Hominid Cave at Thomas Quarry I (Casablanca, Morocco): Recent findings and their context

Jean-Paul Raynal a,e,*, Fatima-Zohra Sbihi-Alaoui b, Abderrahim Mohib b, Mosshine El Graoui b, David Lefèvre c, Jean-Pierre Texier a, Denis Geraads d, Jean-Jacques Hublin e, Tanya Smith e,f, Paul Tafforeau g,h, Mehdi Zouak b, Rainer Grün i, Edward J. Rhodes j, Stephen Eggins k, Camille Daujeard a, Paul Fernandes l, Rosalia Gallotti m, Saïda Hossini n, Alain Queffelec a

a Université Bordeaux 1 Sciences et technologies, UMR 5199 PACEA, IPGQ, Bât. B18, av. des Facultés, 33405 Talence, France
b Université Moulay Ismaïl, Faculté des Sciences, Département de Géologie, BP 11201 Zitoune, Meknès, Morocco
c Largo T. B. Barra, 4, 71022 Ascoli Satriano (FG), Italy
d Department of Environmental and Geographical Sciences, Manchester Metropolitan University, Chester Street, Manchester M1 5GD, UK
e Research School of Earth Sciences, The Australian National University, Canberra ACT 0200, Australia
f Department of Human Evolutionary Biology, Harvard University, 11 Divinity Avenue, Cambridge MA 02138, USA
g Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Deutscher Platz 6, 04103 Leipzig, Germany
h European Synchrotron Radiation Facility, 6 rue Jules Horowitz, BP 220, 38046 Grenoble Cedex, France
i Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Deutscher Platz 6, 04103 Leipzig, Germany
j Research School of Earth Sciences, The Australian National University, Canberra ACT 0200, Australia
k Department of Environmental and Geographical Sciences, Manchester Metropolitan University, Chester Street, Manchester M1 5GD, UK
l Largo T. B. Barra, 4, 71022 Ascoli Satriano (FG), Italy
m Université Paul Valéry Montpellier III, UMR 5199 PACEA, IPGQ, Bât. B18, av. des Facultés, 33405 Talence, France
n Université Paul Valéry Montpellier III, UMR 5140 “Archéologie des sociétés méditerranéennes”, route de Mende, 34199 Montpellier, France

A R T I C L E   I N F O

Article history:
Available online 15 March 2010

A B S T R A C T

The Thomas Quarry I locality was made famous in 1969 with the discovery of a human half-mandible in a cave. In 1985, further investigations revealed the presence of a Lower Acheulean assemblage in lower units of the section. From 1988 onwards, modern controlled excavations took place within the framework of the Franco-Moroccan co-operative project “Casablanca”. Acheulean artefacts, a rich mammalian fauna and four hominid teeth have been excavated from the cave. The faunal set indicates an open woodland environment. Carcasses were processed by carnivores, but cut-marks are absent, which raises the question of any human role in the bone accumulations. Stone knapping was mainly oriented towards flake production and a few bifaces have been imported into the site. Laser ablation ICP-MS dating combining the ESR and U-series data for the modelling of the U-uptake has given an US/ESR age of 382 ka for a human premolar while new OSL measurements yielded an age of 420 ± 34 ka for sediments immediately above the dated tooth and 391 ± 32 ka below. Nevertheless, biostratigraphy and lithostratigraphy point towards a greater antiquity.

© 2010 Elsevier Ltd and INQUA. All rights reserved.

The contribution of Africa to the first European settlements (Bar-Yosef and Belfer-Cohen, 2001; Aguirre and Carbonell, 2001) has been strongly challenged by the recent discoveries in Spain (Carbonel et al., 2005, 2008; Parés et al., 2006). Thus the potential role of Africa in the first occupation of Europe is progressively minored, sometimes abandoned or strictly reduced to a contribution to the Acheulean dispersion at the beginning of the Middle Pleistocene. However, Al Maghreb Al Aqsa (Morocco) occupies a key position at the western extremity of North Africa, to explore the hypothesis of ancient crossings of the Strait of Gibraltar and their potential contribution to the peopling of Western Europe. Although a very ancient presence is argued in northern Algeria (Sahnouni et al., 2002; Geraads et al., 2004; Chaid-Saoudi et al., 2006; Sahnouni, 2006) Morocco stands as a privileged area to study the different stages of African Acheulean evolution far from its eastern origins. Moreover, apart from Tighenif in Algeria, Morocco yields an outstanding record of Pleistocene hominids and several of the Middle Pleistocene ones have been discovered in the prehistoric sites of Casablanca.

A joint Morocco-France research program began in 1978 in Casablanca area, which is well known for its prehistoric Heritage...
and its well preserved quaternary sequences (Biberson, 1961a,b) (Fig. 1). This has particularly allowed the stratigraphic reappraisal of
the classical localities and the discovery of new and important
palaeontological sites in the older part of the sequence, dated at 2.4
and 5.5 Ma. Several excavations were carried on in classical and
newly discovered prehistoric sites: Grotte des Rhinicéros at Oulad
Hamida 1 Quarry, Grotte des Ours and Cap Chatelier at Sidi
Abderrahmane, Sidi Abderrahmane-Extension, Thomas Quarry I,
Grotte des Félins and Grotte des Gazelles at Dar Bou Azza (Raynal
Between Wadi Mellah to the Northeast and Dar Bou Azza to the
Southwest, the hinterland of Casablanca is characterised by a series
of large barrier systems sub-parallel to the present beach (Fig. 2A).
Intertidal depositional units, dune formations characteristic of
regressive sequences, alteration facies (karsts, palaeosoils) and
reworked deposits are associated with each of these morphological
units. Stepped from 180 m above sea level to the present zero, they
form the long “quaternary sequence” of Casablanca (Biberson,
1961a; Stearns, 1978). Since the final Miocene, the long sequence
of Casablanca represents an exceptional register of the global
oceanic level variations relative to the fluctuations of the global
 glaciation in the high latitudes. The age estimates for the different
phases of this sequence have been established by various methods;
lithostratigraphy, biostratigraphy, absolute dating (OSL, ESR),
palaeomagnetism and aminostratigraphy (Texier et al., 1985, 1987,
1994; Occhietti et al., 1993, 2002; El Graoui, 1994; Lefèvre et al.,
1994; Raynal et al., 1990, 1999, Rhodes et al., 2006). The succes-
sion has been particularly detailed for the last one million years and
several morpho-stratigraphic units (MSU) have been defined, each
including several sub-units (Fig. 2 B) (Texier et al., 1994, 2002;
Lefèvre, 2000; Lefèvre and Raynal, 2002).
First investigated by P. Biberson (1961a), Thomas Quarry I was
re-examined in 1985 and investigations revealed the presence of
a Lower Acheulean assemblage in marly limestones at the bottom of
the section (Raynal and Texier, 1989). But it was only from 1988
onwards that modern controlled excavations have been undertaken
in the lower deposits and later extended to a complex of caves
preserved in the north-eastern wall of the quarry. One of these
caves was made famous in 1969 with the discovery by Ph. Beriro of
a half-mandible, first attributed to *Atlanthropus mauritanicus* by
Ennouchi (1969), but more recently considered as a representative
of *Homo rhodesiensis* (Hublin, 2001). This fossil hominid was
associated with lithic artefacts and fauna (Geraads et al., 1980).
Between 1994 and 2008, new hominid fossils have been discovered

---

**Fig. 1.** Location map and position of the main Lower Palaeolithic sites excavated at Casablanca (A). 1, Sidi Abderrahmane Grande Exploitation. 2, Sidi Abderrahmane-Cunette with Cap Chatelier and Bears Cave. 3, Sidi Abderrahmane-Extension. 4, STIC Quarry. 5, Thomas Quarry I. 6, Thomas III Cave. 7, Thomas III “fissures”. 8, Oulad Hamida 1 Grotte des Rhinocéros.
in the cave associated with a lithic assemblage and a rich fauna and microfauna.

1. Stratigraphy and microfacies in Thomas Quarry Hominid Cave (GH)

The stratigraphy of Thomas I Quarry is complex (Fig. 2B). It represents several major episodes of coastal sedimentation that are dated to the final Lower and early Middle Pleistocene on the basis of a detailed regional lithostratigraphical and microfaciological study and form the Oulad Hamida Morpho-stratigraphic Unit. Within this MSU, some lithostratigraphic units fossilize a polyphase paleo-shoreline in which caves have developed. A continental sediments series (Fig. 3) dated to the Middle and Upper Pleistocene on lithostratigraphical and biochronological evidence (Geraads, 1980, 2002; Hossini, 2002) and by OSL (Rhodes et al., 2006) is preserved in the Hominid Cave (GH).

GH general stratigraphy shows at the top a red complex with abundant microfauna (stratigraphic unit 1). Below this, a multilayer dripstone floor interbedded with loose red sands (stratigraphic unit 2–3) caps the lower stratigraphic units (4 and 5). Stratigraphic unit 4 contains artefacts, fauna and hominid fossils and rests on collapsed eolianite blocks imbedded in coarse sands which form stratigraphic unit 5; this lowermost intertidal unit fossilize a notch in the polyphase shoreline (Raynal et al., 1995, 2001, 2002).

Detailed microstratigraphy of unit 4 reveals a complex history for this fossiliferous bed. The bottom of unit 4 comprises well-sorted bioclastic and quartzose sands that are cemented by calcitic crystals which coarsen toward the centers of packing voids. Systaxial calcite crystals are seen around echinoderm fragments (Fig. 4). Bivalves are partially dissolved and recrystallized; a micritic envelope underlines their original forms. The calcitic cement as well as the sedimentary material are affected by large dissolution voids (Fig. 3). Some clayey features, far less abundant than in upper sample, are present; they correspond to grain coatings, to small aggregates occurring in packing voids or to weathered bioclasts. Rare red soil aggregates are also visible. The sedimentary material mainly comes from the reworking of littoral deposits (possibly
After a weak weathering episode that occurred either before reworking or inside the karst, a lithification phase in freshwater phreatic conditions took place and a dissolution episode caused the formation of large voids. The rare soil aggregates originate from the ground surface and were probably entrained into the cavity at the same time as the rest of the sediment.

The main part of unit 4 is composed of bioclastic and quartzose sands. These are well sorted (mean diameter: 200–250 microns) and are associated to more or less abundant red clays that coat grains or make up small aggregates in packing voids (Fig. 5). All these components are cemented by a microspar formed in freshwater vadose conditions. Bioclasts mainly include bivalve and echinoderm fragments as well as peloïds. Most of the bivalves are dissolved and are surrounded by a micritic envelope. Quartz grains are rather numerous and frequently rounded. Some are ferruginized or etched. Some bone fragments are present. The well-graded sorting as well as the mineralogical and petrographical constitution of the sediment indicate that it probably derives from loose dune deposits. Clays associated with these sediments could be due to an in situ weathering of the sedimentary material or/and were brought into the karst by turbid waters. Bone fragments can be related to karst fauna, may have been entrained in the cave at the same time than the sediment, or can attest to an anthropic activity. Lithification achieved in freshwater vadose conditions corresponds to the last diagenetic phase recorded in thin section.

The fossiliferous bed ends with a massive lithofacies (unit 4) overlaid by a bedded lithofacies (units 3 and 2). The massive facies is composed of quartzose sands associated to a clayey plasma. It comprises two juxtaposed areas: 1) dark red areas displaying a porphyric c/f related distribution and a fissural porosity, 2) lighter coloured areas with a gefuric c/f related distribution. The latter seems to derive from the former by washing. The bedded facies...
corresponds to laminae of sorted sands intercalated with massive clayey sands identical to those described above (Fig. 6). Thin clayey coatings are observed around the sand grains of laminae. Sands are mainly composed of (usually etched) quartz and rare gлаucite grains. Numerous gastropod fragments are scattered throughout the sediment. Some calcarenite lithoclasts that have recorded a complex story are also visible. Indeed, included in a mosaic of equant calcite, they comprise recrystallized bioclasts and quartz grains coated by thick micritic cutans. Biologic voids are rather numerous. From their granulometric (clayey sands), mineralogic (mainly composed of often-etched quartz grains) and colorimetric (red) characteristics as well as their malacological content (numerous gastropods), these deposits can be related to the so-called Limons Rouges Formation (Raynal and Texier, 1984; Texier et al., 2002), which is widespread throughout northwest Morocco and is present at the ground surface above the site. These cave deposits probably come from the ground surface by collapse and/or disaggregation of cavity walls.

2. Lithics from GH stratigraphic unit 4

The lithic assemblage recovered by recent excavations in GH stratigraphic unit 4 is similar to the series collected at the time of the discovery of the first Homo fossil in 1969 (Geraads et al., 1980). It is manufactured mainly on various quartzites available close to the site as cobbles of small to medium size and rare blocks as well as a few flint nodules derived from the phosphatic plateau in the hinterland of the Meseta and collected from beach deposits in secondary position. It consists of chopper-cores (mainly unifacial unidirectional cores with a retouched cutting edge) and cores, semi-cortical flakes obtained by direct and bipolar flaking, along with rare handaxes made from large flake or from flat cobbles (Fig. 7: 5; Fig. 8), handaxe-like cores, hammerstones and anvils (Fig. 7). A simplified inventory of the components of the lithic assemblage is given in the following Table 1.

Although the production of flakes was the major objective reflected by the quartzite assemblage, very few flakes have been recovered from the recent excavations. Because of their deficit, the flaking methods have been identified through the analysis of the cores.

Unifacial unidirectional flaking (Fig. 7: 1, 4; Fig. 9: 1, 6). The category of cores with a single flaked surface and unidirectional removals (75) accounts for a majority of the cores. The flaking surfaces frequently possess a distinctly convex profile. Most of these cores (65) exhibit a natural striking platform. Nine cores display one or more removals that occurred on a natural striking platform prior to the detachment of flakes from the flaked surface.

Unifacial bipolar flaking (Fig. 7: 2). Nine flat cobbles and one parallelepiedal cobble have been flaked on the transversal plan adopting the axial bipolar technique on anvil.

Unifacial centripetal/cordial flaking (Fig. 9: 4). This set of cores is represented by five small cores presenting a centripetal or cordal exploitation of the flaking surface and a peripheral natural or rectified striking platform. Several elements link these cores to the discoidal flaking technique that broadens the variability of this method which has been documented for other geochronological contexts (Terradas, 2003). The flaking surface of one core present a flake negative scar similar to that of a preferential flake (Fig. 7: 3).

Bifacial flaking (Fig. 7: 5; Fig. 9: 2). Five of the cores have two flaking surfaces. Alternating use of faces can be identified on four cores on which the two surfaces were successively used as flaking surfaces and as striking platforms to produce several series of flakes. One core has been independently flaked on two surfaces not adjacent to each other.

Peripheral unidirectional flaking (Fig. 9: 3). Four cores have been exploited along the peripheral surface by unidirectional flake removals from a flat natural striking surface.

Mixed flaking (Fig. 9: 5). One core exhibits multifacial unidirectional flaking as a first usage phase followed by bifacial alternate flaking in a second phase.

Simple flaking. 24 cores displaying one or two isolated flake scars have been ascribed to simple flaking.

Flake production is also the only objective of flint core knapping. The blanks used are small pebbles flaked preferentially on a single surface using unidirectional or bipolar removals. In one example the lower face of a flake has been flaked using a series of centripetal removals. Only one was exploited on several surfaces using multidirectional removals (Fig. 9: 7).

The number of flakes is extremely limited in comparison to that of the cores (quartzite and flint) and this was already the case for the series discovered before our excavations (Geraads et al., 1980). Most of them are first flakes extracted from cobbles and pebbles. One first flake has been retouched on its lateral and distal edges. Partially cortical flakes present a cortical but and one or two negative scars on the upper face. Quartzite flakes produced during the full flaking phase bear one or two series of unidirectional or orthogonal removals and two of them are angle flakes from cores with orthogonal plans. The butts are generally flat, rarely dihedral. One flint flake presents a faceted butt and one series of centripetal negative scars on the upper face.

Stone knapping was obviously mainly oriented towards flake production and a part of these was taken out of the excavated area, while retouched cutting edges were shaped on some cores and a bifacial chaîne opératoire was processed (out of the cave) to obtain large cutting tools and heavy pointed tool imported in the site. Subsistence activities probably took place in another part or outside the cave and were devoted to heavy/light-duty butchery, even if no cut-marks have been identified on bones (see infra chapter 4).

Like the upper occupations of the nearby Rhinoceros Cave (GDR) in Oulad Hamida 1 Quarry (Raynal et al., 1993), the GH lithic series represents an original facies of the regional recent Acheulean

![Fig. 6. Thomas I, Hominid Cave, units 3–2, sample 95014. Photomicrograph (PPL). Lamina composed of sorted quartzose grains is superimposed over massive red clayey sands. Thin clayey cutans coat the quartz grains of the lamina. (Frame length: 3.9 mm). Photo J.P. Texier. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).](image-url)
In both sites, the presence of a bifacial chaîne opératoire excludes them from the core and flakes assemblages category. There are very few series of similar age in an indisputable stratigraphic context to be compared with them elsewhere in Morocco and more generally in North Africa. However, in Mediterranean Europe, assemblages with no or rare handaxes from Atapuerca (Carbonell et al., 1995), the Caune de l’Arago cave in southern France (Lumley and Barsky, 2004) and from Notarchirico in southern Italia (Lefèvre et al., 2002 and this volume) present interesting similarities in composition and age.

3. Fauna from GH stratigraphic unit 4

A rich mammalian macrofauna supplemented by the addition of a few reptiles and birds is associated with the lithics in GH stratigraphic unit 4:

Fig. 7. Thomas 1, Hominid Cave, lithic assemblage, quartzite. 1 and 4: chopper-cores. 2: bipolar truncated pebble. 3: core with preferential flake removal. 5: handaxe on cobble. 6: handaxe like core. Drawings by M. Hirbec-Raynal.
Mammals

Primates
- Theropithecus oswaldi – giant gelada baboon
- Homo sp.

Carnivores
- Herpestes ichneumon - mongoose
- Hyaena hyaena - hyena
- Felis cf. libyca – wild cat
- Panthera sp.
- “Canis” sp. nov. - canid
- Vulpes vulpes - fox
- Lycaon magnus – hunting dog
- Mellivora capensis – honey badger
- Lutra sp. - otter
- Ursus biberni - bear
- Monachus sp. - seal

Artiodactyls
- Kolpchoerus sp.
- Phacochoerus africanus - warthog
- Bovini - aurochs or long-horned buffalo
- Hippotragini - oryx?
- Alcelaphini cf. Pammularius - antelope
- Connochaetes taurinus progna - wildebeest
- Gazella cf. atlantica

Perissodactyls
- Equus cf. mauritanicus - zebra
- Ceratotherium mauritanicum – white rhino

Rodents
- Hystrix cristata - porcupine
- Paraethomys tighennifae
- Praomys darelbeidae
- Mus sp. - mouse
- Gerbillus cf. campestris - gerbil
- Gerbillus grandis
- Meriones cf. maghrebianus - gerbil
- Meriones cf. maximus
- Ellobius cf. atlanticus
- Eliomys sp. - garden dormouse

Lagomorphs
- Lagomorpha indet.

Insectivores
- Crocidura sp. - shrew

Chiropteres
- Chiroptera indet.

Reptiles
- Testudo sp. - tortoise

Aves indet.

Table 1
Components of the lithic assemblage.

<table>
<thead>
<tr>
<th>Category</th>
<th>Quartzite</th>
<th>Flint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cores</td>
<td>122</td>
<td>6</td>
</tr>
<tr>
<td>Debris of cores</td>
<td>3</td>
<td>–</td>
</tr>
<tr>
<td>Flakes</td>
<td>25</td>
<td>–</td>
</tr>
<tr>
<td>Small flakes &gt; 3 cm</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>Bilaces</td>
<td>2</td>
<td>–</td>
</tr>
<tr>
<td>Debris</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>Hammerstones</td>
<td>27</td>
<td>–</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>213</strong></td>
<td><strong>37</strong></td>
</tr>
</tbody>
</table>

Most species are probably identical with those from the nearby “Grotte des Rhinocéros” of Oulad Hamida 1 Quarry (OH1-GDR) (Raynal et al., 1993), whose age lies between 435 ± 85 and 737 ± 129 ka (Rhodes et al., 1994, 2006), but some elements suggest that the assemblage from GH stratigraphic unit 4 is earlier.

The abundance and diversity of carnivores attest to their use of the cave. The most common species is a middle-size canid, with enlarged crushing part of the dentition, as in the genus Nyctereutes that is mostly Eurasian but also has some Plio-Pleistocene African representatives. The same canid occurs at GDR, and also in the late Lower to early Middle Pleistocene site of Tighenif (Geraads, 2008). Two other canids are also present: a small fox and the hunting dog Lycaon, a genus seldom found as a fossil, which is also present at
These faunal similarities with this earlier Algerian site push the age of the Moroccan sites towards the early Middle Pleistocene. The bear is close to that found in the European Middle Pleistocene, but differs in its tooth proportions, and could be of an endemic lineage, rooted in the Late Pliocene Ahl al Oughlam Ursus (Geraads, 1997, 2006; Geraads et al., 1998). Although most carnivore species are identical with those of Tighenif, a large felid is a significant exception. By its dimensions that are intermediate between those of the leopard and lion, it is perhaps comparable to the late Lower Pleistocene to early Middle Pleistocene European jaguar, Panthera onca gombaszoegensis. However, this species has never been reported from Africa.

Suids are rare and consist mostly of the warthog, but a molar piece found in 2006 is close to Kolpochoerus, showing that this genus lingered in North Africa later than level L of Thomas I, which was previously thought to be its last occurrence in Casablanca. Thus, this discovery increases the faunal similarity between these levels also pushing the age of the Hominid level towards the Lower Pleistocene.

Precise identifications are difficult for bovids because the material is heavily broken, but there is no doubt that the dominant forms are gazelles and alcelaphines that both indicate an open environment, as does the presence of the zebra Equus cf. mauritanicus and of the rhino Ceratotherium among Perissodactyls. The occurrence, as the single species of non-human Primate, of the ground-dwelling giant gelada baboon Theropithecus, of which Thomas I is one of the latest occurrences in North Africa, is yet another indicator of generally poor tree cover.

GH stratigraphic unit 4 is poor in micromammals. The faunal list is similar to that of OH1-GDR (Geraads, 1994), but there are some significant differences (Geraads, 2002). Eliomys (garden dormouse) is much smaller than E. darelbeidae from OH1-GDR. Two lower m1s of Meriones are also slightly smaller than those of M. maghrebianus from OH1-GDR and later levels of Thomas I GH. A first lower molar of Ellobius has a notched anterior lobe, whereas it is always regularly rounded in later levels of Thomas GH and OH1-GDR, so this is probably a remnant of the folding that is present in Ellobius africanaus of Tighenif. Thus, GH stratigraphic unit 4 is clearly distinct from OH1-GDR, and the smaller size of Eliomys and Meriones, as well as the morphology of the Ellobius m1, suggest that it is earlier than those sites.

Therefore, the fauna from GH stratigraphic unit 4 points to an age earlier than GDR, and probably younger than Tighenif, but the remoteness of this latter site, its distance from the seashore, and the fact that it is an open-air site may account for some of the differences.
4. Taphonomy of the faunal assemblage from GH stratigraphic unit 4

Carnivores were abundant in the macrofauna collected from the central part of the cave during excavations prior to 2005 (43% of number of identified specimens, NISP) while antelopes (25% of NISP) and gazelles (20% of NISP) dominated among herbivores. Carnivores were considered as the first agent for bone accumulation (Bernoussi, 1997). The taphonomic study of the megafauna of unit 4 from recent excavations in the south-eastern part of the cave (2005—2009) involves 921 identifiable remains and 1296 fragments larger than 2 cm (greatest dimension). In the faunal spectrum, gazelles and other antelopes are again dominant among herbivores (respectively 33.5% and 19.6% of NISP) and a middle-size canid, “Canis” sp. nov., dominates the carnivore group (28.6% of NISP) (Table 2). The habits of this animal, whose dentition is comparable to those of the present-day raccoon dog or of the side-stripped jackal, were probably closer to those of an opportunistic scavenger than to those of a predator. Several other mammal genera and species complete the faunal list, in descending order (NISP), for herbivores: the Bovini (6.2%); Equus sp. (0.2%); for rodents: Panthecranium latus (0.5%) and for primates: Homo sp. (0.6%) and T. oswaldi (0.5%).

Although the sample concerns only a part of the excavated level, some remarks must be made about age and skeletal profiles. Apart from gazelles and antelopes, all parts of which are represented, most herbivores are mostly represented by elements of the autopod and by isolated teeth. Axial skeletal material is deficient in all cases. Concerning the ungulate mortality profiles, gazelles and antelopes are documented by every age classes, whereas Bovini, Suidae, Ceratotherium and Equids include juveniles or old specimens. The skeletal and mortality profiles of the large ungulates are characteristic of gathering activities over scavenged carcasses and allow us to refute the hypothesis of a natural origin for the animals. We hypothesize instead that most of the accumulated material results from the selective transportation of limbs. Regarding canids, the virtual absence of deciduous teeth does not support the den hypothesis, but it is impossible to determine the exact cause of this under-representation that may be due to in situ differential preservation (Brain, 1976, 1981; Binford, 1978, 1984; Hill, 1980; Richardson, 1980; Potts, 1983; Klein and Cruz-Uribe, 1984; Blumenshine, 1986; Guadelli, 1989; Lyman, 1994; Fosse, 1996, 1997; Bartram and Marean, 1999).

Apart from encrusted remains (8.3%), the majority of bone surfaces and edges have been preserved from post-depositional alteration. The number of isolated teeth provides a significant bone destruction index (Table 2). In this cave, the articular portions of long bones have been spared from gnawing by big carnivores. The predominance of the middle-size Canid, whose masticatory power is less than that of the hyena is doubtless partly responsible for the preservation of these bone parts. The high index of bone completeness is due to the presence of small joint bones (Table 2). More than 80% of limb shaft fragments have a circumference and a length less than half that of the initial diaphysis. 19.1% of the series bear one or more green bone fractures. Thus, it seems that the recovery of bone marrow was part of the carcass consumption process. Most notches or cortical arcs are associated with tooth marks. Apart one very big ungulate diaphyseal fragment which shows percussion notches, none allow us to associate fractures with a human action (Blumenshine and Selvaggio, 1988, 1991; Villa and Mahieu, 1991; Villa and Bartram, 1996).

19.5% of recorded bones bear carnivore tooth marks (Fig. 10). This proportion is similar to that obtained in fossil hyena dens and is higher than in sites that are just visited by canids (Cruz-Uribe, 1991; Castel, 1999; Monchot, 2005; Coumont, 2006, 2008, 2009; Coumont and Castel, 2007). The distribution of the bite marks on the long bones is homogeneous (Table 3). These proportions, according to experiments made with modern hyenas, indicate the primary action of carnivores on carcasses (Blumenshine, 1988). Some elements, such as bone shafts or teeth of large mammals, could result from the activity of larger predators, such as the hyena. The dimensions of coprolithes also suggest that two different carnivores were using the cave (Fig. 10). About 4% of recorded bones show porcupine tooth marks (Pei, 1938; Brain, 1981; Monchot, 2005; Tong et al., 2008). No cut-marks were found, confirming the virtual absence of human involvement in the making of the assemblage. The state of fragmentation, the presence of the carnivore marks and their distribution on the long bones allow us to attribute the majority of bone modifications to carnivores, and especially to the most common canid in the site, “Canis” sp. nov.

Preliminary taphonomic analysis of the megafauna thus indicates that the carcasses were processed by carnivores. Cut-marks are still absent from this assemblage despite the association with lithic artefacts, which raises the question of any human role in the bone accumulations. Similar cases of accumulations created by carnivores were using the cave (Fig. 10). About 4% of recorded bones show porcupine tooth marks (Pei, 1938; Brain, 1981; Monchot, 2005; Tong et al., 2008). No cut-marks were found, confirming the virtual absence of human involvement in the making of the assemblage. The state of fragmentation, the presence of the carnivore marks and their distribution on the long bones allow us to attribute the majority of bone modifications to carnivores, and especially to the most common canid in the site, “Canis” sp. nov.

<table>
<thead>
<tr>
<th>Taxa (GHTH1D05-09)</th>
<th>MN</th>
<th>%MN</th>
<th>NISP</th>
<th>%NISP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hystrix cristata</td>
<td>3</td>
<td>5.8%</td>
<td>30</td>
<td>4.8%</td>
</tr>
<tr>
<td>RODENTS</td>
<td>3</td>
<td>5.8%</td>
<td>30</td>
<td>4.8%</td>
</tr>
<tr>
<td>Felis cf. lybica</td>
<td>1</td>
<td>1.9%</td>
<td>1</td>
<td>0.2%</td>
</tr>
<tr>
<td>Panthera sp.</td>
<td>1</td>
<td>1.9%</td>
<td>1</td>
<td>0.2%</td>
</tr>
<tr>
<td>Hyaena hyaena</td>
<td>2</td>
<td>3.8%</td>
<td>7</td>
<td>1.1%</td>
</tr>
<tr>
<td>“Canis” sp. nov.</td>
<td>8</td>
<td>15.4%</td>
<td>179</td>
<td>28.6%</td>
</tr>
<tr>
<td>Ursus ibersoni</td>
<td>2</td>
<td>3.8%</td>
<td>12</td>
<td>1.9%</td>
</tr>
<tr>
<td>Mellivora capensis</td>
<td>1</td>
<td>1.9%</td>
<td>1</td>
<td>0.2%</td>
</tr>
<tr>
<td>Monarchus sp.</td>
<td>1</td>
<td>1.9%</td>
<td>1</td>
<td>0.2%</td>
</tr>
<tr>
<td>CARNIVORES</td>
<td>16</td>
<td>30.8%</td>
<td>202</td>
<td>32.3%</td>
</tr>
<tr>
<td>PROBOSCIDIANS</td>
<td>1</td>
<td>1.9%</td>
<td>1</td>
<td>0.2%</td>
</tr>
<tr>
<td>Ceratotherium mauritanicum</td>
<td>1</td>
<td>1.9%</td>
<td>6</td>
<td>1.0%</td>
</tr>
<tr>
<td>Equus sp.</td>
<td>1</td>
<td>1.9%</td>
<td>4</td>
<td>0.6%</td>
</tr>
<tr>
<td>PERISSODACTYLA</td>
<td>2</td>
<td>3.8%</td>
<td>10</td>
<td>1.6%</td>
</tr>
<tr>
<td>Kolochoerus sp.</td>
<td>1</td>
<td>1.9%</td>
<td>1</td>
<td>0.2%</td>
</tr>
<tr>
<td>Phacochoerus africanus</td>
<td>1</td>
<td>1.9%</td>
<td>1</td>
<td>0.2%</td>
</tr>
<tr>
<td>Bovis</td>
<td>5</td>
<td>9.6%</td>
<td>39</td>
<td>6.2%</td>
</tr>
<tr>
<td>Hippopotaginus</td>
<td>1</td>
<td>1.9%</td>
<td>1</td>
<td>0.2%</td>
</tr>
<tr>
<td>Reducini</td>
<td>1</td>
<td>1.9%</td>
<td>1</td>
<td>0.2%</td>
</tr>
<tr>
<td>Alcelaphini</td>
<td>7</td>
<td>13.5%</td>
<td>123</td>
<td>19.5%</td>
</tr>
<tr>
<td>Gazella cf. atlantica</td>
<td>11</td>
<td>21.2%</td>
<td>210</td>
<td>33.3%</td>
</tr>
<tr>
<td>ARKOUTHACLYTA</td>
<td>27</td>
<td>51.9%</td>
<td>376</td>
<td>60.1%</td>
</tr>
<tr>
<td>Homo sp.</td>
<td>2</td>
<td>3.8%</td>
<td>4</td>
<td>0.6%</td>
</tr>
<tr>
<td>Theropithecus oswaldi</td>
<td>1</td>
<td>1.9%</td>
<td>3</td>
<td>0.5%</td>
</tr>
<tr>
<td>PRIMATES</td>
<td>3</td>
<td>5.8%</td>
<td>7</td>
<td>1.1%</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>100.0%</td>
<td>626</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Relative abundance and bone indices for the big fauna (NISP; Number of Identified Specimens; NR; Number of total Remains; MNI; Minimum Number of Individuals per taxon).
artefacts with bones, including human remains, accumulated by predators.

5. Hominid fossils in GH stratigraphic unit 4

Between 1994 and 2005, four teeth of *Homo* were recovered in stratigraphic unit 4, a right third upper premolar (Thl 94 OA 23–24), another right third upper premolar (Thl 95 SA 26 n° 89), a first left upper incisor (Thl 95 SA 26 n° 90) and a left fourth upper premolar (Thl 2005 PA 24 n° 107). The teeth are larger than those of modern humans and show moderate to heavy wear (Fig. 11). The two right upper premolars have a mesiodistal diameter (MD) of 8.5 and 8.7 mm and a vestibulolingual diameter (VL) of 11.8 mm, while for modern populations teeth MD lies between 7.16 and 7.43 mm and VL between 9.49 and 9.67 mm (Keiser, 1990). However, the first left incisor has an MD of 6.3 mm and a VL of 7.5 mm, values similar to those of modern humans.

A fragment of the upper third premolar OA 23–24, previously used for dating (Fig. 12) was analysed to reveal enamel microstructure non-destructively using Phase contrast synchrotron microtomographic imaging. The fragment of enamel was scanned at a voxel size of 0.7 microns (150 mm sample distance, 45 keV, 2000 projections) on the ID 19 beamline, as detailed in Tafforeau and Smith (2008). The microstructure was of good quality, but as of this time we have been unable to determine the long-period line periodicity. The tooth was rebuilt using cyanoacrylate glue and color-matched with dental restorative materials. It was subsequently micro-CT scanned in July 2006 at the MPI-EVA at a voxel size of 13.74 microns (100 KV, 100 µA) as detailed in Olejniczak et al. (2008).

Using VG Studio MAX software, the tooth was reoriented and virtually sectioned to yield a plane through the bucco-lingual cusps (and approximate dentine horns), which was suitable for enamel thickness measurement with Summa Sketch Digitizing Tablet and Sigma Scan software. Wear was corrected for based on the morphology of the remaining enamel crown and enamel-dentine junction profile. The relative enamel thickness of the upper third premolar was calculated as the cross-sectional area of the enamel

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Distribution of tooth marks along the long bone shafts for the three main ungulates (NZ = Number of observable zones).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Epiphyses</td>
</tr>
<tr>
<td></td>
<td>NZc</td>
</tr>
<tr>
<td>Bovini indet.</td>
<td>2</td>
</tr>
<tr>
<td>Alcelaphini indet.</td>
<td>7</td>
</tr>
<tr>
<td>Gazella sp.</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
</tr>
</tbody>
</table>

Fig. 10. 1: Carnivore tooth marks and notch on a Bovini metacarpal. 2; Large carnivore tooth marks on a proximal humerus of a young large herbivore. 3; Large carnivore coprolite (scale = 1 cm). Photos C. Daujeard.
cap divided by the enamel-dentine junction length, which was further subdivided by the square root of the dentine area and multiplied by 100. This was based on Martin’s (1985) index, which is suitable for cross-taxon comparisons. The value was approximately 16.4, which falls in the middle of the modern human range for this tooth type ($x = 17.69$, range = 14.04–22.58, $n = 19$) (Smith et al., 2008).

Potential furrow-type hypoplastic defects (Hillson and Bond, 1997) were noted on the buccal surface of the crown (Fig. 131). It is also possible that this tooth was chipped in vivo, and that the edges of the enamel were smoothed by microwear during use. A detailed histological study may reveal which of these possibilities are correct. Additionally, the interproximal facet showed subvertical grooves likely due to the vertical movement of teeth during occlusion (reviewed in Hillson, 1996) (Fig. 132).

Enamel microstructure among Paleolithic hominins has yet to prove taxonomically distinctive. Nor is the presence of hypoplasias or interproximal wear. Due to the advanced degree of wear of all four teeth, it was not possible to estimate crown formation times. In summary, the enamel thickness of the Thomas I premolar falls within modern human ranges, as do molar teeth from Thomas III (unpublished data). Unfortunately there are no published data on this variable in other fossil hominin premolars.

6. ICP-MS dating applied to an Hominid tooth from GH stratigraphic unit 4

The first right upper premolar discovered in 1994 (ThI 94 OA 23–24) has been dated using laser ablation ICP-MS. The dating procedures followed those applied to the Banyoles mandible (Grün et al., 2006). An enamel fragment with attached dentine was removed from the tooth. The two dental tissues separated during the extraction process. Both were analysed for uranium and thorium using laser ablation ICP-MS (Eggins et al., 2003, 2005). Two
laser ablation tracks across the enamel and dentine yielded concentration values of 4 ± 1 and 88.5 ± 6.3 ppm U for enamel and dentine, respectively. U-series isotopes on the dentine were obtained by laser drilling, two analyses yielding average values of 234U/238U = 1.090 ± 0.005 and 230Th/234U = 0.69 ± 0.02, corresponding to an apparent U-series age of 124±7 ka. For ESR dose analysis, the fragment was mounted in a goniometer and successively irradiated in 11 steps to 3689 Gy. Radiation doses were monitored with alanine dosimeters and evaluated against a calibrated dosimeter set (A. Wieser, Messtechnik, München). Each ESR measurement consisted of a set of 36 angular measurements (over 360° in 10° steps). A dose value of 691 ± 30 Gy was obtained by merging all angular spectra and fitting the natural spectrum back into the irradiated ones. (Grün, 2002; Grün et al., 2008).

For the assessment of the environmental dose rate, two sediment samples were collected immediately above and below the original location of the tooth and were analysed by neutron activation analysis. The average concentrations of the radioactive elements in those two sediment samples were 1.64 ± 0.15 ppm U, 1.75 ± 0.08 ppm Th and 0.29 ± 0.035% K. ThI 94 OA 23–24 was found at a depth of 8.0 ± 0.4 m below the surface. This value was used for the calculation of the cosmic dose rate (Prescott and Hutton, 1994). An earlier OSL study (Rhodes et al., 2006) indicated that the sedimentary sequence at the location was rapidly deposited so that any corrections for initially higher cosmic dose rates would be minor.

For the calculation of the beta dose rate, attenuation values (Marsh, unpublished) were integrated over the cross section of the enamel fragment, yielding an average value of 0.139 ± 0.011. An alpha efficiency of 0.13 ± 0.02 (Grün and Katzenberger-Apel, 1994) was used for the calculation of the internal dose rate. For the assessment of the U-series values of the tooth enamel, we used a 230Th/234U distribution that was measured in situ on the enamel of Thomas III, which had an average 230Th/234U activity ratio that was 10% lower than that extrapolated to the enamel surface. As a consequence, a 230Th/234U ratio of 0.62 ± 0.2 was assumed for the enamel (corresponding to an apparent age of 103±16 ka). Combining the ESR and U-series data for the modelling of the U-uptake (Grün et al., 1988), an US/ESR age of 501±34 ka is obtained (with associated p-values of 1.43 ± 0.59 and 0.75 ± 0.45 for enamel and dentine, respectively).

The sediment samples contained larger lumps of cemented sands, which were used for OSL dating. These lumps were sprayed with black paint, the surface was then removed and quartz was extracted. The OSL measurement followed the procedures applied in previous studies of the Pleistocene successions of Casablanca (Rhodes et al., 2006). The sample above the dated tooth yielded an age of 420 ± 34 ka and that below 391 ± 32 ka. These inverted results are statistically identical and are in agreement with an earlier OSL study, which derived an age estimate of between 360 and 470 ka for the layers containing the Thomas I hominids.

7. Conclusions

The Hominid Cave at Thomas Quarry I is vast, and large parts of its deposit are still under study. This cavity sheltered during the Early Middle Pleistocene a population of hominids and was frequented by different carnivores. Despite a poor tree covered environment an abundant mammal fauna was present in the area and favoured both Hominids and carnivores subsistence. The semi-arid conditions were responsible for complex sedimentation and post-depositionnal processes in the cave. The absolute dates obtained first by OSL placed the stratigraphic unit containing fossil hominids between 360 and 470 ka. The age has been more recently pushed towards 500 ka by laser ablation ICP-MS. Biostratigraphy and lithostratigraphy point nevertheless towards a greater antiquity.

Hominids manufactured a lithic assemblage which represents an original facies of the regional Acheulean in which large cutting tools play a minor role. This assemblage is broadly similar with cores-and-flakes and no or rare handaxes assemblages which are present in Atlantic Morocco and southern Europe at the same time. This undoubtedly throws a new light upon the still pending question of the early Mediterranean straits crossings.

With new hominid fossils brought to light since 1994, Thomas Quarry I Hominid Cave is one of the very rare key African sites for studying individuals and techno-economic behaviors which relate to a crucial period of human evolution during which North African and European populations, facing each other on both sides of the Mediterranean and potentially exchanging genes and technics, started to diverge biologically.

Acknowledgement

The authors thank anonymous readers whose comments allowed us to improve this paper and Peter Bindon for the revision of the English language. Excavations at Casablanca were funded by Ministère des Affaires Culturelles du Royaume of Morocco, Ministère des Affaires étrangères et européennes of France, Région Aquitaine and the Department of Human Evolution of Max Planck Institute for Evolutionary Anthropology at Leipzig.

References


