



Long-term hominin occupation during the Middle and early Late Pleistocene: Chronostratigraphy of the Ter River basin (Girona, North-eastern Spain)

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ABSTRACT

Discussion regarding continuity or discontinuity in the peopling of Europe during the Pleistocene is a key issue in the study of the survival capacity of these hominin groups. However, long-term archeostratigraphic sequences such as Gran Dolina or Caune de l'Arago which can throw light on this potential continuity are limited. Hence, it is necessary to enlarge the analysis by including consideration of fluvial systems with archeological sites on their terraces. This article correlates the chronostratigraphy of sites dated to the Early Paleolithic in North-eastern Spain, located in the Ter and Onyar river terrace systems, in the travertine stream of La Garriga and in the volcanic and karstic context of the Ter basin. While the first half of the Middle Pleistocene is assessed in terms of the relative chronology provided by the terraces and the morphotechnical features of their industries, the second half of that period and the early Late Pleistocene are documented by numerical dates from travertine and stalagmite (U-series and $^{230}\text{Th}/\text{U}$) and from volcanic ($^{40}\text{Ar}/^{39}\text{Ar}$) levels ranging between 350 and 90 kyr. Despite the limited archeological resolution and the reduced number of radiometric dates obtained in the basin, chronostratigraphic analysis contributes to the debate about hominin adaptation to continental paleoclimatic fluctuations during the Pleistocene.

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1. Introduction

Research on the continuous or intermittent nature in the hominin peopling of Europe during the Early and Middle Pleistocene has

been considered a key issue in recent times. The scarce long-term stratigraphic sequences available, such as in Gran Dolina (Atapuerca) (Mosquera et al., 2013) or Vallparadís (Martínez et al., 2010) in Spain, as well as the extensive fluvial series with lithic industries, like the middle basin of the Loire River (Despriée et al., 2011) in France, have given rise to opposed hypotheses. On the one hand, some authors advocate continuity of occupation (García et al., 2011, 2012; Bermúdez de Castro et al., 2013) whereas, on the other hand, other scholars suggest

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discontinuity of population during the late Early and the early Middle Pleistocene (e.g. Agustí et al., 2009; Blain et al., 2009; Moncel, 2010; Hughes et al., 2011; MacDonald et al., 2012; Bermúdez de Castro and Martín-Torres, 2013; Muttoni et al., 2013; Rodríguez-Gómez et al., 2014). Throughout this time period, both an aridity crisis and the impoverishment of the ecosystems were recorded and related to the long-term cooling trend which took place during the 'Mid-Pleistocene Transition', from about 1.2 to 0.7 Myr (e.g. Clark et al., 2006; Head et al., 2008). This climatic harshness seemed to have forced hominin groups to occupy local ecological refugia. According to the 'sink-source' model, during interstadial and interglacial periods, Northern Europe was recolonized by people living in these refugia located in southern areas as well as receiving new immigrants from South-western Asia (Dennell et al., 2011). Thus, during glacial–interglacial transition periods, the more favorable climate would have provided favorable environmental conditions for long-term hominin occupation (Leroy et al., 2011).

Although some interruptions in the settlement record for Central and Southern Italy were detected during the glacial events of the Middle Pleistocene (Orain et al., 2013), these archeological gaps were related to hominin mobility strategies for subsistence by chasing animal communities rather than to a lack of population (Palombo, 2010). Furthermore, there are not many long-term chronocultural series where the Middle–Late Pleistocene boundary (MIS 6–5) is represented. However, the seemingly low occupational density in the Iberian Peninsula during this period has been attributed to deficiencies in dating procedures or in archeological excavations rather than to population gaps (de la Torre et al., 2013). During the second half of the Middle Pleistocene and the earliest Late Pleistocene, all the available records (including technology, settlement patterns and spatial organization) seem to indicate the acquisition of modern behavioral patterns by hominin groups (Rolland, 1999; Conard, 2007). From a technological perspective, the early Middle Paleolithic industries (Mode 3) appeared. Their variability suggests a technological mosaic incorporating raw material constraints, functional or settlement dynamics (Dibble and Rolland, 1992), and functional (Beyries, 1988) or ecological factors (Kuhn, 1995). Available dates for the levels which yielded these industries in Gran Dolina TD10.1 (Rodríguez, 2004) and Bolomor Cave (Fernández Peris, 2007) indicate the coexistence in the Iberian Peninsula of Modes 2 and 3 between 300 and 100 kyr. During this period, bifaces were gradually substituted (Moncel et al., 2011) by other tools such as picks (Carbonell et al., 1992a).

The presence of Mode 1 industries in the Middle Pleistocene formations of the Ter basin (Girona, North-eastern Spain) indicate that this technology could have persisted into this period in the area, when Mode 2 industries were fully consolidated. Furthermore, the common technological basis for Mode 2 and 3 industries in the Ter basin suggests possible technological and occupational continuity. In order to expound on this research, fluvial systems and sites with high-resolution archeological sequences are needed to provide new chronological data. The Middle and early Late Pleistocene in North-eastern Spain is mainly known from research carried out in the Early Paleolithic sites of the Ter basin during the last 40 years. Both the fluvial networks and nearby areas are rich in open air, cave and rockshelter sites with stratigraphic contexts, although these are generally surface sites devoid of faunal remains (Canal and Carbonell, 1989) (Table 1). Despite the fragmentary chronological and archeological data available, this article provides an integrated analysis of all available data to reconstruct the settlement sequence, extending its conclusions into the general discussion of occupational continuity versus hiatus in the area. It also enlarges on the debate about the diffusion of contemporary technologies in Western Europe during the Middle and the early Late Pleistocene.

2. Materials and methods

The hypothesis proposed in this article demands particular attention to the limits and problems derived from the different methods used for

dating hominin occurrences in the Ter River basin. This chronological analysis includes radiometric methods such as U-series, $^{230}\text{Th}/\text{U}$ and $^{40}\text{Ar}/^{39}\text{Ar}$ for the second half of the Middle Pleistocene and the late Early Pleistocene, while for this same time span and especially for the first half of the Middle Pleistocene, further assessment is possible with reference to the relative chronological data from the morphostratigraphical correlation of the terraces as well as the technological comparison of their lithic industries.

The dating technique used at Cau del Duc de Torroella and Ullà is U-series and that applied at Can Garriga is $^{230}\text{Th}/\text{U}$ series, with an optimal dating range of between 400 and 100 kyr (Ludwig and Renne, 2000). The accuracy of these methods can be questionable for impure materials, an issue encountered at these sites. In such cases, a frequent problem is the presence of initial ^{230}Th in the sample, indicated by significant amounts of the thorium isotope ^{232}Th . Here, a correction of initial ^{230}Th is mandatory by an isochron approach calculated by mathematical models which tend to offer questionable results. Another weakness of these methods is the limited availability of materials suitable for dating, such as calcareous materials. In the absence of such formations in other sites of the Ter basin, the application of such methods has been restricted to the speleothems of the Caus del Duc (Tissoux, 1999) and the travertines of Can Garriga (Giral et al., 1995). The third dating method used in this terrace system is $^{40}\text{Ar}/^{39}\text{Ar}$ which is one of most precise techniques available and can be applicable to a wide variety of volcanic rocks (Ludwig and Renne, 2000). There is no practical chronological limit for the method (Renne et al., 1998) and numerical dates are subject to an accuracy of about 2% (Ludwig and Renne, 2000). However, $^{40}\text{Ar}/^{39}\text{Ar}$ is mainly restricted to volcanic materials and in the Ter context can be applied only to the Pla de Dalt-Jueria archeological complex (Lewis et al., 1998).

The absence of materials and formations potentially datable by radiometric methods for the first part of the Middle Pleistocene basically restricts the chronological study to the morphostratigraphical and altimetric correlation of the terrace sequence. Such analyses have been used as an approximate chronological estimation in river sequences (Maddy, 1997; Maddy et al., 2001; Westaway et al., 2002) with important consequences for landscape evolution (Maddy et al., 2000; Bridgland et al., 2004a). On the other hand, the absence of faunal remains in the sites prevents a biostratigraphical analysis, leaving morphotechnical comparison of their lithic assemblages as the only analysis available for chronological estimations. The main weakness of this technological study is that the estimation of hominin presence in the secondary fluvial contexts as much as their lithic assemblages is affected by artifact abrasion and reworking processes, creating temporal palimpsests (Hosfield and Chambers, 2004, 2005). Moreover, artifacts from the oldest sediments on a terrace reworked into the youngest sediments may be two or even three MI stages apart (Hosfield and Chambers, 2005), which demands caution on the interpretation of the MIS-cycle terrace model (Bridgland, 1994; Bridgland et al., 2004a) in contexts like the Ter.

Notwithstanding these constraints, the chronostratigraphy of the Ter River basin can be correlated to fieldwork data regarding the terrace stratigraphy and paleopedology (Buol et al., 2011) of the series. These criteria are used to characterize the Middle–Late Pleistocene boundary, as already noted by Butzer (1964) for the La Selva depression context. The basic sources of information are paleosols and the sediments derived from these soils (Buol et al., 2011) in sites near the Ter River (Costa Roja, Mas d'en Galí, Puig d'en Roca Excavació and III, La Jueria and Domeny Industrial). The empirical results of this fieldwork are mainly elaborated with cartographic information at 1:25,000 (ICC, 1997, 2003) and 1:50,000 scales (IGME, 1983), which we have used as a reference to draw topographic profiles considering the elevation of the site surfaces above the Ter River bed (Fig. 1). Furthermore, the sites are characterized following field description based on sedimentological, paleoedaphologic and post-depositional criteria.

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