CHAPTER 2

THRESHOLDS IN BEHAVIOUR, THRESHOLDS OF VISIBILITY: LANDSCAPE PROCESSES, ASYMMETRIES IN LANDSCAPE RECORDS AND NICHE CONSTRUCTION IN THE FORMATION OF THE PALAEOLITHIC RECORD.

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Introduction: Cave locales in human evolution

This paper addresses some of the challenges in answering a relatively simple question: when did hominins start routinely occupying caves as living spaces? Cave locales, which for the purposes of this paper are taken to include large overhangs (rock shelters), enclosed or unclosed fissures, sea caves as well as entrances to karstic systems, occupy an important position in Palaeolithic archaeology. Caves loom large in our record of the Middle and Late Pleistocene in terms of number of known sites, the good degree of preservation of behavioural and palaeoenvironmental evidence and the sheer density of archaeological finds within concentrated areas of space and sometimes spanning long temporal sequences. In contrast to open air locales, cave systems have produced the vast majority of important hominin fossils for the Middle and Late Pleistocene (Butzer 1982, 1986; 2008; Laville *et al*. 1981; Goldberg and Macphail 2008). Cave records contain multiple proxies for the reconstruction of human behaviour at local and regional scales and provide archaeologists with their key cultural sequences, often accompanied by dating proxies. A single cave site will often provide a wider range of evidence and a deeper time scale than the cumulative total of open air locales within any given region. As a consequence, cave contexts form a proportionately greater focus for research time and resources than the surrounding landscape

(Butzer 2008). We only have to imagine a Palaeolithic record lacking any cave-derived evidence to see their impact on our understanding of the early human past. The absence of cave records for some periods and within particular geographical regions therefore significantly skews our ability to bring the full range of hominin behaviour into focus.

Caves also occupy an important place in the history of our discipline and wider public perceptions of the deep human past, being intrinsically associated with concepts of 'cavemen' and the idea of the cave as the earliest human home (Berman 1999; McCaughey 2007). Addressing the chronology and significance of cave occupation in evolutionary terms therefore has important implications for how we interpret the whole Palaeolithic record and present it to the wider public. It allows us to both challenge misconceptions about our earliest ancestors and consider evidence from closed and open air contexts as part of a single landscape system

With a Palaeolithic record now spanning some 3.3 million years (Harmand et al 2015), and a large corpus of known, scientifically studied and well published open air and closed sites the lack of data is not an obstacle to addressing the question of when hominins first occupied caves. However, the wider archaeological issue of hominin landscape use is as complex as it is extensive. We must consider these complexities at a global scale at the same time as refining the scope of the research questions relating to hominin cave use. This paper makes the case that the obstacles in identifying when hominin groups started to actively seek out and occupy caves, stems more from our lack of suitable analytical frameworks than the paucity of data. This paper reinforces the importance of the subject by considering the degree to which occupation of caves as persistent places in landscapes could represent a key evolutionary marker in human behavioural evolution alongside the more familiar innovations of percussive technology, hunting, the use of fire and symbolic behaviour.

Caves, persistent places and home-bases as examples of human niche construction

Demonstrating the appearance within a given region of persistent places (Schlanger 1992; Shaw *et al* 2016) at which discrete suites of activities took place is a key, but unresolved issue that has been periodically revisited in Palaeolithic archaeology (Washburn 1960; Washburn and DeVore Isaac 1981a; Isaac 1971; 1976a; 1976b; 1981b; Potts 1984; Bunn 1994; Sept *et al* 1994; Kolen 1999; Rolland 2004; Drinkhall 2014; Edgeland 2014). The presence of 'home-bases' - locations, seasonal or permanent, where resources from the surrounding landscape and extractive locales are centralised and redistributed - represents a hierarchical node in a model of hominin settlement. Home-bases are largely lacking among primates yet ubiquitous in the settlement networks of Pleistocene modern humans up to the present day. It is therefore important to establish where, on this trajectory from 'homeless' early hominins to the present, we first see the appearance of structured asymmetries in the behavioural record. These asymmetries might manifest themselves as differences between the extractive (primary butchery, stone acquisition and primary flaking, organic tool manufacture) and domestic (food sharing, tool maintenance, sleeping spaces) spheres. The latter we might comfortably term home-bases and, where demonstrably involving the modification, provisioning of space over time, could be considered an example of human niche construction (Odling-Smee 1993). Home-bases, constructed in terms of utility and centrality to wider, complex patterns of landscape use represent a human niche which persists to the present day in rural and urban settlement systems.

Consequently, establishing in the regional archaeological record the first persistent and apparently targeted use of caves as home-bases, as opposed to opportunistic sleeping sites (Barrett *et al.* 2004), is important. It indicates at a regional scale that hominins were capable of organising themselves in space and time in a radically different way, either compared to earlier hominins or to any observed group of primates. Furthermore, we might hypothesise

that hominin populations which utilised fixed, persistent places as part of their ecology will exhibit a suite of other behaviours not seen in populations which did not operate in this way.

While the evolutionary preconditions which might separate those hominins that used cave locations as home-bases from those who did not might be small, this threshold, once crossed, would have had big advantages for those groups which expanded into, or created, this niche. In Table 2.1 the affordances offered by cave sites are listed alongside their wider advantages to cave-using groups. While the table includes environmental, technological and social/cognitive advantages, these should not be considered as separate from each other. For example, environmental affordances can scaffold cognition in the same way that material culture can form part of a wider human distributed mind (Gintis 2014).

< TABLE 2.1 HERE>

A Middle Pleistocene revolution: Crossing the cave occupation threshold

The chapters in this volume provide ample evidence, at different geographical scales, for important changes in hominin landscape use, ecology and society during the Middle Pleistocene. In a number of cases the hominin use of caves emerges as pivotal to other developments. Barkai et al, (Chapter 4) place recurrent and prolonged occupation at the centre of changes in technology, social behaviour and hunting strategies. Stiner, (Chapter 5), shows how the emergence of cave base-camps with persistent, maintained hearths indicates an important transformation in hominin social behaviour and active niche construction in the late Lower Palaeolithic of the Levant. A change, moreover, which comes before the appearance of the regional Middle Palaeolithic. Kuhn et al, (Chapter 3) see caves used as distinct social spaces from MIS 10 onwards.In particular they draw attention to hearth-side activities that may have had a transformative effect on hominin social complexity, resulting

in the later emergence of the regional Middle Palaeolithic in MIS 7. Similar patterns are shown for Brittany (Ravon, Chapter 6) and the English Channel Region (Scott and Shaw, Chapter 7).

Figure 2.1 shows the temporal distribution of both open air and caves locales across three broad latitudes. These locales are also shown alongside other behavioural and anatomical evolutionary markers. While necessarily schematic, Figure 2.1 clearly shows the early appearance of open air locales at equatorial latitudes in East Africa, a slightly later appearance for such sites in South Africa and, by 1.6Ma, in Europe. The appearance of cave occupation is, for reasons explored below, more problematic, but in each region a consistent pattern emerges. Even sites which present ambiguous evidence for occupation, as opposed to simply preservation of artefacts, occur *later* in each region. Currently cave occupation sites appear earlier in northern and southern latitudes than on the equator, but in all three regions sustained and continuous records of cave occupation is only unambiguous after 500ka, and therefore within the Middle Pleistocene. This threshold in the archaeological record, is crossed towards the end of the Lower Palaeolithic and is coincident with, or within 100ka, of the earliest instances of the Middle Palaeolithic in each region.

< FIGURE 2.1 HERE>

The visibility threshold: geomorphology and process in the pleistocene landscape.

For the reasons outlined above, cave occupation is an important behavioural vector to track in evolutionary time. But this is not an easy undertaking beyond the simple presentation of a complex record as shown in Figure 2.1. To do full justice to the issue would require a detailed study of the entire Palaeolithic record. Documenting all occurrences of human

occupation in cave contexts from the existing literature would be a significant research undertaking. It would, however, be of limited use if the same was not done for open air sites in each region and the geological conditions which create caves, assessed and quantified. Making sense of such a dataset would require a multidisciplinary approach, combining a fully integrated understanding of research histories, geological/tectonic processes, demographic distribution and density of hominin populations. This would have to be set alongside an appreciation of long-term geomorphological processes in each region (Butzer 2008; Pope et al 2015). For the purposes of this paper geomorphology is isolated as the most important factor that has to be accounted for.

A sample of what such a study might look like is presented in Figure 2.2. The time blocks are large, as dating is often imprecise, but it shows clearly the direction of travel. Archaeological evidence from cave contexts is absent for the Tertiary. It occurs first and then sporadically during the Early Pleistocene, becoming more prevalent in the Middle Pleistocene and finishing with a Late Pleistocene explosion in cave use. The key thing to note is that this dataset comprises the surviving archaeological record from cave contexts. It does not differentiate between evidence for *in-situ* cave/rockshelter occupation and material which may have worked its way into karstic sediments from the surrounding landscape, nor does it consider the presence/absence of older cave sediments. These would form a necessary baseline to preserve the earliest traces of occupation in any given region.

<FIGURE 2.2 HERE>

Modelling threshold lag

Taking these factors into consideration, the task for Palaeoanthropologists is to manage the interplay between two thresholds in evolutionary time. This involves,

1. Identifying for each region the time-threshold at which a particular range of behaviours developed within hominin populations and,

2. The time-threshold at which they become visible in the archaeological record.

The interplay of these two thresholds is explored in Figure 2.3 and Table 2.2 where three hypotheses are presented to account for the lag between the appearance of cave occupation in hominin evolution and its visibility in the archaeological record

<FIGURE 2.3 HERE>

<TABLE 2.2 HERE>

These three hypotheses by no means exhaust the possibilities. Other relationships could easily be conceived and explored. Different relationships between these thresholds could play out in contrasting ways at local, regional and continental scales depending on the effects of tectonic, hydrological and other geomorphological controls. It therefore becomes rapidly apparent that the behavioural vector of cave occupation, a key indicator of behavioural change, occupies a precarious position in the archaeological record.

The record of percussive stone technology and animal processing now extends beyond the Pleistocene and into the late Tertiary as reported from Lomekwi (Harmand et al 2015). As a result this record spans transformations in the global landscape which go far beyond the

normal scale of archaeological frameworks and methods. The combination of tectonic processes (uplift, folding and rift valley formation), hydrological changes (river valley incision, migration and phreatic karst system formation) and landscape denudation (scarp recession, graben formation and collapse, and slope processes) all have the capacity to create capture points. These sedimentary 'traps' are then filled with the records of hominin behaviour only to be subsequently released, when eroded, into the wider landscape. Every geological substrate and associated landform within a given region will give rise to a particular rhythm of capture and release, and the prevalence of each substrate within each region will characterise the overall rhythmic character of the region itself. Add to this the patterns of fission and fusion in hominin demography (Foley and Gamble 2009), and the limits on carrying capacity set by ecological and climatic factors, and there is scope for significant differences in lag between thresholds from one region to another.

In summary, identifying the interplay between these two thresholds will not be straightforward given that we might expect the following

1. Many complex, advanced behavioural innovations will be preserved within caves once they are part of the hominin landscape (fire, social feeding, structures etc.)

2. The full integration of these behaviours as part of niche construction will be centred on cave contexts if they are present in a region, and

3. The need to accurately correlate these thresholds with changes in planetary climate, hominin morphology taxonomy and cranial capacity makes it imperative to focus on the potential lag between behavioural and visibility thresholds.

The Lower Palaeolithic record: asymmetries in a landscape

If identifying thresholds and accounting for probable lags (Table 2.2) between behavioural inception and archaeological visibility is currently beyond us at a global scale, consideration of other aspects of the record which are better understood is not. In particular the Lower Palaeolithic which lacks evidence for cave or home-base occupation can be classified as an *Asymmetrical Landscape Record*. We might have evidence for raw material provisioning, tool manufacture and butchery preserved and archaeologically visible, but the less robust or straightforwardly intangible evidence for sleeping, nurturing, caring, resting, watering, feeding or processing of vegetable foods will be relatively invisible because the evidence preserves better in caves. Even if such evidence was preserved, perhaps as phytolith concentrations at nesting sites (Hayden 2012) or starch grains preserved on hammers or anvils used to process plant foods (Revedin 2015), without densely visible concentrations of flaked stone tools such sites are unlikely to be discovered in the course of normal landscape surveys .

Characterising the visible archaeological record and using it to infer the invisible is a useful starting point. In the absence of unambiguous cave occupation sequences for the global Palaeolithic record from the Late Tertiary and Earliest Pleistocene, we are forced to consider what components of early hominin lifeways *are* visible to us. Our core record, being overwhelmingly comprised of stone tools augmented by a sparse record of modified faunal remains, necessarily only documents parts of the landscape in which stone tool manufacturing and stone tool use were taking place. More specifically it only documents locations where tools were discarded during or after these activities, or where they came to rest after sedimentary processes involved in their preservation had ceased. Even in a high-resolution situation, where tools are reliably associated with animal bones and where taphonomic processes can be shown to preserve the material in primary context, we are only

seeing a record of a specific component of hominin lifeways. The widespread co-occurrence of butchered mammalian fauna and stone artefacts, whether indicating primary or secondary butchery, or some inferred degree of food sharing, can never be considered to be a complete record of hominin behaviour. Such sites would have been places of relative danger and only temporary security as they would attract other carnivores, both apex predators and scavengers. Occupation and activities at these sites are unlikely to have continued after dark and cannot reasonably be considered as having provided safe sleeping sites, or places for the safe refuge of vulnerable group members (Koops et al 2012).

Leaving aside the possibility that cave sites might be missing due to the threshold lags described above (Figure 2.3), we first should consider this asymmetry both on its own terms and in contrast to other time periods. For example, the Middle Acheulean record of Africa, Europe and the Near East regularly comprises landscape signatures with significant concentrations of bifaces at particular locales (Isaac and Isaac 1977; Schick 1992; Potts 1994; Pope 2002). This is in stark contrast, however, to the regional records of the MSA/Middle Palaeolithic. There might well be geomorphological reasons for this difference at a regional scale, but given that this transition occurs alongside other behavioural and anatomical changes at a time when global climate rhythms are moving to 100ka cycles, the reduction in the scale and density of landscape signatures could be a behavioural shift rather than a taphonomic arefact. Systematically tracking these landscape variables in quantitative terms is beyond the scope of this paper, but it is a useful avenue for future research. If geomorphological controls over visibility could be more effectively filtered out we could isolate more clearly the contexts under which this behavioural shift is taking place.

The three hypotheses in Table 2.2 bring some clarity to the relationship between behavioural and visibility thresholds. Hypothesis 1 indicates that visibility was the primary control of the archaeological record of cave occupation and settlement patterns involving cave sites could

have emerged earlier and continued developing in a gradual way. The observed trajectory of the ESA/Lower Palaeolithic record presented above (Figures 2.1 and 2.2), showed increasingly abundant landscape signatures and locally dense accumulations of stone tools and butchered animal bones from open locales across the Equatorial region. However, the use of caves in this region starts much later than in either northern or southern to mid-latitude regions. Unless a geomorphological, tectonic or hydrological control for the equatorial region can be found which explains why cave contexts were not available until much later, Hypothesis 1 cannot be upheld. Determining between Hypothesis 2 or 3 will depend very much on further systematic consideration of the dataset for the total human occupation record alongside that for accumulations of faunal material lacking any evidence for human activity. If both are seen to appear suddenly and together in abundance in the Late Pleistocene then Hypothesis 2 might be upheld, while a gradual attenuation of faunal-only accumulations back in time compared to a more sudden drop-off for hominin occupation sites would favour Hypothesis 3.

Convergence in the Middle Pleistocene: characterising a late behavioural threshold.

In Figure 2.1 we can clearly see the appearance (around 1Ma) and then the subsequent expansion (around 0.5 -0.3Ma) in the number of cave records. Interestingly, this increase in cave occupation sites is not evenly distributed by latitude. In the sample of African and European sites, cave records appear earliest in Southern Africa and a little later in Europe, depending on the status of possible doline sites like Pirro Nord (Arazello 2007) and Gran Dolina (Fernández-Jalvo 1999). The increasing use of cave sites in the 'Neanderthal' record of Europe and the record of cave use by Anatomically Modern Humans in South Africa contrasts with the late appearance of cave contexts in equatorial Africa. Considering the

impact of the visibility threshold in both cases is important. It may allow us to determine whether two human populations at mid-latitudes in two separate hemispheres were either continuing an aspect of behaviour with a deeper, and maybe shared, evolutionary trajectory, or both independently exhibiting behavioural change at a broadly similar time period. The fact that the first florescence of cave occupation is occurring at mid-latitudes may be underpinned by geomorphological controls of visibility, but it is also easy to conceive how increased seasonality and the challenges presented by climate change at the extreme limits of human occupation in both hemispheres could be identically selecting for new behaviours involving cave use, home-bases and new patterns of landscape use.

In some regions the impression is given of a trend towards a reduction in the number of large accumulations of stone tools (especially large accumulations of bifaces) while open air sites increasingly show parts of complex *chaîne opératoires* involving prepared core technology, more curation, specialised composite hunting technology and cave sites with distinctive signatures of tool use, sharpening and discard as well as use of fire and intra-site structures (Adler et al 2014; Scott and Ashton 2011; Ashton and Lewis 2002; Roebroeks and Villa 2011; Wadley 2010; Wilkins et al 2012). The evidence for these Middle Pleistocene innovations exist independently of the possible combinations of the behavioural and visibility thresholds outlined above. These innovations allow us to consider how a significant spatial reorganisation of hominin landscape use, and associated social and ecological factors, might be expressed in different parts of the record. For example, it is hard to conceive of taphonomic factors which might explain the reduction in large open air accumulations of bifaces during this period, when our expectation would be for an increase in visibility through time. Where this phenomenon is manifested in an extreme form, such as the relative paucity and prolonged absence of archaeological signatures from Britain in MIS 9-3 (Ashton and Lewis 2002), it is easiest to interpret it as an absence of population during those periods. But

careful consideration of what activities are taking place in specialised parts of the hominin landscape, such as secondary butchery in cave locales (Stiner et al 2009; Chapter 5) or emerging complexity in re-sharpening and discard behaviour (Kuhn and Clark 2015; Barkai 2015; Scott and Shaw Chapter 7), means we should be very cautious in reading changes in the number of sites and the density of artefacts found at them as a proxy for population numbers.

Discussion: Converging worlds, persistent places and the hominin home.

Attempting to untangle the themes explored in this paper will require a new and holistic approach to the Palaeolithic record which goes beyond the regional or even global synthesis of observed data. More serious, concerted and systematic consideration must be given to factors of local sedimentary process, regional geomorphology/collection history and continental tectonic history before we can begin to sensibly interpret our distribution maps and interpret assemblage variability (Butzer *et al.* 2008; Pope *et al*. 2015). The evidence presented here suggests the possibility of a deeper evolutionary relationship between hominin populations and their landscapes which provide the affordances of cave, shelters and overhangs. This relationship could be explored if visibility and taphonomic processes are factored into the study. An important consideration here is the degree to which landscapes which offered caves also offered other affordances to early hominin groups. Even before caves were routinely used, the landscape could have offered safe contexts for repeated activities not associated with food consumption, such as sleeping. Prior to the emergence of later, more complex landscape use behaviour, with the possibility of *Asymmetrical Behavioural Records***,** such landscapes would have provided locales away from lowland game and predator concentrations, extensive plateaus, interfluves and escarpments. These were not only useful for moving through incised landscapes but also for providing extensive views and thereby contributing to successful foraging and scavenging activities. These landforms are

fringed by ecotonal areas of groundwater discharge, either through springs or larger resurgent rivers. In fact there are many reasons why we might imagine these landscapes provide not only important affordances, which might explain an early presence of hominins within them, but also a low chance of discovering their record of hominin occupation associated at greater distances in time.

However, any record of activity directly associated with caves, prior to 1Ma ago is rare and ambiguous. With the possible exception of Wonderwerk Cave (Berna *et al*. 2012) any clear evidence of the targeted use of caves by hominins in the Early Pleistocene is lacking. But unless we envisage early *Homo* as simply a hominin of the plains, lakes and river edges, then we must begin to consider more clearly how areas with contrasting topography could have provided additional affordances. How much depends on the relationship between the behavioural and visibility thresholds in very dynamic and erosive landscapes and whether loss through erosion sufficiently explains the lack of occupation signatures from these landscapes requires further systematic investigation.

By contrast the records of the Middle and Late Pleistocene show qualitative differences in human behaviour, many of which are independent of the visibility threshold (Locht et al Chapter 11). The density of material occurring within caves, the more widespread and sustained use of fire and evidence for secondary butchery and complex artefact re-sharpening can be read against the wider changes in landscape signatures and stone tool technology to suggest that a significant behavioural threshold was crossed at this time and that niche construction of a different nature was being undertaken. The possibility that this was not taking place across all latitudes at an similar rate is a compelling one (Figure 2.1, 2.2). Inter- and intra-continental scale audits of the archaeological record will be necessary to examine the pattern in detail, against geological controls over visibility. However, a hypothesis that

the differences between equatorial and mid-latitude records is essentially controlled by geomorphology can be compared with another which proposes that behavioural adaptation was accelerated at the margins of the hominin world. This is an exciting possibility, especially when we have multiple hominin lineages present with diverging evolutionary and complex evolutionary paths. Understanding the interplay between Middle Pleistocene hominins such as *Homo heidelbergensis*, *Home rhodesiensis* and emerging early Neanderthal populations and *Homo sapiens* lineages will be critical to understanding the persistence of the Acheulean and the emergence of Middle Palaeolithic/MSA cultures. The Middle Pleistocene, far from being a "muddle in the middle", is one of genuine high contrast with the landscapes of the early hominin record. The spatial distribution of tool manufacture, feeding, sleeping and social interaction come together where conditions allow into a *Convergent Behavioural Record* lacking for earlier periods and allow for the development on more complex and resilient settlement models.

These extensions of habitat range and resilience to climate change can be seen most clearly in the mid-latitudes of Europe, the Near East and South Africa, with evidence for the persistent use of fire and established occupation of cave sites emerging during this time (Wadley Chapter 12; Gowlett Chapter 13). Changes in lithic technology, the appearance of unequivocal hunting weaponry and flexible approaches to meat acquisition and redistribution forming key parts of this package. The persistence of *Asymmetrical Behavioural Records* in some spatial/temporal contexts in Africa and Europe, may indicate that not all hominin populations crossed the threshold to *Convergent Behavioural Records* together or that a flexible repertoire of landscape habitation was available.

Conclusion: The hominin home as constructed niche

This paper began by exploring the obstacles to tracking behavioural vectors in the Palaeolithic record, especially given the timescales involved and complex factors involved in the formation of the record. This paper has proposed that, even if caves were routinely used at earlier stages than a potential visibility threshold, changes in the archaeological record of landscape use and technological innovation are compellingly coincident with the appearance of sustained cave occupation. Behavioural convergence of hominin technology, habitation and sociality offer the cultural equivalent of a Petri dish, incubating complexity while extending resilience to environmental change at season and glacial cycle scales. Ultimately the use of caves is not the most important factor here, it is the exploitation of spatial areas offering security and utility, which can then be structured and provisioned for habitation. The creation of such spaces, however temporary, was probably a threshold pushed against throughout the evolutionary journey of *Homo* and precocious examples of habitation sites should be expected, but it is as part of a package of large brained, predatory and fire using hominins with flexible and complex technology that we see it emerge fully formed in the relatively recent Middle Pleistocene past. This behavioural threshold could be regarded, not just as an indicator, but a potential driver in the 'modernisation' of multiple hominin lineages, including Anatomically Modern Human and Neanderthal populations, during the past half million years.

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Figure captions

Figure 2.1: Threshold of ‘Cave Occupation’ set against other evolutionary markers.

Figure 2.2: Key behavioural records in human evolution

Figure 2.3: Possible relationships between behavioural and visibility thresholds and their evolutionary significance. horizontal scale in millions of years.

Caves offer	Caves enable
Shelter	Improved survival outcomes: long term persistence in regions deriving from resilience to climate change, short term persistence in regions deriving from resilience to seasonality. Short term shelter from environmental events (storm, flood, dust storm, volcanic event). Improved health and fitness.
Fixed, Safe Locale	Fragmentation of the group on a daily or longer basis; a safe locale for the care of the very young, old or sick and a safe context for parenting and grand-parenting. Safe focus for group recombination after hunting, foraging or raw material provisioning trips.
Quiet, Dark, Safe Locale.	Allowing for prolonged undisturbed sleep, extension of "night" hours and consequently more rapid healing, recovery from exhaustion and better cognitive functioning (facilitating multiple REM cycles)
Feeding Locale	Safe locale away from dangers of primary butchery site, allowing for secondary butchery, feeding of entire group. Prolonged secondary butchery for more extensive marrow and fat extraction
Material Convergence	The casual accretion of a wide range of organic and inorganic raw materials in an environment which reduces the effects of weathering and scavenging. Caves offer scope for reutilising and combing diverse materials; technological innovation and maintenance of complex technologies.
Combustion Enabling	The combination of sheltered space and diverse available materials enables the creation and maintenance of fire.
Socially Enabling	Caves constrain the human use of space and may stimulate the development of structured spatial use; sleeping, feeding and technological areas, structured use of space around hearths and the building of partitions. These structures may stimulate repeated use of space through stigmergy.

Table 2.1:Affordances provided by cave locales

Ho1: Early punctuated behavioural threshold, late punctuated visibility threshold		Lag effect
	Cave use close to the emergence of genus Homo	*Wide*
Ho2: Early gradual behavioural threshold, late punctuated visibility threshold		
	Cave use initially limited but becoming progressively selected for	*Narrow*
Ho3: Late punctuated behavioural threshold, late gradual visibility threshold		
	Persistent cave use as home bases part of a Middle Pleistocene behavioural 'revolution'	*Minimal*

Table 2.2: Possible relationships between behavioural and visibility thresholds and their evolutionary significance.