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# Hominid Use of Fire in the Lower and Middle Pleistocene

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## A Review of the Evidence<sup>1</sup>

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by Steven R. James

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Archaeological data for the use of fire by early hominids are critically examined at over 30 Lower and Middle Pleistocene sites in Africa, Asia, and Europe. The earliest reported occurrences of fire from these regions consist of indirect inferences, most of which are considered to be equivocal, for no actual hearths are found until the appearance of Neanderthals at the end of the Middle Pleistocene. The role of natural processes in producing the supposed fire evidence in the archaeological record is discussed, and a means for evaluating the extant data is presented. It is concluded that before the use of fire by early hominids can be assessed, better documentation for this important development in human evolution is required.

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1. I am very grateful to Geoffrey A. Clark, Arizona State University, for comments and encouragement. A portion of the research was conducted while I held an Achievement Rewards for College Scientists (ARCS) Scholarship during 1987-88, and I thank the faculty in the Department of Anthropology at Arizona State University and members of the Phoenix Chapter of the ARCS Foundation for this support. Glen E. Rice provided access to the micro-computer facility on campus where the figures were produced. Lewis R. Binford and an anonymous referee offered several useful suggestions on an earlier version of this paper. I also thank Kathryn E. Pedrick for moral support, typing, and editorial assistance.

The manufacture of stone tools and the manipulation of fire are the most important extrasomatic milestones in our early evolutionary trajectory. Stone tools provided hominids with an adaptive advantage over other animals in terms of feeding strategies, protection, and the ability to make other material items. Control of fire, while performing somewhat analogous functions, had other important benefits, particularly warmth, light, and cooking. The earliest stone artifacts appear in the East African archaeological record during the late Pliocene and Lower Pleistocene, 2.5-1.5 million years B.P., at localities such as Olduvai Gorge, Koobi Fora, Kada Gona, and the Lower Omo Valley (e.g., Bunn et al., 1980, Chavaillon 1976, Corvinus and Roche 1980, Isaac 1981, Leakey 1971, Merrick and Merrick 1976).<sup>2</sup> The earliest use of fire, however, is still the subject of considerable debate. Most archaeologists accept the idea, based on the evidence from Zhoukoudian, that *Homo erectus* was using fire in the Middle Pleistocene about 0.5 million years B.P. Controversial claims for controlled use of fire earlier than this have recently been made for Chesowanja, Kenya, dated 1.4 million years B.P. (Gowlett et al. 1981), and for Yuanmou, China, dated 1.7 million years B.P. (Jia 1985). Even for Zhoukoudian, the evidence is not clear-cut, as is noted by Binford and Ho (1985:429):

If the ash layers do represent in-situ fires, the "cave home of the Beijing man" may well have been one of the first "homes" in the temperate zone to have had "central heating." . . . The assumption that man introduced and distributed the fire is unwarranted, as is the assumption that burned bones and other materials are there by virtue of man's cooking his meals. The entire question of man's use of fire at Zhoukoudian needs to be reexamined.

Given the significance that control of fire would have had for early hominid development, one might expect the archaeological evidence to have been thoroughly examined. This is not the case. The association of fire with faunal remains, stone tools, and hominid fossils at Zhoukoudian is far from conclusive and is most likely the result of noncultural postdepositional processes (Binford and Ho 1985, Binford and Stone 1986). Similar natural factors may be responsible for the associations of fire and stone tools at many other Lower and Middle Pleistocene sites. The time has come to reexamine the evidence for fire at these sites. While several researchers have discussed the recent East African evidence (Barbetti 1986, Clark and Harris 1985, Isaac 1984:35-37; Toth and Schick 1986:31-32), there have been few extensive reviews of this topic since Oakley's (1956a, b, 1961) syntheses. This paper draws together and critically examines the available data on fire from Lower and Middle Pleistocene sites. The evidence is largely indirect, for

2. In addition to these early stone-tool assemblages, several quartzite cobbles and flakes have recently been reported from northern Pakistan that are estimated to date around 2 million years ago and considered to have been manufactured by hominids (Dennell, Rendell, and Hailwood 1988a, b).

TABLE I  
Lower and Middle Pleistocene Sites with Evidence of Fire

Site	Age (million years B.P.)		Kind of Evidence <sup>a</sup>											Total
	Range	Mean	BD	H	FR	RA	BC	A	C	FHW	BL	BB	BS	
Africa and Near East														
Chesowanja	—	1.4	—	—	—	—	+?	—	—	—	—	—	—	1
Fxj50 Koobi Fora	1.5-1.6	1.55	—	—	—	—	—	—	—	—	—	+?	—	1
Fxj20E Koobi Fora	1.3-1.5	1.4	—	—	—	+?	—	—	—	—	—	+?	—	2
Gadeb	0.7-1.5	1.1	—	—	+?	—	—	—	—	—	—	—	—	1
Middle Awash	2.0-0.5	1.25	—	—	—	—	+?	—	—	—	—	—	—	1
Melka-Kunturé	—	0.35	—	—	+?	—	—	—	—	—	—	—	—	1
Ologesailie	—	0.4	—	+?	—	—	—	—	+?	—	—	—	—	2
Swartkrans	0.2-0.7	0.45	—	—	—	—	—	—	—	—	—	+	—	1
Jisr Banat Yarub	0.4-0.5	0.45	—	—	—	—	—	—	—	—	—	+	—	1
Kalambo Falls	0.07-0.18	0.125	—	—	—	+	—	—	+	+	—	—	—	3
Cave of Hearths	0.2-0.7	0.45	+	—	—	—	—	—	—	—	—	—	—	1
Klasies River Mouth	0.12-0.13	0.125	—	+	—	—	—	+	+	—	—	+	—	4
Florisbad	>0.043-0.128	0.85	—	+	—	—	—	—	—	—	—	+	—	2
Montagu Cave	>0.058-0.2	0.125	+	—	—	—	—	+	+	—	—	—	—	3
Asia														
Yuanmou	0.6-1.7	1.15	—	—	—	—	—	—	+	—	—	+	—	2
Xihoudu	1.0-1.8	1.4	—	—	—	—	—	—	—	—	—	+	—	1
Trinil	0.5-0.83	0.67	—	—	—	—	—	—	+?	—	—	—	—	1
Gongwangling	0.5-1.0	0.75	—	—	—	—	—	—	+?	—	—	—	—	1
Zhoukoudian	0.4-0.5	0.45	+	+?	—	+	—	+	+	—	+	+	—	7
Jinniushan	0.4-0.5	0.45	—	—	+	—	+	+	—	—	—	+	—	4
Europe														
Vértesszőllős	0.3-0.6/0.185	0.4	—	—	—	—	—	—	—	—	—	+	—	1
Torralba	0.3-0.5	0.4	—	—	—	—	—	—	+	+	—	—	—	2
Ambrona	0.3-0.5	0.4	—	—	—	—	—	—	+	—	—	—	—	1
St. Estève-Janson	0.25-0.3	0.28	—	+	+	+	—	+	+	—	—	—	—	5
Terra Amata	0.23-0.4	0.32	—	+	—	—	—	—	+	—	+	—	+	4
Abri Vaufrey	—	0.235	—	—	—	—	—	—	—	—	—	+	—	1
Orgnac	0.12-0.2	0.16	—	+	—	—	—	—	—	—	—	—	—	1
Fontéchevade	0.12-0.2	0.16	—	+	—	—	—	—	—	—	—	—	—	1
Lazaret	0.12-0.2	0.16	—	+	—	—	—	—	+	—	—	—	—	2
La Cotte	0.12-0.2	0.16	—	+	—	—	—	—	—	—	—	—	—	1
Swanscombe	0.3-0.35	0.33	—	—	—	—	—	—	+	—	+	—	—	2
Marks Tey	0.2-0.25	0.23	—	—	—	—	—	—	+?	—	—	—	—	1
Hoxne	0.2-0.24	0.22	—	—	—	—	—	—	+	—	—	—	—	1
Pontnewydd Cave	0.2-0.25	0.23	—	—	—	—	—	—	—	—	+	—	—	1
Total			3	10	4	4	3	5	16	2	6	10	1	64

<sup>a</sup>BD, burned deposit; H, hearth; FR, fire-cracked rock; RA, reddened area; BC, baked clay; A, ash; C, charcoal; FHW, fire-hardened wood; BL, burned lithics; BB, burned bone; BS, burned shell; +, present; +?, present but questionable.

there are no actual hearths until the appearance of the Neanderthals (*H. sapiens neanderthalensis*) at the end of the Middle Pleistocene. Much of the evidence prior to this time is equivocal, and natural processes may explain it.

## The Evidence

A review of the literature has yielded at least 34 Lower and Middle Pleistocene sites for which some form of evidence for fire has been attributed to hominids (table 1). A preliminary word about the dating of the sites and the compilation of the data is in order.

The Lower Pleistocene begins about 1.8 million years

ago and ends at 730,000 years B.P., the approximate date of the Matuyama/Brunhes paleomagnetic boundary. The Middle Pleistocene terminates about 128,000 years B.P. with the extensive marine transgression of the last interglacial (Riss-Würm in the old Alpine sequence), the division between oxygen-isotope Stages 5 and 6 (Shackleton and Opdyke 1973, 1976). This view is accepted by most Pleistocene researchers (e.g., Cook et al. 1982, Stringer 1985a). While considerable advances in uranium-series, thermoluminescence, potassium-argon, paleomagnetic, and other dating techniques have been made in the past decade, many sites, particularly in Europe, are dated only by relative means such as glacial sequences and biostratigraphic evidence based upon faunal assemblages. Dates for the Middle Stone Age sites

in South Africa are also in flux at the moment because of problems of correlating terrestrial deposits with radiocarbon dates and marine oxygen-isotope stages derived from deep-sea cores (see Binford 1984, Klein 1983). For these reasons, the ranges and mean dates derived from various sources are reported (table 1).

Primary sources and site reports were consulted to the extent possible in compiling the data. Secondary sources were used in some instances. Even in site reports, however, there was often little detailed information on the evidence for fire.

#### AFRICA

Thirteen sites in Africa exhibit early evidence for fire. In the past decade, East Africa has produced the earliest such evidence from Lower Pleistocene sites at Chesowanja, Koobi Fora, Gadeb, and the Middle Awash Valley.

Gowlett et al. (1981; Gowlett, Harris, and Wood 1982) claim that hominids were using and controlling fire 1.42 million years ago at Chesowanja (GnJi 1/6E), near Lake Baringo in Kenya. The evidence consists of 51 clasts of reddish-brown clay, ranging in size from tiny flecks to pieces 5–7 cm in diameter (Clark and Harris 1985), found in association with nonhominid faunal remains and Oldowan stone tools. Although the site is only 15 m from five cranial vault fragments assigned to a robust australopithecine, *Australopithecus boisei* (KNM-CH 304), the researchers attribute the lithics, animal bones, and burned clay to *H. erectus*.<sup>3</sup> Refiring tests on one clay sample indicated that it had been fired at 400° C, a temperature considered normal for campfires. The possibility that it was the result of a natural bush fire is rejected.

Isaac (1982; 1984:36) notes, however, that reddened patches in the ground have been observed by him and others at Koobi Fora, Olorgesailie, and near Bodo in the Middle Awash and at recent bush fire locations in East Africa. These fired clay areas, which appear to have been produced by the burning of stumps in bush fires, disintegrate upon erosion into clasts like those described at Chesowanja. He further points out that the tools, bones, and fired clay have been redeposited in a small channel or runnel and therefore their association may be fortuitous. Clark and Harris (1985:12–6) report that while a linear arrangement of some materials is apparent from distributional plots, suggesting the presence of a possible runnel, no size sorting such as might be expected of water-transported debris is indicated. Thus the archaeological remains appear to have been deposited in a low-energy environment. They nevertheless conclude that controlled use of fire at Chesowanja is still unproven.

Sites FxJj20E and FxJj50 at Koobi Fora, on the east side of Lake Turkana in Kenya, are reported to contain possible evidence of fire. FxJj20E, on the Karari Escarpment, dated to 1.5 million years B.P., is associated with stone

tools of the Karari industry and a hominid mandible (KNM-ER 3230) considered to be that of *A. boisei* (Clark and Harris 1985, Harris and Isaac 1976). Patches of reddish-orange discolored sediments measuring 30–40 cm in diameter and 10–15 cm in thickness are reported. Analyses using paleomagnetic and thermoluminescence techniques have indicated that several of these features were heated to 200°–400° C, although the nature of the fire is equivocal (Barbetti 1986:776; Clark and Harris 1985:10–12; Isaac 1984:36; Toth and Schick 6:31). Discoloration observed on conjoined fragments of a core, suggesting thermal alteration, is noted. Thermal alteration is also evident on some lithics at FxJj50 (Isaac 1984:36), dated between 1.5 and 1.6 million years B.P. (Bunn et al. 1980:113).

For the Middle Pleistocene Acheulian site of Olorgesailie, Kenya, Isaac (1977:93–94, 228) reports that no positive evidence for fire was found. A hearthlike depression contained stones and bones but no charcoal. Microscopic charcoal was observed in the Member 7 silts overlying the main occupations. Isaac (1984:36) indicates that natural bush fires may have been responsible for the burning. Similarly, Leakey's work at the site in the 1940s found no trace of fire (Leakey 1951:159; Oakley 1956b:38), and recent discussions over the interpretations of the faunal remains have not reported burned bones (Binford 1977; Binford and Todd 1982; Isaac 1977:89–93; Leakey 1977; Shipman, Bosler, and Davis 1981).

Possible evidence for hominid fire use is reported from three areas in Ethiopia. Locality 8E at Gadeb in the east-central highlands produced an early Acheulian assemblage and faunal remains, as well as several fragments of welded tuff that appeared to have been burned (Clark and Kurashina 1979). Paleomagnetic analyses on the welded tuff samples were, however, inconclusive, since it was impossible to rule out natural refiring of the rocks due to more recent volcanic activity (Barbetti et al. 1980). The Gadeb sites date between about 0.7 and 1.5 million years, and, because Developed Oldowan and Acheulian tools are present, are thought to have been produced by *H. erectus*. In the Middle Awash River Valley, various cone-shaped concentrations of reddish clay, ca. 40–80 cm in diameter, were observed in sediments ranging from Pliocene to Middle Pleistocene in age (Clark et al. 1984:425; Clark and Harris 1985:17–18). Clay samples from these features found near one Oldowan (Bodo-A4) and one Acheulian (HAR-A3) site were determined on the basis of paleomagnetic analyses to have been baked at 200° C or more. Two other clay features were excavated in the vicinity of several lithic artifacts and a recently discovered *H. erectus* cranial fragment (BOD-VP-1/1) in Middle Pleistocene sediments at a locality about 400 m from the initial Bodo hominid find (Clark et al. 1984:427; Conroy et al. 1978).

Clark and Harris (1985:18) consider the Middle Awash burned clay features to have been created when burning tree stumps baked adjacent clay sediments that had been built up by termites around their bases. They suggest that early hominids may have been burning the stumps

3. The long-standing issue of whether australopithecines or early *Homo* in Africa manufactured stone and bone tools has recently been addressed by several researchers (Foley 1987, Lewin 1988, Susman 1988).

in much the same manner as present-day farmers in India, who do so to have fire available while working away from their habitation areas (p. 20):

Although it is going to be difficult to prove it, this ethnographic evidence provides a ready and simple explanation for the way that fire could have been conserved very successfully from as far back as when our hominid ancestors first began to be bipedal and had their hands available for manipulating things. From observing and making use of burning stumps and branches it must have been a relatively short step for an intelligent primate to make use of already burning wood to set alight other dry vegetation, providing that the advantages fire could give were sufficiently compelling.

There are, however, several problems with this scenario. First, as these researchers point out, the burned clay concentrations found near early hominid artifactual remains in the Middle Awash also occur elsewhere in the valley in Pliocene and Pleistocene deposits that lack cultural materials. Thus the association of artifacts and the clay concentrations is probably fortuitous. Second, none of the faunal remains are reported as having been burned, suggesting that if the stumps were burning at the time of hominid occupations, they were not used for roasting animal meat. Third, archaeological materials from these hominid occupations are for the most part not found in direct association with the burned clay. An exception to this is a potential Middle Pleistocene hippopotamus-butchered site (HAR-A2) containing stone tools and four lumps of baked clay (Clark et al. 1984:427, fig. 3). Finally, the Indian farmers mentioned above are burning stumps to facilitate the exploitation of woodland for building materials and probably clearance for planting. This is quite different from the possible occasional use of naturally burned tree stumps for food processing and warmth by early hominid hunter-gatherers. For these reasons, the idea of hominid use of fire in the Middle Awash Valley should be viewed with caution.

Elsewhere in the Awash Valley, the presence of "burnt stones" is noted from the Upper Acheulian "living floor" of Garba I at Melka-Kunturú, dated about 0.35 million years B.P. (Chavaillon et al. 1979). Unfortunately, no qualitative or quantitative data on these stones are provided. It should be pointed out that volcanic deposits of a welded tuff apparently directly underlie Garba IB (Chavaillon et al. 1979:fig. 3), raising the possibility that the so-called burned stones may have been derived from this stratigraphic unit (Tuff E) and are therefore the result of volcanic alteration.

In summary, the most parsimonious explanation for the reddened patches, burned clay, and burned lithics at these East African sites is that they were produced by natural fires or volcanic activity. At Chesowanja, for example, the overlying Chesowanja basalt formation is located about 200 m from the site containing the burned clay (Gowlett et al. 1981:fig. 1). The role of Pleistocene volcanism and other natural processes in creating the vestiges of fire at these sites needs to be examined in

more detail before we can attribute the evidence to early hominids. In addition, no evidence for fire has been reported from the extensive research at Olduvai Gorge, Tanzania (Leakey 1951:159; Leakey 1971). Even recent analyses of cut marks and butchering patterns for the Olduvai faunal remains have apparently not yielded burned bones, or least they are not mentioned in the current debate over scavenging versus hunting (see, e.g., Binford 1981, 1984, 1985; Bunn 1981; Blumenschine 1987; Bunn and Blumenschine 1987; Bunn and Kroll 1986; Potts 1986; Potts and Shipman 1981; Shipman 1986). This negative evidence suggests that early hominids were not using fire 2–1.5 million years ago and further calls into question the so-called evidence at the other East African Lower Pleistocene sites.

Several Middle Pleistocene sites in southern Africa have produced more tangible evidence for fire: Swartkrans, Kalambo Falls, Cave of Hearths, and Montagu Cave. While the dating of these sites is not secure, they contain Acheulian tools in their basal levels, and this in southern Africa assigns them to the Early Stone Age (ESA) (see Volman 1984:170). The newest evidence comes from recent excavations at Swartkrans (Brain 1985). From the ESA member containing Acheulian tools, several bone tools, bones with hominid-inflicted cut marks, and burned bones have been recovered. Although the only hominid fossils found thus far are those of robust australopithecines, Brain attributes the cut marks and burned bone to *Homo*, concluding (p. 75) that "the sudden appearance of meat-eating evidence at Swartkrans may be a result of the acquisition of fire, permitting *Homo* groups not only to overnight in the cave, but also to sit by the fire and process (?hunted) meat."<sup>4</sup> Although Brain briefly mentioned the burned bones from Swartkrans to me at the First International Bone Modification Conference held in Carson City, Nev., in 1984, he was not completely certain about the burning at that time. Chemical tests should be made to determine whether they are burned or manganese-stained (see Oakley 1954, 1956b, 1961). If the bones are in fact burned, they represent the earliest evidence of fire from the Middle Pleistocene in Africa.

By far the strongest early evidence for fire in Africa comes from Kalambo Falls in northern Zambia (Clark 1969:160–62, 173; 1970:143, pl. 13). Charred logs, charcoal, reddened areas, carbonized grass stems and plants, and wooden implements, possibly fire-hardened, were recovered. The site was initially radiocarbon-dated at about 61,000 years B.P. and later estimated at greater than 110,000 years B.P. on the basis of amino-acid racemization of the wood (Lee, Bada, and Peterson 1976). It is now considered to be around 180,000 years B.P. (see Isaac 1984:35).

Burned cave deposits are present in the ESA levels at Cave of Hearths, South Africa (Mason 1962). The "basal

4. From detailed analyses of robust australopithecine hand bones from Swartkrans Susman (1988) concludes that *Paranthropus robustus* rather than *Homo* sp. manufactured and used the stone and bone tools found in the deposits.

hearth," as the lower deposit was designated, was over 1.3 m thick and at one time was considered the oldest evidence of human fire in Africa. However, after a visit to the site in 1953 and later chemical tests of the deposit, Oakley (1954, 1956*b*, 1961) determined the deposit to be calcined bat guano burned either through natural processes or as a result of later human-made fires in the upper cave levels. Lightning, which could have been attracted to updrafts from the cave, has also been considered a cause of these burned deposits (Brain 1967:294).

The Acheulian levels of Montagu Cave in southwestern Cape Province, South Africa, have long been thought to contain early fire evidence in the form of what once were considered to be burned organic deposits (Deacon 1975:559; Klein 1977:119; Oakley 1956*b*:38; 1961:178). These levels (Layers 3 and 5) are dated in excess of 50,800 years B.P., beyond the range of radiocarbon dating (Keller 1970, 1973). While large amounts of plant opals from grasses and beetle carapaces, legs, and wings are present, the suggestion of fire in these levels has not been substantiated by later excavations (Keller 1970, 1973). Keller (1970:190) has interpreted the Montagu Cave evidence as resulting from Acheulian "occupations during which bundles of grass, to which insects were clinging, were carried into the cave for sitting or sleeping," but elsewhere he clearly indicates that there is no evidence for fire in the Acheulian layers (1973:3). The organic nature of the deposits suggests, in my opinion, that they are primarily bat guano accumulations similar to those described by Oakley (1954) at Cave of Hearths. Charcoal apparently was not observed in the Acheulian levels at Montagu Cave but was present in overlying Layer 2, which yielded Howieson's Poort artifacts (Middle Stone Age [MSA]).

By Middle Stone Age times, ca. 35,000 to 128,000 years B.P. or earlier, the presence of fire is well-established (Klein 1983:33). For example, the initial MSA I levels in Cave 1 and Shelter 1A at Klasies River Mouth (Layers 37-39) contained ash, charcoal, and traces of hearths (Singer and Wymer 1982:16-17, 22). Cave 1 also yielded a small number of burned bones (Binford 1984:159-65), but their provenience by level is not indicated. Although the dating of the MSA deposits at Klasies River Mouth is uncertain, the initial levels could be as old as 0.12-0.13 million years. At Florisbad Spring in the Orange Free State, renewed research has uncovered a Middle Stone Age occupation (Unit F) containing a hearth and burned bones. Scattered charcoal just above the hearth but in the same unit was dated older than 43,700 years B.P. (Pta-3465), beyond the range of radiocarbon dating (Kuman and Clarke 1986). The Florisbad cranium, discovered in 1932, is now considered an archaic *H. sapiens* and is apparently from the earliest levels of the spring deposits (Units O [= Peat I] and P), considerably below the hearth. The age of the cranium is estimated between 0.1 and 0.2 million years on the basis of comparisons with other African hominid fossils (Clarke 1985, Kuman and Clarke 1986).

At the extreme other end of the continent, early hominid evidence of fire is lacking from North Africa.

Even recent excavations at Tighenif (formerly Ternifine) in Algeria have yielded no such evidence (Geraads et al. 1986).

#### NEAR EAST

The only indications of fire from the Middle Pleistocene in the Near East have been found at the Acheulian site of Jisr Banat Yarub, Israel (Clark 1966:219), where a burned tibia and bone splinters were recovered with Middle Acheulian handaxes and cleavers.

At the contemporary Acheulian site of Latamne in northern Syria, Clark (1966:219) initially considered that several concentrations of limestone blocks could have served as cooking stones. He later interpreted these features as the footings of windbreak structures (Clark 1967, 1968). A few lithic items at Latamne exhibited pot-lid fractures and reddening suggestive of burning, but Clark (1966:219) considered these to be the result of frost action. Some of the limestone rubble exhibited similar patterns, a sample of which was submitted to K. P. Oakley for analysis but produced no evidence of thermal alteration (Clark 1968:47).

#### ASIA

Six Asian sites, five in China and one in Java, have yielded evidence of fire from Lower and Middle Pleistocene contexts. The best-known of these is Locality 1, Zhoukoudian, which contained 50 m of cave deposits dated between 0.4 and 0.5 million years B.P. Use of fire by hominids occupying the cave has been suggested by the presence of burned bones, ash, charcoal, burned chipped-stone artifacts, and hearths. Charcoal from deposits is identified as redbud (*Cercis* sp. indet.) (Chaney and Daugherty 1933, cited in Zhang 1985:157). The burned bones are described as black, gray, and blue-to-bluish-green in color, with warping and crazing. Associated with the burned deposits are stone tools and *H. erectus* fossils. Taken together, these materials are considered by most archaeologists to be the earliest undoubted evidence for hominid use of fire (e.g., Movius 1949; Oakley 1956*a*, *b*, 1961; Watanabe 1985; Wu and Lin 1983; Zhang 1985) and are so reported in numerous archaeology and physical anthropology textbooks (e.g., Campbell 1982:294-96; Fagan 1986:117; Wolpoff 1980:195; Wymer 1982:76-77; see also comments by Binford 1981:291-92). A view expressed by Movius (1949:402) 40 years ago epitomizes the way in which archaeologists have until very recently regarded the use of fire by *H. erectus* at Zhoukoudian: "Fire was a basic item in his daily life. He presumably cooked his meat over the open hearth in which he burned the wood of the Redbud (*Cercis blackii*), a type of shrub. Since fire would have provided warmth in the then-existing cave, and since it would keep predatory animals away at night, it must have been an immense asset to him."

Whether the deposits were burned and whether they occurred with hominid remains at Locality 1 have recently been questioned at length by Binford and Ho

(1985). These researchers point out that there are no structurally defined hearths and that the so-called ash layers appear to consist of owl pellets, hyena scats, and other organic accumulations that have been decalcified and burned, perhaps as a result of spontaneous combustion or surface fires. Further, from correspondence recently uncovered at the British Museum it appears that a sample of five "burned" bones from Zhoukoudian was submitted to Oakley for chemical analysis by the Abbé Breuil in 1959 (Binford and Ho 1985:438). The results of this analysis indicated that no burning was present and that the darkened appearance of the bones was due to manganese staining. Similarly, Stringer (1985*b*) has reported new analyses on two bones and a sediment sample of "burnt cave earth" collected by Breuil in 1938 from the "*Sinanthropus* layer" of Locality 1 and given to Oakley in 1951. Although Stringer does not say so, the sediment sample sounds very much like the one depicted by Oakley (1956*b*:39, pl. 2). Results of the new chemical analyses indicate that manganese is absent in the three samples and that one of the bones is probably burned (8.4% free carbon). The "burnt cave earth" is not ash deposit but cave sediment, bone, and other organic matter that includes a trace of charcoaled wood and a carbonized leaf. Other chemical analyses on four "ash layers and many burned bones, burned stones, and charcoal" from Zhoukoudian produced free carbon but no iron or manganese (You 1986).

In contrast, a recent visual examination of faunal remains from the cave indicates that most bones are manganese-stained and not burned (Binford and Stone 1986). There is some evidence of the controlled use of fire by hominids in the upper levels (particularly Levels 3 and 4). This consists of seven equid upper teeth, some with adhering maxillary fragments, that appear to have been burned while fresh in a manner suggestive of the roasting of ungulate heads at the French Mousterian site of Combe Grenal (cf. Binford 1984:160). Although four other equid teeth show evidence of burning in the lower levels, Binford and Stone (1986:460, 467) remain unconvinced that it relates to hominid behavior. Clearly, the entire question of the burned deposits at Zhoukoudian needs to be reexamined.

Several other reportedly early sites in China appear to indicate that the presence of fire and hominids at Zhoukoudian may not be an isolated occurrence. Xihoudu in Shanxi Province has produced 30 crude stone implements and a large fossil vertebrate assemblage from a gravel bed in a stratigraphic section capped by 50 m of Middle Pleistocene clay (Jia 1985). Deer, horse, and other mammalian bones are black, gray, and grayish-green and considered burned on the basis of laboratory analyses. Some Chinese researchers feel that the burning was the result of fire use by hominids in the Lower Pleistocene. The faunal assemblage is considered to be 1.0 million years old, but paleomagnetic readings indicate a date of 1.8 million years B.P. Another problem concerns the association of the stone tools and the fauna, since the artifacts exhibit characteristics of water-transported material. While the artifact drawings are difficult to in-

terpret, the material from Xihoudu could well be natural stream-battered cobbles and flakes.

Another controversial early site is Yuanmou, near Shangnabang, Yunnan (Jia 1985, Pope and Cronin 1984), where two *H. erectus* incisors were found in 1965. Later excavations uncovered several stone tools, nonhominid vertebrate fossils of which two dark-colored mammal bones are suggestive of burning, and considerable amounts of charcoal. Dating of the site is problematic. A paleomagnetic date of 1.7 million years B.P. was initially obtained (Jia 1985), but recent dating places the site between 0.5 and 0.6 million years B.P. (Pope and Cronin 1984, Wu and Wang 1985).

Two other sites in China with Middle Pleistocene evidence of fire are Gongwangling, Shaanxi, and Jinniushan, Liaoning. At Gongwangling, 20 stone tools, a *H. erectus* cranium, and charcoal flecks have been found, but whether the charcoal indicates hominid use of fire is uncertain (Zhang 1985). Paleomagnetic and amino-acid racemization analyses date the site at 0.51 to 1.0 million years B.P. (Wu and Wang 1985:table 2.1). Jinniushan Site C is a cave Layers 4–6 of which have produced stone tools, mammalian fossils, and evidence of fire in the form of burned bones, ash, clay, and stones (Zhang 1985). That the bones are burned has been confirmed by chemical analyses indicating that they contain 3.1% carbon.

At Trinil, Java, where the first *H. erectus* fossils were discovered by Eugene Dubois in 1891, charred wood was also found (Oakley 1956*b*:40; 1961:179). As the region is volcanically active, Oakley infers that it could be the product of natural fires. Dating of the hominid-bearing deposits in Java is very problematic (e.g., Bartstra 1978, Curtis 1981, Ninkovich and Burckle 1978; see Pope and Cronin 1984 for discussion). Several potassium-argon determinations initially placed the "Trinil gravels" (Kabuh Formation) between 0.5 and 0.83 million years B.P., with the latter being derived from an average of four samples (Jacob 1972, 1973). More recently, potassium-argon readings on a split of one of these samples provided a date of 1.2 million years B.P. (Curtis 1981).

Although the evidence from Asia suggests that fire may have been present at several Lower and Middle Pleistocene sites earlier than Zhoukoudian, the charcoal or charred bone found at these open sites most likely was produced by natural fires. Even if their association with the early Paleolithic stone tools is valid, it is difficult to prove that early hominids were the agents responsible for the fires on the basis of existing data.

#### EUROPE

At least 14 sites in Europe have produced evidence for fire during the Middle Pleistocene: Vértesszőllős, Hungary; Torralba and Ambrona, Spain; St. Estève–Janson, Terra Amata, Abri Vaufrey, Orgnac, Fontéchevade, and Lazaret, France; La Cotte, Jersey; Swanscombe, Marks Tey, and Hoxne, England; and Pontnewydd Cave, Wales. The discussion here focuses upon the earlier, more controversial sites.



Perhaps the oldest such evidence comes from Vértesszőllős, which yielded a Buda pebble assemblage in the context of a Biharian-stage "cold" fauna (Howell 1966, Kretzoi and Vértes 1965). Several patches of burned bones constitute the evidence for fire; no charcoal was present. The site is estimated to date between 0.3 and 0.6 million years on the basis of the Biharian fauna and a uranium-series date of  $>0.37$  million years B.P. (cf. Denell 1985:35). However, recent uranium-thorium dating of travertines from the site indicates an absolute age of ca. 185,000 years B.P., much younger than the fauna (Schwarcz and Latham 1984). Since the cultural materials were recovered from travertine deposits, it is highly possible that the "charred-bone areas" (Kretzoi and Vértes 1965:83-84) represent mineral staining from groundwater. By way of an example, Cushing et al. (1986) have recently determined that the supposed fire areas with burned bones on Santa Rosa Island in California, thought by some to be locations where late Pleistocene hunters roasted dwarf mammoths, are probably the result of low-temperature ( $<100^{\circ}$  C) groundwater processes. The "burned" bones from Vértesszőllős might have resulted from similar processes.

At Torralba and Ambrona, dated 0.3 to 0.5 million years B.P., excavations over the years have uncovered Acheulian stone tools, the remains of large mammals including extinct elephant (*Elephas*), and small amounts of charcoal and wood (Butzer 1965; Freeman 1975, 1978; Freeman and Butzer 1966; Howell 1965, 1966; Howell, Butzer, and Aguirre 1962; Howell and Freeman 1982). One of 28 wood fragments collected by Marqués de Cerralbo at Torralba in the early part of this century exhibits a darkened color suggestive of burning (Howell 1966:138; Howell, Butzer, and Aguirre 1962:36). Although the fire evidence at Torralba and Ambrona is not extensive, considerable significance has been assigned to it. In a popular book, Howell (1965) infers that *H. erectus* hunters at the sites were igniting grass or brush fires to drive elephants and other animals into lakeside bogs where they were dispatched and then butchered. Freeman (1978:92) interprets the burned areas in Occupation 8 at Torralba as "the remains of a large smudge-fire, lit to smoke-dry meat or as an insect repellent."

The interpretation of Torralba as an Acheulian kill/butchering site has recently been criticized. Binford (1981:16-17; n.d.a) argues that natural taphonomic processes coupled with hominid scavenging of the carcasses could account for the patterns exhibited at the site. Similarly, scanning electron microscope analyses of bone samples from both sites indicate that the majority of elephant and mammalian bones exhibit marks of sedimentary abrasion and few tool-inflicted marks (Shipman and Rose 1983). While Shipman and Rose minimize the role of hydraulic transport in producing the assemblages, this evidence strongly suggests that the bone accumulations are not as pristine as was originally inferred. Indeed, the initial geomorphic descriptions of the Torralba sediments for the units containing cultural "horizons" (Units IIb and IIc) are inferred to have been deposited by colluvial washing and solifluction trans-

port, and "scattered water-worn bone" is reported to be present (Freeman and Butzer 1966:12).

In the light of this evidence, charcoal found at these two Spanish sites may well represent debris from natural fires (see Binford n.d.a). Apparently no analyses of the charcoal have been reported, and the presence of burned bones has not, to my knowledge, been mentioned. The latter would not necessarily be present at a kill site, but if meat was being smoked or dried as Freeman suggests, some burned bones should be present.

Two sites that have produced the earliest evidence for fire in France are Terra Amata and St. Estève-Janson. Salvage excavations in the 1960s at Terra Amata, on the beach at Nice, revealed the presence of what are considered to be the earliest structures in Europe. The site is dated some 0.25 to 0.4 million years B.P., although a thermoluminescence date of 0.23 million years has been obtained from two burned flints (Wintle and Aiken 1977). In addition to the dwelling foundations, fire was evident from hearths, charcoal, burned lithics, and burned shell.

De Lumley (1969:43) describes the hearths as follows:

A basic feature of each hut is a hearth placed at the center. These fireplaces are either pebble-paved surface areas or shallow pits, a foot or two in diameter, scooped out of the sand. A little wall, made by piling up cobbles or pebbles, stands at the northwest side of each hearth. These walls were evidently windscreens to protect the fire against drafts, particularly from the northwest wind that is the prevailing one at Nice to this day.

Although this description is a little imaginative in comparison with a photograph of one of the hearths (Lumley 1969), it does suggest that burned areas are present. Villa (1983), who has recently analyzed the Terra Amata lithics, provides more specific provenience data on the hearths and other burned items. Charcoal samples, some identified as *Pinus sylvestris*, were collected from all layers of the deposits (Vernet 1975; Villa 1983:80). Burned flakes of flint and silicified limestone, two of which provided the thermoluminescence date mentioned above, are present as well. It is not known whether any vertebrate remains are burned; there are, however, several burned mussel (*Mytilus edulis*) shell fragments (Villa 1983:80-81).

At the less well-known French site of St. Estève-Janson (Escale Cave) in the southern Durance Valley (Boches-du-Rhône), the evidence for fire consists of five hearths represented by reddened areas a meter in diameter, fire-cracked rock, ash, and charcoal (Howell 1966:109). Paleomagnetic analysis of reddened sediment from the cave has tentatively suggested that these areas are burned (Barbetti et al. 1980:299). An early Cromerian fauna of Mindel age was recovered, but aside from the burned materials only a few limestone flakes comprise the cultural remains in the deposits.

Recent analysis of faunal remains from Layer VIII (235,000 B.P.) of Abri Vaufrey by Binford (n.d.b) indicates the presence of several calcined bones among the many



manganese-stained fragments. Binford considers the presence of only a few burned bones consistent with the absence of any report by the excavators of hearths or burned areas. Only in overlying Layer VII (200,000 B.P.) is there evidence for regular use of fire as indicated by larger numbers of burned bones. Other late Middle Pleistocene French sites containing evidence of fire include Orgnac, Fontéchevade, and Lazaret, as well as La Cotte de Saint-Brelade (Jersey) off the coast (Cook et al. 1982:54; McBurney and Callow 1971; Scott 1980); the evidence is summarized in table 1.

Excavations at Pontnewydd Cave near the coastal resort of Rhyl in northern Wales have yielded an Acheulian stone tool assemblage and several Neanderthal-like hominid fragments (Green 1984, Green et al. 1981). Uranium-thorium and thermoluminescence dating techniques place the age of the site between 200,000 and 250,000 years B.P. Five burned stones from three different parts of the cave were submitted for thermoluminescence analysis, but only one, a flint core, yielded a reading—200,000 years. The presence of burning is not mentioned for the six fragmentary hominid bones and teeth or for the faunal remains, although some of the latter exhibit dark-brown to black staining with a crazed appearance. On the basis of the burned core, the investigators suggest that hominids were using fire during the late Middle Pleistocene.

The use of fire at Swanscombe, Hoxne, and Marks Tey has been inferred from changes in pollen frequencies and the presence of minor charcoal fragments in the deposits. Further, this evidence is considered by some to represent intentional brush or forest fires set by Acheulian hunters for driving game as at Torralba and Ambrona (e.g., Dennell 1983:52; Oakley 1964; Wymer 1982:127).

Swanscombe, on the lower Thames River in Kent, is best-known for the Swanscombe skull, recovered from the Middle Gravels (Ovey 1964, J. Wymer 1955) and probably correlated with oxygen-isotope Stage 9 (0.297–0.347 million years B.P.) (cf. Green 1984:150). Carbonaceous lumps from the same strata as the skull were determined by chemical tests to be charred plant material produced by mild thermal alteration (Oakley 1964). Reddened and crazed flints from the Middle Gravels were initially thought to be burned (Oakley 1956b:41; B. Wymer 1955), but upon reconsideration Oakley (1964:64) judged that there were no burned flints or calcined bones.<sup>5</sup> Oakley concluded, however, that the charcoal at Swanscombe was the result of fires ignited by hominids farther up the Thames Valley, since he considered natural grass fires to be rare in temperate climates.

Similar conclusions have been drawn from a palynological study of the interglacial lake deposits at Hoxne in Suffolk. A decrease in arboreal pollen and an increase in grasses in Stratum E of the Hoxne deposits (Substage II) indicated a mixed-oak forest recession that coincided with the presence of Acheulian artifacts. Arguing that climatic changes could not account for the vegetation

shifts, West (1956:337; West and McBurney 1955:135) inferred from a single "piece of charcoal" found in the stratum that a catastrophic forest fire had caused an interglacial deforestation. Moreover, since Acheulian stone tools occurred in the same context, the possibility was raised that the interglacial vegetation changes were produced by hominid-induced forest fires (West and McBurney 1955:139). Though this view has found favor with some archaeologists (e.g., Jarman, Bailey, and Jarman 1982:136; Oakley 1956b:41; 1964; Roe 1981:48; Wymer 1982:127), West (1956:338) felt that a natural forest fire was a more probable alternative. Turner (1970:429; see also 1975:288) has since suggested that West actually "rejected" the role of humans as a causal factor in the deforestation whereas Oakley (1964:65) later "misinterpreted" West's statements.

Aside from the single charcoal fragment, no other physical evidence for fire was present at Hoxne, nor was any other charcoal found in this portion of the stratigraphic section (West 1956:337). Recent analysis of the faunal remains identified a few bones with tool-inflicted marks but no burned bones (Binford 1985:316–17). In contrast, Wymer (1982:127–28) proposes that there may be evidence for cooking at Hoxne:

a few concentrations of smashed bones were found; usually a dozen or so pieces of backbone or skull fragments. Only human selection could account for this, and they formed such tight, closely packed groups of bones that it is possible they were originally within a bag of some sort, since perished. Water may have been added to the bag and, held over a fire, a thin stew created from otherwise non-nutritious pieces. This is rather fanciful but other explanations seem equally so.

This reconstruction is fanciful indeed, particularly since there is only circumstantial evidence that fire was used at all.

Palynological data collected at Marks Tey, Essex, 60 km from Hoxne, have been inferred to contain evidence of a similar interglacial "deforestation" (Turner 1970; 1975:288–89); no archaeological site is present, though a few handaxes have been collected in the vicinity (Wymer 1982:127). The section of the Marks Tey pollen sequence that is of concern here is Hoxnian Interglacial Subzone Ho IIc. A woodland forest of hazel (*Corylus*), yew (*Taxus*), and elm (*Ulmus*) declines during the early portion of this subzone while grasses (Gramineae) increase significantly. These vegetation changes have been interpreted as indicating catastrophic deforestation by a naturally caused forest fire, and microscopic charcoal fragments observed in the sediments are considered to substantiate this (Turner 1970, 1975). At the same time, however, Turner (1970:430) hints that the macroscopic charcoal from Hoxne may be the result of hominid fires, a view that is somewhat contradictory to his argument in favor of natural forest fires.

On closer examination of the Marks Tey pollen sequence, it becomes apparent that, while grasses do increase dramatically in Subzone Ho IIc, birch (*Betula*) and

5. In a recent analysis of faunal remains from the Lower Gravels, no burned bones are mentioned (Binford 1985:316–17).

pine (*Pinus*) increase as well. Similar increases in these two tree species and grasses coincide only at either end of the pollen sequence, in Hoxnian Interglacial Zones Ho I and Ho IV, following and preceding glacial conditions, respectively (Turner 1970:fig. 15; cf. Wymer 1982:fig. 2). Thus, no deforestation actually occurs during Subzone Ho IIc; there is only a change from a somewhat warm temperate forest to a colder forest interspersed with grasslands for a brief interval during the mid-Hoxnian interglacial.

In summary, there is little evidence from Swanscombe, Hoxne, and Marks Tey that hominids were even using fire, let alone intentionally setting fires in pursuit of big game. It is difficult enough to make inferences about natural climatic changes on the basis of pollen samples from various localities in a region (see Currey and James 1982). To assign cultural meanings to these changes from only two pollen sequences dated by relative means is even riskier. The charcoal from these sites is better viewed as the result of natural fires caused by lightning than as a reflection of late Middle Pleistocene hunting strategies.

Omitted from table 1 are Clacton, England, and Lehringen, Germany, which have produced wooden spears described by some prehistorians as fire-hardened and thus indirect evidence for Middle Pleistocene use of fire. Discovered by Hazzledine Warren in 1911 at Clacton-on-Sea, 80 km from London, the Clacton spearpoint has in recent years been found to show no evidence of hardening by fire (Oakley et al. 1977:17, 28). The absence of burning in the case of the Clacton spear calls into question the fire-hardening noted for the Lehringen spear, recovered in association with the remains of a straight-tusked elephant in 1948 (Movius 1950). Restudy of it along the lines of the Clacton spear analysis is needed (Oakley et al. 1977:28).<sup>6</sup>

## Evaluation of the Data

Evaluation of the suggestions of fire use in the archaeological record from the Lower and Middle Pleistocene will require experimental and actualistic studies of natural brush fires, hearths, burned bone, lightning-caused cave fires, and other burning patterns. Several such studies have already produced insightful results (Balme 1980, Barbetti 1986, Chapman 1978, Cushing et al. 1986, Dechamps 1984, Richter 1986, Shipman, Foster, and Schoeninger 1984, Wendorf 1982).<sup>7</sup> Early hom-

inid plant food diet prior to the use of fire has also been discussed (Stahl 1984). Electron spin resonance spectroscopy has proved valuable in evaluating whether materials were heated (Hillman et al. 1983, Wendorf et al. 1984). More chemical analyses of charcoal, burned deposits, ash, and stained bone along the lines of Oakley's (1954, 1956b, 1964) research in the 1950s can be expected to shed further light on the subject. Pending the outcome of such studies, we can perhaps begin to assess the evidence in terms of its diversity. The presence of only one or two kinds of evidence at a site may indicate that fire is a natural occurrence; the presence of multiple kinds of evidence should suggest controlled use of fire by hominids unless natural factors are suspected.

The distribution of the various kinds of evidence among sites is shown in figure 1. Charcoal is the most frequently cited indication of fire and is represented at 16 sites. Hearths are reported at 10 sites, burned bone at 10, burned lithics at 6, and other kinds of evidence at 5 or fewer sites. While different kinds of evidence are present at several sites, more than half have produced only one kind (fig. 2). Seven sites have three or more kinds of evidence: Kalambo Falls, Klasies River Mouth, Montagu Cave, St. Estève-Janson, Terra Amata, Zhoukoudian, and Jinniushan.

The southern African sites of Kalambo Falls, Klasies River Mouth, and Montagu Cave are relatively late Middle Pleistocene and extend into the Upper Pleistocene. Diversity of evidence for fire is to be expected during this period from what we know of the abilities of the hominids of the time. The absence of earlier conclusive evidence in Africa has been considered the result of poor charcoal preservation (Isaac 1977:94; 1984:36), but this explanation has not been examined adequately in the context of natural deposits from the time period in question. Some research on burned fossilized wood from Plio/Pleistocene contexts in Africa, however, is beginning to fill this gap in our knowledge (Dechamps 1984).

The presence of multiple kinds of evidence for fire at St. Estève-Janson and Terra Amata tentatively suggests that fire was being used by hominids in Europe sometime between 0.23 and 0.4 million years B.P. If a conservative approach to the age of Terra Amata is taken, then the use of fire here is in line with the evidence from later Mousterian sites, which have unprepared hearths similar to the ones found at Terra Amata. It is only in the Upper Pleistocene, after the Middle-to-Upper-Paleolithic transition, that structured hearths such as the cobble-lined examples at Abri Pataud (Movius 1966) and La Riera (Straus et al. 1980; see also Dennell 1985:89) occur in the archaeological record.

The diversity of evidence for fire at Zhoukoudian and Jinniushan sometime between 400,000 and 500,000 years ago would appear to be too early in a comparative perspective. There are several ways in which this evidence might be explained.

First, there is some indication that the evidence for fire at Zhoukoudian, at least in the lower levels, is a result of the burning of the deposits and not hominid use of fire (see Binford and Ho 1985, Binford and Stone 1986).

6. Gamble (1987:93-94) calls into question the interpretation of these wooden implements as spears and proposes instead that they were snow probes for locating frozen carcasses during the winter months. Such wooden implements probably served multiple functions depending upon the situational context.

7. There is also a diverse literature from ethnographic accounts and ethnoarchaeological observations on fire use among recent hunter-gatherers, particularly as related to environmental modification and subsistence techniques (e.g., Gould 1971; Jones 1975; Lewis 1972, 1973, 1982a; Mellars 1976; Stewart 1956; see also references in White and O'Connell 1982:93-94, 217).

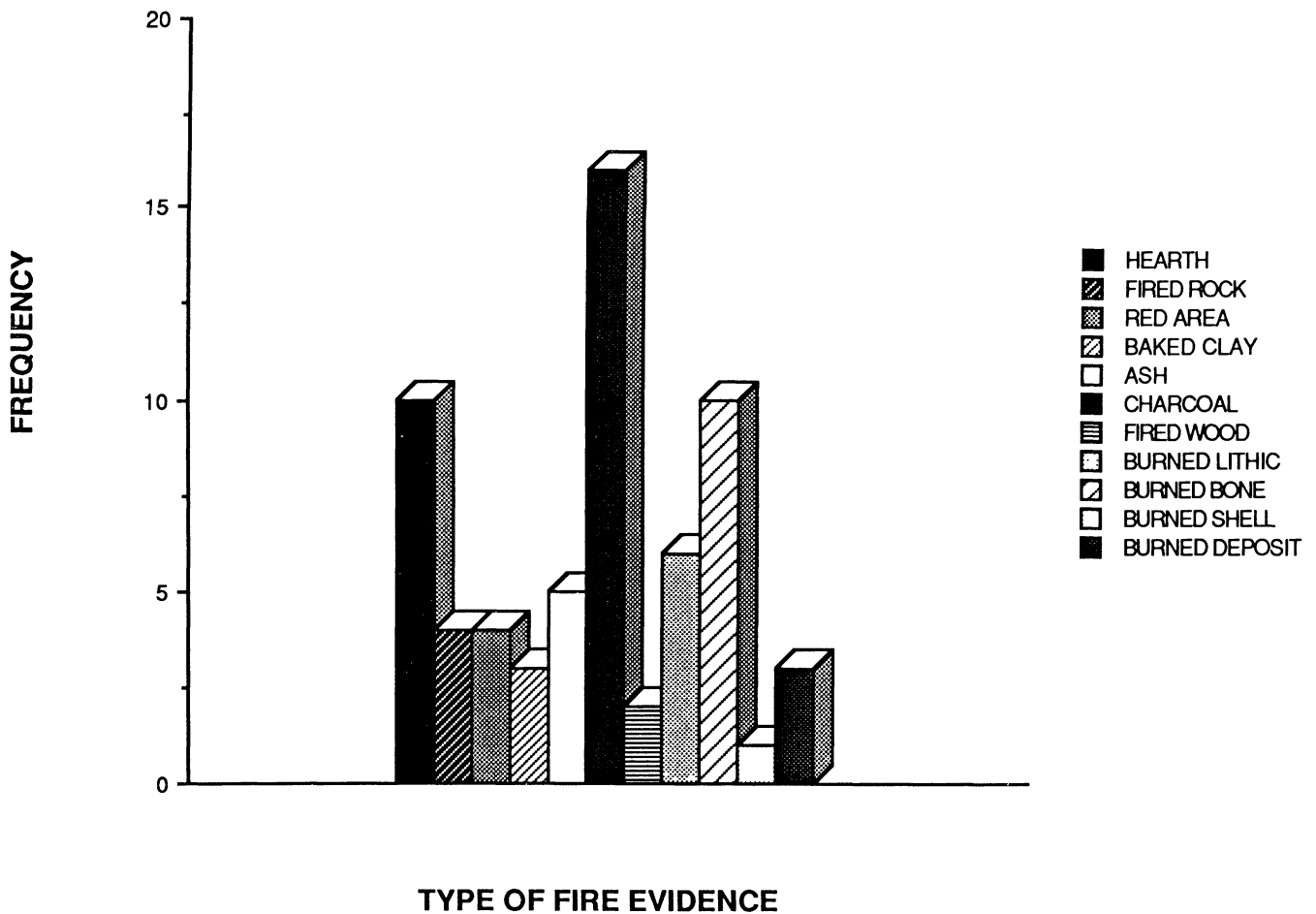


FIG. 1. Distribution of type of fire evidence by frequency from Lower and Middle Pleistocene sites.

Whether the fire was natural or hominid-induced cannot be determined at present, but it is known that when organic-rich deposits in caves are ignited they may burn for several years. Hutchinson (1950:396) notes that a cave in Blanco County, Texas, was set on fire by a hunter in the late 19th century and burned for two years. Elsewhere, the 40,000-year-old deposits of Rampart Cave in northern Arizona, which contained considerable quantities of late Pleistocene ground sloth (*Nothrotheriops shastensis*) dung, were ignited by vandals in 1976 and continued to smoulder for a year despite efforts to extinguish the fire (Kurtén and Anderson 1980:48). Similarly, I have observed several caves in the Great Basin of North America with late Pleistocene and Holocene deposits that were burned in modern times. One in particular, Ladder Cave in eastern Nevada (Currey and James 1982), had a meter or more of burned fill extending downward from the present cave floor; indurated wood rat (*Neotoma* sp.) middens from another part of the cave yielded radiocarbon dates of at least 27,000 years B.P. (Thompson and Mead 1982). The burning of cave deposits in both the Old and New Worlds undoubtedly occurred in the past. If a cave with burned deposits were excavated that also contained evidence of early hominids and we did not know the date of the burning, we

might conclude that early hominids were responsible for the fire. This is the conclusion some paleoanthropologists initially drew from the deposits in Cave of Hearths and Montagu Cave. Such a situation is probable for Zhoukoudian, yet until recently few have questioned the evidence for fire at this site.

Caves have been observed to "breathe out," the result of falling atmospheric pressure during storms (Lawrence 1955:154): "This outward surge of cave air may be aided by rising temperatures around the cave mouth. Free atmospheric convection helps to extend this ionized column further towards thunderclouds, and electric discharges are then led to the opening of the cave. During a thunderstorm, one of the explorers of the Henne-Morte was struck at a depth of 200 feet." The extent of this phenomenon needs to be further examined. As Brain (1967:294) has suggested for Cave of Hearths, lightning strikes may be responsible for some conflagrations in caves that have previously been attributed to early hominids.

Another explanation with regard to Zhoukoudian is that not all of the materials are in fact burned. Manganese staining and other chemical alterations may have created pseudoburning in the case of bones and ash. Binford and Stone (1986:467) note that most of the

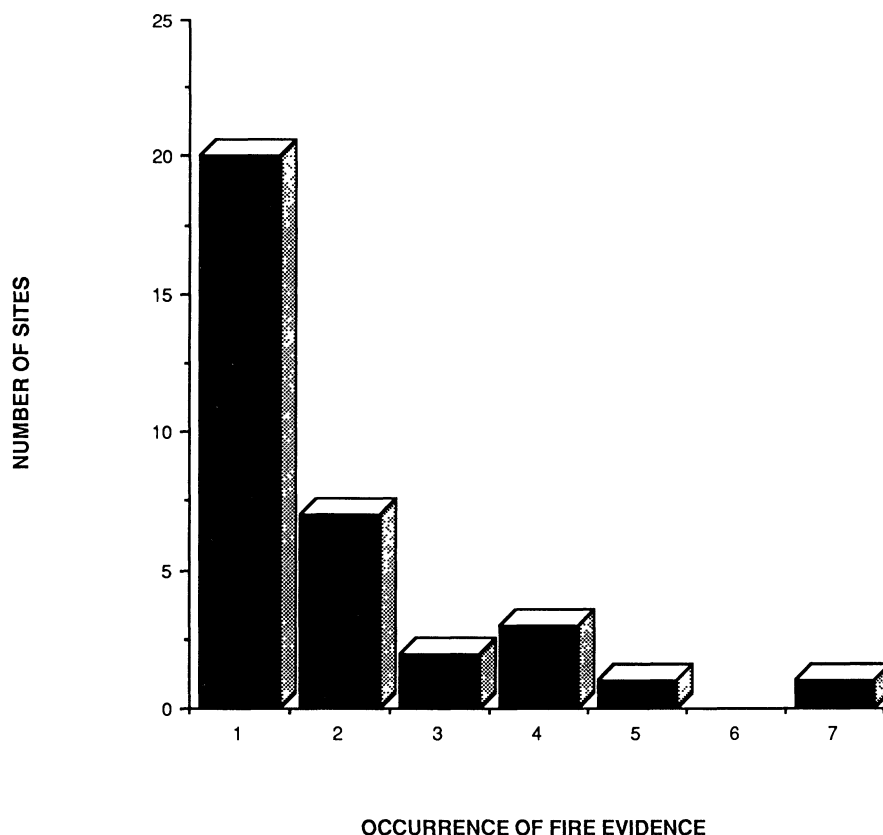


FIG. 2. Distribution of occurrence of different kinds of fire evidence by number of Lower and Middle Pleistocene sites.

bones from the cave that Chinese archaeologists showed them during their 1985 visit were mineral-stained and not burned.

Finally, it is possible that hominid use of fire occurred earlier in China than elsewhere. The controlled use of fire may be an aspect of the overwintering problem (Binford 1985:314; Watanabe 1985:111) involved in the adaptation of early hominids to northern temperate latitudes after they radiated out of sub-Saharan Africa. Early Middle Pleistocene fire use has also figured in a proposed hominid adaptation for Asia based on a nonlithic technology that employed fire in manufacturing bamboo and other wooden implements (Pope and Cronin 1984:389). Before we can begin to model such behavior, we must determine whether fire was actually present at these and other sites in the Middle Pleistocene and whether hominids were using it.

## Conclusion

I have indicated in this review that the evidence is tenuous and pointed to areas in which middle-range studies are required before an objective assessment of hominid fire use in the Lower and Middle Pleistocene can be made. Thorough and rigorous reexamination of the evidence is needed before we can make further claims about the role of fire in shaping our early development.

## Comments

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James's review is timely and useful in showing how tenuous the evidence is for the use of fire by hominids before the Upper Pleistocene. I agree with the overall direction of his arguments, that there is very little evidence indeed that fire was used in the Lower Pleistocene and little evidence for its controlled and systematic use until late in the Middle Pleistocene. He should, however, have made it clearer in his conclusions that the evidence for the use of fire is both *direct* and *indirect*. His figures are particularly misleading in that they imply that all of his criteria are of equal value. It would have been better if he had separated the evidence of hearths—his only direct and unambiguous criterion—from his other six criteria, which are indirect and circumstantial. He should also have distinguished in his figures between cave and open-air sites. Whilst these amendments would not have altered his conclusions, they would at least have shown how little direct evidence there is for the use of fire and how much it is based on data from caves.

What, then, are the implications of his conclusions?

One is that the behavioural distinctiveness of early hominids is further diminished. In recent years, we have seen the erosion of many ideas about hominid "uniqueness": first the discovery that chimpanzees make and use wooden tools, that orang-utans can—if suitably persuaded—make stone ones, and that hominids probably did not hunt systematically until late in their evolution. More recently, we have realised the surprisingly close genetic resemblances between us, gorillas, and chimpanzees (e.g., Diamond 1988) and the likelihood that early hominid tool making was not very distinctive from that of the chimpanzee today. Indeed, McGrew's (1987) paper is worth citing in showing the close similarities in tool-making activities between chimpanzees and Tasmanian aborigines. A few years ago, this might have been seen as racist and reminiscent of Sollas's portrayal of Tasmanians as Neanderthal-like living fossils: now it serves only to reinforce the behavioural as well as genetic similarities between us and the apes. James's review is in keeping with these trends in that early hominids, like their hominid or pongid cousins (depending on how one classes the chimpanzee), did *not* make or use fire systematically. The result of all this is to emphasise the importance of the late Middle Pleistocene in human evolution: the behavioural complex involving systematic hunting, the controlled and regular use of fire, and the use of home bases (as initially conceived by Isaac [1978]) may be unique to *Homo sapiens* and not to earlier types.

After reading this article, I remain uncertain as to the fate of Oakley's (1956*b*) ideas that the colonisation of temperate latitudes of Europe and Asia depended on the controlled use of fire and that this developed first in Eurasia. In terms of the data presented by James, these views can still be maintained, but only just. The best evidence, in the sense of multiple indicators of fire, comes from sites that are both Eurasian and Middle Pleistocene: Zhoukoudian (all seven criteria), St. Estève-Janson (five), Jinniushan (four), and Terra Amata (four). The only African site which matches this pattern is Klasies River Mouth, later in date and with only four criteria. Curiously, there is a gap in the Eurasian data, as the only sites with three lines of data for fire are the two African ones of Kalambo Falls and Montagu Cave. As James suggests, Zhoukoudian should be left in suspense at present until a thorough reexamination has been made and published. If one takes hearths as the only unambiguous indicator, the same pattern prevails, as the only clear African examples (excluding the dubious example from Olorgesailie) are from Klasies River Mouth and Florisbad, both of which are younger than the six European examples he mentions.

However, there may well be a bias here in our evidence from Africa. In the first place, most of the early African sites are ephemeral open-air ones, where charcoal and ash could easily have been blown away, unlike the caves that dominate the evidence from Eurasia. Secondly, there are now very few African Middle Pleistocene sites, as ones such as Olorgesailie and Kilombe have been redated to the late Lower Pleistocene. (Gowlett [1987] asks, "What important African sites can be

placed with certainty in the period 700,000–300,000 years ago?") The absence of pertinent data from African Middle Pleistocene sites may therefore indicate an absence of early- to mid-Middle Pleistocene sites and not just an absence of sites with the right preservational contexts. It may therefore be premature to conclude that fire was first controlled in Eurasia.

But if the pattern holds and fire was not used anywhere before the mid-Middle Pleistocene, how important might it have been in earlier times? The intriguing issue is whether there might have been a more than fortuitous association between natural fires and hominid activities. Early hominids might have benefitted from natural bush fires in several ways. One is by gaining access to otherwise inedible or poisonous plant foods, if, as Leopold and Ardrey (1972) and Stahl (1984) suggest, many plant toxins and fibres could not have been broken down without fire. Other possibilities might have been by catching animals that were trying to escape from a bush fire, by scavenging carcasses of animals that died in fires, by having easier access to below-ground—if somewhat scorched—resources after the ground foliage had been burnt off, by hunting or scavenging animals that were feeding off the regenerating foliage, and perhaps by taking the first tentative steps towards cooking. In time, these practices might have led to hominids' aiding and abetting natural outbreaks of fire. The critical leap here would probably have been the development of ways of storing fire by encouraging it to burn slowly, by adding fuel until it was needed elsewhere, and by devising ways of transporting it. Ideas such as these are, of course, easy to formulate but almost impossible to test (as James shows for the Torralba, Hoxne, and Marks Tey evidence). One particularly difficult issue is the time interval between fire residues (e.g., burnt clay pellets) and hominid discard; if the latter is unburnt and on a burnt surface, the time lapse may be considerable and the association entirely fortuitous. However, even if Palaeolithic remains are found burnt and within or on a burnt surface, the fire may well have occurred after hominids had moved elsewhere. In my view, it will be very hard to demonstrate a *causal* relationship between fire and early hominid sites (especially open-air ones) that lack evidence of hearths or burnt bone without first showing that natural fires were most unlikely to have occurred spontaneously. Given that there are an estimated 100 lightning discharges over the Earth's surface per *second* (Patterson, Edwards, and Maguire 1987), this could well be hard to do. What is clearly needed is very thorough attention to the taphonomic processes resulting in the preservation and distribution of both burnt and unburnt materials within early hominid sites. In this respect, a lead could be taken from the recent critique by Patterson, Edwards, and Maguire (1987) of the use of microscopic charcoal as an indicator of fire; similar studies could begin by looking at how often and at what time of year fires occurred naturally in different types of environment and over what area, and for how long, their residues might last.

On current evidence, it seems that the controlled use

of fire for domestic purposes (warmth, cooking, light, protection against predators, signalling, etc.) dates from the last quarter-million years (or possibly less) and is largely associated with archaic forms of *H. sapiens*. This point implies that prehistorians should distinguish between the opportunistic usage of fire for exploiting the environment and the deliberate use of fire in domestic contexts; the former *may* have occurred before 250,000 years ago but will be very hard to demonstrate, whilst the latter is demonstrable but not evidenced until well after that time.

Some other points can also be made on this article: (1) Yuanmou in China would seem to be Middle Pleistocene in date (Pope 1985). (2) Two-million-year-old artefacts have been reported in a good context from northern Pakistan (Rendell et al. 1987, Dennell, Rendell, and Hailwood 1988a), so we should allow for the possibility that there were late Pliocene tool makers outside Africa even if they are at present unknown. (3) As James notes, stone tools were found with the remains of *Australopithecus boisei* at Chesowanja and Koobi Fora (FxJj20E) and with *Paranthropus robustus* at Swartkrans; yet the consensus is that they (and presumably other archaeological residues) from these sites resulted from the activities of *Homo*. Susman (1988) has argued that the newly found hand bones from Swartkrans shows that *P. robustus* was capable of making tools; perhaps Africanists should face up to what I once called "the awesome prospect" (Dennell 1983:32) that the earliest archaeological record may be composite and that *A. robustus* and *H. habilis* may both have been stone tool makers (and perhaps also opportunistic carnivores), albeit to differing extents and with different abilities. What the early African data do seem to show is that *robustus* occasionally died near areas of natural burning and near discarded items of struck stone and animal bone. Whilst associations can be explained in several ways, they do not seem firm reasons for concluding that *robustus* was not a tool maker, did not eat meat, or, for that matter, did not exploit the opportunities created by natural bush fires.

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Fire is a naturally occurring chemical reaction. Because it had a number of uses, it was apparently captured and maintained by our early ancestors, who subsequently developed the means to create it on their own. The paleoanthropological problem in tracing the history of fire as an artifact is largely a taphonomic one and involves recognizing when the evidence for ancient fire indicates human control and when it indicates natural occurrence. James is appropriately critical of tenuous claims for early use of fire, and his review of the literature tries to show that many reports of fire in the Paleolithic record have not adequately demonstrated a hominid connection. He correctly asks for more rigorous testing of excavated materials suspected to be fire-related, and

he proposes finally that the strongest cases for hominid exploitation will probably be those deposits in which many lines of evidence converge.

Ultimately, carbonization and baked earth may be produced both naturally and artificially, and so it is not necessarily the evidence of burning that counts but the context in which the burning is found. The matter of context is not directly addressed in James's paper, although many of the points raised are related. This comment introduces the contextual dimension into the discussion by illustrating two of the major difficulties in evaluating it.

First, hominid sites of the Lower to Middle Pleistocene are frequently formed from reworked sediments. Erosion, transport, and differential secondary redeposition displace artifacts and obliterate features that would perhaps have suggested a greater degree of functional organization in their intact state. For example, a few burned bones embedded in ancient lakeside tributary channel sediments do not offer any real hope of being linked to a hominid origin even if they did indeed so originate. By contrast, in situ charcoal concentrations and their scatters on occupation surfaces might have been caused by natural burning of an abandoned campsite, yet the still intact deposit provides evidence with which the taphonomic circumstances may be studied in their primary context. Without resorting to speculation, gauging the possibility of fire use in disturbed sites would probably require a findspot with such minor damage from natural forces that an excavator could infer from the disintegrating pattern the initial arrangement. The chances of finding an intact primary context diminish greatly with increasing age of a site, and therefore the best evidence will probably be hard to find.

Second, early hominid living space is likely to be less structured than that of late prehistoric times. Without the kinds of deliberately built containment areas that, in association with burned artifacts and oxidized sediments, signal the presence of what we call hearths, campfires, or cook pits, it becomes potentially more difficult to identify artificial fires even when finds are preserved in primary context. For certain times or kinds of site, then, expectation of special-function installations may be unwarranted. Further, sites visited intermittently over long periods by one or many hominid groups, each utilizing site space differently with each visit, could generate an amorphous spread of numerous overlapping campfires that might be difficult to distinguish from cave sediments naturally set alight. Post-depositional disturbances and episodes of reburial would only add to the complexity.

Recognizing early use of fire will likely consume much effort and require more evidence than that of the burned substances alone. Actualistic taphonomic studies that serve the cause of middle-range theory development should help to focus attention on the critical human aspects of fire making and fire tending that could help to distinguish artificial from natural fires, but excavators will still need a strategy that marshals several methods of materials analysis and considers taphonomic

information for the site in general before an informed judgment on a particular case can be made. Initially, one will need to confirm the presence of burning by chemical, paleomagnetic, or electron-spin-resonance analysis. If the nature of the deposit is not apparent, microsedimentological investigation (e.g., Goldberg 1980, Courty, Goldberg, and MacPhail 1989) of the immediately surrounding matrix might indicate whether burned items remain in primary burial context or in a subsequent hydraulic, aeolian, or colluvial phase of redeposition. If original site surface has survived, spatial analysis and study of sediment components become important tools in understanding fire placement, extent of hearth preparation, frequency or duration of burning, variation in fuel type, etc. Anatomical identification of combustibles through charcoal or phytolith examination and comparison of the geobotanical or zoogeographical habitat of identified species with the paleoenvironment of the site catchment area could then furnish the minimally necessary data for proper evaluation of the possibility of hominid involvement in the setting or care and feeding of the fire.

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Plainly evidence related to burning, in some form or other, is present on a high proportion of early archaeological sites. The problem is how to advance beyond a general statement of this kind. The difficulties of studying fire from its scanty remains have been explored elsewhere (e.g., Perlès 1975). This article is useful for its tabulation of basic data, but it also serves to emphasise the scale of the task before us.

James reports that "Gowlett et al. (1981, 1982) claim that hominids were using and controlling fire 1.42 million years ago at Chesowanja." The use of the word "claim" cuts corners. There is no reasonable doubt that there is burnt material on the 1/6E site at Chesowanja. The difficulty lies in evaluating the likelihood of human control. The key paragraph in our 1981 report is as follows:

Although natural phenomena such as bush fires, lightning strikes, and even volcanic heating could explain the burnt clay at Chesowanja, we are convinced, from examination of the whole occurrence *in situ*, that hominid activity is a much more likely explanation. Thus the new find, together with the more tentative evidence from other sites, greatly strengthens the hypothesis that by 1.4 Myr hominids were using and controlling fire.

It is vital that we have the freedom to talk in terms of "hypotheses," "strengthened hypotheses," and even "working hypotheses" without others' overlooking the cautionary words. As we concluded, "the paucity of evidence bearing on these hypotheses underlines the neces-

sity of locating and investigating new sites of the same period where there is well-preserved and *in situ* evidence of hominid occupation." Nevertheless, the large number of Lower and Middle Pleistocene sites with some evidence of burning makes me highly sceptical of the view that the most "parsimonious" explanation is natural burning, even for the early African sites.

James twice refers to distances on the ground at Chesowanja. In themselves these distances give no good measure of association. Fragments of australopithecine cranium belonging to the same specimen were found on the surface at about 15 m and about 25 m from the 1/6E site. As the Chemoigut Formation sediments slope only gently in this area, there is no available source for the hominid remains except sediments at much the same level as the archaeological horizon. Of course, this is not a direct association. Although the Chesowanja basalt formation outcrops about 200 m from the site with the burned clay, the basalt flow is 50 m or more higher in the local sequence (cf. Bishop, Pickford, and Hill 1978). The law of superposition rules out incorporation of clay baked by the basalt in the 1/6E site. The absence of Chesowanja basalt in the site confirms the point. Although we ourselves mentioned the possibility of volcanic heating (Gowlett et al. 1981), direct heating by lava is by far the least likely of any possible natural explanations for the fire.

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Except for a few specific criticisms of the existing evidence, James's argument does not convince me that the claim for the use of fire in the Lower and Middle Pleistocene is wrong. I see nothing particularly remarkable in the idea that *Homo erectus* would have used fire even if aeons away from being able to make fire or use it to manage resources with the insights and effectiveness characteristic of contemporary foragers (see Boyd 1986; Hallam 1975, 1985; Haynes 1982, 1983; Jones 1980; Kimber 1983; Lewis 1973, 1982b; Timbrook, Johnson, and Earle 1983). It is difficult to accept that an animal with the mental capacity and physical dexterity to make even the simplest stone tools would not have recognized the advantages of using fire—to heat and illuminate caves or open sites, not to mention cooking food or affecting plants and animals—and been able to maintain it and move it from place to place.

I agree with James that the evidence he criticizes is "circumstantial," but I had assumed that all archaeological evidence was. In this respect, his suggested "possibility of lightning-caused cave fires" is circumstantial indeed. As it is in all of science, it is the probability of possible events that concerns us, and the probability that charcoal represents man-made fires within caves is infinitely greater than that it represents lightning-caused fires. In the absence of (any?) verified lightning-caused cave fires, James has to provide more substantial



evidence than his repeated assertion that lightning "may" have been the cause. Lawrence (1953) is the one authority that he refers to other than Brain (1967), who also bases his assertion of the possibility of lightning-caused cave fires on Lawrence's brief "note." Lawrence, however, though briefly mentioning lightning strikes, says nothing about lightning-caused fires while commenting that the microclimates of caves include high humidities ("usually above 90 per cent" [p. 153]) and low temperatures, not ideal conditions for ignition.

Most lightning strikes in fact do not cause fires. According to Pyne (1982:9), most fires are caused by "hot lightning" (known also as "long-lasting current"), which accounts for about 20% of all cloud-to-ground discharges in the Northern Rockies whereas "cold lightning" accounts for the remaining 80%. According to unpublished sources from the Alberta Forest Service, during the two months (usually July and August) in which electrical storms occur here, the ratio of strikes to fires can vary from as much as 1:1 to 1,000:1 or none depending upon the object struck, the fuel conditions, and the weather. Given the microclimatic conditions of caves and the fuels involved, the frequencies of ignition must be extremely low. The suggestion of lightning-caused cave fires is a remotely possible but clearly unlikely explanation for prehistoric charcoal remains.

A functional-causal relationship between the presence of human/cultural remains and charcoal in a cave is no less likely than the association of human/cultural remains and charcoal would be anywhere else and in fact undoubtedly more so. Even in the absence of human/cultural remains, the probability that charcoal anywhere is a consequence of human activities is far greater than that it has natural causes. All in all, humans are much more reliable than nature in igniting fires in or transferring them to caves. Man-made (or transported) fires are consciously acted upon, their sites are purposefully selected, they have an extremely high probability of being ignited (with several tries if necessary), and the pyrotechnics can be repeated for days, weeks, and years on end. As Lawrence (1935:155) says, "the meteorological conditions peculiar to caves—the constant damp cold and still, quiet darkness"—make them places in which we would not expect to find even the least neurologically developed representatives of our genus *unless* they used fire.

James can also be faulted for what he infers about grassland fires. As a number of writers have emphasized (Arthur 1975; Day 1953; Harris 1984; Sauer 1950, 1956; Stewart 1955; Welles 1970), many if not most grasslands are a function of human uses of fire and not merely the consequence of natural fires and edaphic factors. Even lightning-caused prairie fires are relatively infrequent (Rowe 1969). In the absence of man-made fires most grasslands quickly revert to brush and trees. I also find it difficult to believe that, however improvident prehistoric humans may have been, *H. erectus* would not have exploited and helped maintain ecotones and grasslands. Along with other early-succession, opportunistic animal species, early man must have been able to recognize the

advantages of fire-modified habitats, whether the results of natural or accidental fires, and unlike other animals he would have been able to extend and intensify such conditions by simply transferring fire from one area to another.

The simplest and most effective way of exploiting animals with fire is to burn a variety of places, creating a more complex fire mosaic than exists naturally, and then hunt the animals that frequent sites having vegetation at various stages of fire-induced succession. As with other predators that "know" their prey, this requires a knowledge of plant-animal associations, and it certainly seems reasonable to assume that early hominids were at least as intelligent as other predators that hunt in selected habitats and places. Add to this the ability to affect such habitats and places with fire and we surely do have one of the "most important extrasomatic milestones" in human evolution.

It was undoubtedly modern man who developed the forms of habitat burning that are sharply distinct from natural fire patterns, for example, in seasonality, frequency, selection of sites, and intensity (Lewis 1982a) and in the formation of yards, corridors, and mosaics (Lewis and Ferguson 1988). I agree with James that the earlier explanations of fire uses depend on "tenuous lines of evidence." Although proponents of the earlier uses of fire will undoubtedly never provide the necessary "smoking gun" (or, in this case, "smouldering firestick") to make the case for Lower and Middle (or even Upper) Pleistocene uses of controlled fire, the probability that early hominids employed fires in caves, campsites, and fields is infinitely greater than that they did not.

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There are implications here for the archaeology of the New World as well as that of the Old. Most American archaeologists had assumed that Middle Pleistocene control of fire was well established, and a few have even been industriously searching for sites in the Americas, at the same time depth, with this telltale sign of human presence. The resulting forced scenarios, exciting though they may be, are even less satisfying here where more parsimonious noncultural explanations seem so much more likely. James's critical review of supposed early control of fire in the Old World will be a real boon to American archaeologists, who will no longer be under such pressure to show that dubious early artifacts are not associated with burned earth, charcoal, or even manganese-stained rocks (cf. Carter 1950, 1980). Conversely, for those who believe firmly in Lower and Middle Pleistocene control of fire, the Americas no longer present a clearly negative control case.

At Esperança Cave in Brazil, where Maria Beltrão began work in 1985, a mere 1–1.5-m deposit has yielded dates ranging from 2,020 ± 130 B.P. (by radiocarbon on

the topmost level) to 204,000–295,000 years (by the uranium-thorium-decay method on the lowest level). The gamma-ray spectrometry, accomplished at Gif-sur-Yvette, and alpha-ray spectrometry, from Los Angeles and Menlo Park, show good agreement and were done on three pieces of fossil bone. The fauna includes extinct horses as well as a few bones of extinct sloth, armadillo, camelid, and perhaps bear (Beltrão and Danon 1987, de Lumley et al. 1988).

The Franco-Brazilian research team recognizes two quartzite pebble tools and a chopper from the lowest level (IV), in addition to a hammerstone and several flakes from Levels II–IV. The line drawings of the “artifacts” suggest that they are very simple, although Beltrão and Danon (1987) state that at least one is specifically Clactonian in type. They also claim bone tools, human dental moulds (?), campfire structures, and charcoal from all levels, although no mention is made of these in the 1988 French publication. Most significant, both reports indicate that the quartz and quartzite at Esperança are from an outcrop 10 km from the cave.

According to these investigators, “It is of course not surprising that *Homo erectus*, who occupied the continent of China from at least 700,000 years ago . . . and had domesticated fire 400,000 years ago (Zhoukoudian), would have crossed the Bering Strait a number of times” (de Lumley et al. 1988:245, translation mine).<sup>1</sup> We have a problem here. Are we to use Esperança Cave as reinforcement for the thesis of Middle Pleistocene control of fire, which would surely have been necessary to cross the Beringian North, whether or not there are hearths with the claimed artifacts at Esperança, or do we take the current skepticism about systematic control of fire in the Middle Pleistocene as grounds for questioning the cultural nature of the remains in Brazil? Most Americanists will take the latter course.

De Lumley et al. buttress their case for the early occupation of Esperança Cave with recent shaky claims from Piauí in the Brazilian Northeast (human presence as early as 32,000–40,000 B.P. [Guidon and Delibrias 1986]), the claimed association of man and mammoth on Santa Rosa Island, and the supposed Middle Pleistocene human occupation of the Calico Hills alluvial fan, also in southern California. To these the Franco-Brazilian team might well add the recently published possibility from Chile, where at Monte Verde simple stone artifacts may be associated with fire at 33,000 to as much as 40,000 years ago (Dillehay and Collins 1988:152). Brazil, Chile, and southern California have a lot in common. I have much trouble with all of these putative cases of early human occupation and fire use in America and have expressed my doubts and criticisms fully (Lynch n.d.). The Santa Rosa and Calico claims have been thoroughly discredited and nearly universally rejected, the “evidence” for fire having been accounted for by simpler and

more likely natural causes (Bischoff, Ikeya, and Budinger 1984, Cushing et al. 1986). Just as formal hearths enter the Old World record only in Neanderthal contexts at the start of the Upper Pleistocene, they appear suddenly in the Americas, accompanied by indubitable stone tools, only in the Paleo-Indian horizon, at the end of the Pleistocene. We need a study equivalent to the one by James on the reports of Upper Pleistocene control of fire in the New World.

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James is to be commended for this comprehensive yet concise review on the origins of the use of fire in the Pleistocene. The collation and critical scrutiny of the evidence will be useful to a wide range of prehistorians and should affect the “received” treatment of the topic in textbooks. However, his evaluation of the data raises some questions:

1. James juxtaposes from the outset two alternatives: natural, noncultural, uncontrolled fire, as exemplified by a lightning-ignited bush fire, and human, cultural, controlled fire, as exemplified by use of a hearth. Implicit is the idea that control of fire appeared only after the emergence of the hominids. This dichotomy does not allow for the possibility of cultural and controlled but prehuman use of fire, such as by an ancestral ape.

2. James rightly focuses from the beginning on the control of fire. (Presumably this is the same as Clark and Harris’s [1985:19] *predetermined* as opposed to *opportunistic* use of fire.) In reviewing the often scanty evidence available, however, he seems to change the criterion from *control of* to *use of or association with* fire. In many cases, the problem is even more serious, that of determining whether there is any evidence of fire at all. By the time the summary figure 1 is presented, only 1 (hearth) of the 11 criteria is unequivocal evidence of control, while the other 10 would seem to show probabilities of control ranging from zero (for charcoal) to something unquantified but higher (for fire-hardened wood). Clarification would be helpful as to how one operationally infers control from the archaeological record.

3. The question of controlled but nonhuman use of fire is not just a hypothetical one. Brink (1957) has reported that cigarette-smoking chimpanzees in the Johannesburg Zoo regularly maintained and extinguished fire in pursuit of their addiction. Chimpanzees being rehabilitated into the wild in Senegal managed campfires in a rudimentary way for cooking and warmth (Brewer 1978:174, 176). They also collected roasted wild seeds after bush fires (p. 232). In none of these cases were the apes taught by humans; rather, they spontaneously imitated human models or invented the practices. Whether wild chimpanzees naturally (or culturally?) make controlled or uncontrolled use of fire is an open question. Few field studies of apes have been done in areas in which seasonal fires occur, and these (e.g., Gombe, Mt.

1. “Il n’y a donc rien d’étonnant à ce que *Homo erectus* qui occupait le continent chinois depuis au moins 700,000 ans . . . et qui a domestiqué le feu depuis 400,000 ans (Chou-Kou-Tien), ait franchi à plusieurs reprises l’isthme de Béring.”

Assirik) have not focused on responses to fire. This should be done. Also, it should be easy enough to present captive chimpanzees with opportunities to use fire in specified (and safe!) settings.

4. Use of data from living hominoids may sharpen the modelling of the evolution of fire use. For example, in their array of opportunistic uses of fire, Clark and Harris (1985:19) concentrate on animal foods made available after bush fires, such as fallen bees' nests, burnt termitaries, suffocated burrowing animals, and carcasses of larger animal victims. Brewer's chimpanzees at Mt. Assirik (though otherwise eaters of bees, termites, and mammals) showed none of this hypothesised scavenging for animal prey. Instead, they collected plant foods roasted or released (from dehiscing pods) by the fire.

5. Problems of modelling are illustrated by the vexing example of what to make of baked clay. This has been well aired, as James describes, but an example may help to bring this home. First, termite earth can be remarkably uniform in content, texture, and particle size. Presumably this is a function or by-product of macrotermitine natural history, e.g., mound architecture or mandibular gape in worker termites. What may result is bias toward the creation of clasts. Second, coevolved associations between termites and certain species of woody vegetation may enhance the probability of clay's being naturally fired. At Mt. Assirik, *Cubitermes* sp. termites and *Combretum* sp. shrubs are found together in open grassland. After bush fires pass through, dead branches of *Combretum* may burn for days, thus baking the clay of the mound from which the branches protrude. Third, sympatric animals, including primates, make use of the *Cubitermes-Combretum* association. Patas monkeys (*Erythrocebus patas*) preferentially sit atop the *Cubitermes* mounds in the shade of the *Combretum* leaves, using the site for resting, vigilance, and probably nocturnal sleeping (C. Henty, personal communication). The result is a statistical likelihood of the discovery of faunal remains in an association with baked clay that is entirely spurious.

6. Much of the evidence for the use of fire in the Lower Pleistocene would seem to be just as readily attributable to pongids as to hominids. At present, there seems to be no way to distinguish them. This is a further example of the current debate (as pointed out by James) over which of the various extinct hominoid taxa was responsible for which elements of the paleo-archaeological record.

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James has rendered a service by bringing together this material on the early-prehistoric "evidence" for hominid controlled use of fire and providing a preliminary general reassessment. Several of his points are well made. My comments are intended as complementary and focus on some of the (usually implicit) conceptualizations of evi-

dence and inference of the various writers, many of which seem poorly developed if not fallacious.

This area of inquiry apparently still suffers from blatant advocacy—a blessing, perhaps, in comparison with more subtle forms of nonevaluation. The concept of proof is sometimes invoked, oddly, without the accompanying concept of "beyond a reasonable doubt." Reliability is rarely an explicit consideration. The *evidence* for burning can be "appeared to be burned" or "color suggestive of burning." Moreover, expert opinions based on visual inspection appear to be assigned the same factual status as the results of laboratory tests. This leads us to a number of technical questions, for example, What are the most appropriate criteria for detecting thermal alteration? When are charcoal flakes really evidence of fire? Perhaps, at present, the best that we can do is to speak of *purported evidence* and *purported occurrences* and use quotes for the term "burned" at the beginning, not just the end, of critical analytical passages, including instances in which the reviewer does not question the judgment of the source but no laboratory corroboration is presented.

More often than not, we have the problem of equivocal evidence (to risk an oxymoron). The concept of "association" seems nebulous, sometimes vacuous, when applied to deposits hundreds of thousands of years old. With possible geomorphological dispersal of originally associated elements through tens of centimeters of deposits or across several meters of paleoterrain and absence of relevant temporal markers or controls, how can "associations" provide unequivocal evidence for early hominid-controlled use of fire? For the Upper Paleolithic we have built features containing the residua of fire and the possibility of establishing the remoteness of natural sources of fire in caves which also contain archaeological materials. For earlier periods structurally defined hearths are apparently nonexistent. Even the hearths of Terra Amata are said to be "unprepared," although the quoted description is of prepared features. For remote antiquity, what are the criteria for hominid agency? Surely more than a notion of multiple kinds of (purported) evidence is called for.

Fallacious arguments appear to be common in this literature. Most seem to be not the result of negligence with regard to logical form or failure to consider the ambiguities of language but rather what logicians call material fallacies (cf. Aristotle's fallacies *extra dictionem*), for example, the fallacy of immense benefits, the fallacy of appeal to uncritical imagination, the fallacy of alternative explanations' being just as fanciful. To put it simply, the common form of (fallacious) argument that we encounter appears to be begging the question.

In general we want to decide whether some hypothetical situation appears factual in the light of the sampled evidence or which of a number of hypothetical situations is best supported by the evidence at hand. But what about the risk that one is willing to take in making the wrong decision? The null hypothesis (to use a statistical metaphor) is that the fired occurrences are natural (non-hominid in origin), i.e., that the observed evidence is

what would be expected under natural conditions. (The alternative here is that the occurrences are hominid in origin.) A conventional scientific decision rule is to make the probability of falsely rejecting the null hypothesis (Type I error) very small, i.e., to avoid rejecting the null hypothesis when it is true. Not rejecting the null hypothesis when it is false (Type II error) is theoretically more likely when we reduce the probability of Type I. Not rejecting it can also be thought of as exercising the option of suspending judgment. That we do not find the evidence implicating a hominid agent convincing (we still have reasonable doubt) does not require us to accept the null hypothesis of a natural origin or agent. Exercising this option can be especially useful when, as appears to be the case here, much of the "evidence" does not clearly establish the occurrence of fire itself. We have yet to accumulate a data base detailed and reliable enough to specify what we would in fact expect to see in the prehistoric record as evidence of natural vs. hominid-controlled fire without built features. Not rejecting the null hypothesis may be the logical option we need to see us through this one hopes temporary situation.

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Although James's review of the evidence for the use of fire by early hominids is generally thoughtful, his Binfordian approach prevents, at least in some cases, a truly impartial consideration of the evidence. Nowhere is this more apparent than in the treatment of Zhoukoudian, which consists primarily of a reaffirmation of conclusions based on an incomplete review of the literature that neglects major Chinese sources (Binford and Ho 1985) and a cursory examination of a portion of the Zhoukoudian fauna (Binford and Stone 1986) that many Asian specialists feel is a misleading and speculative use of both statistics and taphonomic techniques (see Olsen 1986, Pope 1988).

Building on Binford and Ho's (1985) speculation that spontaneous combustion was the source of the Zhoukoudian fires, James revives the comparison of the Zhoukoudian evidence with the results of naturally occurring cave fires in the arid Southwestern United States. Comparing temperate Pleistocene North China with the arid Great Basin is inappropriate, especially in light of fairly good evidence that hominid occupation of the cave coincided with relatively wet and warm periods (Pope 1988, Aigner 1986, Liu et al. 1985). Furthermore, despite James's contention that the association of burned material, artifacts, and faunal remains is "far from conclusive," such associations are confirmed by original site reports to which Binford and Stone did not have access.

The speculation about lightning-caused cave fires is interesting, but after more than ten years of research and exploration of karst caves in East Asia I have never ob-

served or heard of evidence for such a phenomenon there, despite seasonally frequent lightning strikes. I have, however, observed the yearly burning of forests for nonagricultural reasons, and it is this that I alluded to in my nonlithic-technology model (Pope and Cronin 1984) and not the use of fire to manufacture "bamboo and other wooden implements."

I think it useful that James has pointed out that evidence for fire at other early Asian sites is in many cases equivocal. The fact remains, however, that some form of burning has been reported from all the early Asian sites, including one Middle Pleistocene site in Thailand that shows unequivocal evidence of a hearth in association with artifacts and fauna (Pope et al. 1981). Surely these widespread associations cannot be dismissed as the result of nonhominid agents.

Finally, this review would have been much more credible if it had avoided adopting the Binfordian hypothesis of minimal cultural capacities for Pleistocene hominids—imposing impossibly rigorous standards of evidence on archaeological assemblages and postulating elaborate natural alternatives (lightning-caused cave fires, spontaneous combustion, chemical staining, etc.) to explain phenomena most parsimoniously understood as the result of hominid activity. The "postdepositional processes" that have been so prominent in recent discussions of Zhoukoudian are in fact more effective in destroying original archeological evidence than they are in creating spurious new patterns in archeological assemblages. This is especially important to remember in trying to reconstruct the behavior of such relatively rare animals as early hominids.

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The archaeologist interest in the Lower and Middle Pleistocene two decades ago felt frustrated by a dearth of archaeological evidence; however, the construction of scenarios to accommodate the existing evidence seemed a straightforward process. The existence of basic "human" behaviors such as tool use, control of fire, hunting, etc., seemed easy to demonstrate, even from very early contexts. The past 15 years have seen a continuous erosion of numerous "facts" of hominid evolution presented in introductory texts. The image of our early ancestors as social creatures cooperating around a cozy hearth, sharing the profits of a day's hunting, seems less tenable in the face of more rigorous analyses of site formation combined with a greater awareness of problems associated with using contemporary peoples and nonhuman primates as analogs for modeling hominid behavior (e.g., Isaac 1984, Cartmill, Pilbeam, and Isaac 1986). James's article contributes to this literature by reevaluating the evidence for controlled fire and questioning the "facts" that have entered the realm of archaeological folklore. Although the depth of coverage is at times un-

even, James casts an appropriately skeptical eye over the literature and concludes that the evidence for controlled fire prior to ca. 400,000 years ago is equivocal at best.

Although I agree in large part with James's conclusions, I question his suggestion that the *number* of "types of evidence" is the best means of sorting out occurrences of controlled as compared with natural fire available to us at present. What his discussion lacks is explicit mention of a very basic concept in archaeology of which we often lose sight: *associations*. In the final analysis, many of the reinterpretations of Plio/Pleistocene sites have hinged on arguments about the quality of associations, and many of the early sites suggested to evidence controlled fire may be judged equivocal on the basis of poor associations between evidence for fire and artifacts. Chesowanja is a case in point. Thus, a site with only one or two types of evidence for fire, if they occur in clear association with evidence of hominid occupation, may be judged less equivocal than a site with several indications of fire in poor association.

James's focus is clearly upon assessing the *antiquity* of fire. This is reflective of a concern on the part of past researchers to establish its "earliest" occurrence; however, merely demonstrating the existence of controlled fire tells us very little about its evolutionary significance once its control has been mastered. For example, we have yet to gain a clear understanding of the implications of cooking for hominid dietary strategies despite preliminary discussions of some important variables (Stahl 1984, 1988). One thing that does seem likely is that the "advantages" accrued through the control of fire were not realized simultaneously. Use of controlled fire as a source of warmth may have preceded systematic use of fire in food preparation by thousands or hundreds of thousands of years. Thus, criteria must be developed not only for identifying the *existence* of controlled fire but also for delineating the uses of fire. The latter is a key issue that has yet to be sorted out but that has fundamental implications for our understanding of hominid adaptations both before and after the systematic control of fire.

## Reply

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Most commentators are essentially in agreement with the viewpoint I have expressed, and I see their comments as complementing and clarifying certain points of my argument. As would be expected in any anthropological audience, there are several who disagree. Lewis is right in saying that modern hunter-gatherers used fire to manipulate plant and animal resources, but the same cannot necessarily be assumed of early hominids. Given the shifts in opinion in paleoanthropological studies that are noted by Dennell and Stahl, it is difficult to deter-

mine what the behavior of early hominids was like. Some researchers now argue that scavenging rather than hunting constituted a large part of their subsistence behavior. To assume that our early hominid ancestors were like contemporary hunter-gatherers in their use of fire or any other behavior is to deny the evolutionary variability that has developed over the past several million years.

Lewis minimizes the role of lightning in igniting forest and grassland fires. Clearly, we are reading different literature on the causes of natural conflagrations, particularly for the Rocky Mountain forest and prairie fires that he uses as examples. In western North America during periods of summer drought, lightning is the *primary cause* of natural fires in Pacific coast and Rocky Mountain forests dominated by Douglas fir (*Pseudotsuga menziesii*). It has been recorded to account for more than 50% of the forest fires in west-central Oregon from 1910 to 1977 (Wright and Bailey 1982:255, 256, 274). Historical records from the northern grasslands of Canada and the United States indicate that lightning was the sole cause of fire other than humans. A range researcher in southern Alberta reported that of a dozen grass fires he observed between 1949 and 1964 all but two (which were man-caused) were the result of lightning (Nelson and England 1971:295). Similar situations can be documented for the Old World. Clark (1983:32) argues that prior to human settlement of Australia 40,000 years ago, "lightning would have been the most common ignition source, with volcanic eruptions and spontaneous combustion of coal and peat being important at times." Patterson, Edwards, and Maguire (1987:4) also consider lightning the most important source of natural fires.

Finally, until recently researchers have often attributed the co-occurrence of stone tools, animal bones, and charcoal in early archaeological deposits to hominids. This view has changed within the past several decades as archaeologists have studied taphonomic processes that affect the archaeological record and have begun to distinguish natural factors from hominid behavioral patterns. Contextual problems are apparent in both caves and open sites, areas subjected to myriad natural processes in which early hominids occupied but a small niche. Assumed associations of lithic artifacts and charcoal flecks in early archaeological deposits, in the absence of substantial other evidence of fire, cannot be taken as indicating hominid control or even fortuitous use of fire.

Pope considers the evidence for fire in "all the early Asian sites" unquestionable. The Middle Pleistocene site in Thailand to which he alludes appears to be Kao Pah Nam, a limestone cave/rockshelter that he and others excavated in 1979-80. Although several possible stone tools were recovered, the cave deposits were formed by a number of natural processes: "Bones are generally gnawed and broken. . . . The presence of *Crocota* sp. [hyena], *Panthera tigris* [tiger], *Hystrix* sp. [porcupine], and apparently hominids suggests that one or all of these agents were at least partly responsible for the accumulation of bones at Kao Pah Nam. An alternative interpreta-

tion may indicate that deposition of the Kao Pah Nam fauna may be the result of animals falling into a fissure" (Pope et al. 1981:156–57). Further, there is no discussion of a hearth in this report, although in a later article Pope (1983:4991) mentions the presence of fire at an unspecified locality in Southeast Asia—presumably Kao Pah Nam, since the interim site report is referenced.

With regard to Pope's model for Middle Pleistocene adaptation in Asia, it was not clear that the "processing of non-lithic resources" with fire to which Pope and Cronin (1984:389) refer was not the making of bamboo tools, and I thank him for clarifying this matter. However, Pope (1983:4991) has written elsewhere:

The use of bamboo in conjunction with other non-lithic materials constitutes a highly portable technology that may have arisen as a specific adaptation to the heavily forested areas of Southeast Asia. . . . The widespread evidence of fire at early Chinese sites (and at least one locality in Southeast Asia [Pope et al. 1981]) also supports this hypothesis as fire is an important part of woodworking forest technology.

That Pope has seen no lightning-caused cave fires in ten years of East Asian research is worth noting, but until we look more closely at this phenomenon, which has apparently received only a few brief comments (Brain 1967, Lawrence 1953), we cannot rule it out.

Gowlett admonishes me for overlooking the words "working hypotheses" in his reports on the evidence for fire at Chesowanja (Gowlett et al. 1981, Gowlett, Harris, and Wood 1982). The words are indeed used several times in both the initial article and the reply to the late Glynn Isaac. Nevertheless, one does not get the feeling that the fire evidence is viewed as a hypothesis open to question and debate: "We emphasize again that the evidence of fire at Chesowanja is quite definite: the clay was burned, and its association with the artefacts is direct and physical" (Gowlett, Harris, and Wood 1982: 870). Rather than being a hypothesis, the evidence of fire and the idea of its possible control by hominids seem to be a post hoc accommodative argument (see Binford 1981, G. Clark 1988). Although Gowlett et al. (1981:128) do mention the possibility that "bush fires, lightning strikes and even volcanic heating" might have produced the burned clay at GnJi 1/6E and even examined the "baking around a recently burned tree stump near Chesowanja," they reject these natural processes. What needs to be done, as I have said, is to examine the range of variability in natural and cultural factors that produce fire and develop testable hypotheses based on signatures of these patterns. I thank Gowlett for specifying the distances from the site of the five *A. boisei* cranium fragments and for noting the stratigraphic position of the Chesowanja basalt formation. I did not doubt that the australopithecine fragments were derived from the same sediments as the lithic and bone materials recovered at GnJi 1/6E. What I questioned was the assumption that the stone tools were made by *H. erectus* and not australopithecines even though tangible evidence for the

former was lacking at the site. Dennell here expresses a similar concern.

As for volcanism, it would be worth examining the active lava flows of Kilauea Crater in Hawaii and other such areas of the world with a view to ascertaining the depth, temperature, and result of ground heating beneath them. Data on this subject may even be available in the geological literature. Temperatures recorded for basic lavas range from 750°C to >1,200°C with an average of 1,100°C; cooling is slow and may take years (Bullard 1976:52–53, 69; 1979:14–15). Even months later, temperatures at the base of the crust may be in excess of 1,000°C. The underlying sediments are undoubtedly heated, and although this heating would probably not extend the 50 m required to bake the clay deposits at Chesowanja it is important for us to know more about it for interpretations of early fire.

Dennell's informative comments bring out some points I did not consider. He is correct in distinguishing between direct and indirect evidence for fire. The reason I did not weight hearths, often considered direct evidence of fire use, was that the language used to describe them is ambiguous and varied. To me a hearth is a circular or elliptical feature about 0.5 to 1.0 m in diameter and 5 to 30 cm deep that often contains charcoal, ash, burned soil, fire-cracked rock, and possibly charred bone and other organic matter. The hearths reported at Zhoukoudian, for instance, are by this definition not hearths at all (see Binford and Ho 1985). For example, Campbell (1982:267) describes them as containing about 7 m of charcoal. There is clearly a problem of semantics in the literature with regard to the interpretation of hearths.

I concur with Dennell that the sample of Middle Pleistocene sites from Africa is very small, but the fact remains that most of the evidence is negative. As he notes, Olorgesailie has recently been dated between 0.6 and 0.93 million years B.P., with most of the artifacts derived from deposits in excess of 0.7 million years (Bye et al. 1987, Gowlett 1987). Thus there really appears to be a "muddle in the middle." The dating of Yuanmou in China is more problematic. Initial paleomagnetic dates placed the two *H. erectus* incisors and artifactual materials in the Lower Pleistocene at 1.7 million years B.P., a view that some still hold (Jia 1985:140–41); later paleomagnetic analyses date the deposits as younger than the Matuyama-Brunhes boundary, about 0.5 to 0.6 million years B.P. (Jia 1985:141; Wu and Wang 1985). The review by Patterson, Edwards, and McGuire (1987) of taphonomic processes involved in charcoal production, dispersal, and deposition and of techniques for the identification of microscopic charcoal is well worth considering. Several other studies using microscopic charcoal have been reported within the past few years (e.g., Burney 1987; J. S. Clark 1988a, b, c; R. Clark 1983).

I wholeheartedly agree with Lynch about the problems with the supposedly early associations of fire, faunal remains, and crude stone tools at several South American localities. At the rockshelter of Boqueirão do Sitio da



Pedra Furada, for example, "well-structured hearths" are reported from deposits radiocarbon-dated to as early as 32,000 years B.P. A close examination of the stratigraphic profile (Guidon and Delibrias 1986:fig. 1) reveals that the so-called hearths measure between 2 and 7 m in length, range from 20 to 50 cm in thickness, and follow the natural slope of the strata. One "hearth" extends across the top of the deposits directly below the uppermost level (Layer E). The appearance of these "features" suggests that they are not hearths but burned deposits, calling into question the nature of the "cultural" evidence from the site. In order to determine whether these features are actually hearths, an observation team composed of various archaeologists and other scientists should be charged with examination of the evidence. The team assembled to assess the reported 28,000-year-old evidence for early humans at Tule Springs, Nevada, determined that the earliest artifacts dated only to 10,000–11,000 years B.P. (Haynes 1988, Wormington and Ellis 1967). In fact, the "hearth" at Tule Springs turned out to be partially fossilized plants from springs and the "fire-reddened earth" sediments stained by iron oxide from groundwater (Haynes 1988:6). More recently, four bone tools from the Old Crow locality in Yukon Territory, Canada, initially radiocarbon-dated around 27,000 years B.P. (Irving and Harington 1973), have been accelerator-dated between 1,350 and 2,930 years B.P. (Nelson et al. 1986). When reputed pre-Clovis sites in the Americas have been thoroughly examined, the claims about them have not been verified. Such will probably be the situation with Pedra Furada, Esperança Cave, and Monte Verde.

McGrew's remarks about the possibility of occasional fire use by pongids or their hominoid ancestors are thought-provoking. One way to examine this, as he suggests, would be to conduct modern primate field studies along these lines. I do not feel, however, that occasional tool use or even fire use by lower primates produces enough patterning to be recognizable in the archaeological record even if it did occur. McGrew's comments on the interrelationship of termite mounds, *Combretum*, and bush fires bring to mind a somewhat similar observation on the bone-collecting behavior of harvester ants (*Messor barbarus*) in East Africa (Shipman and Walker 1980). If ant hills and the microvertebrate remains that these ants collect had been burned in bush fires in Plio/Pleistocene times, the resulting material might be considered evidence of hominid fire use and perhaps even diet. McGrew asks how control of fire can be distinguished in the archaeological record. The strongest evidence for controlled use of fire is, as I have said, a hearth in an archaeological setting.

Gilbert is essentially in agreement with me and mentions that the matter of context is not directly addressed. He notes two major difficulties in assessing context with regard to fire in the Lower and Middle Pleistocene: that the older the site, the more tenuous is the evidence and that early hominid living space is probably less structured than that of late prehistoric sites. I see no problems

with his remarks. Peters brings a philosophical viewpoint to the discussion of early hominid use of fire. His view is complementary to my argument.

Finally, Stahl points out that many long-accepted "facts" of hominid behavior are now beginning to be treated with caution. She advocates a distinction between controlled use of fire for warmth and for cooking, particularly since the latter may be much more recent. I tend to agree, but the distinction may be hard to make. The presence of charred food remains would be an indication of cooking and their absence an indication of the use of fire for warmth. However, preservation is a problem in Pleistocene sites, and even in late prehistoric contexts in which charred plant and animal remains are preserved in hearths it is sometimes difficult to distinguish the functions hearths may have served. Stahl mentions association as a criterion for hominid-induced fire—a point also touched on by Gilbert. I did not specifically address archaeological association in some instances because it was not the association of artifacts and the evidence of fire that was in doubt but the nature of the fire or its evidence. This is the reason I turned to the number of types of evidence in attempting to evaluate the extant data, which are often disparate and ambiguous. Until we have an objective understanding of the evidence and the taphonomic processes that produced it, we can only speculate about early hominid control of fire.

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## Calendar

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- March 30–April 2*. Society of Ethnobiology, 12th Conference, Riverside, Calif., U.S.A. Deadline for papers December 15. Write: Elizabeth Lawlor or Sharon Rachele, Department of Anthropology, University of California, Riverside, Calif. 92521, U.S.A.
- August 23–26*. Society for the Encyclopedia of Ideas on Ultimate Reality and Meaning, 5th Biennial Conference, Toronto, Ont., Canada, including the symposium "The Invention of Nature: The Impact of the Concept of Nature on the Concept of Man." Write: Thomas Bargatzky, Institut für Völkerkunde und Afrikanistik, Universität München, Ludwigstr. 27, D-8000 München 22, Federal Republic of Germany.
- September 3–8*. 3d Aleš Hrdlička Anthropological Congress, Prague and Humpolec, Czechoslovakia. Write: V. V. Novotný, Medical Faculty, Charles University, Salmovska 5, 120 00 Prague, Czechoslovakia.

*October 3–5*. 3d International Conference on Food Science and Technology Information, Budapest, Hungary. Themes: Utilization and Deficiencies of Databases in Food Science with Special Reference to Marketing Aspects, Information Systems in Food Science and Technology, Computer Control in Food Production. Write: Udo Schützsack, International Food Information Service, Herriotstr. 5, 6000 Frankfurt am Main 71, Federal Republic of Germany.

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*September 3–9*. International Association for the History of Religions, 16th Congress, Rome, Italy. Theme: The Notion of "Religion" in Comparative Research. Write: XVI International Congress of the History of Religions, Dipartimento di Studi Storico-Religiosi, Facoltà di Lettere e Filosofia, Università di Roma "La Sapienza," Piazzale Aldo Moro, 5, I-00185 Rome, Italy.