Fuente del Trucho, Alonsé, Legunova, and Forcas (Domingo and Montes, 2009; Montes and Domingo, 2013; Utrilla et al. 2014, 2018).

The analysis of procurement strategies in the southern Pyrenees in most of these sites have revealed a wide territorial articulation based on the exploitation of local, territorial and transpyrenean resources, indicating this region was highly integrated in human mobility networks during the Late Pleistocene (Utrilla et al., 2012; de la Torre et al., 2013; Roy-Sunyer et al., 2013; Sánchez de la Torre et al., 2020a; Jiménez et al., 2024).

Although raw material-based studies are frequently applied to Palaeolithic sequences, comprehensive analyses that integrate broad occupational and diachronic data remain scarce (Roy-Sunyer, 2016). Such studies are critical for identifying continuities and ruptures in hunter-gatherer procurement strategies through time (Belmiro et al., 2025; Sánchez de la Torre et al., 2025), and for assessing variations in lithic organization associated with distinct cultural behaviours (Sánchez-Martínez, 2022). This approach is only possible with archaeological sites encompassing continuous and repeated human occupations with low incidence of post/syn depositional processes that may result on stratigraphical discontinuity. In this sense, Cova Gran de Santa Linya is a critical site to investigate diachronic shifts in lithic raw material procurement and human–landscape interactions. This site encompasses an archaeological sequence with intense and repeated human occupations spanning from MIS 3 to MIS 1 (Mora et al., 2011). Its long occupational sequence provides an opportunity to examine how human groups with different technological and cultural traditions managed and exploited the lithic resources. Within the same geographical setting, can we discern distinct patterns of land use and resource exploitation? Were the territories for resource acquisition broadly similar? Do we identify divergent human ecodynamics resulting from differentiated strategies according to cultural affiliation?

This work aims at identifying if raw material procurement strategies in the central-southern Pyrenees and the management of lithic resources remained stable during the Upper Palaeolithic and whether changes in resources use patterns reflect broader cultural dynamics among hunter-gatherers. To test this, we have analysed the siliceous raw materials from the Upper Palaeolithic sequence of Cova Gran de Santa Linya using a multi-scale approach to explore trends in the acquisition of chert resources over time. This approach allows addressing differences in resource caption and exploitation within the same geographical setting, then evaluating how human behaviour shaped cultural dynamics. Future works on the frame of the ERC SPEGEOCHERT project are aimed at conducting elemental composition analysis to precisely indicate the geological formations exploited by past populations to infer potential networks and connectivity among source areas and the site.

2. Regional setting

Cova Gran de Santa Linya (X = 318.541, Y = 464.3877, UTM H31 N ETRS89) is a large rock shelter of approximately 2500 m^2 located at 385 m.a.s.l in the municipality of Les Avellanes-Santa Linya (Spain). Situated on the southern slopes of the Pre-Pyrenees, this site contains a well-preserved archaeological sequence documenting the presence of both Neanderthals and anatomically modern humans over the last 50,000 years (Martínez-Moreno et al., 2010b; Mora et al., 2018; Sánchez-Martínez, 2022).

The site is divided into three main morpho-stratigraphic sectors: Ramp, Transition, and Platform, and the recently discovered V unit (Transition sector), each containing evidence of human occupation from distinct chrono-cultural phases (Mora et al., 2011) (Fig. 1).

The Ramp sector (~50 m^2), located near the outer area of the shelter, has yielded an extensive Middle Palaeolithic assemblage together with contexts associated to the EUP. The base of the sequence is composed by up to 11 MP levels separated to each other by sterile layers. The contact with the EUP sequence (ca 40 -31 ka cal BP) starts with the level 497D and continues with levels 497C and 497A. All of them also separated by sedimentary hiatus where no evidence of human occupation was detected. Sector integrity has been analysed through fabric analysis, micromorphology, geospatial analysis, refittings (Benito-Calvo et al., 2009, 2011; Polo-Díaz et al., 2016; Martínez-Moreno et al., 2019; Mora et al., 2020; Sánchez-Martínez et al., 2021; Sánchez-Romero et al., 2024). The preservation of combustion structures and post-holes related to domestic activities revealed the overall good preservation of EUP sequence. The presence of edge damage and different degrees of patina indicated light and local post-depositional effects with low incidence in the general composition of the assemblages.

The Platform sector (~40 m^2), situated in the inner part of the shelter, contains an extensive sequence from the LGM that includes several archaeological levels preliminarily attributed to the Badegoulian (8P), Lower Magdalenian (7P and 6P) and Middle Magdalenian (5P and 4P) (ca 22.9 – 16.8 ka cal BP) (Mora et al., 2011; Sánchez-Martínez et al., 2022a). These levels are stratigraphically separated to each other by sterile layers, but the upper levels (5P and 4P) are partially affected by negative structures from the Neolithic period (Rodríguez-Pérez et al., 2025). Geospatial analysis, refittings, hearths and post-holes support the well preservation of the assemblages, which are not affected by edge-damage neither patina has happened in the EUP sequence of the Ramp sector.

The Transition sector (4 m^2), located in an area near the cave wall between the Ramp and the Platform, has provided evidence of the occupation of the site during the Middle/Upper Magdalenian and the Neolithic, as suggested by radiocarbon dating and technological attributes of lithic tools (Sánchez-Martínez et al., 2022a). This sector has yielded up to 6 archaeological levels with narrow archaeo-stratigraphic boundaries. The assemblage is mainly composed by lithic tools highly patinated. Technological refits have not been identified in any of these levels.

The V unit has been excavated since 2015 in an area of 12 m^2. It is located inTransition sector slopy area and towards the exterior part of the site, coinciding with the drip line of the shelter. This sector encompasses 13 archaeological levels (14.5-13.5 ka cal BP) that place this sequence in the Late Upper Palaeolithic based on chronometric and technological data, and more specifically in the Upper Magdalenian/