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Shifting occupation dynamics in the Madriu–Perafita–Claror valleys (Andorra) from the early Neolithic to the Chalcolithic: The onset of high mountain cultural landscapes[☆]

Hector A. Orengo^{a,b,*}, Josep M. Palet^b, Ana Ejarque^{b,c}, Yannick Miras^{d,e}, Santiago Riera^f^a Department of Archaeology, University of Nottingham, University Park, NG7 2RD Nottingham, UK^b Landscape Archaeology Research Group (GIAP) – Catalan Institute of Classical Archaeology (ICAC), Pl. Rovellat s/n, 43003 Tarragona, Spain^c School of Earth Sciences & Environmental Sustainability, Northern Arizona University, 602 S Humphreys, AZ 86011 Flagstaff, Arizona, US^d CNRS, GEOLAB, UMR 6042, Laboratoire de Géographie physique et environnementale, 4 rue Ledru, F-63057 Clermont-Ferrand, France^e Clermont Université, Université Blaise Pascal, GEOLAB, Maison des Sciences de l'Homme, BP 10448, F-63000 Clermont-Ferrand, France^f Seminar of Prehistoric Study and Research (SERP), Department of Prehistory, Ancient History and Archaeology, University of Barcelona, C. Montalegre 6, 08001 Barcelona, Spain

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ABSTRACT

The Madriu–Perafita–Claror valleys (MPCV) (Eastern Pyrenees, Andorra) were the focus of a multidisciplinary microregional landscape research project that aimed to study the long term shaping of this UNESCO World Heritage Site in the category of cultural landscape. The study area is situated on a glacial modelled high mountain environment ranging from 1250 to 2800 m.a.s.l.

Multidisciplinary approaches integrating archaeology and palaeoenvironment have been directed towards the unravelling of the long-term human–landscape relationships, which ultimately resulted in the MPCV cultural landscape. The development of high-resolution temporal and spatial studies could successfully correlate archaeological and palaeoenvironmental data. This study leads to the location of more than 400 archaeological structures, 55 of which were excavated, and the multiproxy study of 7 palaeoenvironmental sequences. The combination and analysis of all these data have permitted developing a history of human–environment interactions from the Mesolithic to the 20th century. In this paper, data gathered in the MPCV corresponding to the Neolithic and Chalcolithic periods are presented for the first time.

During the Early Neolithic small groups are documented with a diversified economy in which grazing, hunting, fishing, gathering and an incipient cereal agriculture activities are well represented. These groups seem to follow highly mobile occupation patterns with continuous high mountain seasonal grazing exploitations that lasted one or two centuries. They appear to frequent diverse altitudinal belts in order to take advantage of different resources. A strong pastoral orientation is related to the exploitation of high mountain areas.

During the Middle/late Neolithic human groups show a higher degree of sedentism. Hunting and gathering are still important activities although agriculture and animal husbandry increase in importance. During this period an augmentation in the pastoral pressure in the MPCV is also documented, linked to the first use of fires to create grazing areas. Symbolic landscape appropriation practices are also firstly documented during this period.

During the Chalcolithic, human landscape use becomes intensive enough to cause permanent landscape changes. The upper parts of the MPCV are deforested by the action of fire while intensive agriculture takes place at the lower valleys.

The evidence presented by the MPCV project demonstrates that it was during the Neolithic when this high mountain cultural landscape was firstly formed. This process is probably related to an increase in the population and progressive sedentism, which required a more intensive and organised use of resources and, eventually, the adoption of landscape management practices.

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* Corresponding author.

E-mail address: Hector.Orengo@nottingham.ac.uk (H.A. Orengo).

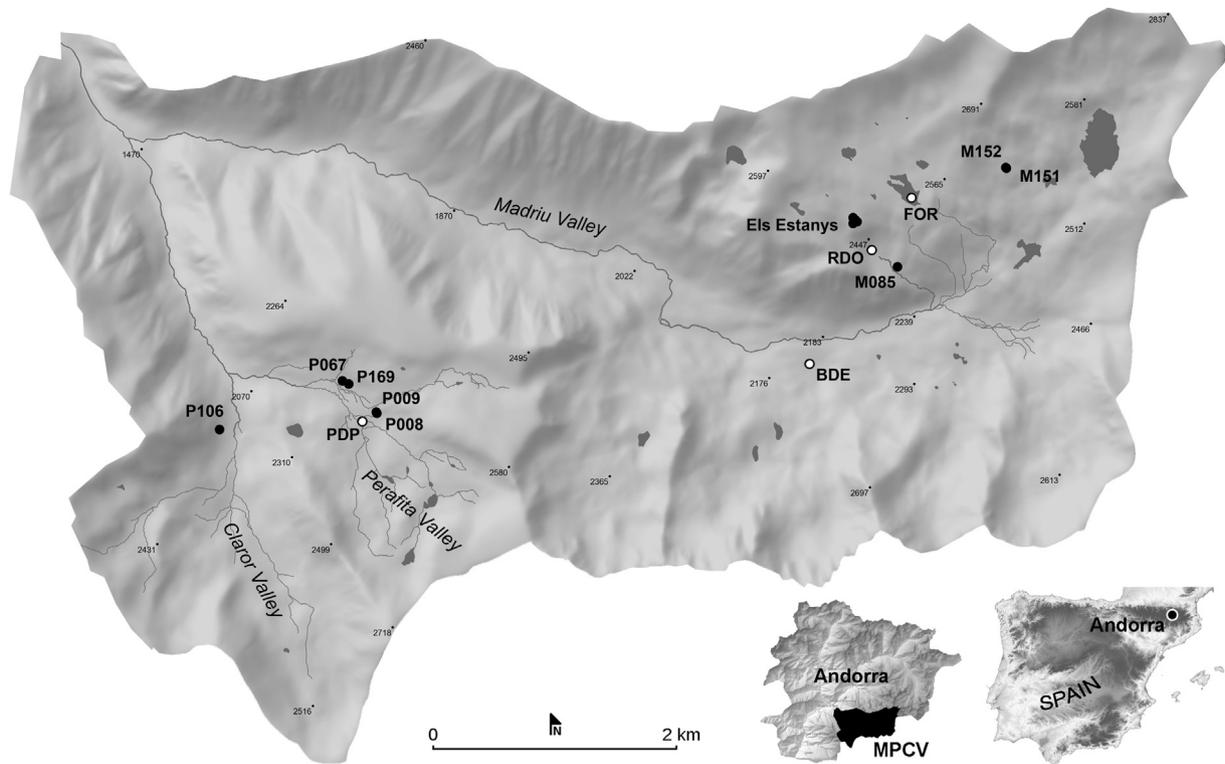


Fig. 1. Location of the study area, the archaeological structures dated to the Neolithic, and the palaeoenvironmental registers used in the text.

1. Introduction

High mountain European areas, which for a long time have been considered marginal spaces due to their extreme climatic conditions and topography, are acknowledged today as human induced environments and, in consequence, cultural landscapes. Palaeoenvironmental and archaeological research in these highlands have played an important role in the conceptualisation of high mountain areas as cultural landscapes proving that human occupation and landscape management practices can be traced back to the Mesolithic period (Oegg and Wahlmüller, 1993; Biagi and Nandris, 1994; Galop, 1998; Moe and Hjelle, 1999; Rendu, 2003; Efstratiou et al., 2006; Palet et al., 2007; Ejarque et al., 2010; Orengo, 2010; Palet et al., 2010; Ejarque, 2013; Servera et al., 2014).

The Madriu–Perafita–Claror valleys (MPCV) (Eastern Pyrenees, Andorra) were the object of a transdisciplinary microregional landscape research project, aiming to study the long term shaping of this high mountain area listed as a UNESCO World Heritage Site in the category of Cultural Landscape. Although the MPCV project employed a long-term diachronic research perspective, this paper will focus on the results obtained for the Neolithic period. The project's general research objective of studying the long-term shaping of cultural landscapes is here reduced to focus on the first human landscape modifications recorded in the study area and, therefore, it attempts to analyse the onset of Pyrenean high-mountain cultural landscapes. As discussed elsewhere (Ejarque and Orengo, 2009), the formation of cultural landscapes follows a cumulative process in which earlier landscape modifications determine future human uses of the landscape. Therefore, understanding the origins of cultural landscapes, in this case the first human–landscape modifications in the high mountain Pyrenees, is essential for the correct analysis of their long-term evolution. This

study aims to explore this topic and, by doing so, endeavours to unravel the social, economic and environmental factors involved in its shaping, the landscape management tools employed, and the social, economic and environmental outcomes of the MPCV Neolithic occupation.

Palaeoenvironmental studies have provided evidence of human impact in European High mountain areas since the early Neolithic (e.g. Ejarque et al., 2010; Orengo, 2010). However, the characterisation of this impact in cultural terms has been largely neglected. This can be related to the lack of proper integration of palaeoenvironmental studies and archaeological research. In this regard, archaeology can be considered as a much needed proxy able to provide cultural explanations for the earliest human impacts in high mountain environments reflected in the palaeoenvironmental record (see, for later periods, Orengo et al., 2013, 2014). Thus, this paper fulfils a double purpose: to show how archaeological data can provide meaningful explanations to changes in the palaeoenvironmental record by relating them to demographic, cultural and socio-economic factors and, by doing so, to contribute to the analysis of the creation and development of high mountain cultural landscapes.

2. The physical setting

The MPCV valley, ranging from 1250 to 2800 m.a.s.l., is located at the axial area of the Eastern Pyrenees, Andorra. It follows an NW–SE orientation and it is formed by the main Madriu valley and the Perafita–Claror valley (Fig. 1). The geomorphology of the study area is characterised by glacial, periglacial and fluvial modelling. The granitic geologic substratum, formed by granodiorites and biotite, creates in this area a very abrupt relief characterised by steep cliff-like slopes, glacial cirques, and tarns where lakes and peatbogs

have been formed. Periglacial deposits of lobular morphology that expanded from the glacial cirques are also found in the upper parts of the Madriu valley. These valleys form in their lower areas narrow V shaped sections as a result of glacial modelling and subsequent Holocene slope scree deposits. The upper parts present an open morphology modelled by glacial cirques and ice transfluence processes.

The altitudinal variation and the slopes' orientation promote important vegetation diversity in the study area, characteristic of high mountain zones (Gómez, 2001). In the lower sectors of the MPCV, from approximately 900 to 1700 m.a.s.l., a Scots pine (*Pinus sylvestris*) forest dominates over mixed deciduous woodland and occasional hazel (*Corylus avellana*) and silver birch (*Betula pendula*) formations. In the subalpine altitudinal belt the mountain pine (*Pinus mugo ssp. uncinata*) gradually increases its presence until, approximately, 2300 m.a.s.l. Mountain pine is more dense and mixed with rhododendron in the northern slopes while in south oriented slopes it is more dispersed and mixed with juniper. Furthermore, silver birch and silver fir (*Abies alba*) are respectively present at the upper- and lower-most part of the subalpine woodland. From 2300 m.a.s.l. upwards *Caricetalia curvulae* alpine grasslands dominate the landscape until the appearance of massive scree slope deposits and the vertical rock walls of the upper glacial cirques at around 2600 m.a.s.l.

3. Methodology

This five-year project included researchers from a diverse array of palaeoenvironmental and historical sciences in order to unravel the long-term human–landscape relation, which ultimately resulted in the MPCV cultural landscape. The approach is based on the integration of datasets from diverse nature, including palaeoenvironmental multi-proxy studies and archaeology. The methodology followed in the project was designed to obtain a high degree of correspondence between the archaeological and the palaeoenvironmental records based on the use of high-resolution temporal and spatial frameworks and the premise that local scale case studies is the most suitable approach to analyse human–environment interactions (Dearing et al., 2006), particularly in upland environments (Davies, 2007; Ejarque et al., 2010).

In this regard, the MPCV offers an ideal setting: the presence of multiple peatbogs and lakes from which palaeoenvironmental sequences were obtained could be matched by numerous closely located multi-period archaeological sites.

3.1. Archaeology

Archaeology, as a complementary proxy to those offered by palaeoenvironmental sciences, is particularly useful since it provides data specifically related to the use of the landscape. These data are chronologically and spatially referenced. The attributes of archaeological data allow the documentation of specific human action on the landscape that can be linked to human-related disturbances in the palaeoenvironmental record by the use of high resolution chronological frameworks obtained through radiocarbon dating of organic material recovered in well-defined archaeological contexts.

In order to retrieve a significant amount of archaeological data, total coverage survey was carried out. Geographic Information Systems (GIS) software was employed to incorporate high resolution orthophotographs (0.25 m/pixel), 1:5.000 digital maps, 1:25.000 vegetation maps, 1:25.000 digital geomorphological maps, and a 5 m/cell digital terrain model of the study area. These data were employed in a first assessment of the study area by photointerpretation procedures (Orengo, 2010). On a second stage,

field walking allowed the verification of these structures and the incorporation of new ones. Field walking was also useful in assessing preservation issues and the typological diversity of the structures. These criteria were essential in selecting those structures fit for test pit digging. The information collected during photointerpretation and field walking was incorporated in several vector layers linked to a database where the georeferenced plans of the structures and information related to typology, construction techniques, surface material, and geographical setting, could be queried.

Of those structures located during field walking the most representative in terms of typology and preservation were selected for archaeological excavation. Archaeological trenches covered an area of at least 2 m². Their purpose was to record the typology of the excavated structure, to recover information related to the human use of the landscape and to obtain adequate samples for radiocarbon dating. The excavation process followed standard procedures of stratigraphic excavation. The limited time availability in high mountain archaeology, however, forced the adoption of a combination of digital photogrammetric recording and differential GPS measurements to record the excavation process (Orengo, 2013). This methodology permitted an accurate and fast recording of the excavation process and allowed the generation of plans and profiles of both test pits and structures at a later stage.

The excavation methodology included besides the standard recording of all materials dry-sieving of all sediment from occupation levels. Also, from each excavated stratum a minimum of four litres of sediment was kept for environmental processing. For those structures presenting adequate continuous sedimentation a micromorphological core was retrieved to conduct micromorphological analysis at a later stage. Some natural soils located close to excavated archaeological structures were also excavated in order to correlate natural sedimentation to that documented inside human occupation structures. This is particularly important since occupation levels inside prehistoric stone-made habitation structures are, typically, lower than the surface outside them. The excavation of test pits outside the structures could confirm whether or not occupation levels were limited to the space covered by the habitation structure and were related to it. In this way, the excavator could avoid dating levels preserved under the structure that were previous to its construction.

3.2. Palaeoenvironmental multi-proxy analyses

A total number of seven sequences from the MPCV were studied for pollen analyses: two lakes and five fens. From these, only four provided Neolithic dates. In the Madriu valley the three studied records are taken in such a way that follows an altitudinal range with distinctive vegetation settings (Fig. 1). Bosc dels Estanyons (BDE) is a small fen of 0.7 ha located within the subalpine mountain forest belt at 2180 m.a.s.l. (Miras et al., 2007). Riu dels Orris (RDO) is a black sedge acidic fen of 0.8 ha set on the tree limit of the subalpine pine woodland at 2390 m.a.s.l. (Ejarque et al., 2010). Forcat (FOR) is an oligotrophic alpine lake at 2545 m.a.s.l. settled in a glacial basin of 3.5 ha surrounded by alpine grasslands (Ejarque, 2013). In Perafita valley, Planells de Perafita (PDP) is a fen of 2.9 ha located at 2240 m.a.s.l. in the tree limit of the subalpine pine woodland. The fen is surrounded by a patchwork of open grasslands and small pine groups (Miras et al., 2010). These multi-proxy sequences include the study of pollen, non-pollen palynomorphs (NPPs: fungal spores, parasites and stomata) micro- and macro-charcoal. Details of the sampling and analytical procedures that were followed in the palaeoenvironmental study of these sequences can be found in Miras et al. (2007, 2010), Ejarque et al.

(2010) and Ejarque (2013). The inclusion of NPPs and macro-charcoal provides a local counterpart to the mainly regional character of the pollen record, providing altogether spatially precise palaeoenvironmental information that can be analysed in conjunction with nearby archaeological structures. Also, both the relatively small size of the studied basins and the distribution of multiple sequences in the different sectors of the MPCV offer a high spatial resolution, which allows the documentation of differences in local dynamics that can be then compared with the distribution of archaeological sites.

The integration of palaeoenvironmental and archaeological data was further achieved by employing high-resolution chronological parameters. The studied records had an accurate chronological framing, each palaeoenvironmental register accounting for at least two radiocarbon measurements for the Neolithic period. A remarkably high temporal resolution can be observed for the RDO fen during the early and middle Neolithic, with temporal intervals between samples of *ca.* 55 years, and for the FOR lake during the Late Neolithic, with temporal intervals between samples of *ca.* 25 years. In addition, at FOR fine-resolution pollen analysis was conducted for the late Neolithic–Chalcolithic transition, with the analysis of contiguous 1 cm samples encompassing between *ca.* 15–35 years of pollen rain (Ejarque, 2013).

4. Results

4.1. Archaeological results

A total of 421 multi-period structures were located and 55 of these, corresponding to periods from the Neolithic to the 20th century, were excavated. From the 30 AMS ¹⁴C dates from material recovered in well-contextualised archaeological layers only 12 correspond to Neolithic occupation levels or ancient soil surfaces (Fig. 2). Six of these were obtained from occupation levels inside habitation stone structures while four others from occupation levels inside enclosure structures. The last two correspond to Neolithic soil levels with no associated structure.

4.1.1. Early Neolithic

P009 (Fig. 3) is the earliest structure dated to this period. This roughly circular structure of a maximum of 6 m in diameter includes several occupation layers. The first one, P009107, is dated to the Mesolithic period. This date corresponds to the construction of

the structure. Its construction technique and size distinguishes it from later structures. Structure P009107 has walls made of local granitic stone cut in large pointed triangles. These stones were assembled using the ‘fish-scale’ technique with their longest corner towards the interior of the structure, probably to avoid them falling towards the inner side of the structure. The early Neolithic inhabitants reused this structure, which resulted in several occupation levels. P009110 was radiocarbon dated to 5544 ± 69 cal. BC. Levels P009106 and P009109 provided similar material culture to that of P009110, mainly local schist work debris and tools but also local and extra-regional flint debris (Fig. 4). This suggests a long occupation period for this structure. As in the case of all other occupation structures from the period, the occupation levels inside the structure were excavated, and therefore, they were much lower than the ancient soil level outside the structure. This accounted for a good preservation of the structure’s occupation layers.

Structure M152 (Fig. 3) is a stone hut of small size located at 2518 m.a.s.l. at Pleta de les Bacives I site, a natural enclosed space modelled by glacial movements. A ring of medium and big-sized granitic stones demarcates the elongated circular habitation area defining an inner space of around 3 m². This structure presents two phases of occupation: the earlier corresponding to the early Neolithic and the latest to the Late Roman period. As seen for the previous structure, the early Neolithic occupation levels were excavated under the surface, possibly in order to preserve heat and reduce the need for high roofing. The occupation level presented scarce material culture, including a hearth dated to 4481 ± 112 cal. BC. Both the stratigraphic relationships between the excavated levels and the levels documented in a second test pit located a few meters from this structure confirmed that the M152 occupation level is confined inside the limits of the structure and therefore the conserved structure was part of the Neolithic habitation construction.

4.1.2. End of the middle Neolithic/late Neolithic

P008 (Fig. 5) is also a habitation structure. As it was reused during the early medieval period, its original shape and construction methods were not documented except from two small post-holes associated to the occupation levels. These suggest that this was a large roofed structure and therefore it probably was a habitation space. Despite the lack of direct archaeological evidence of walls, the size of the trench (2 × 0.5 m) confirms the bigger size of this structure compared to that of other habitation structures. The

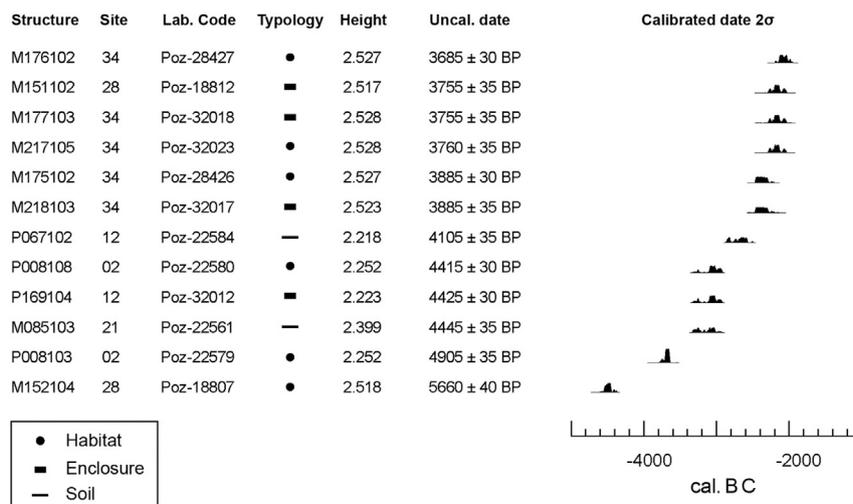


Fig. 2. Radiocarbon dates corresponding to the Neolithic occupation of the MPCV.



Fig. 3. Plan and section of structures M152 and P009.

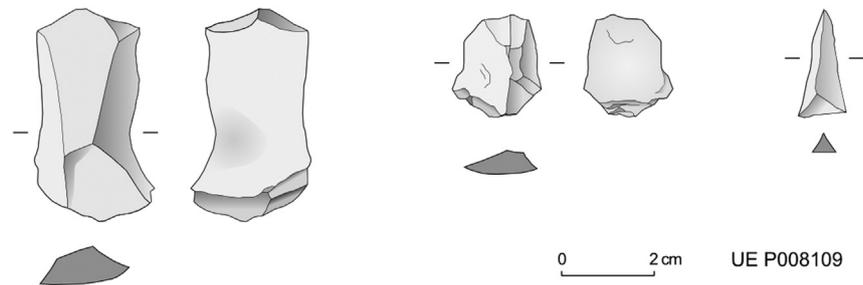


Fig. 4. Selected lithic material from occupation levels P008109.

test pit excavation documented various prehistoric occupation layers with stone tool production debris made from local schist. As in the case of previous habitation structures, the occupation area was lower than the external circulation level. The oldest occupation level was dated to 3116 ± 197 cal. BC. However, a previous radiocarbon date made on the early medieval (as proven by identified material culture) occupation level (P008103) provided a date of 3702 ± 62 cal. BC. This date could be the result of the disruption of the Neolithic occupation layers by the later early medieval occupation, which probably saw the re-excitation of earlier soil levels.

Structure P169 (Fig. 5) is formed by a group of medium sized stones arranged in a roughly quadrangular shape. The occupation level, provided fragments of handmade ceramics, too fragmented to allow any inference on their use, and organic material radiocarbon dated to 3123 ± 200 cal. BC. In contrast to the occupation levels documented in the previous structures, this layer is not excavated with respect to the external circulation level and the stones delimiting the structure lay directly over it. The distribution and size of the stones suggest that this was not a wall like those found in M152 or P009, but a simple lining of stones. No rubble was found in the excavation belonging to this wall. This perimeter wall was clearly not designed to sustain a roof that, given the size of the structure, would have required thick walls. The fact that the occupation level was not excavated also suggests this was not a habitation structure and, therefore, did not require excavating the terrain to obtain extra height or keep the inside warm. These data suggest that the structure can be interpreted as a pastoral enclosure where the wall served as a delimiting structure and, possibly, as a base for a fence made of perishable materials.

A similar date to that provided by P169, 3132 ± 202 cal. BC, was obtained from level M085103. This layer is not associated to any structure and, according to sedimentological evidence, it corresponds to a palaeosol.

A final structure, P106 (Fig. 5), could be dated to this period. This funerary cist was excavated but no organic element related to its construction could be recovered due to its re-use during the modern period as a shepherd's refuge. Reuse of megalithic monuments during the modern and contemporary period has been well documented in high mountain Pyrenees (Gassiot and Jiménez, 2006, pp. 105–106). The structure covers a space of 2.9×0.9 m with a depth of 70 cm in respect to the modern ground level. The big rectangular granitic blocks located at the sides of the funerary space are covered by three flat blocks of granitic stone. The stone corresponding to the eastern side cover was removed to allow entrance to the chamber and deposited beside the cist (Fig. 5).

The chronological ascription of cist P106 must be related to this period given the proximity of P008 and P169, at only 1100 m, but also due to the presence of multiple cist burials in Andorra also dated to this period.

4.1.3. Late Neolithic/Chalcolithic

The Els Estany site (Fig. 6), consists of a group of four habitation structures, one enclosure and a large wall enclosing the main habitation area. All elements present a similar construction style, suggesting the contemporaneity of all structures. Additionally, five radiocarbon dates obtained from three of the habitation structures, the enclosure and the wall, demonstrate a continuous occupation of the site from 2356 ± 113 cal. BC to 2080 ± 114 cal. BC. Radiocarbon dates obtained in the occupation levels of the structures provided dates corresponding to the last stages of the third millennium cal. BC (Fig. 2).

The coherence of the radiocarbon dates seems to suggest a continuous occupation of the site. Also, the relation between the different structures of the site, documented during the excavation of the structures M175 and M176 on one side and M217 and M177 on the other, further confirms their contemporaneity. In the habitation structure M218103, a seed of *Triticum dicoccum* was identified together with cooking ceramic recipients and other ceramic fragments in a hearth stratum. An interesting characteristic of the site is the existence of a wall of 1.5 m wide (M177) and other unexcavated walls closing the spaces between rock outcrops and, in this way enclosing the area. The shape of the space enclosed by this wall and the very organic sediments excavated suggest this area was also employed as an animal enclosure.

Another structure, the enclosure M151 (Fig. 6), has been dated to this period. Its occupation horizon, M151102 provided a radiocarbon date of 2162 ± 124 cal. BC. This date is identical to that provided by the M177 enclosure. The proximity between this structure, unrelated to any habitation structure, and the Els Estany site, only 1350 m (Fig. 1), suggests that this structure was used by the same population group.

The last evidence of habitation/use in the study area during this period was obtained in the Perafita valley. This corresponds to a palaeosol, P067102, identified sedimentologically and dated to 2684 ± 182 cal. BC in the Planells de Perafita I site.

4.2. Palaeoenvironmental results

Details of the palaeoenvironmental results obtained in BDE, RDO, FOR and PDP can be consulted in Miras et al. (2007, 2010), Ejarque et al., 2010 and Ejarque, 2013. Here simplified percentage and accumulation rate diagrams of these records were produced for the Neolithic period (Fig. 7). These diagrams include summary curves of dung-related fungal spores and of apophytes, the latter referring to pollen taxa indicative of anthropogenic impact. Those curves were produced following the modern pollen and NPPs assemblage study performed in the MPCV (Ejarque et al., 2011). Different phases of local woodland opening and grazing pressure are highlighted in the diagrams.

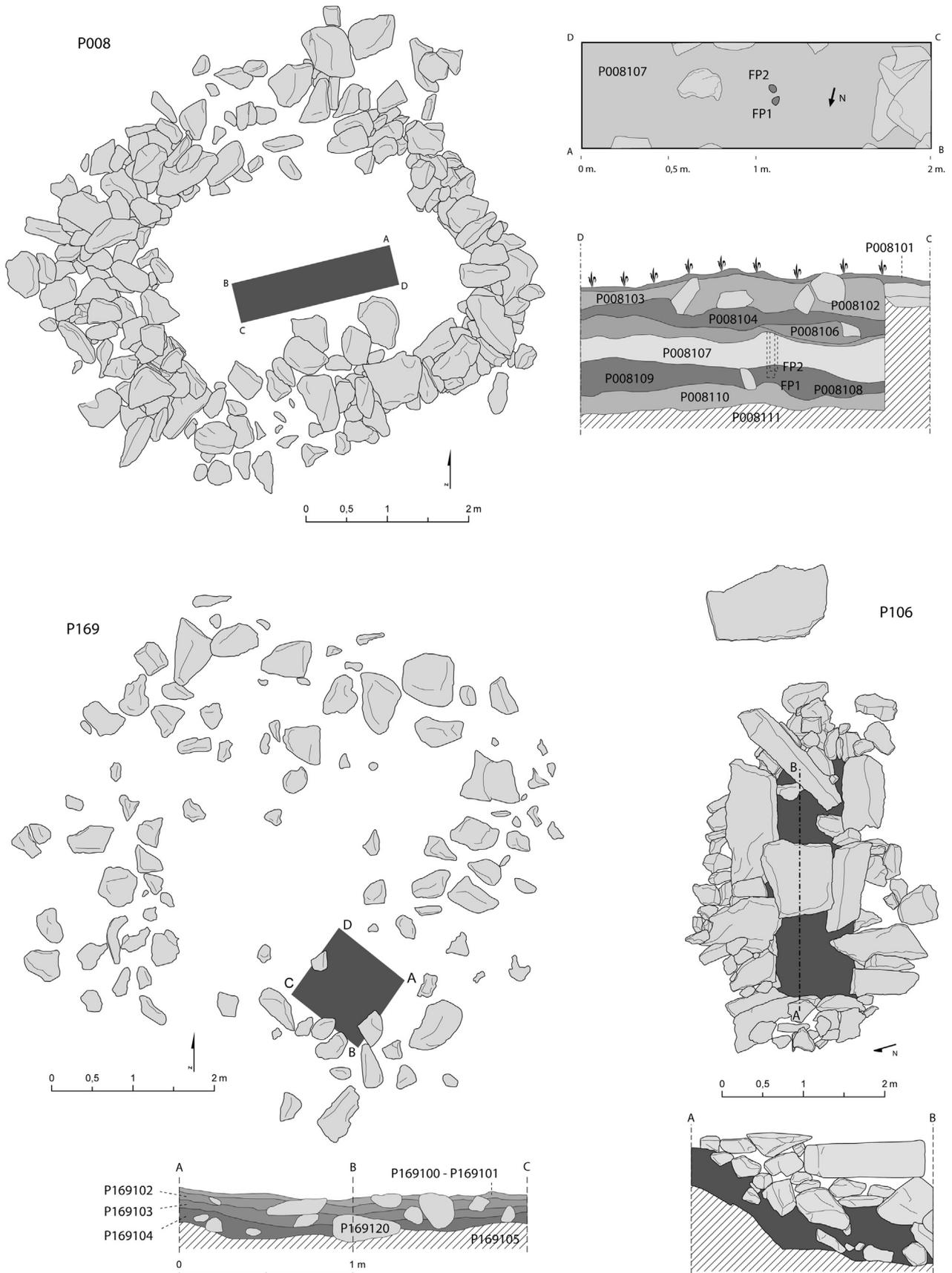


Fig. 5. Plan and section of structures P008, P106 and P169.

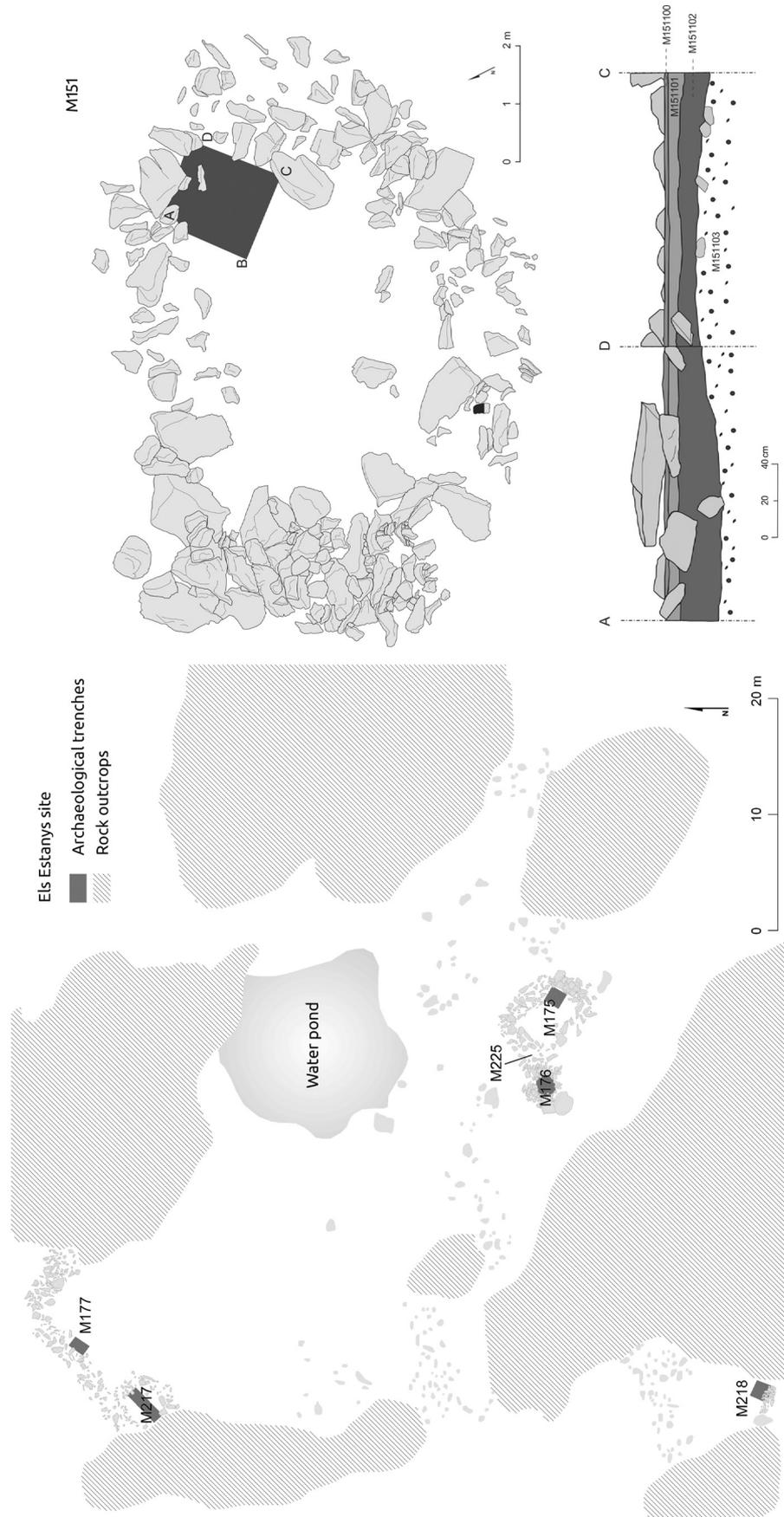


Fig. 6. Plan of Els Estany site and enclosure M151.

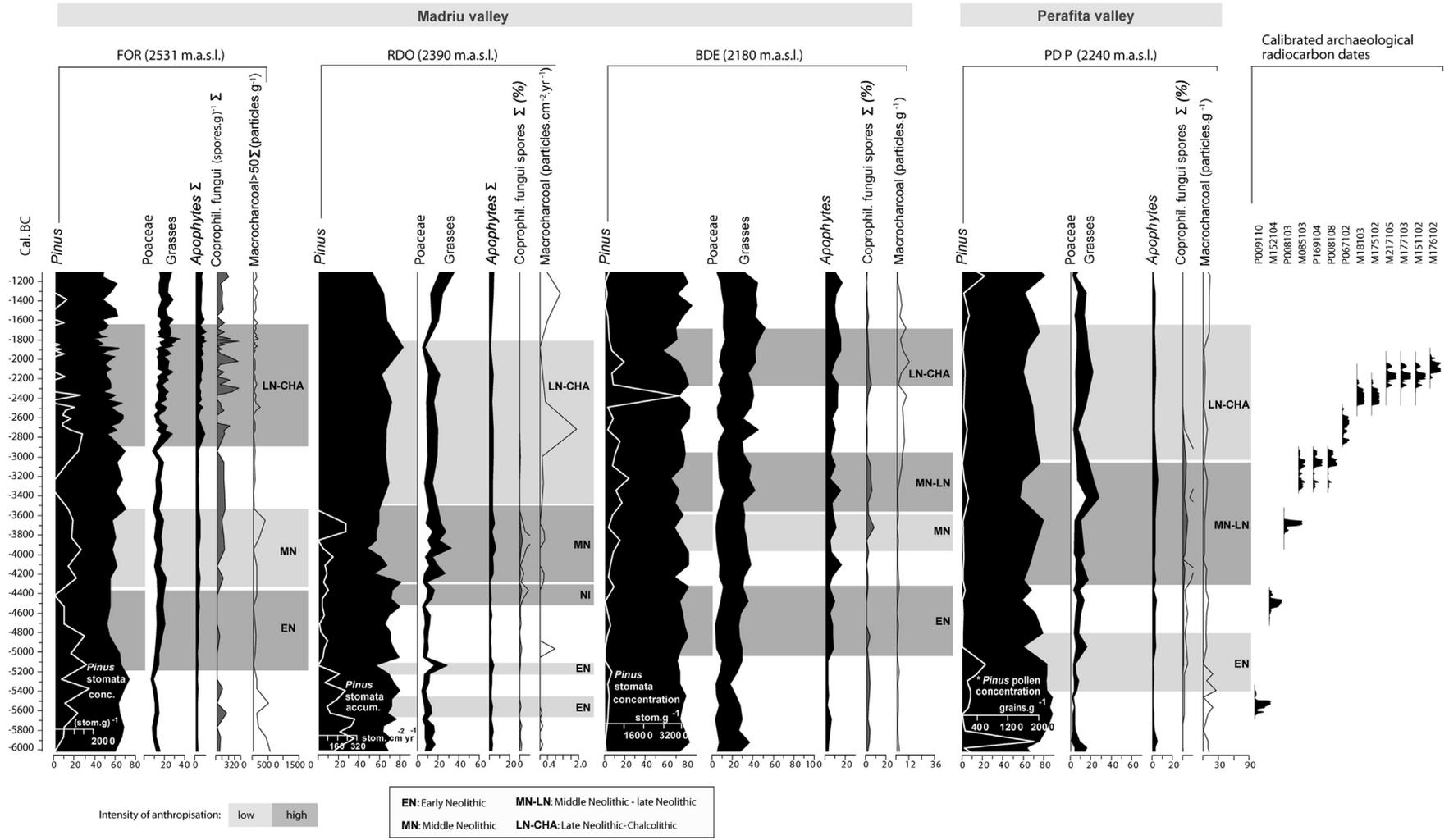


Fig. 7. Comparison of the different palaeoenvironmental sequences providing data on human impact during the Neolithic.

5. Discussion

In this section each Neolithic cultural period will be dealt with separately in order to provide a clear picture of human induced landscape changes over time. The archaeological and palaeoenvironmental evidence is compared and discussed and the resulting human–environment dynamics are contrasted against the evidence gathered in neighbouring Pyrenean high mountain areas.

5.1. Early Neolithic

Both early Neolithic structures are located close to palaeoenvironmental registers, where local human impact was detected during this period. In Perafita valley, habitation structure P009 is located just a few meters away from the PDP fen, which documents a phase of local human impact between 5300 and 4900 cal. BC with a reduction in pine and an increase in ruderal indicators (Miras et al., 2010) (Fig. 7). Although the dating of the first occupation level, 5544 ± 69 cal. BC, is around 250 years earlier to the early Neolithic palaeoenvironmental impact phase, the presence of another two occupation levels with similar material culture than that of the dated level attests to its long term occupation.

In the Madriu valley, the size of M152 hut, the only structure fully excavated for this period, suggests a small group probably composed for a maximum of four people. Its construction technique indicates that the structure was not conceived for long-term habitation but it was a temporary shelter. This perhaps may be related to the local activities of small nomadic pastoralist groups transiting the upper areas of the valley, which is consistent with the available palaeoenvironmental information in the area.

The Madriu valley at the time of this first highland settling shows more intense human-related landscape impact than that recorded in Perafita. From 5800 cal. BC the extension of pine forest up to the most elevated sectors of the MPCV (around 2600 m.a.s.l.) is documented in a context of climatic amelioration (Ejarque, 2013, pp. 118). In this context, the occupation phase of M152 coincides with human-induced local pine forest openings documented at FOR lake from ca 5200 to 4400 cal. BC and RDO fen from ca 4500 to 4350 cal. BC (Ejarque et al., 2010; Ejarque, 2013). The retreat and disappearance of pine stomata together with the increase of apophytes and herbaceous pollen taxa at FOR and the increase of apophytes and dung-related fungi at RDO at the moment of occupation of the pastoral enclosure M152 (Fig. 5) reinforces the hypothesis of pastoralism-related clearances for the increase of grazing areas at Madriu valley. A further insight into this activity is provided by the RDO's resolution, documenting between 5650 and 4350 cal. BC three forest opening phases spanning approximately from 90 to 170 years which are embedded within pine recovery phases (Ejarque, 2013, pp. 128).

Results obtained from BDE fen (Fig. 4) are consistent with the picture provided by the FOR and RDO records. It shows a decrease in pine stomata while herbaceous and anthropic indicators increase and diversify between 5050 and 4350 cal. BC. These include the strict coprophilous fungal spore *Sporormiella* (Miras et al., 2007), indicating the existence of local pastoral activities also at the subalpine areas of Madriu valley.

Both archaeological and palaeoenvironmental evidence document a human frequentation of the MPCV related to discontinuous pastoral practices. These seem to entail small-scale pine forest clearances for livestock grazing, followed by woodland recovery, which favoured the configuration of open pine woodland at high altitudes. Although the time length of these impacts is variable, they were probably seasonal and, as indicated by the short forest clearance phases of RDO, they were repeated during one or two

centuries. The observed highland shifting grazing system was probably complemented by incipient agricultural activities developed in the lower subalpine and mountain belts of Andorra. The MPCV palaeoenvironmental records attest openings in the deciduous oak, hazel and birch forest located in the lower subalpine and mountain belts together with the first recordings of Cerealia-type in RDO and PDP between 5600 and 5300 cal. BC and the more regular presence of Cerealia-type in FOR, between 5375 and 4850 cal. BC (Miras et al., 2010; Ejarque, 2013). This evidence points to the existence of agricultural activities and forest openings in the lower Andorran valleys, and is further corroborated by the recording of wheat (*Triticum* sp.) and barley (*Hordeum vulgare*) in the early Neolithic levels of the Balma de la Margineda site (Andorra) at 970 m.a.s.l (Marinval, 1995).

Regional archaeological data seem to suggest a Pyrenean early Neolithic model of mountain use entailing a wide spectrum economy as evidenced in the Balma de la Margineda site, where hunting of animals, such as the Iberian wild goat (*Capra pyrenaica*), deer and wild boar coexisted with pastoral activities that included species, such as sheep (*Ovis aries*), goat (*Capra hircus*) and pig (*Sus scrofa domestica*) (Geddès, 1995). This site also provided evidence for fishing, gathering and agricultural activities, with the presence of both wheat and barley (Marinval, 1995, pp. 130). Balma de la Margineda also sees an increase in the number of the site's inhabitants towards the end of the period at the same time that a space of the site is employed as a stabling area (Llovera, 1984, pp. 44). A second archaeological site from this period has been located in Andorra. Segudet Tomb is an individual inhumation that also provided evidence supporting a wide economic orientation for these early Neolithic groups. The identification of Cerealia, honey and milk inside a votive vase close to the tomb attest to the diversification of the group's economic activities. This site also provides evidence for wild fruit gathering, while a fish scale found in a sample of dental calculus indicated the consumption of fish (Yáñez, 2005, pp. 55). The presence of objects made of non-local materials at both sites further attest to the high level of mobility of these groups and/or the existence of contacts with other groups with which ideas and objects could be exchanged.

When comparing the evidence gathered in the MPCV with that from other neighbouring Andorran areas, a consistent picture emerges for the early Neolithic of small groups with a diversified economy where pastoralism, hunting, fishing, gathering and an incipient cereal agriculture are well represented. These groups seemed to have highly mobile occupation patterns with constant exploitation of high mountain seasonal grazing areas that lasted one or two centuries. They would frequent diverse altitudinal belts in order to take advantage of the different resources that each ecological niche had to offer. Therefore, a strong pastoralist focus related to the exploitation of high mountain areas can be observed while lower Andorran valleys are mainly used for agricultural activities. Such mountain land-use system is comparable with the itinerant agropastoral system, the so called "landman model" described for lowland European Neolithic communities (Iversen, 1941; Vuorela, 1986; Behre, 1988; Riera, 1994).

5.2. Middle/late Neolithic

During the middle Neolithic and the transition to the late Neolithic the archaeological evidence of human occupation increases in the MPCV as they do in other Pyrenean areas. The synchronous occupation of P008 habitation structure with that of P169, a pastoral enclosure, provides important data on the type of activities carried out in the area by middle/late Neolithic groups. These were probably recurrent summer occupations focused on pastoral activities. The human groups had probably a more

sedentary character and were probably linked to lower habitation sites. The presence of the P106 burial cist in the area can also be linked to a more sedentary character of these groups and can offer a cultural context for them. These monumental tombs have been frequently linked to assertions of territoriality (Barrett, 1993; Muir, 2000; Agirre García et al., 2010), characteristic of sedentary groups.

The site of Feixa del Moro lying at a lower altitude (1335 m.a.s.l.) offers a complementary image to that of Perafita valley. This site has yielded two radiocarbon dates corresponding to 3712 ± 362 and 4152 ± 654 cal. BC (Llovera and Bertran, 1991, pp. 20). It includes both habitation layers and cist burials. From the three cists recorded, two still preserved the inhumations and the funerary offerings, characteristic of the so-called *Sepulcres de Fossa* Culture. The presence of votive axes made of serpentine and shale and decorative items made of variscite from the mines of Can Tintorer, in Gavà (135 km to the south of Andorra) attests to the participation of this group in long-distance trade networks. Feixa del Moro has been described as a seasonal but stable site (Yáñez, 2005, pp. 57). Inside the habitation areas various artefacts related to the process of food, such as hand mills, were recovered. Close to these structures several ceramic containers were discovered with cereals and hazelnut (*C. avellana*) shells (Llovera and Bertran, 1991; Yáñez, 2005, pp. 56–57). Close to Feixa del Moro, the sites of Camp del Colomer and Carrer Llinàs 28 (Fortó et al., 2009), provided two hut occupation levels (excavated with respect to the external surface) and seven grain silos of around 170 cm depth. The presence of mill stones together with the silos affirms the strong agricultural orientation of Camp del Colomer. This site has been interpreted as a stable settlement periodically occupied by an itinerant group that would move inside a well delineated territory. There is also evidence to highlight the agricultural orientation of the group that seems to be involved in deforestation activities, as suggested by the high number of axes with use marks found at Carrer Llinàs 28, for the creation of open areas for agricultural exploitation (Fortó et al., 2009).

The middle Neolithic groups in the Perafita valley had a significant impact on their immediate landscape as attested by the palaeoenvironmental study of the PDP fen, located in the vicinity of structures P008, P169 and P106 (Fig. 1). The pine forest opening and the extension of alpine grasslands together with the rise of anthropogenic indicators and dung-related fungal spores documented between 3600 and 3050 cal. BC are linked to the increase of local pastoral activities (Miras et al., 2010), which were synchronous with the presence of the human groups occupying the area.

Human occupation seems to favour Perafita valley during the middle Neolithic given the scarce evidence documented at Madriu valley. However, palaeoenvironmental data indicate the existence of grazing activities and pine woodland clearances also in the Madriu valley. The RDO fen shows a more permanent pine clearance between 4350 and 3500 cal. BC that can be related to local, occasional fires. The continuous presence of stomata together with coprophilous fungi spores and local grazing indicators at this period suggests that forest clearance was aimed at the creation of an open forest that was employed for grazing purposes. The disappearance of pine stomata in RDO towards 3500 cal. BC indicates the definitive stabilisation of alpine grasslands probably, as a consequence of the pastoral pressure in a first phase of the middle Neolithic. From this moment onwards the area around RDO (located at 2390 m.a.s.l.) remained deforested until today as pine forests grow only at lower altitudes (Ejarque, 2013, pp. 131). During the final phase of the middle Neolithic (ca. 3500 to 3000 cal. BC) in the highland alpine belt of the Madriu valley a decrease in anthropogenic activities is documented while at lower sectors of the valley the BDE fen at 2130 m suggests continuity of grazing with a moderate opening of the pine forest, associated to low intensity

local fires (Miras et al., 2007). This is archaeologically attested by a circulation level or palaeosol, M085103, from the Riu dels Orris I site (2390 m.a.s.l.) dated to 3132 ± 202 cal. BC. The limited time lag between this circulation level and the occupation levels documented in Perafita may suggest that Madriu and Perafita valleys were frequented during the same period. This would thus attest to the frequentation and pastoral exploitation of the neighbouring Madriu valley.

Archaeological and palaeoenvironmental data point to a stronger human frequentation of the Perafita valley and the highest sectors of the Madriu valley during the last stages of the middle Neolithic compared to the early Neolithic phase, and was probably associated to animal husbandry. Both datasets indicate longer human occupation, according to the two radiocarbon dates of P008 hut, in contrast with the shorter occupation period documented during the early Neolithic. Although only one habitation structure in each period was excavated enough to allow the extrapolation of the size of the habitation space, the size of P008 is much bigger than that of M152. This increase in size may suggest an increase in the number of individuals forming the middle Neolithic group with respect to that of the early Neolithic. This could explain the changes observed in the palaeoenvironmental record, with the increase of deforestation and the expansion of alpine grasslands, particularly at Perafita, where these expand over 2000 m.a.s.l. (Miras et al., 2010).

The dating of sites such as those at Perafita and Feixa del Moro in Andorra and other neighbouring sites, such as Serrat de la Padrilla and Cova del Sardo are concurring with an increased stability in settlement patterns. At Serrat de la Padrilla site, at 2300 m.a.s.l. (French Cerdanya), two closely located habitat structures evidence continuous occupation between 4287 and 3051 cal. BC and are related to an opening of the pine forest at 3353 cal. BC (Galop, 1998; Rendu, 2003, pp. 215–228). In the Pallars Sobirà region (Central Pyrenees, Spain) evidence of occupation during this period is reported in several highland sites such as the Abric del Estany de la Coveta I, 2431 m.a.s.l., at Obagues de Ratera site, 2322 m.a.s.l., at Coll del Portarró site, between 2280 and 2327 m.a.s.l., and at Cova del Sardo site (Vall de Boí, Alta Ribagorça) at 1830 m.a.s.l. (Gassiot and Jiménez, 2006; Jiménez, 2006). This last site shows a long occupation sequence with middle Neolithic phases dated to 2745 ± 69 cal. BC and to 3864 ± 98 cal. BC. Microwear analysis performed on the tools found on site, showed these have been employed to work non-woody plants (Gassiot and Jiménez, 2006, pp. 100; Jiménez, 2006).

It is thus tempting to link this stability in the highlands with the increasing intensity of agricultural activities documented in both the palaeoenvironmental and archaeological record at lower altitudes. The different palaeoenvironmental records studied in the MPCV between 4500–4200 and 3000 cal. BC document a generalised opening of the lower mixed deciduous woodland (i.e. deciduous oak, hazel, elm, lime tree), and the more regular recording of *Cerealia*-type (Ejarque, 2013, pp. 132). Archaeological data obtained in these areas (e.g. Feixa del Moro site) corroborate this picture. A more agriculture-oriented economy of the middle Neolithic groups would imply higher sedentism as opposed to the higher mobility pattern suggested for the early Neolithic. The development during this period of monumental funerary practices interpreted as territorial assertions can be linked to this process. However, according to the archaeological evidence at the MPCV, these groups would still be involved in seasonal movements linked to the exploitation of different resources along the altitudinal belt. This reduced mobility would not entail a decrease in exchanges between groups as indicated by the high percentage of non-local materials recovered in various sites, such as Feixa del Moro. It is possible that the sedentary character of these groups can also be related to the increase in population that was demonstrated in the

archaeological record by the increase in the size of habitation structures and the multiplication of occupation documented at a regional level.

5.3. Late Neolithic–Chalcolithic

During the last part of the third millennium cal. BC new evidence of occupation were recovered in the MPCV, such as the four habitation structures inside an enclosed area, and the large enclosures M218 and M151 at the site of Els Estanys (Fig. 6). Dating evidence suggests the seasonal occupation of the site for about 300 years, covering the period between 2356 ± 113 and 2080 ± 114 cal. BC. Els Estanys shows important changes in respect to previous periods: this is a group of clearly delimited habitation structures forming a small village. This village is the higher Neolithic or Chalcolithic settlement ever found in Europe and, as such, deserves special attention. In general, the structures are bigger than those of previous phases, particularly M175 and M217. M175 is particularly large, its interior covering an area of 17 m^2 and prohibiting the employment of a circular plan. This is the earliest quadrangular structure in the study area. It is also constructively linked to M176 and M225. These habitation structures cover approximately 40 m^2 and if they are all indeed for habitation, they could have hosted comfortably up to 20 people, suggesting is a significant increase in the number of people inhabiting the area respect to that of previous periods. This settlement probably accommodated a whole group and not only a part of a group specialised in summer pastoral practices. The presence of cooking ceramics and a seed of *T. dicoccum* associated with a hearth found in M218 occupation can be indicative of a relation of this group with agricultural practices developed at lower altitudes. In fact, palaeoenvironmental analysis in the MPCV also registers the retraction of birch, fir, hazel and oak at the lower subalpine and mountain areas together with a more regular recording of Cerealia pollen, the latter possibly related to the expansion of agricultural practices during this period (Ejarque, 2013, pp. 138).

This group probably spent the winter in lower areas and the summer in high mountain environments. Their summer occupation can be linked to pastoral activities, as attested by the presence of two enclosures and the use of Els Estanys site central area as an enclosure itself (Fig. 6). The total amount of enclosed space covers about 1300 m^2 . In accordance with archaeological data, palaeoenvironmental analyses point to a strong change in both the landscape configuration of the MPCV and the means employed to achieve this during this period. The FOR sequence from 2800 cal. BC and until 1650 cal. BC, demonstrates local opening of the pine forest that reaches its peak towards 2450 cal. BC. It is in this moment when the highest areas of the Madriu valley, around Forcat Lake, are cleared and covered by alpine grasslands, which will dominate the alpine belt in the Madriu valley for the rest of the late Holocene. The increase in apophytes, including nitrophilous and ruderal taxa, together with the presence of coprophilous fungi spores, points towards the strong grazing orientation of the forest clearance during this phase. Pastoral pressure is intense, constant and continuous in a way that forest regeneration is not allowed (Ejarque, 2013, pp. 136). In this sense, the spatial and chronological relation between the palaeoenvironmental evidence provided by FOR lake and the occupation at Els Estanys and the M151 enclosure (Fig. 1), strongly suggests that the group inhabiting this site was responsible for the deforestation of the area and its conversion to pastoral grasslands.

Although of lower intensity, human impact was also detected in the subalpine vegetation zone. Thus, at 2180 m.a.s.l., the BDE record shows an increase of grasses and anthropic indicators and the presence of coprophilous fungi spores together with a decrease in

pine pollen and stomata that indicate the existence of forest openings and local grazing activities between 2200 and 1650 cal. BC. The increase of macro-charcoal in BDE suggests that these deforestations were aided by the use of fire (Miras et al., 2007). The use of human-induced fires as a landscape-forming tool is only documented in the lower part of the Madriu valley while the upper area's deforestation can be related to a more intensive and sustained pastoral exploitation (Ejarque et al., 2010). Differences between valleys in the MPCV were also recorded: in Perafita valley only a circulation level, P067102, was archaeologically attested. However, the PDP register shows a decrease in the human exploitation of this area (Miras et al., 2010). The existence of such different landscape management strategies between different areas of the same valley and even between adjacent valleys during the same period demonstrate the development of a land-use system characterised by a strong human-directed landscape organisation of high altitude areas.

Human activities become, for the first time, intensive enough to result in a perdurable landscape change in the Madriu valley during this period. From this moment onwards the upper areas of the Madriu valley will remain treeless until today due to continuous human pressure (Ejarque, 2013), as it was the case of the Perafita valley from the middle Neolithic onwards. These woodland clearances resulted from the need to create grazing areas in the upper high mountain valleys and agricultural areas in the lower mountain belt. In relation to this need, fire becomes generalised as a landscape modification tool. Uppermost mountain areas are transformed into grasslands. It is possible that the stronger economic focus on agriculture and pastoralism could have influenced these deforestations. The importance of hunting and gathering activities is reduced and therefore, forest was probably no longer considered the principal resource for subsistence.

6. Conclusions

This study has presented strong evidence for the first development of high mountain cultural landscapes in the Pyrenees. The data point to an increase in both the size and the degree of sedentism of the human groups frequenting the MPCV and neighbouring areas during the Neolithic. This tendency is particularly evident in the increase in both the number and size of human-made structures, in the landscape impact of these groups, i.e. forest clearances and the use of fire as a landscape management tool, and the emergence of monumental funerary elements that have been claimed to assert territoriality. The increase in cereal cultivation in the lower areas of Andorra as attested by pollen data and archaeological evidence corroborate these observations. It is difficult to speculate what the causes and the consequences were of these processes, but a long-term relationship between population increase, sedentism, cereal agriculture and intensive pastoralism (as reflected in the everlasting deforestation of the upper areas of the Madriu and Perafita valleys) seem to have played an increasing role in the MPCV during the Neolithic.

This research has also stressed how the integration of archaeology with palaeoenvironmental analysis can contribute to the interpretations not only of landscape changes, but also of the economic, demographic and social processes driving them. This is only possible if a microregional integrated methodology is followed, where spatial and chronological contexts can be compared. In the past few years, there is an increasing number of studies that endeavour to integrate palaeoenvironmental and archaeological data, some of the problems in attempting such an approach might be related to a number of factors: (1) the adoption of a regional approach in which the study area includes different environmental settings, (2) the scarcity of palaeoenvironmental sequences/

archaeological data to be employed in conjunction in the explanation of human-directed landscape changes, (3) lack of high-resolution chronologies which prevent the correlation of archaeological and palaeoenvironmental data and (4) the lack of multiproxy palaeoenvironmental studies combining pollen and other bio-indicators that allow a better understanding of the local and extra-local palaeoenvironmental signal. The MPCV project demonstrates how adopting a high spatial (multiple multiproxy sequences and total coverage archaeological survey and excavation) and chronological resolution can result in meaningful data integrations and, consequently, in the explanation of highly complex interaction dynamics between humans and their environment.

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References

- Agirre García, J., Moraza Barea, A., Mujika Alustiza, J.A., 2010. Los elementos físicos como reivindicación del territorio y de sus frutos en los espacios de montaña. In: Fernández Eraso, J., Mujika Alustiza, J.A. (Eds.), Proceedings of the International Congress on the Study of Megaliths and Other Contemporary Burials in a Social, Economic and Cultural Context, Munibe, suplemento 32. Sociedad de Ciencias Aranzadi Zientzi Elkarte, Donostia, pp. 286–313.
- Barrett, J.C., 1993. Fragments from Antiquity. An Archaeology of Social Life in Britain, 2900–1200 BC. Blackwell, Oxford.
- Behre, K.E., 1988. The role of man in vegetation history. In: Huntley, B., Webb, T. (Eds.), *Vegetation History*. Kluwer Academic Publishers, Dordrecht, pp. 633–672.
- Biagi, P., Nandris, J. (Eds.), 1994. *Highland Zone Exploitation in Southern Europe*. Monografie di 'Natura Bresciana', vol. 20.
- Davies, A.L., 2007. Upland agriculture and environmental risk: a new model of upland land-use based on high spatial-resolution palynological data from West Africa, NW Scotland. *Journal of Archaeological Science* 34, 2053–2063.
- Dearing, J.A., Battarbee, R.W., Dikau, R., Larocque, I., Oldfield, F., 2006. Human-environment interactions: learning from the past. *Regional Environmental Change* 6, 115–123.
- Efstratiou, N., Biagi, P., Elefanti, P., Karkanas, P., Ntinou, M., 2006. Prehistoric exploitation of Grevena highland zones: hunters and herders along the Pindus chain of western Macedonia (Greece). *World Archaeology* 38 (3), 415–435.
- Ejarque, A., 2013. La alta montaña pirenaica: génesis y configuración holocena de un paisaje cultural. In: *British Archaeological Reports International Series*. Archaeopress, Oxford.
- Ejarque, A., Orengo, H.A., 2009. Legacies of change: the shaping of cultural landscapes in a marginal Mediterranean range, Garraf Massif, North-eastern Spain. *Oxford Journal of Archaeology* 28 (4), 425–440.
- Ejarque, A., Miras, Y., Riera, S., Palet, J.M., Orengo, H.A., 2010. Testing microregional variability in the Holocene shaping of high mountain cultural landscapes: a palaeoenvironmental case-study in the Eastern Pyrenees. *Journal of Archaeological Science* 37 (7), 1468–1479.
- Ejarque, A., Miras, Y., Riera, S., 2011. Pollen and non-pollen palynomorph indicators of vegetation and highland grazing activities obtained from modern surface and dung datasets in the eastern Pyrenees. *Review of Palaeobotany and Palynology* 167 (1), 123–139.
- Fortó, A., Vidal, À., Maese, X., 2009. Darreres troballes del neolític a Juberri (Andorra). *Cota Zero* 24, 14–16.
- Galop, D., 1998. La Forêt, l'Homme et le Troupeau dans les Pyrénées. 6000 Ans d'Histoire de l'Environnement entre Garonne et Méditerranée. In: *Contribution Palynologique*. GEODE-Laboratoire d'écologie terrestre-Framespa, Toulouse.
- Gassiot, E., Jiménez, J., 2006. El poblament prefeudal de l'alta muntanya dels Pirineus occidentals catalans (Pallars Sobirà i Alta Ribagorça). *Tribuna d'Arqueologia* 2004–2005, 89–122.
- Geddès, D., 1995. La fauna mesolítica i neolítica de la Balma de la Margineda. In: Guilaine, J., Martzluff, M. (Eds.), *Les excavacions a la Balma de la Margineda (1979–1991)*, vol. II. Edicions del Govern d'Andorra, Andorra, pp. 83–91.
- Gómez, A., 2001. El necesario equilibrio entre preservación y explotación del paisaje: el caso del Principado de Andorra. *Scripta Nova. Revista electrónica de Geografía y Ciencias Sociales* V, 103.
- Iversen, J., 1941. Landnam i Danmark Stenalter. *Danmarks Geologiske Undersøgelse* 66, 1–68.
- Jiménez, J., 2006. La imagen de los espacios de alta montaña en la prehistoria: el caso de los Pirineos Catalanes Occidentales (Unpublished dissertation). Autonomous University of Barcelona, Barcelona.
- Llovera, X., 1984. Carta Arqueològica del Principat d'Andorra (Unpublished dissertation). Autonomous University of Barcelona, Barcelona.
- Llovera, X., Bertran, R., 1991. Juberri (Andorra): un exemple de centre receptor i de comerç de joies cap a l'any 3000 aC. In: *Les Joies de la Prehistòria, catàleg de l'exposició*. Govern, d'Andorra, Generalitat de Catalunya, Museu de Gavà, Ajuntament de Barcelona, Andorra la Vella, pp. 20–24.
- Marinval, P., 1995. Recol·lecció i agricultura de l'epipaleolític antic: anàlisi carpològica de la Balma de la Margineda. In: Guilaine, J., Martzluff, M. (Eds.), *Les excavacions a la Balma de la Margineda (1979–1991)*, vol. II. Edicions del Govern d'Andorra, Andorra, pp. 65–77.
- Miras, Y., Ejarque, A., Riera, S., Palet, J.M., Orengo, H.A., Euba, I., 2007. Dynamique holocène de la végétation et occupation des Pyrénées andorranes depuis le Néolithique ancien, d'après l'analyse pollinique de la tourbière de Bosc dels Estanyons (2180 m, Vall del Madriu, Andorre). *Comptes Rendus Palevol* 6 (4), 291–300.
- Miras, Y., Ejarque, A., Orengo, H.A., Riera, S., Palet, J.M., Poiraud, A., 2010. Prehistoric impact on landscape and vegetation at high altitudes: an integrated palaeoecological and archaeological approach in the eastern Pyrenees (Perafita valley, Andorra). *Plant Biosystems* 144 (4), 946–961.
- Moe, D., Hjelte, K.L., 1999. Mesolithic human adaptation to changing alpine/subalpine vegetation in the Central and Eastern Alps, based on vegetational historical study from Val Febraro, Spluga Valley (Italy). *Universitätsforschungen zur Prähistorischen Archäologie* 55, 207–214.
- Muir, R., 2000. *The New Reading of the Landscape: Fieldwork in Landscape History*. University of Exeter Press, Exeter.
- Oeggli, K., Wahlmüller, N., 1993. Vegetation and climate history of a high alpine mesolithic camp site in the Eastern Alps. *Preistoria Alpina* 28, 71–82.
- Orengo, H.A., 2010. *Arqueologia de un paisaje cultural pirenaico de alta montaña. Dinámicas de ocupación del valle del Madriu-Perafita-Claror (Andorra)* (Ph.D. thesis). Rovira i Virgili University, Spain.
- Orengo, H.A., 2013. Combining terrestrial stereophotogrammetry, DGPS and GIS-based 3D voxel modelling in the volumetric recording of archaeological features. *ISPRS Journal of Photogrammetry and Remote Sensing* 76, 49–55.
- Orengo, H.A., Palet, J.M., Ejarque, A., Miras, Y., Riera, S., 2013. Pitch production during the Roman period: an intensive mountain industry for a globalised economy? *Antiquity* 87 (337), 802–814.
- Orengo, H.A., Palet, J.M., Ejarque, A., Miras, Y., Riera, S., 2014. The historical configuration of a UNESCO world heritage site: the cultural landscape of the Madriu-Perafita-Claror Valley. *Archeologia Postmedievale* 17 (in press).
- Palet, J.M., Ejarque, A., Miras, Y., Riera, S., Euba, I., Orengo, H.A., 2007. Formes d'ocupació d'alta muntanya a la Vall de la Vansa (Serra del Cadí - Alt Urgell) i la vall de Madriu-Perafita-Claror (Andorra): estudi diacrònic de paisatges culturals pirinencs. *Tribuna d'Arqueologia* 2006, 229–253.
- Palet, J.M., Orengo, H.A., Ejarque, A., Euba, I., Miras, Y., Riera, S., 2010. Formas de paisaje de montaña y ocupación del territorio en los Pirineos orientales en época romana: estudios pluridisciplinares en el valle del Madriu-Perafita-Claror (Andorra) y en la Sierra del Cadí (Cataluña). *Bollettino di Archeologia on line* 1, 67–79.
- Rendu, C., 2003. La montagne d'Enveig. Une estive pyrénéenne dans la longue durée. *Trabucaire*.
- Riera, S., 1994. *Evolució del paisatge vegetal holocè al Pla de Barcelona, a partir de les dades pol·líniques* (Unpublished doctoral thesis). Universitat de Barcelona, Barcelona.
- Servera, G., Miras, Y., Riera, S., Julià, R., Allée, Ph., Orengo, H., Paradis-Grenouillet, S., Palet, J.M., 2014. Tracing the land use history and vegetation dynamics in the Mont Lozère (Massif Central, France) during the last 2000 years: the interdisciplinary study case of Countrasts peat bog. *Quaternary International* 353, 123–139. <http://dx.doi.org/10.1016/j.quaint.2013.10.048>.
- Vuorela, I., 1986. Palynological evidence of slash-and-burn cultivation in South Finland. In: Behre, K.E. (Ed.), *Anthropogenic Indicators in Pollen Diagrams*. A.A. Balkema, Rotterdam, pp. 53–64.
- Yáñez, C., 2005. El neolítico. In: Belenguier, E. (Ed.), *Història d'Andorra. De la prehistòria a l'edat contemporània*. Edicions 62, Barcelona.