Oh, For a Muse of Fire: An Archaeological Perspective on Anthropogenic Fire

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I. INTRODUCTION.

Fire is a physical reaction that results when suitable fuel and oxygen are brought together and exposed to heat. Controlled use of fire by humans ("anthropogenic fire") is a behavioral universal. All known historical and ethnographic human groups make and use fire. No other living species controls fire.

Earlier societies recognized the importance of fire and explained it in supernatural terms, as a gift from the Greek Titan, Prometheus, or as a prize stolen by the Inuit hero, Raven. Early scientific accounts of human origins [1], and some recent ones as well [2], view fire as a transformative force, something that changed ancestral hominins into us. As scientists, archaeologists base our hypotheses about prehistoric behavior, including the use of fire, on what we know about source of behavioral variability among recent humans. Humans use fire as a strategy for releasing latent energy from the environment. All strategies have benefits and costs. One cannot understand the one without the other.

The benefits of fire are many. Fire provides heat, permitting humans physiologically adapted to tropical habitats to persist in colder ones. Fire allows foods, such as meat and plants with toxic compounds and high fiber content, to be cooked, shared, eaten, and digested with lower energetic costs and higher caloric returns [3,4]. The light from fire enlarges the day, lengthening the period in which visual clues about social interactions can be perceived. Fire is an effective anti-predator defense, blinding the carnivores that stalked our ancestors' nightmares. Fire vastly increases the speed with which wood can be carved into useful tools and animal hides can be turned into leather. Fire also undergirds pyrotechnology, enabling humans to create novel materials, such as mastic,

ceramics, and metals. At a larger scale, controlled burning of the landscape, "fire-stick farming", allows humans to change the plant and animal communities around them to suit their needs [5].

The costs of fire receive much less consideration in the anthropological literature. First among these costs is knowledge [6]. Even for those who know how to make fire using friction or collision ("flint and steel"), it is still a difficult thing to do and requires a lot of practice [7]. Fuel is another significant cost. Prolonged occupation by fire-using humans quickly strips the nearby landscape of burnable materials, requiring ever greater energy be devoted to gathering fuel. Transporting fire is a less-often-discussed cost. Making a torch that burns brightly for a few minutes is relatively simple, but moving fire tens of kilometers across a windy, rain-sodden, carnivore-infested terrain is a challenge few undertake just for the fun of it.

II. THE EVIDENCE FOR ANTHROPOGENIC FIRE.

When archaeologists seek evidence of anthropogenic fire, we look for spatially-concentrated occurrences of burnt stone tools, charred bones, and ash deposits. Such evidence for fire pervades the archaeological record for the Holocene Epoch, (<12,500 years ago). Not all archaeological sites preserve evidence for fire, but there are no major geographic or chronological gaps in the evidence for human use of fire during the Holocene.

Evidence for fire is nearly ubiquitous at sites associated with *Homo sapiens*, Neanderthals and other large-brained hominins during the Late Pleistocene (>12,500-128,000 years ago)[8]. The levels of Liang Bua Cave (Flores, Indonesia) associated with relatively small-brained *Homo floresiensis* preserve evidence for fire, but only for contexts younger than 40,000 years ago, when *Homo sapiens* was also in the region [9]. Late Pleistocene *Homo sapiens* use of fire is distinctive mainly in its

technological applications, to heat-treat lithic raw materials [10], to vary the color of mineral pigments [11], and to create ceramics [12 13].

The Middle Pleistocene (0.13-0.7 Million years ago) is transitional period in the record for anthropogenic fire. The archaeological record for this period is much better documented in Europe than in other regions. There, a recent review of evidence for fire suggests that even though hominins were present in Europe from at least 1.2 Ma onwards, evidence for habitual fire use does not feature regularly in the archaeological record until after 0.3-0.4 Ma [14]. The principal objection to this view of the Middle Pleistocene evidence is that it is almost inconceivable early humans persisted in cold European habitats without recourse to fire. Using fire to make vegetal mastic for hafting stone tools appears to have been an important innovation in Middle Pleistocene hominin pyrotechnology [15].

The best-documented evidence for anthropogenic fire in the Early Pleistocene (0.7-2.5 Million years ago) comes from the very end of this period at Gesher Benot Yaacov in Israel. There, at 0.8 Ma, several patches of burnt flints occur at habitation sites near the edge of the Jordan Valley paleo-lake [16]. Burnt sediments from Wonderwerk Cave in South Africa also point to fire use ca. 1.0 Ma [17]. Older claims for anthropogenic fire are controversial. Two sites in Kenya, Chesowanja (1.4 Ma)[18] and Koobi Fora (1.6 Ma)[19] both preserve burnt clay patches that are viewed as evidence for fire by some researchers. Burnt bones from Swartkrans cave in South Africa (1.6 Ma) are also attributed to hominin activity [20]. Pliocene contexts (2.5-5.3 Million years ago) preserve no generally accepted evidence for anthropogenic fire [21].

Nearly of the evidence for anthropogenic fire is associated with large-brained species of the genus *Homo* (*H. sapiens*, *H. neanderthalensis*, *H. heidelbergensis*, *H. erectus*, *H. ergaster*). Little or no evidence for anthropogenic fire is associated with relatively small-brained species of *Homo* (*H. floresiensis*, *H. habilis*) or with *Australopithecus*,

Paranthropus, or earlier hominins. This correlation suggests there may be some connection between the use of fire by earlier hominins and such qualities as we infer from our large brains, such as capacities for social and technological complexity, a broad ecological niche, and wide geographic dispersal. Nevertheless, important derived features of the Genus *Homo,* such as brain enlargement and reduced dental robusticity, long precede the oldest evidence for fire. [8]

III. DISCUSSION AND CONCLUSION

Assessing "anthropogenic" fire's role in human evolution places us in a position very much like those of the optimist and the pessimist confronted with a half a glass water. The optimistic "half-full" perspective holds that earlier hominins controlled fire even if archaeological evidence is wanting, chalking the absence up to preservation biases or inadequate evidence. The pessimistic "half-empty" perspective argues that fire was not in use any earlier than the oldest preserved evidence for it. I think it is better to be a realist, to see a half a glass of water, and then ask, why is there water in that glass? So, for fire,

1. Are we seeing evidence for fire when and where we ought to expect it, and if not, why not?
2. When we *do* see clear and convincing evidence for fire, what can we infer from that evidence about hominin behavior? What were earlier humans doing with fire?
3. How broadly can we generalize from single occurrences of fire? What does a hearth that burned at one site for a day or two imply about habitual fire use more broadly in time and space?
4. Are we equating pattern with process? Is the trend towards weaker evidence for fire more ancient Pleistocene contexts "real," or does it reflect taphonomy and geological preservation biases?

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