Quaternary International xxx (2017) 1–14

Contents lists available at ScienceDirect

Quaternary International

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

Late Neolithic-Chalcolithic socio-economical dynamics in Northern Iberia. A multi-isotope study on diet and provenance from Santimamiñe and Pico Ramos archaeological sites (Basque Country, Spain)

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A R T I C L E I N F O

Article history:
Received 13 December 2016
Received in revised form
23 May 2017
Accepted 24 May 2017
Available online xxx

Keywords:
Carbon, nitrogen and strontium isotopes
Palaeodiet
Mobility
Mesolithic
Neolithic
Chalcolithic

A B S T R A C T

There are few carbon and nitrogen isotope ratio studies for prehistoric periods in the northern part of the Iberian Peninsula, none of strontium isotopes. While most of the questions so-far addressed have been concerned with the transition to farming, the transition to social complexity has been greatly ignored even if multi-isotope studies could shed new light on internal socioeconomical dynamics during the emergence of complex societies in the region. The present study analyses a total of 67 archaeological samples (28 from human bones, 13 from animal bones and 26 from human tooth enamel) obtained from the deposits at Santimamiñe (Kortezubi, Bizkaia) and Pico Ramos (Muskiz, Bizkaia) dated to the Mesolithic, Late-Neolithic and Chalcolithic periods, and samples from different geological areas to characterize the bioavailable strontium of the region. These analyses provide new data about the diet on the coast of the Basque Country, confirming that the consumption of seafood was irrelevant already during the later stages of the Neolithic. The first $^{87}Sr/^{86}Sr$ analyses suggest the possibility of migration movements from other parts of Northern Iberia (i.e. Navarra) to the sites being studied.

1. Introduction

The dialectic between the use of marine and terrestrial resources in Prehistory has motivated considerable literature in recent decades (e.g. Arias, 2005; Colonese et al., 2011; Salazar-García et al., 2014a). At the same time, lines of research have been opened to define and determine hunting areas, grazing land and migrations of prehistoric communities. Through the analysis of carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$) and strontium ($^{87}Sr/^{86}Sr$) isotopes, we report here new data from the eastern sector of the northern coast of the Iberian Peninsula; specifically, from the Basque sites of Santimamiñe and Pico Ramos. Few isotope studies have been carried out in this area, and the nearest cases are represented by the research of P. Arias and R. Schulting (Arias, 2005; Arias and Schulting, 2010). Their studies examined the sites of La Poza l'Egua, Colomba and Los Canes (Asturias), Cotero de la Mina and La Garma A (Cantabria), J3 (Basque Country) and Braña Arintero (León). The age of these sites is quite diverse, ranging from the Mesolithic (Poza l'Egua, Colomba, Los Canes, J3 and Braña Arintero) to the Neolithic (Cotero de la Mina) and the Bronze Age (La Garma A). Most of them, and differently to this study, where mainly focused on the transition to farming in the region. The results of their analyses indicated the importance of seafood in the diet of

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http://dx.doi.org/10.1016/j.quaint.2017.05.049

coastal Mesolithic populations, and an abandonment of the use of marine resources during the Neolithic. The authors additionally proposed the hypothesis of territorial behaviour in the Mesolithic, based on differential access to marine resources (Arias, 2005). On the other hand, more studies have been developed in the neighbouring region of southern France both for the Mesolithic (e.g. Meiklejohn et al., 2010) and Neolithic (e.g. Le Bras-Goude et al., 2013). Additionally, we can find several other studies in Portugal, mainly from the Muge, Sado and Tagus regions (e.g. Umbelino, 2006; Lubell et al., 1994).

The present study seeks to determine whether this behavioural pattern is equally valid in other geographic areas and chronologies, and thus obtain insight into the dietary patterns and provenance at the onset of the Age of Metals amongst Late Neolithic-Chalcolithic populations in the Basque Country. The main handicap to achieve this goal is the scarcity of faunal remains at funerary sites dated to those periods, coupled with the difficulty in finding analysable human remains in habitat sites, where more faunal remains are present (Ontañón, 2003). Complementary to this study, $^{87}Sr/^{86}Sr$ analysis will be used to assess mobility patterns diachronically. This constitutes a pioneering line of research in prehistoric studies in Northern Iberia and it is therefore able to provide valuable information about the mobility and provenance of farming communities at the onset of metallurgy. To date in the Basque Country, the mobility patterns have mainly been studied through flint or other material culture distribution patterns, from the Palaeolithic onwards (Tarriño, 2011; Arrizabalaga et al., 2016; Utrilla et al., 2015).

1.1. Isotope studies

1.1.1. $\delta^{13}C$ and $\delta^{15}N$ stable isotope studies

One of the most-often used tools to reconstruct prehistoric diets in recent decades has been the analysis of stable isotope ratios of carbon and nitrogen (e.g. Schwarcz and Schoeninger, 2011; Makarewicz and Sealy, 2015). This technique is based on the premise that the isotopic composition of foodstuffs is reflected in the consumer's tissue and changes only through the phenomenon known as isotopic fractionation, according to which the $\delta^{13}C$ data will vary between 0 and 1‰ and the $\delta^{15}N$ data between 3 and 5‰ from foods to consumer (DeNiro and Epstein, 1978, 1981; Schoeninger and De Niro, 1984; Bocherens and Drucker, 2003). Several more recent studies, however, suggest the increment of nitrogen through fractionation could be higher (Hedges and Reynard, 2007; O'Connell et al., 2012). Although other skeletal substrates, such as bone apatite (e.g. Tieszen and Fagre, 1993) and dental calculus (e.g. Salazar-García et al., 2014b), have been used and evaluated as dietary markers, collagen is still the preferred material for this type of analysis since it allows studying both isotopes and has internationally accepted quality controls to evaluate the degree of diagenesis (e.g. Van Klinken, 1999). The $\delta^{13}C$ values on bone collagen are able to determine the relative weight of protein depending on its source, in particular between plants following the C_3 and C_4 photosynthetic pathways and the products of animals feeding on these plants (Van der Merwe, 1982; Chenery et al., 2010). In the region and period in which this study is framed, C_4 plants (mainly tropical plants) practically did not exist, being therefore carbon isotope ratio analysis mainly useful for discriminating for the consumption of terrestrial and marine resources (Arias, 2005). Furthermore, these $\delta^{13}C$ 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). Concerning nitrogen stable isotope ratio analyses, the $\delta^{15}N$ values are related to the complexity of the trophic chain in which the analysed specimen is integrated. Marine ecosystems have a higher number of trophic levels than terrestrial environments, leading this to an overall higher level of $\delta^{15}N$ in their organisms compared to their terrestrial counterparts (Minawaga and Wada, 1984).

Even more information is obtained by correlating the data of the two isotope systems, not only in connection with dietary habits but also about the exploitation of the environment and possible differences in access to biotic resources according to, for example, the age or sex of the individual (e.g. Lillie and Richards, 2000; Lillie et al., 2003). This type of information could also shed light into social structure and be indicative of social inequality (e.g. Lillie, 1997). At the same time, the interpretation of the results of these analyses must take into account that plant proteins are masked by animal proteins, mainly because of their different density in each of them (e.g. Richards et al., 2003; Bocherens, 2009). Similarly, if the analysed individual is infantile, nitrogen isotope values may be higher than expected because during breast-feeding the child is, literally, feeding from the mother and therefore taking on her nitrogen values, to which the isotopic fractionation phenomenon aforementioned would be added (e.g. Fuller et al., 2004). Finally, as the isotopic composition of the bone is continually regenerated, it should always be considered that stable isotope results refer only to protein diet in the last years of the individual's life, depending on the collagen turnover for each different type and part of bone (Hedges et al., 2007; Meiklejohn, 2009).

1.1.2. $^{87}Sr/^{86}Sr$ isotopes

Strontium isotope ratio values ($^{87}Sr/^{86}Sr$) depend on geographical location due to variations in their proportions in the different geologies. Each geological zone possesses a particular value, of between ca. 0.700 and 0.750, as the radiogenic isotope of strontium (^{87}Sr) is derived from the decomposition of rubidium (^{87}Rb) and therefore will depend on the age of the rock. Consequently, older rocks have higher levels of ^{87}Sr, as they have experienced the decomposition of ^{87}Rb for a longer time (Bentley, 2006). Strontium isotopic values in the rock go through the trophic chain from the lithosphere to plants and animals, and finally to the body tissue of humans, without isotopic fractionation. However, this incorporation is not so straightforward. Effects such as weathering, hydrological cycles, biopurification and diagenesis will also affect the ultimate bioavailable Sr ratio in a specific location, and should be thus considered when designing the geological sampling strategy and discussing the interpretation (Bentley, 2006; Slovak and Paytan, 2012). Because of the mentioned strontium incorporation into humans and fixation during enamel mineralization, the studies of this isotope system have been shown to provide useful evidences about mobility, both in humans and fauna, by reflecting were the analysed individuals potentially lived during the mineralization process (e.g. Britton et al., 2009; Goude et al., 2012). Even if there are no strontium isotope studies in the investigated region for prehistoric periods yet, we can find relevant data from other chronologies in Western European regions (e.g. Ortega et al., 2013). In this archaeological study, samples of human tooth enamel have been analysed to obtain strontium isotope ratio data corresponding to the time each dental piece mineralized. At the same time, it is necessary to obtain data on bioavailable strontium in order to determine the strontium isotopic ratios incorporated into living organisms at each area (Price et al., 2002). We should also keep in mind for interpretations that, regardless of geological characteristics, coastal areas usually present marine-influenced bioavailable strontium values due to the sea spray effect (Bentley, 2006; Hartman and Richards, 2014).

2. Description of the sites

Both of the assemblages studied here are located in caves (Fig. 1)