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Fire production in the deep past? The expedient strike-a-light model

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ABSTRACT

Clear examples of tools used to artificially ignite fire are virtually absent in the archaeological record until the late Upper Palaeolithic. One explanation is that, until this point, hominins were (by and large) simply fire *users* dependent on the environment to provide conflagrations for exploitation, as opposed to fire *producers*. An alternate scenario is that the tools they used to perform this task are difficult to recognise in artefact assemblages. To account for this, we propose the 'expedient strike-a-light model', a concept that draws inspiration from the apparent *ad hoc* nature of many hunter-gatherer lithic technologies, especially those of the Middle Palaeolithic. The model contends early flint strike-a-lights were not formalised or specialised tools used to kindle multiple fires, as seen in later time periods. Instead, we postulate that flakes, retouched implements or other fragments made from siliceous lithic raw materials were utilised on a very short-term basis in conjunction with the minerals marcasite or pyrite (sulphuric iron) to generate fire. Building on previous research and our own experimental data, we establish criteria to identify expedient fire-lighting tools, and discuss the testing of our research model on five Middle Palaeolithic assemblages. Although results were negative from this limited data set, this research offers an alternative view of early fire production and a protocol for recognising expedient strike-a-light technology.

1. Introduction

There is widespread agreement that the ability to ignite and control fire was crucial to hominin cultural and (perhaps) physical evolution, but there is no agreement about when humans or their ancestors developed these abilities (Berna et al., 2012; Roebroeks and Villa, 2011a, 2011b; Sandgathe et al., 2011a, 2011b; Wrangham, 2009). Use of fire must have conferred distinct advantages on early hominins, but unfortunately for archaeologists, it is notoriously difficult to identify in the archaeological record. Furthermore, knowing, using and producing fire may have been successive stages in the evolution of humanity's relationship with fire (Frazer, 1930); even nowadays, with all humans using fire, not all necessarily know how to produce it (Hill et al., 2011).

Some researchers believe controlled use of fire to be a very early phenomenon. Richard Wrangham (Wrangham, 2009; Wrangham and Carmody, 2010) cites biological and morphological aspects of human evolution as evidence that fire has been an integrated part of human behaviour for the last two million years. However, the physical evidence for fire use in the form of hearth locations is at best very sporadic in the archaeological record of early *Homo* (Bellomo, 1994; Berna et al., 2012; Brain and Sillen, 1988; Gowlett and Wrangham, 2013; Gowlett et al., 1981; James, 1989). Europe, occupied before one million years ago, has no clear traces of habitual fire use until 300–400,000 years ago (Roebroeks and Villa, 2011a). This implies hominins inhabited Europe hundreds of thousands of years before becoming intentional fire users in the Middle Palaeolithic (MP) period. For the MP, there are good data for habitual use of fire (Roebroeks and Villa, 2011a), including use of fire as a tool, e.g. for cooking (Henry et al., 2011) and the production of adhesives (Koller et al., 2001; Mazza et al., 2006). Based on these data, Roebroeks and Villa (2011b) suggest that Neandertals probably had the ability to make fire, and certainly the ability to appropriate and transport it.

Sandgathe et al. (2011a, 2011b) state that while hominins may have used fire sporadically from about 300,000 years ago onward, even late Neandertals did not know how to produce fire, and only used it during warmer intervals when higher frequencies of natural fires made it more readily available. If their hypothesis is correct, fire production would be a very late phenomenon restricted to the archaeological record of modern humans at the end of the Pleistocene.

Differentiating opportunistic, episodic use of fire from the production of fire in the archaeological record is a challenge. Currently, there is little clear evidence of fire production before the late Upper Palaeolithic (UP), only indirect proxy data (i.e. charcoal, ash and

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heated flint and bone) suggesting fire use. This study attempts to identify and describe direct artefactual evidence of fire-starting in the Palaeolithic. This is an important issue, as we archaeologists have yet to ascertain—even in coarse chronological terms—when in our early prehistory fire became a standard part of the human tool kit.

2. Fire-starting tools, from the present to the past

Ethnographic data show two basic means by which fire is produced by hunter-gatherers (Hough, 1926, 1928; Weiner, 2003). The first system employs wood-on-wood friction; the second utilises stone-on-stone percussion or friction, generally using the combination of a 'strike-a-light' composed of flint (or another siliceous rock or mineral) and marcasite and/or pyrite, referred to hereafter as "sulphuric iron" (after Weiner, 1997, 2003). Both methods have been used historically with various types of tinder that 'catch' a spark or coal and allow it to be more easily fanned to flame (Hough, 1926, 1928). The fungus *Fomes fomentarius* is arguably the most effective tinder (Weiner, 2003), but whether it was used for this purpose in the Palaeolithic is not known. Reports of its presence at the MP site Salzgitter-Lebenstedt (Germany) (Grahmann, 1956; Oakley, 1961) have shown to be unsubstantiated (Johannes and Schuh-Johannes, 1991), while *Fomes* finds at the late UP site of Endingen (Germany) could not be related to human activities (Terberger, 1996). *Fomes* was found with the c. 5300 year old ice mummy Ötzi (Peintner et al., 1998), exhibiting trace amounts of sulphuric iron powder (Sauter and Stachelberger, 1992).

It is possible that both the wood-on-wood and stone-on-stone methods were independently invented and reinvented many times. The chronological relationship of these methods is still debated (Weiner, 2003) and difficult to establish given the poor preservation of wood. However, the relative durability of the stone-on-stone tool kit provides a more promising avenue of research. Furthermore, the stone-on-stone method may also have had a wider applicability, as it could have been a more reliable method for generating sparks in cool-humid settings than the wood-on-wood method. Testing by the authors has shown flint and sulphuric iron to produce sparks even while wet, unlike the wood-on-wood technique (Hough, 1926). The stone-on-stone method, observed historically throughout the world (Roussel, 2005), is the dominant technique among groups living at higher latitudes in both North and South America (e.g. Gusinde, 1931, 1937, 1974; Hough, 1928).

Regarding the archaeological visibility of the stone-on-stone method, we made an inventory of possible strike-a-lights known from the Palaeolithic record, yielding a small number only (Table 1). The majority of these specimens were originally compiled by Stapert and Johansen (1999; Johansen and Stapert, 2001). Not all were physically examined by these (or the present) authors, but were interpreted as potential strike-a-lights based on descriptions in the literature of heavy edge-rounding and (if present) photos of use traces, as this tool type is rarely incorporated into Palaeolithic researchers' typological lists (Patte, 1960). The geographical clustering of the strike-a-lights in the northwest corner of Europe and Great Britain is likely an artefact of sampling bias based on these researchers' region of interest. A lone MP artefact exhibiting possible traces of use as a strike-a-light—a Mousterian point from Bettencourt (France), level N2b (MIS 5a)—is hinted at by Rots (2011, Table 2 "Briquet"), but is not discussed in the text, nor are any photos included. More information on this piece will be available in the near future (Rots, in press).

As for sulphuric iron fragments, even fewer have been recovered (Table 2). Most in this list were originally compiled by Weiner and Floss (2004), followed by Roussel (2005). Nearly half are from MP deposits; however, specimens exhibiting obvious signs of use have only been recovered from UP contexts. Of particular interest is the (now lost) La Cotte à la Chèvre (Jersey, United Kingdom) nodule (Sinel, 1912, 1914), recovered in association with a MP hearth feature, and of which Sinel said it "no doubt had been used in conjunction with a flint for striking fire, for similar nodules have been found under similar conditions in other caves" (1912, p. 210). Unfortunately, Sinel failed to provide any further specifics on this matter. Also noteworthy is the Drachenloch Cave (Switzerland) nodule, its association to MP deposits tenuous due to conflicting site reports (Bächler, 1940, 1947) and radiocarbon dates from the associated hearth (Leuzinger-Piccard, 2003), and its state of use confounded by modern traces made by the original excavator 'testing' the nodule with a piece of flint (Bächler, 1940; Weiner and Floss, 2004).

3. The expedient strike-a-light model

To determine what the earliest fire-starting tools might have looked like, we propose three hypotheses based on the apparent *ad hoc* nature of many Palaeolithic technologies: 1) Any flake, tool or other flint fragment suitable to the task of making fire—whether specifically produced for this task or not—may have been used as a strike-a-light, likely for only one fire-making episode, before being discarded or reused for another task. 2) Subsequent reuse or resharpening of tools may have removed or obscured the evidence of their use as strike-a-lights. 3) While strike-a-lights may have been expedient in nature, fragments of sulphuric iron were likely curated given their relative rarity.

The commonality of *ad hoc* tool use by humans has been demonstrated repeatedly for both earlier hominins (Dibble, 1984, 1987; Dibble and Rolland, 1992; Roebroeks et al., 1997) and more recent prehistoric and historic hunter-gatherer groups (Binford, 1973, 1979; Frison, 1968), including the expedient use of blades and other flint tools as strike-a-lights in late UP contexts (Johansen and Stapert, 2001). There is rarely anything formal or standardised about the pieces of flint selected to function as strike-a-lights (Gechter-Jones and Pawlik, 1998; van Gijn et al., 2006). The strike-a-light as a tool type is defined almost exclusively by its distinctive wear pattern, not its morphology (Honegger, 2001). Artefacts utilised as strike-a-lights in archaeological and ethnographical contexts include flakes, blades, core fragments, unifacial and bifacial forms, and stream gravels (Hough, 1926; Jeffreys, 1955; Stapert and Johansen, 1999; van Gijn, 2010; van Gijn et al., 2006). Moreover, it has been shown that individual tools in MP contexts underwent numerous changes in form and function before being discarded (Dibble, 1984, 1987; Turq et al., 2013). Assuming a tool was used at some point to make a fire—unless performed near the end of its use-life, as seen in some 'recycled' Neolithic tools having been used as strike-a-lights (Honegger, 2001)—evidence of this task could be difficult to discern after subsequent use, or absent completely due to resharpening events.

The most well-known and recognisable prehistoric strike-a-light specimens are described from Bronze Age and Neolithic sites (Stapert and Johansen, 1999; van Gijn, 2010; van Gijn and Niekus, 2001; van Gijn et al., 2006), many likely to have been 'curated' examples that exhibit very distinctive rounded and/or faceted edges indicative of repetitive use. Most of the probable UP strike-a-lights listed in Table 1 exhibit only moderate wear, though generally visible with the naked eye (Stapert and Johansen, 1999). It is difficult to know whether these strike-a-lights were used to kindle one or multiple fires. Most modern experiments have focused on recreating moderate to more heavily used specimens, often using experimental pieces for 5–30 min. This is roughly 350 to 2100 strokes, assuming a rate of ca. 70 strokes a minute (Johansen and Stapert, 1996). Yet, demonstrations by survivalists