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Territorial mobility and subsistence strategies during the Ebro Basin Late Neolithic-Chalcolithic: A multi-isotope approach from San Juan cave (Loarre, Spain)

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ABSTRACT

The use of isotopic analysis in human and animal remains from the Holocene has proved to be a very useful tool to explore the exploitation and adaptation of past populations to different environments. In this study we present isotopic analysis results of carbon, nitrogen and strontium from the Late Neolithic-Chalcolithic site of San Juan cave (Loarre, Spain). We analysed 33 humans, divided in adult and subadult groups, and 16 animals recovered from the same archaeological context. Stable isotope analysis of carbon and nitrogen has allowed to distinguish an homogeneous subsistence pattern during the Late Neolithic-Chalcolithic transition. The use of strontium isotopes ($^{87}Sr/^{86}Sr$) in human dental enamel suggests 19% (4 out of 21) are non-local individuals, based on comparison with the local bioavailable $^{87}Sr/^{86}Sr$ range calculated using microfauna teeth from the archaeological context, modern plants and snails. This new study gives information about Late Neolithic communities located in the north-east of the Iberian Peninsula, and it allows inference of the socio-economic structure, territorial mobility and individual provenance of humans.

1. Introduction

Stable isotope measurements in human and animal remains has proved to be a very useful tool to explore the exploitation and environment adaptation of past populations (e.g. Makarewicz and Sealy, 2015). Specifically, stable isotope ratio analysis of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) of bone collagen is a common method used to quantitatively approach protein dietary input from both prehistoric and historical populations (e.g. Salazar-García et al., 2016a). $\delta^{13}C$ values are suitable to discriminate between the consumption of terrestrial and aquatic resources (e.g. Carvalho and Petchey, 2013; Lillie et al., 2011; Schoeninger and DeNiro, 1984), as well as of plants with different photosynthetic pathways (i.e. C_3 and C_4) (e.g. Lee-Thorp, 2008; Van der Merwe, 1982). $\delta^{13}C$ values are lower in estuarine and brackish fish, giving rise to what has been defined as the "fish paradox" when interpreting human fish consumption in the past (Salazar-García et al., 2014a). $\delta^{15}N$ values

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are able to provide information about the trophic level a specific organism holds in the food chain of its environment (Bocherens and Drucker, 2003; Minagawa and Wada, 1986). $\delta^{15}N$ values are considered to increase generally between 3‰ and 5‰ with each trophic level up the foodweb (Bocherens and Drucker, 2003; Schwarcz and Schoenniger, 1991). Some researchers suggest this range could be wider (Hedges and Reynard, 2007), being estimated in ca. 6‰ combining short-scale studies from red blood cells with measured offsets in other studies (O'Connell et al., 2012). It is necessary to highlight that diet studies based on stable isotope analysis of bone collagen present two important traits to take into account: 1) collagen turnover is low during adulthood and therefore reflect an average diet of the last 10–20 years before the individual died (Hedges et al., 2007); and 2) collagen stable isotope ratios mainly reflect protein sources and this is the reason why plant food consumption could be masked by diets high in protein content (Ambrose and Norr, 1993). To complement isotopic dietary information from bone collagen, the study of trapped plant microremains (starches and phytoliths) inside dental calculus can be very useful to detect plant consumption (e.g. Power et al., 2014; Salazar-García et al., 2013a).

Strontium isotope ($^{87}Sr/^{86}Sr$) analyses of tooth enamel have the potential to provide insight on the use of a geological area by tracking territorial mobility of the individuals studied (Bentley, 2013; Copeland et al., 2011). $^{87}Sr/^{86}Sr$ ratios vary depending on the geology and bedrock age, and, because there is no isotopic fractionation due to their very small relative mass differences, they are incorporated directly into the foodweb (plants, animals, and eventually humans). Strontium is fixed during enamel mineralization and reflects the bioavailable strontium values from the region where an individual lived when enamel mineralization took place (Bentley, 2006; Ericson, 1985; Price et al., 2002). Enamel from second (M2) and third (M3) molars from the same human individuals are preferentially selected for this kind of analysis as they allow comparison of a childhood signature not influenced by breastfeeding and weaning (M2) with a signature from early adulthood (M3) (Hillson, 1996).

Although prehistoric dietary studies based on stable isotope ratio analysis have been increasing during the last decade in Spain (e.g. Arias, 2005; Fontanals-Coll et al., 2015; García-Guixé et al., 2006; Salazar-García et al., 2013b), territorial mobility studies based on strontium isotope analysis are still scarce in Iberia (Díaz-Zorita, 2014; Salazar-García, 2012a; Waterman et al., 2014). Most of the previous studies have focused on the "transition to agriculture", leaving some gaps on other "transitions" between the Late Neolithic and the so-called Metal Ages in the Iberian Peninsula (López-Costas et al., 2015; McClure et al., 2011; Salazar-García, 2012b).

The aim of this paper is to bridge this gap by assessing, through a multi-isotope study of the Late Neolithic-Chalcolithic collective burial of San Juan cave in the Ebro Basin (Huesca, Spain), the socio-economical dynamics at the onset of metallurgy in northeast Iberia.

2. San Juan cave site and its archaeological context

Late Neolithic-Chalcolithic and early Bronze Age periods in Iberia are characterized by the presence of a high number of burials where people were usually buried together in shared spaces (Andrés, 1998). The use of both caves and rock shelters as burial sites is contemporary to the use of megalithic tombs during the Late Neolithic in northeastern Iberia (Fernández-Crespo, 2010). Overall, some authors suggest that the use of different types of burials was linked to different groups of people, or to people with different socio-economic status (Chapman, 1981; Hodder, 1984; Renfrew, 1976; Sherratt, 1990). In northeastern Iberia, there is still no solid explanation for the differential use of the diverse types of burials (Andrés, 1998, 2005). However, some studies from the middle-high Ebro Valley reveal an overrepresentation of adult male individuals in Megalithic tombs, while subadults and female individuals are more abundant in cave burials (Fernández-Crespo and de-la-Rúa, 2015). Since at the site here studied there has been no sex or age selection when burying the remains, they are more representative of the whole past population of the region. San Juan cave is one of very few sites in the Ebro Basin for which the entire human burial population is available. Additionally, there are very few anthropological studies on the total sample of human remains recovered from the burial caves in the Ebro Basin, and to date there are no multi-isotopic studies carried out on these samples. Furthermore, the end of the Neolithic is still poorly understood in northeastern Iberia, where there are no clear limits between the Neolithic and Chalcolithic periods unlike what happens in the south when the Millares culture appears. In this context, the site of San Juan cave is of interest to fill in this gap.

San Juan cave is a burial site located between the Ebro Valley and the pre-Pyrenean mountain range, close to the town of Loarre, Huesca, Spain (X.697155; Y. 4688532, UTM30N, WGS84). It is a 2.5 × 1.5 × 1.5 m. limestone cave situated in the western slope of *Los Vallazos* gorge, at 983.37 m.a.s.l. (metres above sea level) (Fig. 1). This site was excavated by M. Victoria Pastor and Diana Vicente in 2007 (Pastor and Vicente, 2009) in the framework of a rescue excavation of the Gobierno de Aragón. Material culture recovered as grave goods include stone and bone beads, *Cardium* and *Dentalia* seashells, two bone and wild board tusk pendants, flint tools, and some ceramic pot fragments. Also comingled with the human remains were several faunal remains (Pastor and Vicente, 2009). Since the collective burial has no clear archaeological stratigraphy, direct radiocarbon dates from several of the human remains show that the burial site was used mainly during the Late Neolithic-Chalcolithic, with only a single date pointing to the Bronze Age (Table 1, Fig. 2). The individuals were deposited individually and accumulatively over the surface of the cave. Most of the human remains were found commingled and disarticulated, with no anatomical connexions, suggesting that buried corpses were displaced to accommodate new ones (Pastor and Vicente, 2009).

3. Materials and methods

3.1. Study of faunal and human remains

Faunal taxonomic identification has been based on the works of Fernandez (2001), Pales and Lambert (1971), Rowley-Conwy et al. (2012), and Sanchís (2010), as well as on the zooarchaeological reference collection of the University of Zaragoza (UZ) and the Natural Science Museum of Zaragoza. In order to assess the skeletal representation of the assemblage from San Juan cave, we used the Number of Remains (NR), the Number of Identified Specimens (NISP) and the Minimum Number of Individuals (MNI), all of which have been calculated in accordance with Brain (1981) and Lyman (1994). Hillson (1992) and Morris (1978) were followed in order to determine age at death, dental replacement and degree of dental eruption. The degree of long bone epiphyses fusion was measured following Morris (1972). Different types of carnivore tooth marks have been differentiated (pits, punctures, grooves, furrowing, crenulated edges and impact points) according to the definitions of Binford (1981), Haynes (1980, 1983), and Sala (2012).

The total amount of human remains present at the site is 2148 bones and bone fragments according to a previous study (Gimeno, 2009). In that study, the Minimum Number of Individuals (MNI) was calculated to 47. No postcranial element is complete, so the MNI, sex and age diagnoses were based on cranial and mandibular