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Domestic spaces as crucibles of Paleolithic culture: An archaeological perspective

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ABSTRACT

The places in which people live, sleep, prepare food, and undertake other activities—known variably as homes, residential sites, living sites, and domestic spaces—play a key role in the emergence and evolution of modern human culture. The dynamic influence of domestic spaces began early in human evolutionary history, during the Paleolithic/Stone Age. Drawing on examples from Africa and western Eurasia, this article explores aspects of the changing social and cultural significance of domestic spaces throughout this time using several lines of evidence: repeated site visitation, behavioral structuring of living spaces, and information gained by dissecting palimpsest records. With the development of pyrotechnology, living sites become hearth-centered domestic spaces that provided a common hub for activities. Through time the activities around hearths increased in their complexity and diversity. The parsing of palimpsest records by archaeologists also reveals changes in the nature, variety, and intensity of on-site activities through time, indicating shifts in site function and the spatial expression of cultural norms. Archaeological evidence shows that the entwined development of domestic spaces and human cultural activities was gradual, albeit nonlinear from the Lower Paleolithic through the Upper Paleolithic/later Middle Stone Age. In this process, domestic spaces emerged as common arenas of opportunity for social interaction and knowledge transmission, qualities that may have contributed to and enhanced the development of cumulative culture in Paleolithic society.

1. Introduction

Many animals modify their environment to make safe places for sleeping or rearing their young, such as digging a burrow or building a nest. Examples among mammals include farrowing by wild female pigs and nest building by voles, packrats, and bears (Vaughan, 1990; Mayer et al., 2002; Miller et al., 2017; Zhong et al., 2022). Corresponding structures built by humans have a much broader range of uses that may include child rearing, food preparation and sharing, storage, tool manufacture, and maintaining social bonds through conversation and physical contact. Human habitations—specifically domestic spaces—also function as a theater for the performance, reenactment, transmission, and acquisition of cultural knowledge and skills (Kent, 1984; Gamble, 1999; Clark and Ranlett, 2022).

As nodes of information sharing, domestic spaces increasingly became places where culture could be perpetuated (Kuhn et al., 2018; Kuhn and Stiner, 2019). Without these spaces, the propagative engine of cumulative culture would have remained very weak in human evolution. A niche-constructing dynamic (Laland et al., 2000; Odling-Smee et al., 2003) exerted reciprocal influences between human ancestors and domestic spaces (Dunbar, 2003; Maher and Conkey, 2019). Whereas many readers may agree with all or parts of this claim in principle, making the case with scientific evidence requires that we deal effectively with the fuzziness of Paleolithic records (Stiner, 2021).

The social interactions and knowledge transmission that underlie cumulative culture are contingent on the proximity among individuals. Domestic places thus emerged as common arenas of opportunity. Here we explore evidence about the evolution of human culture in the context of domestic spaces. We begin with a closer look at the core functional properties of domestic spaces as they pertain to earlier human lifeways, and then examine the archaeological evidence for trends. These trends include the

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repeated visitation of certain locations, the use of fire, and the decoration, structural elaboration, and organization of living spaces. This evidence seldom comes in neat, clearly interpretable packages. Rather, we must find ways to make greater sense of palimpsest phenomena as well as the rare 'smoking guns' in the archaeological record. Archaeologists can learn a lot from artifact assemblages even if they have become somewhat jumbled or temporally compressed. Because domestic spaces are subject to destructive postdepositional processes and not easily interpreted, we require robust methodologies to extract meaningful information about what transpired in these locations (Clark and Gingerich, 2022).

In this review, we summarize evidence for the transformation of these spaces from >3 ma to ~30 ka in western Eurasia and Africa. Patterns detected within these time-averaged records are cumulative and thus reflect habitual actions that traverse time, improving our understanding of the function of domestic spaces and evolution of human behaviors in relationship to those spaces in the past. We begin by exploring the concept of domestic space and its role in the development of cumulative culture. Next, we review some important changes seen in the archaeological record across five roughly defined intervals. Finally, we highlight methods to extract additional information by dissecting palimpsest records, information that cannot be had from single-component records.

2. Domestic space and its role in cumulative culture

The phenomenon of domestic space has a deep history in human evolution. Early hominins established domestic spaces to satisfy their daily physical needs, albeit in relatively straightforward ways. The defining feature of recent and ancient (Pleistocene) human domestic spaces is food preparation and consumption, usually assisted by technology. Based on prior literature and early archaeological patterns, Stiner (2021) defines domestic spaces as "widely repeated interaction nodes that involve food preparation and consumption, with which humans interact and to which other benefits and costs and miscellaneous (neutral) phenomena can adhere in evolutionary time. More than just places where food is taken to, domestic places are and were also spaces of social interaction" (Stiner, 2021: 64). Minimally, domestic spaces typically are safe or protected locations that are spatially distinct from where food and other resources are procured.

These safe locations can be described using a variety of terms, including homes, domestic spaces, base camps, and residential campsites, but all refer to the physical arena in which a group prepares food, performs other activities, and, often, sleeps. The task-oriented nature of these activities, particularly food preparation, across cultures has traditionally provided a basis from which to make comparisons (Lévi-Strauss, 1966; Lawrence, 1982; Hardin, 2010). Today, human homes are structured by both the intentional organization of objects and behaviors and the inadvertent outcomes of habitual actions. These actions and the material patterns they create reflect not only personal choices and idiosyncrasies but also some cultural norms, essentially how people compartmentalize their world. In addition to being a place to sustain ourselves, domestic spaces tend to be the epicenter of our social connections, or at least the baseline for building them.

The importance of the relationship between domestic spaces and the cultural and social dynamics of the people who live in them has been extensively explored in ethnographic work and the archaeology of recent human societies. For example, Lévi-Strauss' concept of 'house-societies' (Lévi-Strauss, 1982, 1987) recognizes the household as the dominant physical and conceptual locus of social and cultural relationships, and thus paramount in establishing, organizing, and maintaining society. This organization is reflected physically within the space of the home (e.g., Carsten and Hugh-Jones, 1995; Joyce and Gillespie, 2000; Chesson, 2003; Chiang, 2015). When the concept is mobilized more broadly, homes still play an important role in social organization, even if they are not the principal organizing unit of a society (González-Ruibal, 2006; Borić, 2007). These kinds of humanized spaces can thus be understood on multiple levels: as a space for meeting basic survival needs, as an environment for establishing a social system, and as the starting point for understanding the wider conceptual universe (Leroi-Gourhan, 1993: 319–322).

Within these spaces, people participate in a diverse array of activities which, by their nature and routinization, develop a feedback effect on social relationships and identities. According to Leroi-Gourhan, the human use of space is an "instrument" by which people organize society and conceptualize their place in the world—a "concrete symbol" of those ephemeral social and cultural dynamics (Leroi-Gourhan, 1993: 322). The specific activities which create these social and cultural dynamics are widely considered in recent human societies (e.g., Buchli, 2002; Dawson, 2002; Borić, 2003; Rose, 2003; Empson, 2007; Birch and Williamson, 2015; Chiang, 2015; Gaudzinski-Windheuser, 2015), but these basic cultural phenomena are not limited to the recent past.

Domestic spaces need not be permanent (sedentary) for the material signatures of social learning, cultural norms, and collective memory to be rendered archaeologically visible. Throughout time and across cultures, domestic spaces have facilitated social learning through activities that include food preparation, tool production, and collaboration. Cumulative patterns generated by these activities point to the operation of cultural norms. Not only do domestic spaces show powerful links to social and cultural memory, but they are also reified in some cases by decoration, burial of loved ones, storage of materials, and repeated visitation. Of course, some of these kinds of activities can also take place outside of a domestic setting, but their imbrication with, and elaboration within, the places in which basic survival needs (protection from the elements, eating, and sleeping) are met is what makes domestic spaces a uniquely compelling setting for cultural production.

At the heart of the present discussion is our assumption that domestic spaces have the potential to mirror some kinds of social contracts among individuals. These contracts play out within a bounded domestic space (temporary or permanent) that simultaneously creates unique advantages while also constraining the users in some way. A tradition of domestic space creation, even if they are frequently abandoned and re-created cyclically on landscapes, makes cumulative information sharing possible within and across generations (Tomasello, 1999), the latter being a defining trait of our genus (Tennie et al., 2009, 2016). Social learning, the passing of information from individual to individual through contact and proximity (Henrich and McElreath, 2003), is a core mechanism for building cultural knowledge. Reciprocally, the accumulation of cultural knowledge plays a part in physically structuring the world in which we live through norms of personal space, infrastructure, technology, and, today, formal education and information libraries. Cumulative culture has much to do with making groups of people distinct from one another in traditions and material culture.

The origins of cumulative culture phenomena certainly lie in the Pleistocene, although the time frame, circumstances, and associated hominin taxa are debated. Some argue that the stone tools manufactured by Early Stone Age (ESA) groups in Africa were products of cumulative culture (Stout et al., 2019), whereas others feel that this assumption has not been demonstrated (Tennie et al., 2016, 2019). Cumulative culture, by definition, requires fidelity of transmission through imitation, teaching, or both. Unfortunately, the social processes associated with Oldowan tools or Acheulian

handaxes are being inferred only from the physical characteristics of the stone artifacts and their coarse-grained distributions in time and space (Tennie et al., 2016).

By the beginning of the Late Pleistocene, we see more robust evidence of cumulative culture in the patterns of food waste and artifact accumulation, and site structure. This is especially true within the times of the Neanderthals and anatomically modern humans. Neanderthals are associated with a narrower range of technologies but very complex core preparation methods (e.g., Levallois) and the occasional burial of the dead (see below). Early presence of anatomically modern humans in the southern Levant (120–90 ka BP) also exhibit these behavioral traits, along with rare use of shell ornaments at the caves of Skhul and Qafzeh (Vanhaeren et al., 2006; Vandermeersch and Bar-Yosef, 2019). Culture did not seem to accumulate with as much speed or consistency during earlier phases of the Stone Age/Paleolithic, perhaps due to the fragmented nature of populations, smaller social networks, and/or different ways of socializing (Hopkinson et al., 2013; French, 2015; Wrangham, 2019). By the late Middle Paleolithic (MP) in Eurasia and the later part of the Middle Stone Age (MSA) in Africa (Marine Isotope Stage 4 and after), we see burgeoning expressions of regional and temporal cultural traditions in material culture (McBrearty and Brooks, 2000; Delagnes and Meignen, 2006; Mackay et al., 2014; Uthmeier, 2016). Regionally distinct traditions indicate that population densities had grown in some places and time intervals to such an extent that social networks were more spatially bounded. In these contexts, cultural indicators more extensively permeated material, and presumably nonmaterial life as well. The archaeological signatures of cumulative culture can be traced through the Pleistocene, revealing an accelerating pattern of diversity and complexity. Domestic spaces lay at the nexus of these interactions.

3. Notable shifts in the character of domestic spaces

The major changes in the use of domestic space described below are broadly related to the amount of time and effort hominins were expending to create and maintain a habitable space. In the African and western Eurasian records, this notably includes the repeated visitation of sites, use of fire, occasional management of waste, structural modifications, as well as the development of symbolic elaborations with, and within, a space. Here we describe what is known archaeologically about the chronology of these behavioral phenomena, divided into 5 intervals. These coarse 'temporal bins' allow us to highlight perceived developments while also recognizing that the resolution of archaeological records increases to the recent. Following other researchers, we use MIS 5e (~125 ka) as a cut-off between the early and later MP/MSA (Conard and Fischer, 2000; McBrearty and Tryon 2006; Lombard et al., 2012; Tryon and Faith, 2013; Wurz, 2013).

3.1. Interval 1 (>3 Ma–400 ka)

In this earliest interval, occupations of sites began to exhibit enough intensity that material signatures survive in the archaeological record. They provide the first glimpses of a uniquely human way of organizing sites through the revisiting of favored locales and the earliest use of fire.

Archaeologists find clusters of stone artifacts as early as the Oldowan (Isaac, 1981; Shea, 2017a). These clusters testify to multiple, repeated actions in one location. In some cases, there is also evidence of repeated visitation. As such, these early artifact clusters testify to fundamental differences between early hominins and the great apes. Modern great apes are known to construct sleeping platforms nightly by bending and manipulating foliage (Groves and Sabater Pi, 1985; Stewart, 2011; Samson, 2012). These nests are used only for sleeping, and they are occupied solely by one individual or a mother and her infant. There is no attachment to a particular location; a suitable spot is chosen each evening, and another one is found the following night. No objects or food are brought to these places. These resting places contrast fundamentally with human 'homes' in regard to the centrality of food preparation, the presence of multiple individuals, and the diversity of activities undertaken. Certain locations began to acquire greater significance for hominins and were revisited periodically. While evidence for stone tool use extends back before 3 million years ago (McPherron et al., 2010; Harmand et al., 2015; but see Dominguez-Rodrigo and Alcalá, 2019; Harmand et al., 2019; Archer et al., 2020), a more robust record of tool use emerged by around 2.6 Ma (Semaw et al., 1997; Semaw, 2000). Easily defined sites became common only after 2 Ma (Shea, 2017b; Kuhn, 2021). Reuse of places clearly contributed to their greater visibility to archaeologists.

The narrative of what may have transpired at these Early Pleistocene localities has shifted over several decades. Glynn Isaac (1978) and Owen Lovejoy (1981) saw these localities as places where food was shared and some sort of gendered division of labor practiced. Paleoanthropologists have since backed away from this social interpretation (as well as Isaac himself in 1984). These places nonetheless were 'favored' locales based on the amount of material accumulated there. Probably they were situated near a renewable resource such as water or shade, among other affordances (Schick, 1986; Kroll, 1994). Some of these locations may also have functioned as raw material caches, regardless of whether this was a preconceived benefit of the manuported materials (Potts, 1984). The duration of visits to these places and the number of co-users is not known, but the consensus among archaeologists is that each visit tended to be brief (Potts, 1984; Plummer, 2004; Domínguez-Rodrigo and Cobo-Sánchez, 2017a).

The presence of animal remains at some of the localities, in addition to the relatively low position of humans in the trophic pyramid at that time, suggests that these generally were not places for sleeping but rather were oriented to stone working and/or carcass processing (Bunn et al., 2017). The sites display some of the basal features of a domestic space on account of the evidence for food preparation and consumption, but they were quite different from the domestic spaces of later Paleolithic cultures (Domínguez-Rodrigo and Cobo-Sánchez, 2017b). The relatively large accumulations of bones and stones at a few of these early sites suggest the presence of multiple individuals and/or multiple visits (e.g., FLK Zinj 22 and PTK 1, Domínguez-Rodrigo and Cobo-Sánchez, 2017a). As simple as they may have been, these early sites may have become arenas for social learning that had not existed previously.

Controlled use of fire is a key development in human evolution that provided the foundation for the development of ever more complex pyrotechnologies and their association with diverse tasks such as the processing of food, production of tools, and symbolic activities (Chazan, 2017; Sandgathe, 2017; Wrangham, 2017). The highly variable visibility of fire in sites makes tracing its history difficult (Goldberg et al., 2017). That being said, early evidence for in situ burning in an archaeological context is found around 1 Ma at Wonderwerk Cave in South Africa, where quantities of grass and other vegetation are thought to have been brought deep into the cave and burnt by hominins (Berna et al., 2012; Goldberg et al., 2017). Another early example of fire use is reported at the open-air site of Gesher Benot Ya'akov (GBY) on the upper Jordan River in the Levant. Dating to 780 ka, GBY contains concentrations of burned artifacts, along with evidence for processing of prey animals and plant foods (Goren-Inbar et al., 2000, 2002, 2004; Alperson-Afil et al., 2009; Melamed et al., 2016). New analyses at Evron Quarry, also in the Levant, have recently revealed spectroscopic evidence

for fire use, in the absence of visual signatures, at 1.0–0.8 ma (Stepka et al., 2022). These claims are not universally accepted by archaeologists, but the next cases of fire use in the Levant at <400 ka are clear (Karkanas et al., 2007; Shimelmitz et al., 2014). The long gap between the cases of Wonderwerk and GBY and later evidence is concerning, but perhaps these early cases represent lucky flukes of exceptional preservation and/or examples of an opportunistic cultural development that was not perpetuated due to local extinction. At the same time, the results from Evron indicate that new analyses might reveal further early evidence for fire use.

3.2. Interval 2 (~400–250 ka)

Increasing consistency in the human control of fire provided new technological and social opportunities for human groups. During this Interval, some living sites are more intensely or repeatedly occupied, and hominins undertook a greater variety of activities within them.

It was not until well into the Middle Pleistocene that fire appears consistently in sites as a coherent technology (e.g., MacDonald et al., 2021). These fire records associate with dense accumulations of stone artifacts and bones, nearly always in caves and rock shelters. Kuhn and Stiner (2019), Roebroeks and Villa (2011), and others have argued that it was not until this time that fire became a central feature of residential camps (see also Rolland, 2004; Gowlett, 2006). Whether intended or not, the unique properties of fire would have created temporary but oft-repeated socioeconomic forums. These forums had unprecedented evolutionary possibilities, and the intimate pairing of economic and social significance of inhabited places really took off.

Fire technology lies at the heart of many debates in paleoanthropology, from the cooking hypothesis to whether or when hominins were able to master it (Carmody and Wrangham, 2009; Wrangham and Carmody, 2010; Roebroeks and Villa, 2011; Sandgathe et al., 2011a, 2011b; Gowlett and Wrangham, 2013; Wrangham, 2017; Dibble et al., 2018). Paleoanthropologists' fixation on fire is understandable, as it may confer numerous benefits to human at once—predator protection, cooking and improving nutritional yields from foods, improving the performance of raw materials, radiant warmth, light, and so on. Arguably, hearths also created an intimate yet movable environment that was ripe for social interaction, and a renewable facility that foragers could plan around. Some locations may have been occupied for longer periods as fire became part of the technological mix, supporting more varied tasks, storytelling, resting time for dependents, and opportunities for learning and socializing (Wiessner, 2014; Stiner, 2018). The use of fire in the Paleolithic does indeed correspond, at least at some sites, to longer occupations, a higher density of archaeological remains, and/or evidence for larger groups (Supplementary Online Material [SOM] Table S1). Some of this may be explained by preservation biases that work against the visibility of ephemeral or open-air sites (most examples are in caves), but these are insufficient to explain the overall trend and its behavioral significance.

Combustion features had much to do with the cultural structuring of domestic space. Indications come in several forms, including the extent to which wood ash was a major contribution to sediment accumulation (Karkanas, 2021), rates of re-burning of refuse, and the vertical stacking of combustion features in cultural layers (Goldberg et al., 2017). We shall focus here on the southern Levant because it preserves a continuous record of fire use from at least 320 ka to the present, and probably back to 350–400 ka. The richness of this record is explained at least partly by favorable sediment chemistries and the high density of archaeological work conducted in the region. The Lower Paleolithic (LP) sequences in Qesem and Tabun caves testify to repeated hearth-building events over tens of thousands of years. Qesem Cave, for example, contains over 8 m of archaeological deposits that span roughly 400–200 ka (Barkai et al., 2003; Gopher et al., 2010; Shahack-Gross et al., 2014). The concentrations of burned bones distributed vertically through the deposits suggest repeated fire-building activities throughout most of the sequence (Stiner et al., 2011). However, hearth areas that preserve wood ash residues were identified only midway through the sediment column, mainly in the deposits dating to ca. 320 ka (Karkanas et al., 2007). Wood ash is quite sensitive to degradation, and experimental evidence shows that the probability of preservation and visibility of wood ash residues increases where rebuilding and reburning events are most frequently repeated (Karkanas, 2021). Burned bones, on the other hand, are preserved in a wider range of conditions, and in Qesem occur throughout the stratigraphic sequence (Stiner et al., 2011). Variation in burned bone abundance indicates that fire use intensified mid-way through the sequence. Fire use in Qesem Cave shows strong links to large game carcass processing. Ungulate limbs and heads (mainly from fallow deer) were brought back to the site for late-stage butchering and consumption by multiple individuals, with a notable focus on marrow extraction (Stiner et al., 2011; Blasco et al., 2016). Rates of accidental burning of bone fragments were also high, confirming multiple fire-building events.

Unfortunately, few other cave sites of this period preserve detailed faunal records alongside stone artifacts, much less intact wood ash deposits. Tabun Cave is poor in bone but contains a remarkably long archaeological record (Jelinek et al., 1973; Ronen et al., 2011), portions of which were coeval with Qesem. The fire record in Tabun extends back to at least 350 ka, as documented by Shimelmitz et al. (2014) using frequencies of burnt flint artifacts. The late LP records in both Tabun and Qesem caves indicate repeated occupation of the caves by mobile groups over thousands of years. Fire technology was an important feature of the encampments in each cave. These and certain other caves held long-standing importance to hominin populations in the southern Levant, not only as nexuses for warmth and food but presumably also for social interaction. Evidence for anthropogenic combustion features is absent or very spotty before ca. 400 ka in Eurasia (Roebroeks and Villa, 2011) and Africa (Chazan, 2017). It seems reasonable to assume that the late phases of the LP/ESA represent a formative and highly dynamic interval in the evolution of fire technology. Most importantly, this is when it became a regular part of hominin life within and across populations.

3.3. Interval 3 (~250–125 ka)

In addition to increasingly complex use of fire and intense/repeated occupation of sites, this Interval yields archaeological evidence for deliberate amelioration of the domestic space in the form of bedding areas.

By roughly 250 ka, cave sites with deep, repetitive records became common in some parts of Eurasia and Africa, when MP/MSA technocultures were also widely established. The fire record picks up in deeply stratified Levantine cave sites such as Qesem and Tabun (Karkanas et al., 2007; Shahack-Gross et al., 2014; Shimelmitz et al., 2014), but it intensifies through the early MP records in Hayonim and Misliya caves (Schiegl et al., 1996; Shahack-Gross et al., 2014; Weinstein-Evron and Zaidner, 2017). MP people were building fire after fire inside Hayonim Cave after 200 ka, which resulted in thick vertical stacks of hearth features (Fig. 1; Meignen et al., 2006). A similar situation is reported in Misliya Cave (Yeshurun et al., 2020). Hearth features are even more abundant and densely stacked in later MP cave sites such as Kebara Cave (Bar-Yosef et al., 1992; Speth, 2006; Bar-Yosef and Meignen, 2007;

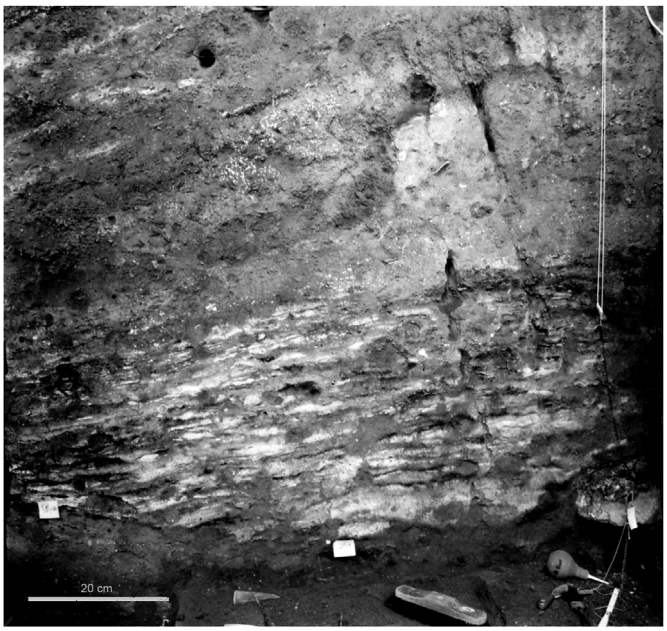

Figure 1. Stacked Middle Paleolithic hearth lenses visible in section in the central excavation area of Hayonim Cave, Galilee region of the southern Levant. Image adapted from Stiner (2005: Fig. 2.6).

Meignen and Bar-Yosef, 2019) and Amud Cave (Hovers, 1998; Alperson-Afil and Hovers, 2005; Hovers et al., 2011).

The earliest well-dated evidence for bedding areas occurs in this period. Wadley and colleagues note the use of bedding throughout the sequence of Border Cave in southern Africa starting around 200 ka, based on traces of silicified grasses concentrated in the back of the rock shelter and near hearths (Backwell et al., 2018; Wadley et al., 2020). The occupants periodically refreshed the bedding by burning the old layer of grasses, spreading wood ash over the surface (perhaps to deter insects), and laying down new bundles. This is the earliest evidence of a trend that becomes more visible in the later MSA/late MP (see below). However, demonstrable shifts in the use of living spaces are few during the early half of the MSA and early MP. Rather, we observe only a gradual intensification of domestic space use until later in these culture periods of western Eurasia and Africa. Additional information on shifts in how domestic spaces were used can be identified through the dissection of patterns observed in palimpsest deposits (next section).

3.4. Interval 4 (~125–40 ka)

The improvement and management of domestic spaces is increasingly apparent during the late MP/later MSA. It takes on a finer grain and the range of behavioral components increases. Some of the main themes described below include intensified use of fire, structural modifications, management/redeposition of waste materials, as well as symbolic behavior (including inhumations) and marking places of repeated importance. One implication is that, with longer stays or more persons present, there were greater pressures to use domestic spaces more efficiently. Another is that these places came to represent metaphors for shared social experiences and memories (Stiner, 2017).

In the southern Levant, the accumulation times represented by stacked features in cave sites become shorter over the course of the MP; for example, 1 m of early MP deeply stacked hearths in Hayonim spans about 10,000–15,000 years of accumulation, whereas those in the later MP of Kebara span only about 3000 years (Bar-Yosef et al., 1996; Goldberg et al., 2007). Clear examples of stacked hearth features are also found in South African (Henderson, 1992; Deacon, 1995; Goldberg et al., 2009; Miller et al., 2013) and European cave sites (Meignen et al., 2001; Goldberg et al., 2012) from MIS 5a onward. Examples include El Salt (Spain), Roc de Marsal (France), Sibhudu Cave (South Africa), Diepkloof Rock Shelter (South Africa), and Klasies River main site (South Africa; Fig. 2; Henderson, 1992; Deacon, 1995; Gómez de la Rúa et al., 2010; Aldeias et al., 2012; Goldberg et al., 2012; Larbey et al., 2019). Importantly, some of the combustion features show evidence for cleaning or 'raking out' of ashes such as at Pech de l'Azé IV (France; Goldberg et al., 2012) and at Sibhudu Cave and Diepkloof Rock Shelter in South Africa (Goldberg et al., 2009; Wadley et al., 2011; Miller et al., 2013). Miller et al. (2013) argue that, while the stacked hearths from these sites may appear similar to those in Kebara and Hayonim caves, micromorphological analysis reveals a distinct set of formation processes. Rather than the superposition of intact hearth features, the stacked features at Sibhudu, Diepkloof, and Pech de l'Azé IV are the result of space management and hearth renewal, including deliberate rake out and ash relocation. It should be noted that at none of these sites do we find evidence for a formally 'built' hearth ringed or otherwise enclosed in stones. Such elaborations are rare or absent in MP and MSA contexts (Chazan, 2017). However, Barham (1996) reports on large hearths whose margins were delimited by limestone blocks in the upper MSA layers at Mumbwa Caves (Zambia). These particular hearths may associate with a windbreak, as discussed more fully below.

Intimately connected to the maintenance of hearths is the further structuring of occupation surfaces with bedding areas. No doubt hominins sleeping in sites was not new to this period, but discernible bedding areas are an archaeological novelty that is increasingly visible within Interval 4. Beginning around 77 ka, a regime of bedding maintenance similar to that found at Border Cave is reported in Sibhudu Cave, 300 km to the south (Goldberg et al., 2009; Wadley et al., 2011). Sedges were combined with allelopathic plant species, presumably to keep the insects at bay. Dating to about the same time or slightly earlier, bedding features are also discerned micromorphologically at Diepkloof Cave (Miller et al., 2013). Here, bedding was also repeatedly burned and replaced. Earlier occupants (>80 ka) of Diepkloof lived on the exposed dirt floors, as indicated by micromorphological evidence of trampling, but plant flooring may have helped to control the dust and make the living space more comfortable in the post-80 ka occupations.

Evidence of bedding materials is found in Neanderthal sites by at least 60 ka based on grass phytolith concentrations in Amud Cave and Tor Faraj Rockshelter in the southern Levant and in Grotte XVI and Esquilleu Cave in southern Europe (Karkanas et al., 2002; Madella et al., 2002; Cabanes et al., 2010; Henry, 2012). In addition, a nonpedogenic organic horizon interpreted as bedding or a mat is reported at La Folie, an open-air site on the Clain River floodplain in France (Bourguignon, 2010; Bourguignon et al., 2002, 2006; Fig. 3). Although the use of bedding is becoming more widely recognized at MP sites, there are as yet no reports of routine burning and reapplication of bedding materials as seen in South Africa.

Along with bedding loci, we see additional structural investments in living spaces. Most of these structures are difficult to interpret because they may be represented by only a post hole, some imported stones, or a grossly circular arrangement of material or residues. Some of these structures may have been windbreaks, which would have been instrumental in keeping the occupants warm and protected in harsh weather. Computer simulation modeling of windbreak efficiency in wind tunnels by Chu (2009) indicates that significant thermoregulatory benefits can be gained even from very simple constructions. Examples of these can be

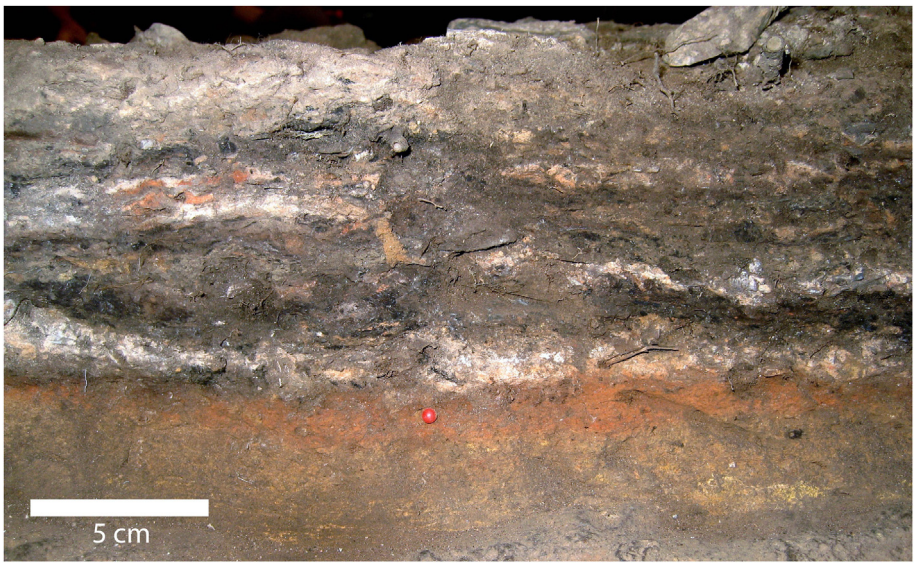

Figure 2. Stacked hearths in Layer 9 of Roc de Marsal, France. Photo credit: S. McPherron.

found in both MP and MSA contexts. At La Folie (France), the bedding materials mentioned earlier associate with a post hole and a ring of transported stones encircling the bedding area and a small hearth (Bourguignon et al., 2002, 2006; Bourguignon, 2010). Another open-air site, Wallertheim layer A (Germany), contains large limestone manuports that may have been used to stabilize a windbreak (Adler et al., 2003). Demay et al. (2012) report a circular ring of mammoth bones that could have functioned as a windbreak at Molodova (Layer 4) in Ukraine. This early structure is reminiscent of the famous mammoth bone huts of the later Paleolithic in the region (Gladkih et al., 1984), but its taphonomy is complicated and its construction may have been much more expedient. Demay et al. (2012) found that the bones comprising the circular feature were a biased sample that may represent intentionally selected elements. However, the site itself is strewn with mammoth bones and several ash concentrations occur within the walls of the proposed structure (Kolen, 1999). Texier (1985) reports on four post holes at Chaperon-Rouge I (Morocco), an open-air late Aterian (MSA) site, which he interprets as stake holes for supporting a shelter. Wadley and Langejans (2014) likewise found one post hole, and potentially a

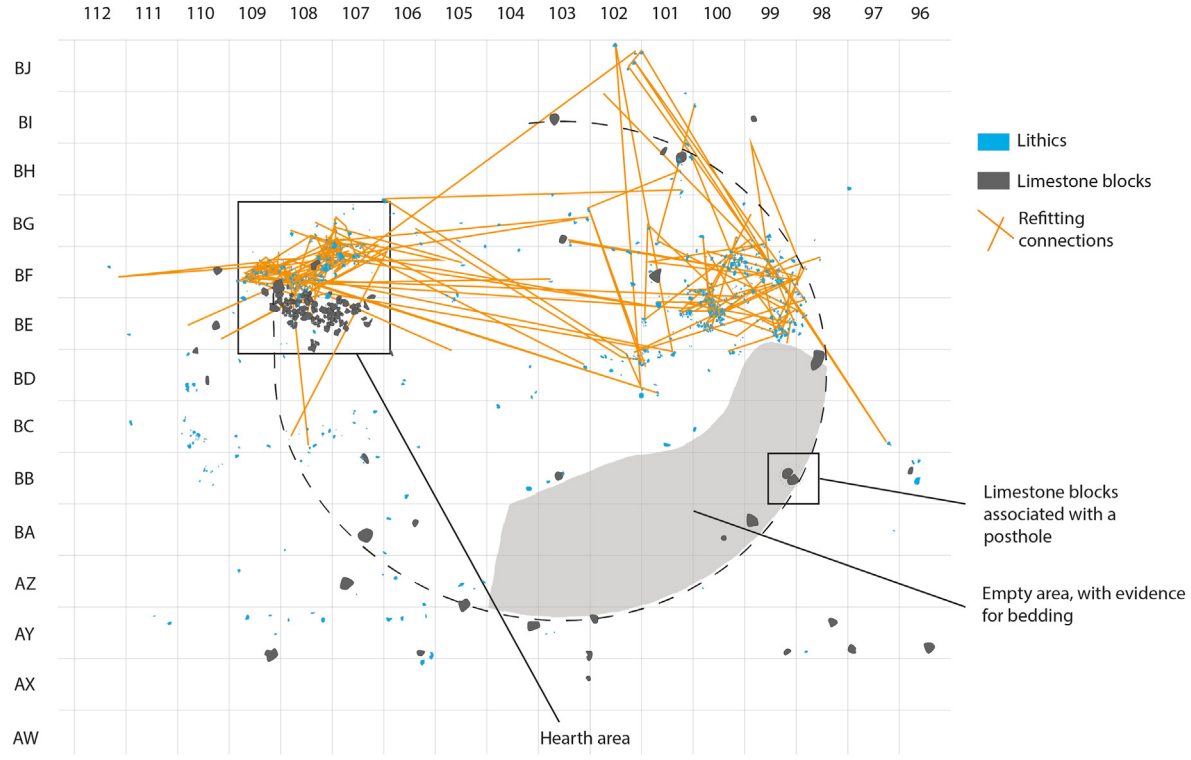

Figure 3. An excavation plan from the site of La Folie exemplifying some of the increasing complexity in hearth-centered activities at living sites after Marine Isotope Stage 5. The dashed line is the hypothesized extent of a windbreak which protected the bedding area and hearth. Adapted from Bourguignon (2010).

second, associated with a hearth in layer SS at Sibhudu, dating to around 58 ka. The authors suggest that these post holes may form a frame for smoking or scraping hides; a windbreak function is also possible. In the upper MSA layers of Mumbwa Caves (Zambia), Barham (1996) interpreted a semicircular arc of debris and post holes as possible remnants of a windbreak. The area within the windbreak was clear of debris (perhaps swept clean), whereas the areas outside the structure were dense with discarded material. Barham also reports evidence for previously built structures, suggesting that windbreaks were constructed more than once at this site.

It is normally difficult to interpret the organization of materials within rock shelter and cave sites. However, thanks to high sedimentation rates relative to artifact accumulation, the MP layers in Abric Romaní (Spain) and Oscurusciuto Rockshelter (Italy) present unusually clear spatial patterning. At both sites, the hearths in some layers were arranged linearly along the rock shelter wall (Gabucio et al., 2018; Spagnolo et al., 2018). Layer 13 in Oscurusciuto, which directly overlies a thick layer of tephra and averages only 10 cm in thickness (Spagnolo et al., 2018), includes what appear to have been resting or sleeping areas. Interpretation of these activity zones is based on much lower densities of archaeological material between the hearths and the shelter wall, in contrast to the opposite sides of the same hearths. Sleeping and resting areas are also inferred for layers M and O in Abric Romaní. Two lines of hearths were found, one immediately adjacent to the wall and another in the middle of the shelter (Gabucio et al., 2018). The hearths next to the wall were smaller and likely burned less intensively, and these may have been used simply to keep sleepers warm (Hayden, 2012; Vallverdú et al., 2012). Lithic artifacts and faunal material in these sites also display heterogeneous distributions. In Oscurusciuto layer 13, for example, faunal evidence shows that carcass processing was concentrated mainly in the southern part of the site, whereas lithic production took place in both the northern and southern sectors (Spagnolo et al., 2018). Much of the material in both sites associates with the hearths.

In addition to hearth clean-out practices, there is also some evidence for low-level management of other kinds of waste—cleaning up—in some MP and MSA sites. The occupants at Abric Romaní discarded large animal bones away from the central domestic areas (Gabucio et al., 2018). A similar situation is suggested at Oscurusciuto, where a particularly high concentration of large bones, lithic production waste, and exhausted cores occur in one area of the shelter. In the southern Levant, Speth et al. (2012) found strong evidence for deliberate waste concentration in level X of Kebara Cave, where three circular zones were filled or piled with bones. Similar concentrations were found along the north wall of the shelter, and these are interpreted as middens (Speth, 2006). Miller et al. (2013) report ash dumps at Diepkloof based on sediment micromorphology. Also in South Africa, at the Klasies River main site, Deacon (1995) describes well-defined middens of shell and food waste in the MSA layers, which continue through the LSA layers, along with discrete hearths. He argues that this continuity indicates a shared set of norms governing the use of space and cleanliness that spanned the two periods.

We also see increased evidence for the repeated occupation of many different kinds of localities during this period. Much of this review has focused on natural shelters due to archaeological preservation and visibility to archaeologists. However, repeated use of places was not confined to cave sites. The reassembly of knapped lithics can be a powerful tool in intrasite spatial analysis because it clearly links disparate parts of a site within a very short span of time, and thus can elucidate how activities unfolded in space. In a study examining the spatial structure of seven late MP open-air sites in France, Clark (2016, 2017) used lithic refitting and the distribution of lithic artifacts to demonstrate that most sites were reused. Two clusters of artifacts connected by many refits indicate that these clusters were used simultaneously (see example from La Folie, France; Fig. 4a). Conversely, clusters lacking refittable artifacts would imply that they derived from different occupations (see example from Le Prissé, France; Fig. 4b). Based on this, and other, evidence, Clark (2016, 2017) found that many of the open-air sites studied were the result of multiple reoccupations. Sites with similar patterns exist throughout the loess belt of northern Europe (e.g., Roebroeks 1988; Depaepe, 2007; Goval, 2008; Hérisson, 2012).

Early humans' reasons for re-occupying certain locations over others likely varied. In some cases, the draw was a lithic raw material source such as La Doline de Cantalouette (France) that contains a flint deposit of high quality (Bourguignon et al., 2005). In other cases, certain geographic features attracted people again and again, such as at Bettencourt-Saint-Ouen, a stratified open-air site situated at the base of a slope sheltered from prevailing winds and near water and chert deposits (Locht, 2001, 2002). Multiple activities occurred at these localities; even Cantalouette was not exclusively a flint workshop. Bones are not preserved at Cantalouette but use-wear on flint tools indicates that multiple tasks were performed, including animal butchering, hide working, and wood working (Bourguignon et al., 2005). The spatial distributions of the refitted artifacts demonstrate that many of the lithics produced on site were used there, rather than being manufactured simply to be exported. Clark (2019) identified concentrated knapping clusters and, further away, a small number of selected lithics, often Levallois flakes or blades, that were likely abandoned where they had been used (Fig. 4d). Although it is hard to determine how long MP foragers stayed at these sites, multiple activities typically were performed during each stay and the locales were revisited. Certain places—caves, rock shelters, and open locals—drew groups back again and again, including those that lacked obvious resources. The revisiting of sites creates the possibility for some locations to take on a larger sociocultural significance—part of the shared knowledge of a group about 'historied places' on the landscape.

There is evidence that at least some residential MP Neanderthal sites had a special conceptual significance for the occupants. This is most apparent where multiple burials occur in caves such as Shanidar (Iraq), La Ferrassie (France), and Dederiyah (Syria; Peyrony, 1934; Heim, 1976; Solecki, 1971, 1972; Heim, 1982a, 1982b; Trinkaus, 1983; Akazawa et al., 1995, 1999; see also reviews by Zilhão and Trinkaus, 2002; Stiner, 2017). Neanderthal burials have also been found in sites such as Roc de Marsal and Spy Cave in western Europe, Kebara and Amud caves in the southern Levant, and Mezmaiskaya Cave in Russia (Riel-Salvatore and Clark, 2001; Zilhão and Trinkaus, 2002; but see Sandgathe et al.'s 2011 critique of the Roc de Marsal burial). Stiner (2017) observes that these early people tended to bury their dead in places that were frequented by the living, evidence that domestic spaces had taken on a more elaborate collective significance. Although only a small fraction of all known MP sites contains burials, the MP practice of burying their dead in domestic spaces, and specifically in sites that continued to be visited, suggests a sense of place that transcended the pragmatic functions of cave sites. Although some archaeologists contest the idea of burial customs in the MP, the remarkably rich fossil record of Neanderthals must be due largely to this; the same scholars invariability fail to account for the extreme rarity of human skeletons dating to the early UP in the same regions and geological contexts.

A sense of place and symbolic attachment to certain localities is suggested in a few other MP and MSA sites as well. Human burials are present in the MSA but are much rarer. The earliest human burial in Africa dates to 78 ka at Panga ya Saidi in Kenya (Martinón-

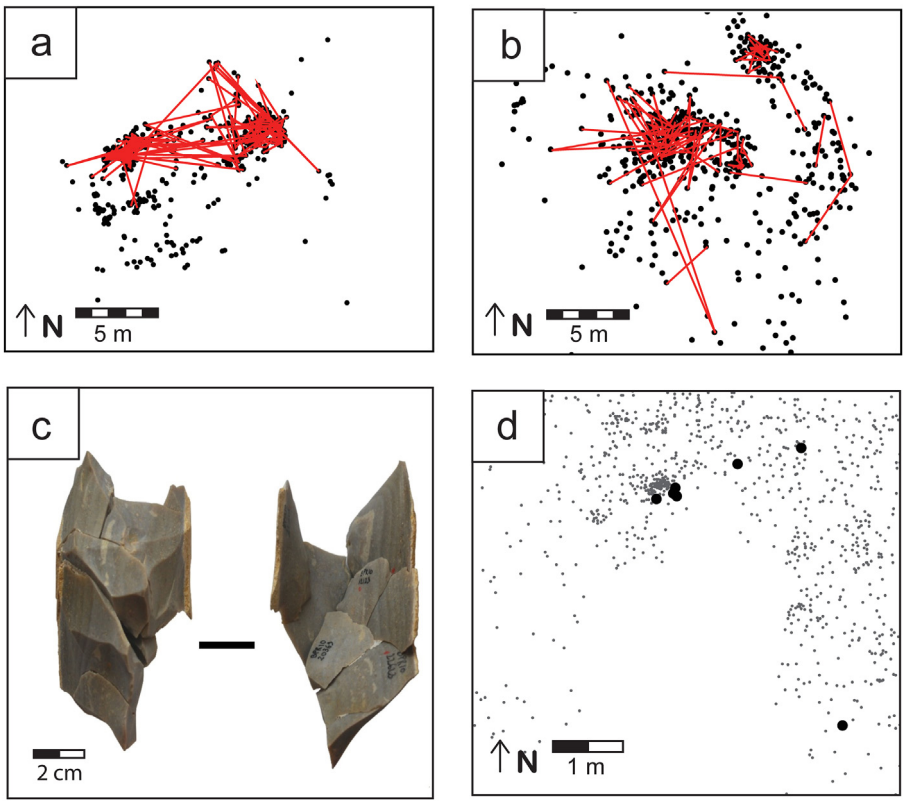

Figure 4. Examples of how lithic refitting can inform about site use. Many refitting connections between clusters at La Folie (a) clearly demonstrate that these areas were used simultaneously. The relationship between artifact clusters is more ambiguous at Le Prissé de Bayonne (b) where few direct refits connect the two clusters. This points to the conclusion that La Folie is arguably the result of a single occupation, whereas this layer at Le Prissé could have accumulated over several occupations. c) An example of seven refitted lithics from Le Prissé. d) The spatial position of seven refitted lithics from Bettencourt-Saint-Ouen (large black dots) demonstrates a common pattern: four lithics are tightly concentrated, two others are located a couple meters away, and the seventh lithic is located more than three meters from the concentration, most likely the result of anthropogenic movement. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article).

Torres et al., 2021). Taramsa (Egypt) and Border Cave (South Africa) also contain burials which date slightly later, although the Border Cave burial was excavated in 1941 with limited documentation (Vermeersch et al., 1998; d'Errico and Backwell, 2016; Martinón-Torres et al., 2021). All three examples were burials of a child or infant. Other displays of symbolic attachment are found in MSA (>50 ka) levels at Klipbak 1 (South Africa) where humans were modifying their living sites by carving hundreds of cupules, 40 outline circles, as well as five meandering lines into the wall (Bednarik, 2013). Cupules have also been recorded in an MSA context at Potholes Hoek (South Africa) and Nchwaneng (South Africa; Bednarik, 2013). In the later MSA at Rhino Cave and Corner Cave in Botswana, there is further evidence for cupules and grooves (Coulson et al., 2011; Bednarik, 2013).

In MP Europe, the evidence for symbolic attachment to place (other than burials) is more ambiguous. In a deep chamber of Bruniquel Cave (France) 336 m from the entrance, MP humans arranged over 400 pieces of broken stalagmites in circles and piles, although there is no evidence of a more extensive occupation of the site in this case (Jaubert et al., 2016). At La Roche-Cotard cave (France) panels of finger flutings have been attributed to Neanderthals and are proposed to relate to an MP occupation located at the cave entrance (Marquet et al., 2014). Some parietal art in three Spanish caves has been dated to 64 ka or earlier by Hoffman et al. (2018; see also Pitarch Martí et al., 2021), a time when it appears that Neanderthals were the only hominins in Europe, but others dispute these dates (Slimak et al., 2018; White et al., 2020). Finally, a cross-hatched pattern engraved on the floor of Gorham's Cave in Gibraltar was found in a context possibly attributable to the MP (Rodríguez-Vidal et al., 2014). Although these examples have captured headlines on account of their rarity, we do not, in fact, have much evidence for MP groups marking places symbolically apart from the example of mortuary practices.

Other archaeological signatures for symbolic behaviors emerge during this Interval in the form of personal ornaments and abstract engravings. In South Africa, engraved ostrich eggshells occur at Diepkloof in the later MSA occupation levels (105 ka; Texier et al., 2013). Ostrich eggshell beads occur in the archaeological record of eastern Africa around 52 ka and in southern Africa by 42 ka (McBrearty and Brooks, 2000; Miller and Wang, 2022). Notched or incised ochres and hematite have been found at several South African sites dating to the later MSA, 105–65 ka, including Hollow Rockshelter, Klasies River, Blombos, Wonderwerk, Howiesons Poort, and Klein Kliphius (Stapleton and Hewitt, 1928; McBrearty and Brooks, 2000; d'Errico et al., 2003; Henshilwood et al., 2004; Mackay and Welz, 2008; Bednarik, 2013; Vanhaeren et al., 2013). At Blombos (South Africa), the engraved ochres associate with 41 perforated shell beads and over 8000 raw pieces of ochre. The latter provide evidence for ochre processing at their living site (d'Errico et al., 2003; Henshilwood et al., 2004; Vanhaeren et al., 2013). Around 120–90 ka, modern humans in the southern Levant are using shell ornaments in a limited way at the caves of Skhul and Qafzeh (Vanhaeren et al., 2006; Vandermeersch and Bar-Yosef, 2019). Shell ornaments are also found in numerous cave sites in Morocco, including Bizmoune Cave, recently dated to >143 ka (Sehasseh et al., 2021). Except for Blombos, most of these examples tend to involve naturally holed shells that people collected from shorelines; elaborate modification of decorative objects comes later

(Steele et al., 2019). In France, occupation levels attributed to the Châtelperronian (transitional MP–UP/early UP) of Grotte du Renne (Arcy-sur-Cure) have yielded 39 personal ornaments made on animal teeth, bone and fossils, as well as 18 kg of yellow black and (mostly) red mineral materials that have been interpreted as colorants (Leroi-Gourhan, 1958; Caron et al., 2011; but see White, 2002; Bar-Yosef and Bordes, 2010). These symbolic behaviors are not tied to place in the same way as parietal art, but they do begin to occur within domestic spaces. Though archaeological evidence for symbolic behavior is neither abundant nor ubiquitous throughout this Interval, its presence attests to the increasing breadth, and cultural complexity, of tasks that took place in domestic spaces.

3.5. Interval 5 (40 ka and younger)

There is a lot more evidence to talk about in Interval 5, thanks in part to better preservation of more recent sites. It seems clear the structural complexity of sites really did increase throughout the Upper Paleolithic (UP) in western Eurasia and the later MSA in Africa. People were investing more in some of their encampments, especially where they planned to stay longer. We can see the roots of this investment in the repeated application of bedding at MSA sites in Interval 4 (Border Cave, Sibhudu, and Diepkloof). By Interval 5, we also see greater diversity in the types of combustion features, including more specialized or elaborately constructed types as well as some overt expressions of a symbolic connection to sites. Because the number of sites, and variation in homemaking behaviors, really take off during this period, we will draw upon fewer examples that help illustrate the overall trends, drawn especially from our own fieldwork. Two important themes are structural elaborations of hearths and other features within sites and evidence for the symbolic marking of places.

The archaeological sequence from Üçağızlı I Cave (southernmost Turkey), exemplifies a trend toward greater complexity or investment in combustion features as well as greater diversity of activities represented from the Initial UP through the Ahmarian occupations (ca. >41–29 ka; Kuhn et al., 2009). Hearth features and wood ash remnants are present throughout the cultural sequence, but hearths and ash dumps are omnipresent in the Ahmarian (B-B3). Extensive maintenance of diverse combustion features is indicated by ash rake-out events and concentrated ash dumps, which are confirmed by micromorphological analysis (Kuhn et al., 2009; Mentzer 2012). In addition to hearths, a very large combustion feature thick with wood ash was built along the back wall of the shelter and enclosed by a line of large rocks (Fig. 5). This feature is interpreted as a meat-drying facility based on spatial and zooarchaeological evidence (Stiner, 2009).

Another remarkable example, from the Aurignacian (early UP) occupations of Klissoura Cave 1 in southern Greece, includes many clay-lined and unlined hearths (Koumouzelis et al., 2001; Karkanas et al., 2004). Specifically, the lower and middle Aurignacian layers are riddled with 90 small hearth features within an excavated area of only 15 m^2 at most. More than half of these features are basin structures lined with clay. Karkanas et al. (2004) hypothesize that these structures were used to contain fire in the incandescent stage, after transferring live coals from the primary hearths. This diverse array of combustion features surrounds a persistently 'vacant' area in Level IV (lower Aurignacian) that displays a large organic stain and a significant concentration of shell ornaments (Fig. 6; Stiner, 2010). The enclosed area is interpreted as a small shelter or bedding area of some kind.

So-called basin hearths are also found in Aurignacian rock shelters along the Vézère River in France. Instead of being lined with clay, these basins were excavated into the bedrock inside the shelters (White et al., 2017; Clark and Ranlett, 2022). At the sites of Abri Castanet, Abri Blanchard, Abri Cellier, and Abri Pataud, a central hearth was accompanied by an axillary, special purpose hearth to which hot embers were likely transferred. This pattern is most visible at Abri Castanet, a shelter excavated more recently using modern methods. The excavation revealed a large multicomponent combustion feature with three distinct parts. Magnetic susceptibility analysis (White et al., 2017) indicates that the central hearth contained an active fire, the adjacent depression was used as a dump, and a smaller basin about 15 cm away contained embers transferred from the main hearth (Fig. 7a). Evidence for a similar hearth setup is noted at other rock shelters along the Vézère River, including Abri Cellier and Abri Blanchard, but we know less about these sites because they were emptied in the first half of the twentieth century (Didon, 1911; White et al., 2017). Hallam Movius documented a comparable arrangement of central and auxiliary hearths at Abri Pataud during excavations in the 1950s and 1960s (Movius, 1977). These examples collectively indicate that fire

Figure 5. Massive ash deposits between cave wall and rock alignment in the northern end of the excavation of layer B1–3 in Üçağızlı Cave I (Hatay coast of Turkey), interpreted as a meat smoking/drying installation. This feature dates to the Ahmarian (early Upper Paleolithic). Image credit: S. L. Kuhn.

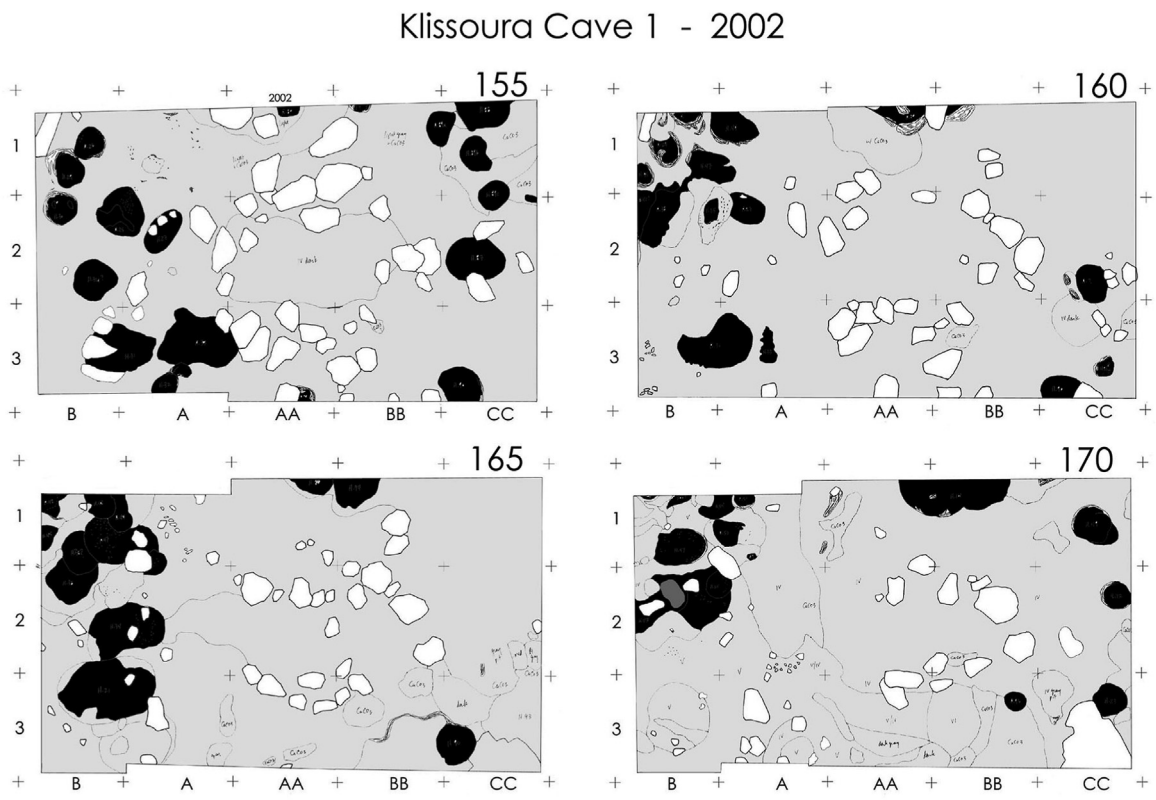

Figure 6. The distributions of limestone rocks (white) and abundant hearth features (black and dark gray) in 5 cm cuts from 155 through 170 cm below datum in Klissoura Cave 1. The inferred shelter feature is in the area where hearths are consistently absent. A large organic stain lines the interior and is accompanied by large numbers of shell ornaments. This feature dates to the earliest Aurignacian (Level IV) occupations of the cave. Image adapted from Stiner (2010).

technology—specifically the designs of combustion features—capitalized in sophisticated ways on variation in temperature, luminosity, and heat conservation as early as 38 ka.

In addition to digging into the bedrock floor to make basins for hearths, the UP occupants of the Vézère River shelters modified the walls and ceiling with abstract and figurative engravings as well as making a series of holes (Fig. 7b, c; White et al., 2012; Bourrillon et al., 2018; White et al., 2018; Clark and Ranlett, 2022). Because these perforations tend to occur along the drip line of the shelter, Denis Peyrony theorized that they were used for hanging animal skins to close off the domestic space for the retention of heat and as protection from the wind (White et al., 2017). This hypothesis is viable at Abri Castanet, as the ceiling would have only been about 2 m above the floor. The age of the engravings and perforations has been debated, since many were identified in the early twentieth century, but recent research indicates that many if not all of them date to the Aurignacian (White et al., 2012, 2018; Bourrillon et al., 2018). Engravings, multi-component hearths, and other structural modifications would have defined these spaces not only as domestic environments but also places of larger social (and possibly spiritual) significance to the users. Consistencies in the modifications and embellishments made by the occupants to the Vézère Valley rock shelters seem to reflect a standard plan for residential camp structure that was widely repeated within the local community.

Local cultural traditions of homemaking likely existed long before the Aurignacian Paleoculture, but they had not become robust enough to be clearly expressed archaeologically. Another factor that contributed to their expression was greater occupation intensity at some sites. The Aurignacian, in particular, is known for having more stable or well-established cultural regions, along with longer duration occupations, in contrast with the earlier Proto-aurignacian (Anderson et al., 2015). Nevertheless, a great many briefly occupied UP and later MSA sites are not very different structurally from the MP/MSA sites before them. This situation is exemplified by occupations spanning the late MP through Ahmarian at Üçağızlı Caves II and I, located less than 1 km apart on the Hatay coast. Densely stacked hearth lenses are typical within the MP layers of Üçağızlı II, whereas thin, isolated hearth features occur in the earliest initial UP layer in the neighboring cave of Üçağızlı I (Kuhn et al., 2009; Stiner, 2009; Baykara et al., 2015). Both periods involved simple hearth constructions but differed in the rates of reconstruction (Fig. 8). As noted earlier, the Ahmarian occupations display greater complexity in combustion feature structures as well as in the intensity of hearth maintenance and renewal. Greater structural complexity is confined mainly to sites that were occupied longer or revisited more often, possibly accommodating more people at a time. It remains difficult to disentangle the effects of unique socioeconomic systems and simpler pressures to use space more efficiently in these contexts. What we can say is that both phenomena—social structuring and efficient use of tight spaces—are increasingly apparent with the UP and later MSA in Interval 5.

Symbolic activity is well known in the UP and later MSA records. These expressions are recognized because they involve durable materials, which among recent human cultures represent only a fraction of overall symbolic expression (Kuhn and Stiner, 2007). The UP and later MSA technocultures nonetheless stand apart from earlier Intervals in the prevalence of these durable expressions—personal ornaments, portable painted and inscribed surfaces, and carved objects (Plug, 1982; Mason et al., 1988; McBrearty and Brooks, 2000; Kuhn et al., 2001; White, 2007; Mackay and

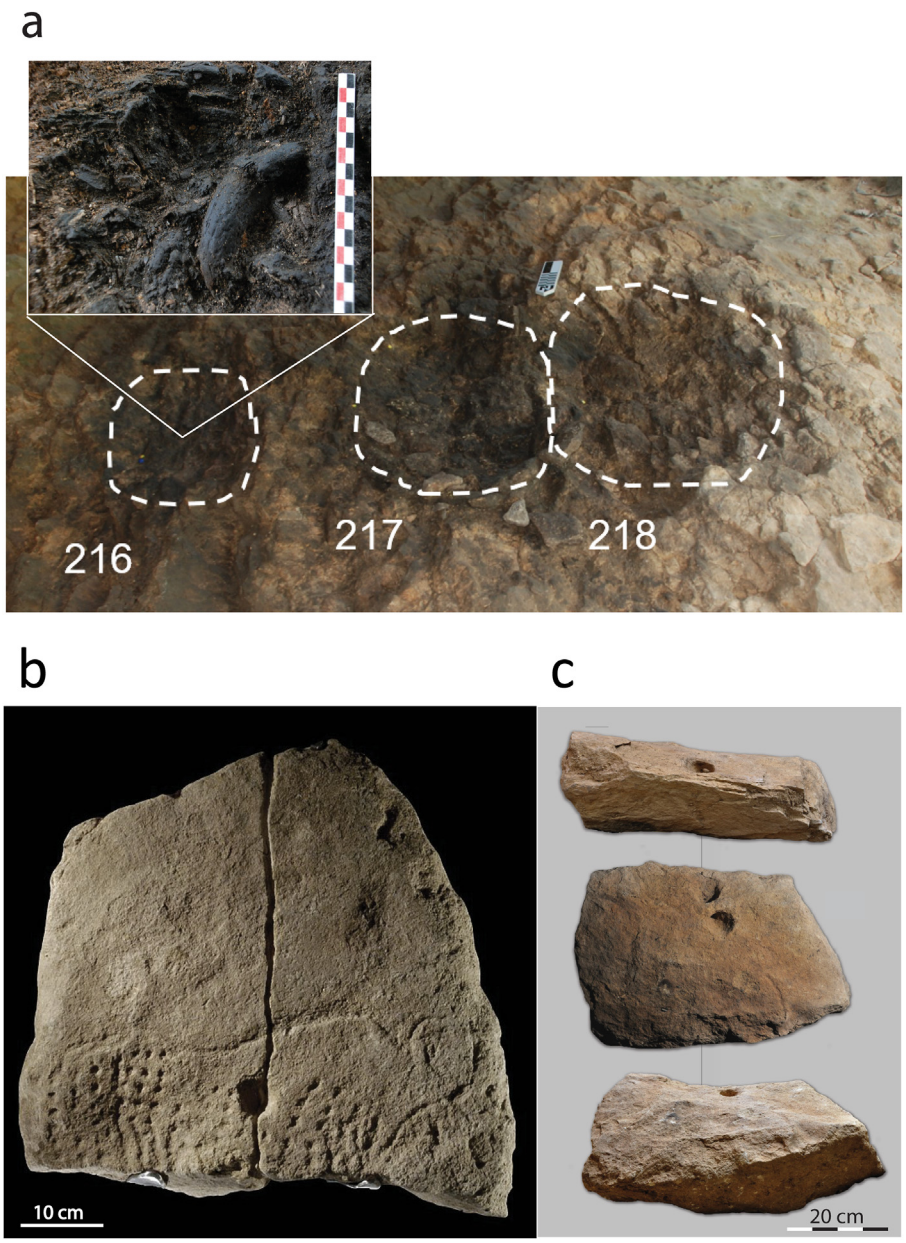

Figure 7. Examples of living space amelioration in Aurignacian rock shelters of the Vézère Valley (France) that are commonly shared across sites and likely indicate a shared local tradition in homemaking. a) Multicomponent hearth from Abri Castanet. Structure 217 was the main hearth, 218 was used as an ash dump, and 216 was a small basin where hot embers were moved. b) Engraved image of an aurochs (*Bos primigenius*), an extinct wild ox, from Abri Blanchard (photo courtesy of R. Bourrillon). It was found face down on the occupation surface but would have decorated the rock shelter ceiling. c) Perforated block from the ceiling of Abri Cellier (photo courtesy of R. Bourrillon).

Welz, 2008; Conard, 2009; Bourrillon et al., 2018; Bednarik, 2013; Kind et al., 2014; Rybin, 2014; Lbova and Volkov, 2016; Langley et al., 2020; Miller and Wang, 2022). Cave and rock-shelter sites were sometimes decorated with engravings, and communal structures were erected in some of them (Iakovleva and Djindjian, 2005; Coulson et al., 2011; Bednarik, 2013; Bourdier, 2013; Aubert et al., 2014; Lacombe et al., 2015; White et al., 2018; Maher and Conkey, 2019; Pryor et al., 2020). The practice of marking of locations symbolically in the form of cave art in remote underground locations and within living sites in the European UP is uncontested, and some of these examples are magnificent (Leroi-Gourhan, 1982; Clottes et al., 1992; Lorblanchet, 1995; White, 2003; Clottes, 2008; Ghemiş et al., 2011; Clottes and Geneste, 2012; García-Diez et al., 2015; White et al., 2018; Feruglio et al., 2019; Fuentes et al., 2019; Ruiz-Redondo et al., 2020). The more important observation for our purposes is that it became geographically widespread and frequently associated with domestic spaces during this Interval (e.g., Bosinski, 1991; Fritz and Tosello, 2001; Bégouën et al., 2012; Bourdier, 2013; García-Diez et al., 2013; Bourdier et al., 2014; Bourrillon and White, 2015; Balbín-Behrmann et al., 2017). Starting in the earliest UP in southwest France, for example, Aurignacian peoples were decorating their living sites by painting and engraving stone surfaces (White et al., 2012, 2018). Later UP examples include the Magdalenian rock shelter living sites of Roc-aux-Sorciers and Cap Blac (France) which both contain large-scale sculpted friezes (of animals and human figures). These would have been a lasting backdrop to the everyday activities at the site, as well as readily visible on the landscape. It is proposed that the marking of places in this way served as an expression of social cohesion and land use that "… establishes a group physically and

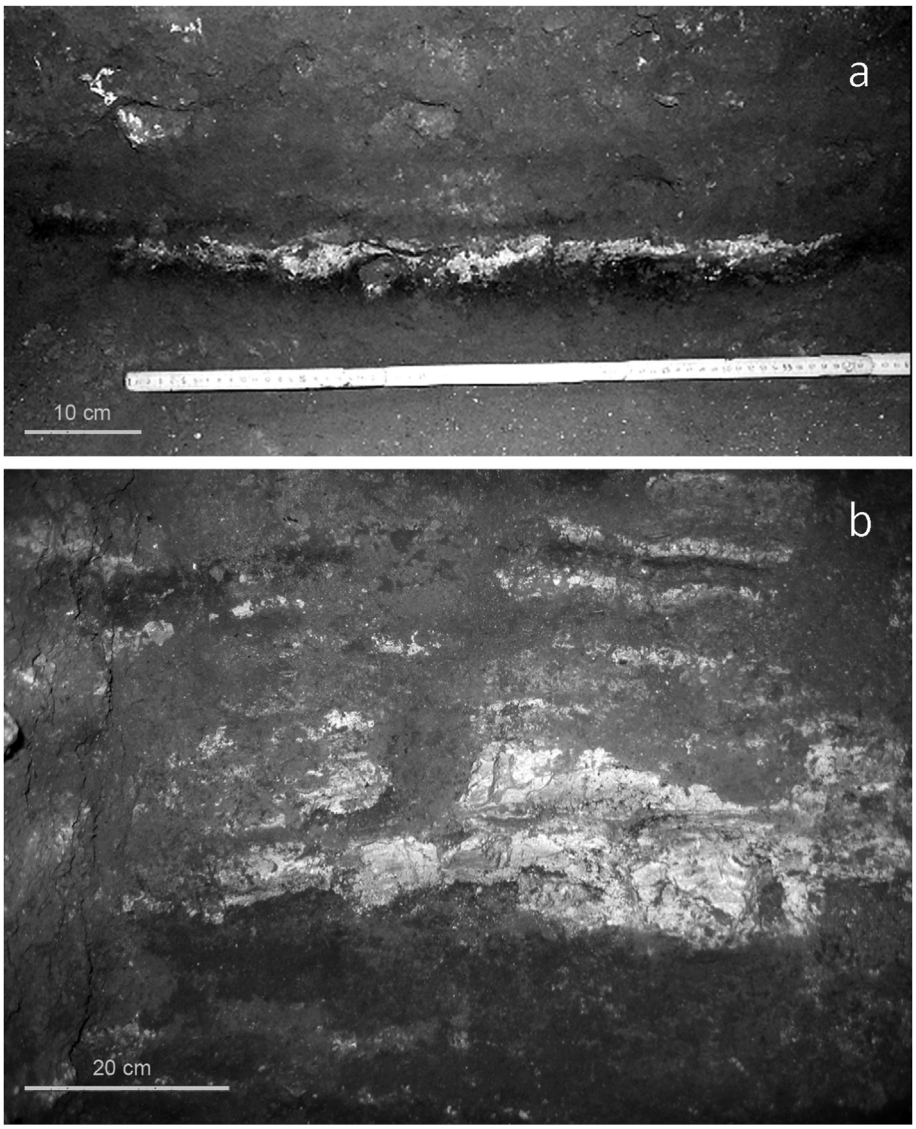

Figure 8. Comparison of combustion features visible in section: a) thin isolated hearth in Initial Upper Paleolithic layer I in Üçağızlı Cave I; b) multiple superimposed Middle Paleolithic hearth lenses in the low layers of Üçağızlı Cave II. Image from M.C. Stiner.

symbolically on the landscape" (Bourdier, 2013: 368; Bourrillon and White, 2015). This symbolic marking of place potentially represents yet another means by which people used domestic spaces to mediate relationships with others and negotiate their place in the world.

UP living spaces, though inhabited on a seasonal basis, arguably present all the elements of what we would recognize as a 'home' among contemporary hunter-gatherers (Maher and Conkey, 2019; Clark and Ranlett, 2022). Earlier sites, such as those occupied by Neanderthals, served similar socioeconomic purposes. These were places for sleeping, childcare, relaxing, preparing and eating food, manufacturing tools, and maintaining a comfortable body temperature—in other words, a wide range of activities. The collective social importance of these places during the MP and early MSA was not signaled as vividly as in some UP or later MSA records—in terms of nonperishable displays—but the rise of mortuary practices midway through the MP (by roughly 120 ka) was also very significant from a symbolic standpoint. Burial of loved ones reflected the perennial importance of certain places to the living and a symbolic means for maintaining connections to the deceased (Stiner, 2017). By the UP, however, people's attachment to domestic spaces was accompanied by more persistently visible displays of symbolism, when we also see increased formality in the organization of space in some sites. In Interval 4 and even more so in Interval 5, some places came to loom large in collective social memory, or what Gamble (1998: 441; 1999: 87) describes as a "landscape of habit." These localities would have had a kind of sentimental but also practical familiarity. They acquired larger significance with repeated use and the accumulation of human experiences tied to these places.

To summarize, the pace and patterns of change suggest a relatively gradual evolution of residential sites, and of the nature of domestic spaces in particular. Abrupt shifts do exist in the evolution of durable art records, though perhaps the evolution of symbolling behavior itself would appear more gradual were archaeologists able to view the full range of artistic expressions (but see Finlayson et al., 2012). On the other hand, elaborate osseous technologies appear relatively suddenly in western Eurasia (e.g., Hoffecker, 2005; Tartar, 2015; d'Errico et al., 2018; Martisius et al., 2022), whereas they developed somewhat more gradually on the African

continent (McBrearty and Brooks, 2000). Instead of sharp transitions in people's investments in residential camp sites from the late LP onward, gradual developments with considerable variability in time and across regions better fit the archaeological evidence. These developments do not display the thresholds of classic Stone Age/Paleolithic periods that were based on lithic artifacts. The role of domestic spaces in the accumulation of culture likely began quite early in human evolutionary history and gained momentum with time. Residential encampments came to support a wider range of activities. The co-evolutionary feedbacks taking place between humans and domestic spaces increased at a nonlinear pace (Kuhn and Stiner, 2019).

4. Unpacking palimpsests for more clues

In the preceding narrative, we showed how Paleolithic living spaces increasingly supported a wider range of purposes and tasks with time. Much of this evidence comes from the overt spatial structuring of features, artifacts, and waste materials. In this section, we try to unpack some fuzzier structural aspects of early Paleolithic records to further understand the socioeconomic dynamics that shaped them. This is challenging due to time-dependent taphonomic processes and the fact that many archaeological patterns, even in well-preserved sites, require considerable translation (Schiffer, 1983; Binford, 1983, 1987; Bailey, 2007; Malinsky-Buller et al., 2011; Clark, 2022). Hominin behaviors in earlier periods could have been quite different from those of later foragers, and so the patterns that arose from on-site activities are that much more difficult to translate for early periods. Analyses of pattern overlays—or palimpsests—seldom reward archaeologists with crisp results. Even recently developed techniques, such as a method for estimating the minimum number of occupations in each archaeological layer based on the microstratigraphy of soot preserved in carbonate crusts at Grotte Mandrin (Vandevelde et al., 2017, 2018), will not completely disentangle palimpsest deposits. Yet, through a combination of careful documentation, step-wise hypothesis testing, and a background understanding of how depositional and postdepositional processes operate uniquely important insights can be gained.

Archaeologists are most accustomed to identifying cultural norms as rendered in objects, such as Levallois points or the decoration of a ceramic bowl. But cultural norms also structure humans' living spaces through a combination of conscious action and unintended consequences (Gamble, 1999; Galanidou, 2000; Clark and Ranlett, 2022). Even in the smudgy records of the Paleolithic, there are clues other than combustion features that reveal shifts in the nature and spectrum of activities on site, and how spaces were structured cumulatively. One important question, already considered, is the overall diversity of activities that were typically conducted at these sites. Activity diversity can serve as a loose proxy for the overall complexity in collaborative work and cooperation within the group (Kuhn and Stiner, 2006). Next, we consider a series of oblique clues that may relate to how cultural norms came to shape the archaeological patterns of the late LP and MP, with many examples coming from our own research in the Levant. Virtually all the archaeological records discussed earlier, many of which we shall return to here, represent palimpsests of debris that accumulated from the repetition of relatively short-lived activities over long time spans.

4.1. Rates of burning damage

A first source of insight, or clue, has to do with just how bones and other materials in sites got burned. Cooking was not directly responsible for the burning of most bones and artifacts in Paleolithic sites (Stiner et al., 1995, 2001). Burning damage arising from the use of bones as supplemental fuel in fires can be another cause, as it has been shown in some high latitude sites (Théry-Parisot, 2002), but this was not the norm in the Levant. Much of the burning damage in the Levantine sites occurred after bones and other materials were discarded by humans.

The frequency of postdepositional burning damage depends on at least three factors: (a) how intensively the site was used and reused; (b) the tendency to conduct activities within a confined space where fires were especially likely to be rebuilt; and (c) the overall rates at which insulating sediments accumulated in the site. These phenomena have been studied especially intensively in Levantine cave records. The frequencies of burned bones are quite high in many units of Qesem Cave, Hayonim Cave, and Kebara Cave, which together form a chrono-series spanning the late LP through the MP, and later (Stiner et al., 1995, 2011; Weiner et al., 1995, 2002; Schiegl et al., 1996; Goldberg and Bar-Yosef, 1998; Meignen et al., 2006, 2010; Bar-Yosef and Meignen, 2007; Shahack-Gross et al., 2014). Certain zones within each site were used repeatedly by humans, and fire building and maintenance were regularly practiced. These observations cannot by themselves reveal the rate of reoccupation (and presumably the pace of fire rebuilding), but with other lines of evidence can help to clarify general differences through time.

The early MP occupations in Hayonim Cave must have been comparatively light, given the low number of prey animals and long formation time as determined from chronometric dating (Stiner, 2005). Moreover, demographic characteristics of the prey also indicate that hunting did not exert heavy effects on the local ungulate and tortoise populations (Stiner et al., 2000). Fire nonetheless was already a central fixture of these encampments (Meignen et al., 2001). The same appears to have been true for much of the late LP in Qesem Cave, where burned bones are locally abundant but the number of individual prey animals low in relation to time elapsed (Barkai et al., 2003; Stiner et al., 2011). Incidental burning of small items, especially bone detritus, was commonplace in both sites—the smaller the specimen, the higher the likelihood that it is burned (Stiner et al., 1995). Although there is some evidence for roasting tortoises and perhaps also ungulate crania, most of the burning damage is randomly distributed across taxa and body parts in Hayonim. In Qesem, we find evidence of heating of limb bones in connection with marrow extraction, but much of the burning damage in this cave was also random in regard to taxon and body parts (Stiner et al., 2011). The structure of the combustion features attests to frequent fire building in Qesem Cave only after about 320 ka, but burned bones occur throughout the sequence. Bone preservation in Tabun Cave is poor, but the frequencies of burned lithics (Shimelmitz et al., 2014) parallel observations of bone burning in Qesem and Hayonim. Prior to 350 ka, burned lithics are few, about 1.3% of the lithic assemblage, but the frequencies jump to about 10% around 350 ka and after. Another major uptick occurs midway through the MP, around 165 ka.

Frequent fire-building is apparent throughout much of the early MP in Hayonim Cave, where wood ash was a major contributor to sediment volume (Goldberg and Bar-Yosef, 1998). By the later MP in Kebara Cave, ash buildup accelerated in relation to the build-up of other cultural materials. The dominance of accidental (post-depositional) burning damage on bones and stone artifacts underscores the core importance of fire facilities in early Paleolithic social and economic life. It was a dominant feature of encampments (at least in caves) that routinely affected other materials. Evidence for habitual use of fire begins in the later part of the LP. Combined with the information from sedimentation rates for dated stratigraphies and prey MNI values, we have a picture of increasing

intensity of site use from combustion features in the Levant from the late LP through the early MP, and significant acceleration in the later MP.

4.2. Tool mark distributions and orientations on bones

The second clue comes from tool marks on bones, which relate to how the benefits extracted from prey carcasses were staged, and the meat and marrow distributed among consumers (Stiner et al., 2009, 2011). Patches of multiple cut marks on bones in late LP deposits of Qesem Cave show notably mixed orientations, in contrast to MP and later examples. The great diversity of cut mark orientations on limb bones in Qesem suggests the formation of sequential overlays of marks from distinct cutting actions and postures. Haphazard arrangements of cutmarks are also found at the site of Schöningen in Germany (ca. 320 ka, Starkovich and Conard, 2015), where the phenomenon was also studied. Examples from the MP and early UP show much more regularity in cut mark alignments, which suggests that (a) butchering was undertaken by one or a few skilled individuals and (b) food then moved quickly down the social pathways of entitlement, whatever they may have been. A study by Soulier and Morin (2016) found that some cutmark orientations from MP and UP sites in France were consistent with filleting, with increasing evidence for this skilled butchery technique over the course of the UP. The situation before roughly 200–250 ka was notably simpler, with less staging in carcass dismantlement and less evidence of skilled butchering as handled by one or just a few individuals (Stiner et al., 2011). Remarkably, tool use of all kinds was more heavy-handed and less efficient in carcass processing, despite the impressive stone-working skills of the late LP hominins. Controlling for numbers of ungulate bone elements affected, the incidence of cone fractures and tool marks, for example, is roughly triple that for comparison MP and UP sites (Stiner et al., 2011, Tab. 6).

This shift in the nature of cut marks on ungulate leg bones is taken to signal an important transformation in the cultural rules pertaining to the butchering and sharing of animal foods. It is not clear that this shift occurred precisely at the temporal boundary between the two periods. Rather, the procedural shifts in butchering may have shifted within the earliest MP (Meignen, in prep.; Stiner, in prep.). The Qesem pattern implies a simpler or less evolutionarily derived pattern of meat consumption around hearths. Social feeding no doubt occurred at Qesem, but it may have been less socially canalized than in subsequent Paleolithic periods. Perhaps we are seeing evidence for reorganization in patterns of food sharing.

4.3. The rhythm of site visitation as reflected in lithic assemblages

A third clue concerns shifts in how sites functioned within the overall land use system. Many authors have attested to routinized patterns of site use documented in lithic discard during the Middle and Upper Paleolithic periods (Riel-Salvatore and Barton, 2004; Kuhn, 2004a; Riel-Salvatore et al., 2008; Clark, 2015; Kuhn and Clark, 2015). These interpretations were developed through the comparison of two variables: the ratio of tools-to-flakes and artifact density (computed volumetrically). In MP and UP layers, when these variables are plotted against one another (with each point representing a short stratigraphic interval—usually a palimpsest of multiple occupations), they exhibit a negative relationship. When the number of tools compared to flakes is high, the density of artifacts is low; when there are fewer tools compared with flakes, artifact density is higher. This relationship specifically represents the amount of lithic knapping that occurred on site and how much it overwhelmed discarded tools, varying according to how long occupants stayed at the site. Brief occupations may see the discard of some exhausted tools, but few cores reduced and low artifact density overall. Prolonged occupations tend to associate with more raw materials carried to the site and core reduction products overwhelming the discarded tool kit (Kuhn, 1995, 2021).

The late LP (Acheuleo-Yabrudian) layers of Tabun Cave do not conform to the patterning typical of the MP and UP (Clark, 2015; Kuhn and Clark, 2015). These LP layers have consistently high tool-to-flake ratios, independent of the overall density of artifacts. In other words, the higher density layers do not seem to be the result of longer occupations with abundant raw material provisioning and core reduction, which are evidenced in the MP layers of the same site. Instead, the percentage of retouched pieces stays consistently high in the late LP layers. In the MP context, this pattern would imply short-term visits, but in the late LP, we find no relationship between site visitation and lithic provisioning. The change from the late LP to the MP cannot be explained by the rate of sediment accumulation, raw material availability, or the shift in stone tool industry (Clark, 2015). Instead, this anomaly implies a fundamental shift in how Tabun Cave was used within a larger land use system during the LP to the MP. Just as individuals may have been carving off their own portions of meat at Qesem, there may have been an individualistic and somewhat stochastic strategy to mobility and cave use during the late LP. It could be that groups did not move as one unit as is typical for extant and historically documented hunter-gatherers. Rather, smaller subgroups or even solitary persons may have moved between sites. This would result in high frequencies of discarded tools in large assemblages.

Intergroup mobility is prevalent among modern forager populations, most often by individuals or small subgroups moving between residential groups (Hill et al., 2011; Bird et al., 2019). Mobility of the core residential group would produce the dominant archaeological signal in artifact assemblages. The same was likely true for the MP and UP populations. Regardless of the details of interpretation, the late LP record in Tabun is a palimpsest representing many visits yet the pattern in the lithic artifacts is unlike anything we find in later periods. This rough but marked contrast in the formation of lithic assemblage palimpsests indicates subtle but important organizational shifts in the underlying routines of site use and their socioeconomic complexity. Although the available evidence would seem to put the shift between the LP and MP, the present observations are wanting for more information on the earliest MP occupations in the region. The shift could well have been more gradual than present evidence suggests.

4.4. Site provisioning patterns

We see an emergent pattern of site use in the MP that is reflected by tool frequencies and artifact densities and was driven by the mobility and provisioning strategies of a core group. Interrogating site provisioning strategies a bit further reveals a fourth clue about the relationship between the circumstances on arrival to sites and the intended length of stay, based on how sites were provisioned with raw materials (Kuhn, 1995, 2004b, 2021). As demonstrated earlier, longer-term occupations associate with more lithic material and more core reduction. The longer a group stayed, the more opportunity they had to explore the surrounding area and bring back local raw materials to the site. Sometimes, however, we can see evidence for more directed provisioning with certain raw materials, often of high quality, from farther away. Along the Tyrrhenian coast of Italy, for example, the types of lithic raw materials used by MP humans remained very stable over time and were dominated by chert pebbles collected from beach deposits near the site (Kuhn, 1995). During UP occupations of the region, an entirely different strategy was sometimes used. Nonlocal raw materials

were stocked up in large quantities, to be used as needed for extended occupations. This strategy is even more evident in the Epipaleolithic period.

A similar phenomenon was observed within the UP series at Üçağızlı Cave I in Turkey (Kuhn, 2004b). For most of the initial/early UP occupations, core reduction was performed on flint obtained from secondary pebble deposits near the cave. In the densest Ahmarian (B-B3) occupation, however, a significant change was observed. Nodule cortex became dominant over rolled cortex, which indicates that the occupants were importing many nodules from primary deposits located about 20–30 km away.

The shift in raw material provisioning of sites associates with other evidence for longer-term and more intensive occupations in these cases. The complexity of features and greater range of activities undertaken also greatly increased. These examples indicate a diversification in raw material provisioning strategies over time, and perhaps a trend toward longer occupations and intensified use of some locations. Importantly, it was the site that was the focus of provisioning, rather than individuals. Although raw materials were stocked up at some MP sites in preparation for future needs, this effort was on a much smaller scale than in the UP and Epipaleolithic examples. Some UP sites were not only provisioned with knappable lithic materials but also with metamorphic stones to be used as anvils, grinding stones, boiling stones, and other functions (Brenet et al., 2018; White et al., 2018).

4.5. Secondary signatures of spatial heterogeneity in sites

The fifth clue concerns the detection of spatial heterogeneity within archaeological layers based on observations other than Cartesian coordinates alone. The processes that created these patterns may not be overtly heterogeneous yet were the result of variation in space-sensitive behaviors of Paleolithic humans. Some of these kinds of information persist surprisingly well in archaeological records, but their palimpsest structure must be recognized a priori.

Whereas the spatial structure within 'high resolution' sites, such as Abric Romaní, is easily discerned, thanks to high sedimentation rates and/or infrequent occupation, heterogeneity can also be detected within extremely dense deposits from indexes that reflect technological decisions. Examples of the latter include palimpsests of cultural events in Roc de Marsal (France; Reeves et al., 2019) and Riparo Bombrini (Italy; Riel-Salvatore et al., 2013) and in Amud and Kebara Caves in the southern Levant (Alperson-Afil and Hovers, 2005; Speth, 2006; Hovers et al., 2011; Speth et al., 2012).

Artifact densities at Layer 9 of Roc de Marsal average 940 lithics per square meter per 10 cm of depth—very dense accumulations that represent a mixture of multiple depositional intervals. Nevertheless, Reeves et al. (2019) found that lithic indices tracking the production, use, and discard of stone tools were spatially patterned. Sometimes this patterning was consistent across multiple layers, suggesting a highly routinized use of the site over time. For example, the cortex-to-mass ratio is a proxy for reduction stage, so that areas within the site with higher values (i.e., more cortex) reflect initial core reduction activities. This index showed clear clustering within layers but the particular clustering pattern was not repeated between layers. Another index, the core-to-flake ratio, can help to determine where cores were discarded. This index was also spatially clustered within layers and the same pattern was repeated within several of the layers, showing that core discard was spatially routinized. Alperson-Afil and Hovers (2005), as well as Hovers et al. (2011), likewise detected differential distributions of lithic artifacts throughout the late MP site of Amud Cave based on technological characteristics and artifact size. The early stages of core reduction were performed repeatedly in one area in particular.

Spatial patterning discerned from these high-density palimpsests indicates that there must have been a strong spatial repetition of behaviors across visits. Of course, the spatial arrangement of quotidian daily tasks must respond to permanent natural features such as cave walls, boulders, and slope, as well as to the positions of key anthropogenic features (Bailey and Galanidou, 2009). The overall size of the usable space is another conditioning factor and may be particularly limited inside natural and human-made shelters. We have already mentioned the pressures to manage waste in crowded or heavily used spaces. In the absence of direct indications of the spatial distributions of materials, one may also turn to micromorphological (microscopic) indications of the state of wood ashes and trampled surfaces (e.g., laminated or not, see Mentzer, 2012; Goldberg et al., 2017; Karkanas, 2021) and/or tracking the secondary chemical products of organic materials (Weiner et al., 2002) to test hypotheses about pre-existing but largely masked patterns in the deposits. These traces can also reveal habitual use and activities in some parts of the habitable space as opposed to others.

In summary, palimpsest accumulations in Paleolithic sites indicate, albeit in a coarse way, that the earliest Paleolithic cave records resulted from repetition of a narrower range, or less complex set, of socioeconomic activities in domestic spaces. Triangulating among the potential clues described earlier may reveal, negate, or corroborate indications of site function within the larger system of land use, how sites were populated by individuals, butchering and food sharing behaviors, technological pursuits, and how humans provisioned sites with resources and/or infrastructure. Many of these indications will remain general signatures rather than easily read patterns that require minimal translation. Yet the rhythm of visitation, the social scale of individual interactions, and even the extent to which established cultural norms overwrote more pedestrian or ergonomic forces in the structuring of sites can be revealed by the techniques for unpacking palimpsests.

There is a strong link between the intensity of site use (duration and/or number of concurrent users) and spatial heterogeneity of activities, activity diversity, combustion feature visibility, and needs for site provisioning and clean-up. Despite this apparently necessary association, one can be certain that the trend toward greater complexity of domestic environments accelerated in the late MP, later MSA and after. The trend is mirrored by diversification in technology and foraging. Time-averaged records are extremely important to reaching robust conclusions about the evolution of human behavior because they dominate so much of the Paleolithic record. They are also important because they yield unique insights that are not apparent from the study of discrete occupations, where the difference between idiosyncratic and habitual behaviors is difficult to separate. In this way, palimpsest records can contribute greatly to our knowledge about highly repetitive behaviors and the emergence of cultural norms.

5. Conclusions

We have endeavored in this article to examine human behavioral shifts and transitions over large spatial and temporal scales as manifested in domestic spaces. Some of these changes emerged well before the dawn of so-called modern human behavior (Wadley, 2001; Nowell, 2010; Ames et al., 2013). With time, the places where hominins met their basic survival needs increasingly became central hubs for a greater diversity of tasks. With these changes came the possibility for more complex and productive social interactions. The first hints of these dynamics emerged within the Middle Pleistocene and can be seen archaeologically from the control and management of fire and its role in shaping

social spaces, but also significant expansions in the spectrum of activities on site, intensity of site occupation, waste management, symbolic marking of social spaces, and eventually the emergence of local cultural traditions for homemaking (Fig. 9).

Many of the changes in the co-evolution of humans and domestic spaces do not divide neatly by the Paleolithic period, which historically were defined from formal stone artifacts. Attempts to assign the developments described earlier to a particular hominin lineages or cultural periods seem to obscure the underlying processes involved. The changes followed a gradual rather than stepwise pattern, albeit with the acceleration typical of a nonlinear developmental process. In fact, many inventions seem to come and go in Pleistocene archaeological records, occurring sporadically at best, and only a few passing to the innovation phase which allowed them to proliferate. It seems likely that most inventions of the Paleolithic period had multiple origins and suffered nearly as many extinctions (e.g., French, 2015). Only the innovations that involved widespread adoption would have had significant evolutionary impacts.

Middle Pleistocene examples of domestic spaces take humbler forms than those famously described for the UP and later MSA, but they may have been no less transformative in their time. By 200 ka in South Africa and western Eurasia, we see convincing evidence for hearth-focused activities, though mainly in cave sites. Evidence for symbolic marking of social space precedes the UP, if MP burial practices are taken into consideration. Yet this development occurs mid-period in western Eurasia and receives remarkably little recognition in the headlines about human symbolic evolution. It was around this time in Africa and the southern Levant when durable decorative objects come into use (Henshilwood et al., 2004; Vanhaeren et al., 2006; Bouzouggar et al., 2007; d'Errico, 2008; Sehasseh et al., 2021). Later behavioral developments are more vivid and easily interpreted, but many of these were additive in nature and appear more spectacular as the result of the nonlinear pace of development and better preservation.

A critical factor in the evolutive role of domestic space is its function as a central hub of activities that was frequently repeated in the lives of the social group. This observation might lead one to ask whether there can be a home without a hearth? In the absence of cooking and warmth and light, can a location really function as a domestic environment at all? If food preparation and consumption, with or without cooking, is central to the basic definition of domestic space (Stiner, 2021), then the simple answer is 'yes.' It would be a mistake to argue that fire technology marks the beginning of 'sites' or domestic spaces. Earlier hominins used and accumulated items at certain beneficial locations within their home ranges. However, the range of activities performed and their duration at these early cases was very limited. Once fire became a regular component of Pleistocene-era technology, the evolutionary arena—or petri-dish—shifted in what a camp could become for multiple users. With pyrotechnology, the evolutionary potential of domestic spaces extended well beyond the basic physical and nutritional conveniences that a simple safe place provides.

We are not alone in arguing that fire technology added greater dimensionality to the phenomenon of domestic spaces from the MP/MSA onward, or that it probably exerted an outsized influence in humans' social and cultural trajectories (Rolland 2004; Wrangham, 2009; Wiessner, 2014; Chazan, 2017; Kuhn and Stiner, 2019; MacDonald et al., 2021). Throughout most of the hominin global range during the later Middle Pleistocene, the emergence of hearth-centered encampments was accompanied by the development of more sophisticated toolkits. And roughly mid-way through the MP/MSA, we see subtle tendencies for regionalization of technological traditions (McBrearty and Brooks, 2000; Delagnes and Meignen, 2006; Uthmeier, 2016; Tryon, 2019). Indicators of an emerging cultural geography became almost universal during the UP and the later MSA (Vanhaeren and d'Errico, 2006; Mirazón Lahr 2016; Fuentes et al., 2019; Schmidt and Zimmermann, 2019; Tryon 2019; Miller and Wang, 2022), but the phenomenon is not altogether unique to these and later periods. The same can be argued for ascribing lasting social significance to certain localities, which in the MP of western Eurasia is evidenced by the interment of deceased group members in oft-visited cave sites. Cultural norms were already structuring behavior and the depositional patterns in these sites to some extent.

Before the digital age, cultural transmission could only be facilitated by higher rates of proximity among individuals. Hearth-centered domestic spaces would have supported this to an unprecedented degree in human evolution, as crucibles for the development of human culture. Social and behavioral changes evidenced within living spaces signal an increasing role for cultural transmission and conservation of cumulative knowledge—technological and subsistence know-how, ecological knowledge, food processing methods, childhood education, belief systems, and essential social skills. Social skills learned in the early years of a life, especially within living spaces where adults and children gathered, would have provided the model for social relationships more generally. These knowledge-sharing relationships were the edifice upon which the web of information transfer and information longevity could expand.

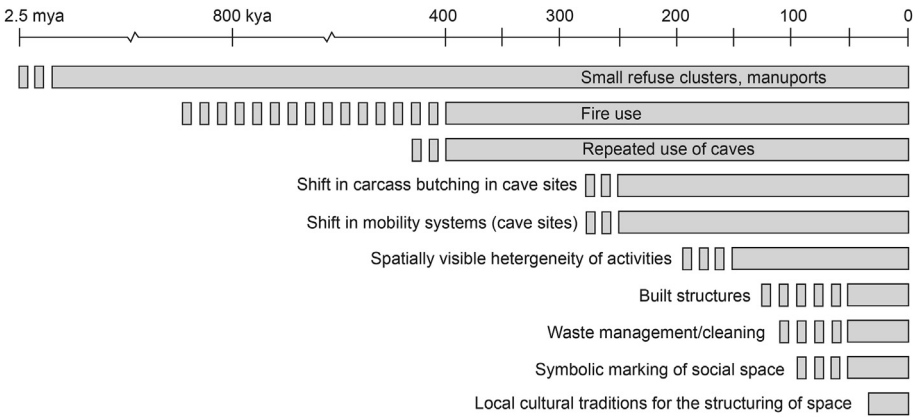

Figure 9. A visual representation of many of the trends in the co-evolution of human culture and domestic space described in the article. Perforated bars indicate scattered evidence; solid bars indicate the evidence is more widespread. Please note that these are broad estimations of when these processes began and are intended to illustrate the gradual changes in living spaces over time. See SOM Table S1 for specific dates, examples, and references.

Domestic spaces thus provided the type of common arena of opportunity and interaction. It is because of this that they could play such a vital role in the acceleration of cumulative culture. As more activities occurred in them, and more social interactions transpired, humans put more effort into the construction of these spaces, equipping and modifying them. Social interactions become even more prolonged, presenting new tensions along with benefits, and selecting for further norming of social relations and institutions. Institutions that created an extensive network of non-genetically related kin, such as marriage, may have been established mainly in this context (Gamble et al., 2011). Evidence for specific cultural norms is elusive in the archaeological record, but there are glimpses into the blueprints for what constituted a home, even from the palimpsests left behind by early humans. As people revisited sites, decorated them, invested in their infrastructure, and recalled the diversity of experiences that transpired there, places took on a greater collective meaning. These places become spatial nodes in their shared social and cultural memories. The iterative, cumulative nature of these dynamics made domestic spaces uniquely powerful cultural engines that, over time, transformed 'occupation loci' into 'homes.'

A final take-home message of this presentation concerns the scope of spatial analysis in archaeological inquiry and discovery. Most archaeological discussions center on the 'organization of space' as indicated by the raw distributions of artifacts and other materials within sites. Interpreting the evidence through the filter of site formation processes is much more challenging and requires an understanding of the dynamic interactions of place, technology, and human activity spectra. A more holistic approach that incorporates all these methods will capture considerably more information about the origin and transformation of domestic spaces, or what 'home' meant to people over the full course of human evolution.

Declaration of competing interest

The authors declare no conflict of interest.

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Supplementary Online Material

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