Quaternary International xxx (2017) 1–15

Contents lists available at ScienceDirect

Quaternary International

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

On the relationship between climate and Neandertal fire use during the Last Glacial in south-west France

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ARTICLE INFO

Article history:
Received 19 May 2016
Received in revised form
30 September 2016
Accepted 3 October 2016
Available online xxx

Keywords:
Fire
Neandertals
Middle Palaeolithic
Last Glacial
Lightning
Fire regime

ABSTRACT

Both environmental and cultural factors dictate how, when and where hunter-gatherers use fire in the landscape, as well as how well evidence for any one fire will preserve in the archaeological record. Variability in the production and preservation of anthropogenic fire traces can potentially skew our perception of fire use in the past. With this in mind, the research presented in this article weighs in on the debate concerning Neandertal fire use and fire making, specifically, the assertion that Neandertals were unable to produce fire for themselves (Sandgathe et al., 2011a, 2011b). This hypothesis is based on the inferred correlation between climatic deterioration, concurrent lowering of lightning-ignited fire frequencies, and reduced signals for fire use in layers presumably deposited during the Lower Pleniglacial (Marine Isotope Stage 4) at the Middle Palaeolithic sites of Roc de Marsal and Pech de l'Azé IV (Aquitaine Basin, southwestern France), the logic being that if Neandertals could produce fire at will, fire use signals would remain largely consistent throughout the deposits despite there being limited access to natural fires in the landscape during this colder period. This review challenges these assertions at multiple scales by looking at regional lightning and fire regime dynamics, comparing the fire signals observed at Roc de Marsal and Pech de l'Azé IV to those of other sites nearby and around France, and exploring the various environmental and cultural factors likely influencing these signals. Ultimately, the data suggests that estimated reductions in lightning frequencies and fire regime during the Lower Pleniglacial (and colder stadial periods, in general) were not adequate to severely limit Neandertal access to natural fire, while possible artefactual evidence for Neandertal fire making challenges the assumption that they were at all reliant on lightning-ignited fire. Moreover, at the nearby Neandertal site of Combe Grenal, the majority of the layers exhibiting evidence of fire use have cold climatic signals, suggesting the fire use trends observed at Roc de Marsal and Pech de l'Azé IV are potentially local expressions of changes in regional site use patterns, possibly brought on by increased reliance on highly mobile, migratory reindeer prey species and reductions in local woodfuel availability during cold periods. Other factors potentially reducing the archaeological visibility of cold climate fire use are discussed.

1. Introduction

Fire has been integral to the human toolkit for a long time. Its uses are manifold and include providing heat for warmth, cooking and tool manufacture, light for night time working and protection from predators, smoke to reduce harassment by flying insects, and flames to burn old bedding, manipulate the landscape or aid in hunting (for an overview, see Clark and Harris, 1985). But just when and how fire entered the human technological repertoire is still subject to intense debate (Goudsblom, 1986; James, 1989; de Lumley, 2006; Wrangham, 2009; Roebroeks and Villa, 2011a; Sandgathe et al., 2011a; Fernández Peris et al., 2012; Gowlett and Wrangham, 2013; Stahlschmidt et al., 2015).

Human interaction with fire likely occurred in four stages: 1) conceptualizing and understanding fire (Pruetz and LaDuke, 2010; Parker et al., 2016), 2) passive use of fire, 3) active control, i.e. the collection, preservation, and transportation of fire, and 4) artificial production of fire using stone percussion or wood friction (Frazer, 1930; Goudsblom, 1986). Determining what constitutes each stage and how to recognise it archaeologically is central to the debate and is often the main source of ambiguity when it comes to the positioning of the onset of these stages chronologically (and spatially). Further compounding the issue are the problems

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http://dx.doi.org/10.1016/j.quaint.2016.10.003
1040-6182/

inherent in differentiating anthropogenic fire from natural fire (e.g., Bellomo, 1993; Gowlett et al., 2005; Mentzer, 2014), as well as our understanding of how various fire residues and other evidences for fire use are produced and preserved (Sergant et al., 2006; Mallol et al., 2007, 2010; Carrancho and Villalaín, 2011; Courty et al., 2012; Henry, 2012; Vallverdú et al., 2012; Mallol et al., 2013; Carrancho et al., 2016; Rhodes et al., 2016).

Neandertals were certainly knowledgeable about the properties of fire and not only used it passively for warmth and light, but actively as a tool for cooking food (e.g., Henry et al., 2011; Blasco et al., 2016), or for synthesizing birch bark tar adhesive for hafting (for an overview, see Wragg Sykes, 2015). This latter activity, while not only being complex (i.e., entailing many steps), appeared early in the archaeological record, at least prior to Marine Isotope Stage (MIS) 6 at Campitello Quarry in Italy (Mazza et al., 2006; Modugno et al., 2006), and again in Germany at Königsaue (Koller et al., 2001; Grünberg, 2002) during the Last Glacial (MIS 5a). Despite demonstrating some Neandertals had developed by at least 200,000 years ago a complex hafting technology for which controlled use of fire was essential, these findings are not proof-positive evidence of fire production, despite perhaps lending credence to the idea (Roebroeks and Villa, 2011b).

The case for artificial fire making (see Section 2.4.5.) is further supported, however, by the recovery of Mousterian fire making tools from multiple Middle Palaeolithic (MP) archaeological sites in France dating to the Last Glacial (Rots et al., 2011; Sorensen et al., 2014; Sorensen and Claud, 2016; Sorensen and Rots, 2014; Rots, 2015; Heyes et al., 2016), suggesting at least some Neandertal groups had developed the ability to produce fire.

This paper focuses on the transition between active fire use and fire production. This act was arguably the first true instance of domestication by humans (Goudsblom, 1992), wherein all the benefits conferred by fire are instantly made available. Roebroeks and Villa (2011a) contend the increasing regularity with which fire is observed in the MP suggests Neandertals (and their immediate predecessors) were habitual fire users from 400 to 300 ka onwards in Europe and the Near East (see also Gowlett et al., 2005; Shahack-Gross et al., 2014), and likely capable of producing fire for themselves (Shimelmitz et al., 2014). Conversely, Sandgathe et al. (2011b, 2011a) suggests this trend of increasing fire use through the MP is an artefact of taphonomy and does not reflect the more regular use of fire by Neandertals, going so far as to suggest fire was not a *fixed* component of the Neandertal toolkit. They cite the sporadic nature of fire use at European MP sites as evidence for Neandertals being *obligate* fire users (i.e., reliant on natural sources of fire, predominately caused by lightning strikes), while anatomically modern humans (AMH), on the other hand, were the first to kindle fire artificially (Sandgathe et al., 2011b). However, fire-making tools are largely absent from the early Upper Palaeolithic (UP) record, as well (Sorensen et al., 2014), and archaeological evidence for fire use by AMH during this period is also sporadic (Roebroeks and Villa, 2011b). Without evidence for fire making, could not any increase in the prevalence of fire traces during the UP also be interpreted as a relic of taphonomy? Moreover, these presumably fire-wielding groups had no noticeable effect on fire regimes in SW France and Spain upon their arrival to the region (Daniau et al., 2010a). Are we to presume then that the earliest AMH inhabitants of Europe were also obligate fire users? If not, what factors might then account for the variation in fire use signals between these two groups, as well as between conspecific groups over time and space?

Using the observed trends for fire use at Roc de Marsal and Pech de l'Azé IV as a point of departure (Sandgathe et al., 2011a), the goal of the research discussed here is to test the strength of the concept of obligate fire use by Neandertals during the Last Glacial by comparing and contrasting archaeological signals for fire use during cold and warm climatic periods in SW France with shifts in modelled lightning fire ignition frequencies and palaeofire regimes, and to provide possible explanations for fire signal variability between 'cold' and 'warm' occupation layers and between sites.

1.1. The environmentally determined Neandertal fire use model

Sandgathe et al. (2011b, 2011a) assert that if Neandertals were dependent on natural, lightning-caused conflagrations as their primary source for domestic fire, the prevalence of anthropogenic fire should be linked to prevailing climatic conditions. Thus, changes in the fire use signal within MP archaeological sites should correspond to shifts in climate. The fundamental assertions of this model (both implicit and explicit) are as follows (see also Table 1):

1) Global and regional climate phenomena influence lightning frequency, with cooler climates resulting in reduced lightning frequencies (cf., Rakov and Uman, 2003).
2) Lightning frequency determines the regional and local *fire regime*, defined as the pattern of frequency, season, type, severity and extent of fires in a landscape (Bond and Keeley, 2005), meaning fewer lightning strikes would result in fewer overall ignitions.
3) Shifts in fire regime directly determined the frequency of Neandertal access to fire and should thus a) manifest similarly in contemporaneous layers at nearby archaeological sites, and b) coincide with climatic shifts indicated by the faunal and floral records. In other words, archaeological layers with strong fire signals should, as a rule, coincide with environmental proxies that indicate warm conditions, while fire-poor layers should coincide with cold climate environmental proxies.
4) If Neandertals were capable of artificially producing fire at will, then the archaeological signals for fire use should be similar throughout the glacial and interglacial cycle—if not more pronounced when it is cold.

Sandgathe et al. point specifically to the apparent decrease in fire use during colder periods observed at the late MP sites of Roc de Marsal and Pech de l'Azé IV (Dordogne, France) as evidence for this model.

1.2. Site descriptions and fire evidence

Roc de Marsal (hereafter, RdM) is a small south-facing cave situated about 80 m above a tributary valley of the Vézère River (located 1.7 km to the north-west), approximately 1.5 km south-east of Campagne and 5 km south-west of Les Eyzies (Fig. 1). The site has yielded high numbers of flint tools, cores and flakes (more than 23,000 artefacts $\geq$2.5 cm), large numbers of faunal remains, and numerous combustion features (Bordes and Lafille, 1962; Turq, 1979; Sandgathe et al., 2007, 2008; Turq et al., 2008). With a total thickness between 1 and 2 m, the stratigraphic sequence at Roc de Marsal is comprised of seven geological lithostratigraphic units containing 13 archaeological layers (Fig. 2; for more detailed descriptions of the stratigraphy, see Aldeias et al., 2012, and Goldberg et al., 2012).

Pech de l'Azé IV (hereafter, Pech IV) is a south-facing collapsed cave situated approximately 50 m above a small, usually dry stream valley that runs into the Enéa, a small tributary of the Dordogne River (1.7 km south of Pech IV), 5 km south-east of Sarlat-la-Canéda, and roughly 20 km east of Roc de Marsal (Fig. 1). Pech IV is one of a series of four caves in the area bearing MP deposits (Bordes, 1972, 1975). Using revised lithostratigraphic designations, eight major stratigraphic layers (17 levels in total, including subdivisions) have

Please cite this article in press as: Sorensen, A.C., On the relationship between climate and Neandertal fire use during the Last Glacial in south-west France, Quaternary International (2017), http://dx.doi.org/10.1016/j.quaint.2016.10.003