Journal of Archaeological Science: Reports 9 (2016) 427–436

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

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

Fire in the Early Palaeolithic: Evidence from burnt small mammal bones at Cueva Negra del Estrecho del Río Quípar, Murcia, Spain

S.E. Rhodes [a,b,*], M.J. Walker [c], A. López-Jiménez [d], M. López-Martínez [c], M. Haber-Uriarte [e], Y. Fernández-Jalvo [f], M. Chazan [a]

[a] Dept. of Anthropology, University of Toronto, Toronto, Canada
[b] Institute for Archaeological Sciences, University of Tübingen, Germany
[c] Murcian Association for the Study of Paleoanthropology and the Quaternary (MUPANTQUAT), Murcia, Spain
[d] Departmento de Zoología y Antropología Física, Universidad de Murcia, Murcia, Spain
[e] Departmento de Prehistoria, Arquelogía, Historia Antigua e Historia Medieval, Universidad de Murcia, Murcia, Spain
[f] Museo Nacional de Ciencias Naturales (CSIC), Madrid, Spain.

ARTICLE INFO

Article history:
Received 3 May 2016
Received in revised form 10 August 2016
Accepted 11 August 2016
Available online xxxx

Keywords:
Fire
Zooarchaeology
Microfauna
Taphonomy
Scanning electron microscopy
Human evolution

ABSTRACT

The development of pyrotechnology is a hallmark of human history, providing our ancestors with warmth, security and cooked food. Evidence for fire use before 400 thousand years ago (kya) remains contentious due largely to the taphonomically fragile nature of charcoal and ash. As such, it is imperative to the study of prehistoric fire that we develop techniques and methodologies for identifying anthropogenic fire use via more robust materials. A new methodology described by Fernández-Jalvo and Avery (2015) based on small mammal taphonomy to identify high intensity fire events from the distant past is replicated herein. When we applied this method to assemblages from Cueva Negra del Estrecho del Río Quípar, an upland rock-shelter in southeastern Spain, dated to between 780 kya and 980 kya, we recognized a spatial relationship between highly heat modified micromammal specimens and a previously reported delineated feature of thermally altered and carbonate rich sediment which also includes heat-fractured chert and calcined bone (the fire feature). The proportion of heavily heat-modified specimens (charred and/or calcined specimens) identified within the stratigraphic context associated with the fire feature proved statistically significant ($x^2 = 169.18$, $p < 0.001$) when compared with the proportion of similarly modified specimens from overlying deposits (within other stratigraphic layers). The degree of discolouration seen on the micromammal remains within the fire feature has been linked to temperatures exceeding 600 °C (Shipman et al., 1984), and as such supports claims that the fire feature may have an anthropogenic origin. Environmental scanning electron microscopy and energy dispersive spectroscopy (SEM-EDS) of bone specimens confirms that this discolouration is due to burning rather than post-depositional mineral staining. This confirms that methodology, which represents a novel line of evidence for identifying pyrotechnical events at early Palaeolithic sites, can be used to identify potentially anthropogenic fire events from the distant past when alternative scenarios are excluded. Furthermore, studies of this type showcase the value of including detailed taphonomic studies of microfauna assemblages within multidisciplinary research projects.

1. Introduction

Studies into the development of pyrotechnology draw on a wide range of research including ethnographic records of fire production (Mallol et al., 2007, Sorensen et al., 2014), morphological and biological changes in the hominin lineage (Wrangham and Carmody, 2010, Wrangham and Carmody, 2009; Wrangham, 2009; Wrangham et al., 1999; Aiello & Wheeler, 1995), social evolutionary theory and the role of fire tending in social development (Twomey, 2014; Gowlett, 2010, 2006; Ofek, 2001), and technological studies into the addition of fire as part of the *chaîne opératoire* of hunting technologies (Alperson-Afil, 2008). Yet the question of exactly *how* and *when* fire became a component of the human tool kit remains (Sorensen, Roebroeks & Gijn, 2014; Roebroeks & Villa, 2011; Sandgathe et al., 2011a, 2011b). This is largely due to the fact that direct evidence for anthropogenic fire, such as ash and charcoal, is susceptible to taphonomic disturbance and destruction and the inherent difficulty in definitively distinguishing between anthropogenic and natural fire (Goldberg et al., 2012; Karkanas and Shahack-Gross, 2007). A further problem is that even when there is relatively high confidence that the presence of fire in a locality is the result of human agency it remains challenging to identify the precise nature of human intervention. For example, there is a lack of clear diagnostic criteria for identifying collection of wild fire as opposed to controlling the means to ignite fire.

* Corresponding author at: Institute for Archaeological Sciences, Universität Tübingen, Rümelinstraße 23, Tübingen, 72070, Germany.
E-mail address: sara.rhodes@uni-tuebingen.de (S.E. Rhodes).

http://dx.doi.org/10.1016/j.jasrep.2016.08.006
2352-409X/

In recent years there has been a trend towards the incorporation of multiple lines of well-contextualized micro-material as support for claims of past fire use. At Gesher Benot Ya'aqov the spatial distribution of burnt flint microdebitage has been used to identify fire features with otherwise ambiguous stratigraphic boundaries (Alperson-Afil, 2012). At Wonderwerk Cave, in South Africa, anthropogenic fire use is indicated by microscopic inclusions of ash and burnt bone within micromorphological samples as well as evidence of burning on lithic and faunal material recovered during excavation (Berna et al., 2012). Recently, Fernández-Jalvo and Avery (2015) have proposed a new methodology to characterize the burnt bones of small mammals from Wonderwerk cave. A chromatic scale of bone modifications associated with heat exposure was proposed based on other authors experiments working with remains of both macro (Shipman et al., 1984; Stiner et al., 1995; Shahack-Gross et al., 1997; Cáceres et al., 2002; Clark and Ligouis, 2010) and microfauna (Lloveras et al., 2009; Medina and Teta, 2012). These chromatic stages were also combined with textural traits (surface cracking, flaking, exfoliation) observed on experimental bones exposed to flames and heating. Chemical analyses (EDS and RAMAN) are used to discount mineral staining of the bone (manganese, iron, phosphates or calcitic minerals) that could be confused with burning chromatic stages. Fernández-Jalvo and Avery (2015) also analyzed the spatial distribution of taphonomic traits and found two squares in the excavation area with small mammal fossil assemblages bearing signs of high temperature fire exposure (calcined bones). High bone fragility within these assemblages bearing evidence of burning was also experimentally observed and indicated by a low survival rate of skeletal elements (low fossil content). These taphonomic results were also correlated with those obtained by FTIR from the sediment (Berna et al. 2012; Chazan et al., 2012). This methodology has herein been applied to the micromammal collection from the late Early Palaeolithic site of Cueva Negra del Estrecho del Río Quípar in Southern Spain (referred to as Cueva Negra hereafter), specifically to assemblages recovered within and surrounding a potentially anthropogenic fire feature identified during the 2011 excavation season (Walker et al., 2016a,b). The research presented here further confirms the use of micromammal remains from spatially controlled contexts as an alternative line of proxy evidence for fire events from archaeological cave deposits. This research does not make broad claims about the development of hominin interactions with fire. Rather the intent is to provide a significant data set to our understanding of a critical locality. Additionally, our use of the Fernández-Jalvo and Avery method constitutes replication of their claims on a geographically and temporally different assemblage, further extending the application of this technique both in time and space. The broader methodological implications of this project are discussed further in the Conclusions.

During the 2011 excavation season at Cueva Negra a clearly delineated feature of thermally altered and carbonate rich sediment was uncovered (referred to as the fire feature). This feature was located ~4 m inward from the drip line of the cave, contained heat-fractured chert and calcined bone and has been the subject of significant multidisciplinary research since its discovery (Walker et al., 2016a,b). In assessing the significance of discolouration on the microfauna stratigraphically associated with the fire feature it is necessary to determine whether a) the sample exhibits evidence of post-depositional transport or modification and b) if the discolouration can be identified as occurring due to exposure to fire (specifically, if oxide staining can be excluded as the agent of modification). The first step is necessary to exclude the possibility that micromammal specimens discoloured elsewhere were re-deposited on the site by fluvial or other natural agents, and to ensure that any spatial patterning in discolouration is not due to differential preservation of specific skeletal elements. Ultimately analysis of the small mammal assemblage must be integrated with data from micromorphology and lithic analysis. However, the focus of this article is on the analysis of the small mammal assemblage specifically, while syntheses of the results of analysis of all material types have been published elsewhere (Walker et al., 2016a,b).

Small mammal (<5 kg in live weight) material recovered from Cueva Negra was examined and all heat-induced modifications, including cracking and discolouration of bone surfaces, were documented. While a number of taphonomic agents can mimic thermal discolouration (the most common being oxide staining), these agents can be excluded through examination of the bone surface topography and composition via environmental or low-vacuum scanning electron microscopy using backscattered electron mode (BSE-SEM), following Fernández-Jalvo & Avery (2015) and Chazan et al. (2012). Other phosphatic secondary minerals can be discarded by RAMAN (Fernández-Jalvo & Avery, 2015) and cathodoluminescence spectrometries (Fernández-Jalvo and Tormo, *in progress*). Our analysis in Cueva Negra revealed a statistically significant pattern in the distribution of burnt small mammal bones corresponding to the stratigraphic limits of the fire feature and consistent with the occurrence of a high temperature, potentially anthropogenic (Walker et al., 2016a), fire event at the site in the distant past. These results do not allow us to say more regarding the nature of the fire event than has been previously published (mainly that the high temperatures and/or long durations of the fire indicate the possibility that natural fire was tended, but not necessarily generated, by the cave inhabitants. However, they do provide important corroboration of the applicability of the Fernández-Jalvo and Avery (2015) method to studies of prehistoric pyrotechnology.

2. Site background

Cueva Negra del Estrecho del Río Quípar rock-shelter is located at 740 masl on an Upper Miocene biocalcarenite cliff overlooking the Río Quípar River in the province of Murcia, Spain (Image 1.0; Walker et al., 2013). Systematic excavation has taken place on an annual basis since 1990 under the direction of M.J. Walker. Reverse polarity is indicated throughout all deposits suggesting an age greater than the Matuyama-Brunhes Boundary (0.78 mya) yet younger than the Jaramillo episode of normal polarity at 1.07–0.99 mya (Walker et al., 2013). These findings are supported by an abundant record of extinct arvicolid remains, which place the site as contemporaneous with Gran Dolina, Atapuerca, levels TD4 through TD8 (Walker et al., 2013, 2006.). The lithic assemblage has been characterized as comprising artifacts of Shea's modes A through G (Shea, 2013, 2016; Walker et al., 2016a).

The fire feature is a stratigraphically discreet feature within the deepest deposits of five 1 m^2 excavation units located between 4 and 6 m into the cave from the drip line (Fig. 1b). The presence of the fire feature was first detected during the excavation of a test pit [meter square C2a (Walker et al., 2006)]. Subsequent excavation revealed that the fire feature covered a portion of the southwest and northwest subquadrants in meter square C2g and all of the southeast, southwest, and northwest subquadrants of meter square C2d. Except for the southwest edge of C2d and the deposits in C2a, where the fire feature was recognized after excavation within soil samples, all of the other units contained a clear delineation of the fire feature from sedimentary deposits above and below it. Moderate discontinuity in the horizontal shape of the feature indicates slight fluvial displacement of the darkened sediment along a pre-existing slope (Angelucci et al., 2013; Walker et al., 2016b). At the time of analysis, only meter squares C2a, C2d, and C2g were excavated to the depth of the fire feature (therefore, comparative samples of microvertebrate remains were taken from deposits stratigraphically above and below the fire feature in these three units).

Micromorphological analysis has recorded no significant physical or chemical alteration of sediments within the three depositional components (numbered 1–3 from youngest to oldest) that make up the stratigraphy of the site (Angelucci et al., 2013; Walker et al., 2016b). As well, there is no evidence of vertical interruption or disturbance of the sedimentary sequence that was deposited by periodic low energy fluvio-lacustrine flooding (Angelucci et al., 2013). These authors provide a detailed description of the micromorphological components of