



HAL
open science

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

Jean-Paul Raynal, Fatima-Zohra Sbihi Alaoui, Abderrahim Mohib, Mohssine El Graoui, David Lefevre, Pierre-Jean Texier, Denis Geraads, Jean-Jacques Hublin, Tanya M. Smith, Paul Tafforeau, et al.

► **To cite this version:**

Jean-Paul Raynal, Fatima-Zohra Sbihi Alaoui, Abderrahim Mohib, Mohssine El Graoui, David Lefevre, et al. Hominid Cave at Thomas Quarry I (Casablanca, Morocco): Recent findings and their context. *Quaternary International*, 2010, 223-224, pp.369-382. 10.1016/j.quaint.2010.03.011 . halshs-00475759

HAL Id: halshs-00475759

<https://shs.hal.science/halshs-00475759v1>

Submitted on 27 Jan 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

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 Grünⁱ, Edward J. Rhodes^j, Stephen Egginsⁱ,
Camille Daujeard^a, Paul Fernandes^a, Rosalia Gallotti^k, Saïda Hossini^l, Alain Queffelec^a

^aUniversité Bordeaux I Sciences et technologies, UMR 5199 PACEA, IPGQ, Bât. B18, av. des Facultés, 33405 Talence, France

^bDirection du Patrimoine, Institut National des Sciences de l'Archéologie et du Patrimoine, Rabat, Morocco

^cUniversité Paul Valéry Montpellier III, UMR 5140 "Archéologie des sociétés méditerranéennes", route de Mende, 34199 Montpellier, France

^dCNRS UPR 2147, 44 rue de l'Amiral Mouchez, 75014 Paris, France

^eDepartment of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Deutscher Platz 6, 04103 Leipzig, Germany

^fDepartment of Human Evolutionary Biology, Harvard University, 11 Divinity Avenue, Cambridge MA 02138, USA

^gLaboratoire de Géobiologie, Biochronologie et Paléontologie Humaine, UMR 6046, CNRS, Université de Poitiers, 40 Avenue du Recteur Pineau, 86022 Poitiers Cedex, France

^hEuropean Synchrotron Radiation Facility, 6 rue Jules Horowitz, BP 220, 38046 Grenoble Cedex, France

ⁱResearch School of Earth Sciences, The Australian National University, Canberra ACT 0200, Australia

^jDepartment of Environmental and Geographical Sciences, Manchester Metropolitan University, Chester Street, Manchester M1 5GD, UK

^kLargo T. B. Barra, 4, 71022 Ascoli Satriano (FG), Italy

^lUniversité Moulay Ismail, Faculté des Sciences, Département de Géologie, BP 11201 Zitoune, Meknès, Morocco

Abstract

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 501±9476 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.

Introduction

The contribution of Africa to the first European settlements (BarYosef and Belfer-Cohen, 2001; Aguirre and Carbonell, 2001) has been strongly challenged by the Out of Asia hypothesis strengthened 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 Rhinocéros at Oulad Hamida 1 Quarry, Grotte des Ours and Cap Chatelier at Sidi Abderrahmane, Sidi Abderrahmane-Extension, Thomas Quarry I, Grotte des Félines and Grotte des Gazelles at Dar Bou Azza (Raynal et al., 1990, 1993, 1995, 1999, 2001, 2002, 2008) (Fig. 1A).

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 amino-chronology (Texier et al., 1985, 1987, 1994; Occhiotti et al., 1993, 2002; El Graoui, 1994; Lefèvre et al., 1994; Raynal et al., 1990, 1999, Rhodes et al., 2006). The succession 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 in the cave associated with a lithic assemblage and a rich fauna and microfauna.

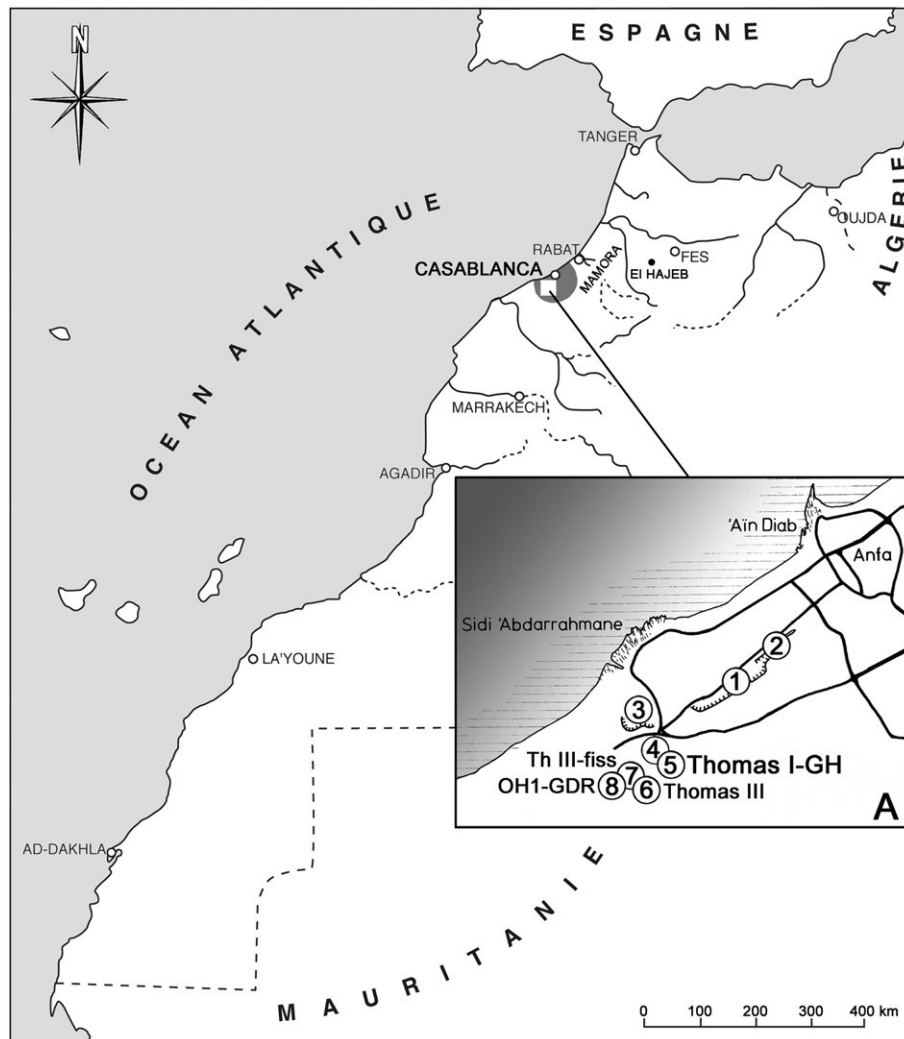


Fig. 1. Location map and position of the main Lower Palaeolithic sites excavated at Casablanca (A). 1, Sidi Abderrahmane Grande Exploitation. 2, Sidi Abderrahmane-Cunette with Cap Chatelier and Bears Cave. 3, Sidi Abderrahmane-Extension. 4, STIC Quarry. 5, Thomas Quarry I. 6, Thomas III Cave. 7, Thomas III "fissures". 8, Oulad Hamida 1 Grotte des Rhinocéros.

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 Morphostratigraphic Unit. Within this MSU, some lithostratigraphic units fossilize a polyphase paleoshoreline 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 2e3) 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 wellsorted bioclastic and quartzose sands that are cemented by calcitic crystals which

coarsen toward the centers of packing voids. Syntaxial 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 intertidal). 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: 200e250 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 peloids. 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 geyuric 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 glauconite 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 mudflow processes (massive facies). Liquid flows have then brought about the washing and the sorting of the initial sedimentary material giving rise to the light coloured areas and the bedded facies. The calcareous lithoclasts are probably the result of the disaggregation of cavity walls.

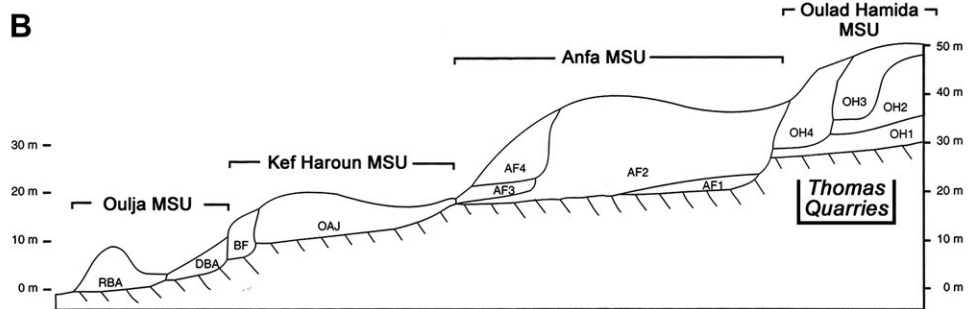
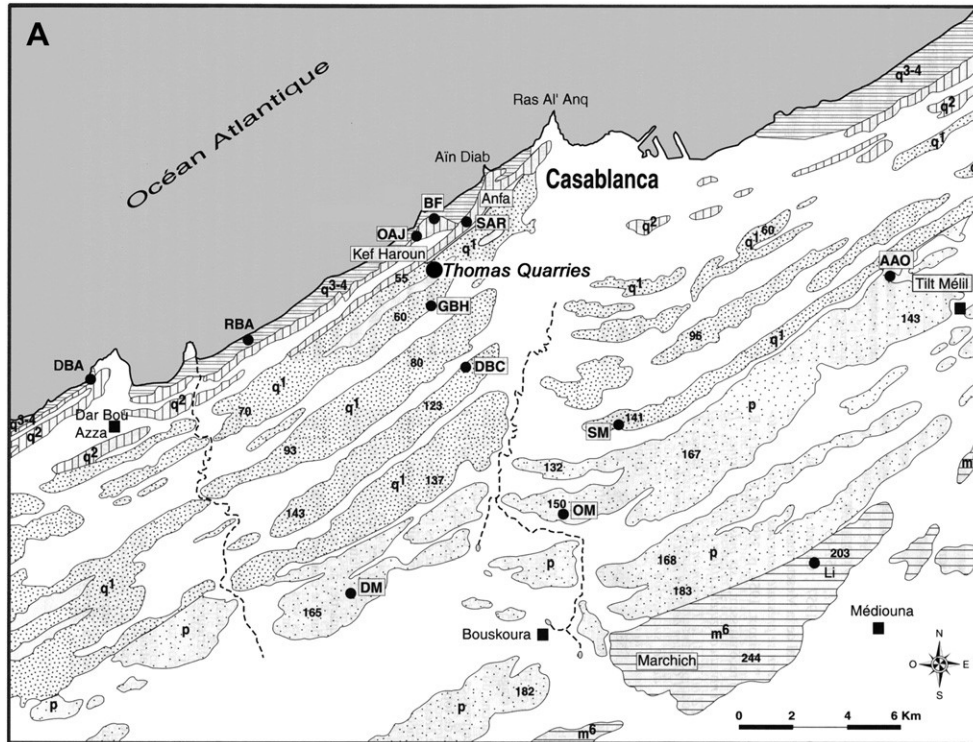


Fig. 2. A; Mio-Plio-Pleistocene formations of the Casablanca area. q3e4, Upper Pleistocene and Holocene. q2, Middle Pleistocene. q1, Lower Pleistocene. p, Pliocene. m6, final Miocene (Messinian). Localities are; Thomas quarries (Thomas I, Thomas III, Oulad Hamida 1); AAO, Ahl Al Oughlam; BF, Bir Feghloul; DBA, Bar Bou Azza; DBC, Dar Bouchaïb Oulad Caïla; DM, Douar Mouhak; GBH, Ghandour Ben Habib; Li, Lissasfa; OAJ, Oulad Aj J'mel; OH, Oulad Hamida; OM, Oulad Malik; RBA, Reddad Ben Ali; SAR, Sidi Abderrahmane quarries; SM, Sidi Messaoud. B; Synthetic morpho-lithostratigraphy of Quaternary formations in the Sidi Abderrahmane and Thomas quarries area. MSU; morpho-lithostratigraphic units (after Texier et al., 1994, 2002; Lefèvre, 2000; Lefèvre and Raynal, 2002).

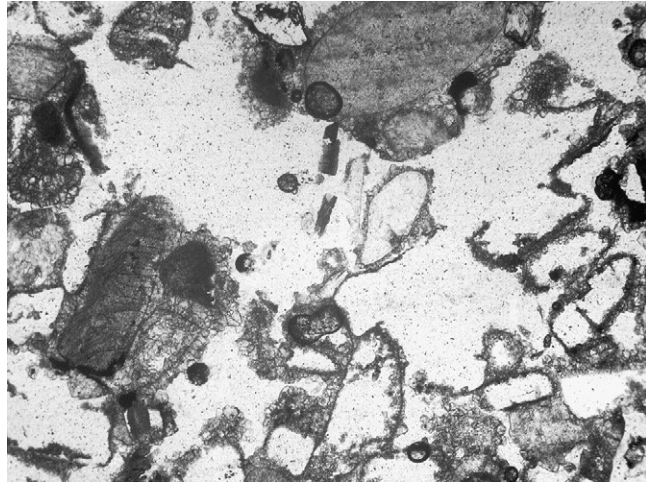


Fig. 4. Thomas I, Hominid Cave, unit 4 bottom, sample GH28-08. Photomicrograph (PPL). Large dissolution voids develop at the expense of the calcitic cement and bioclasts. A micritic envelope underlines the original form of bivalves. Syntaxial calcite is visible around echinoderm fragments. Some argilized bioclasts are present. (Frame length; 2 mm). Photo J.P. Texier.

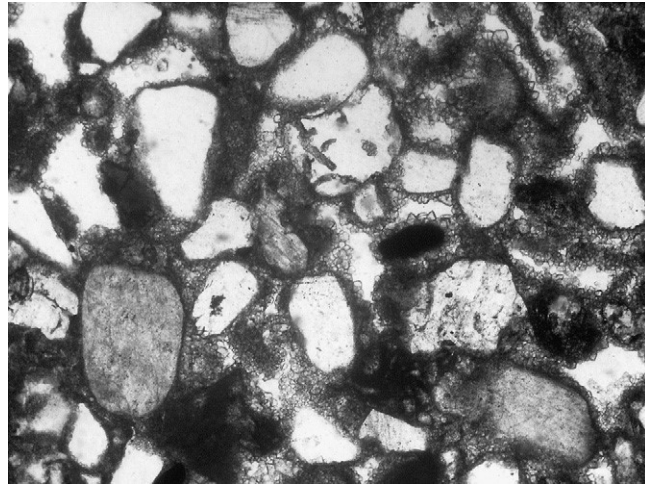


Fig. 5. Thomas I, Hominid Cave, unit 4 middle part, sample 95019. Photomicrograph (PPL). Well-sorted bioclasts, peloids and quartz grains are cemented by vadose microspar which partially fills the intergranular voids. Skeletal grains are coated by clays which also form small aggregates in intergranular voids. (Frame length; 1,7 mm). Photo J.P. Texier.

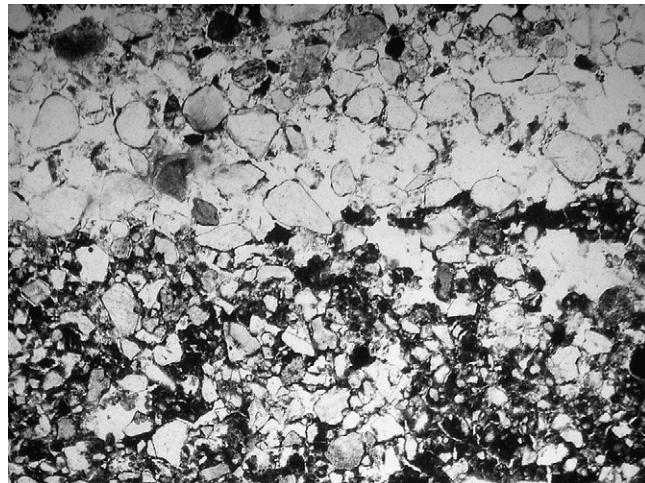


Fig. 6. Thomas I, Hominid Cave, units 3e2, sample 95014. Photomicrograph (PPL). Lamina composed of sorted quartzose grains is superimposed over massive red clayey sands. Thin clayey cutans coat the quartz grains of the lamina. (Frame length; 3,9 mm). Photo J.P. Texier. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

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 parallelepipedal cobble have been flaked on the transversal plan adopting the axial bipolar technique on anvil.

Unifacial centripetal/cordal 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 but 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 (Raynal et al., 2009). 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.

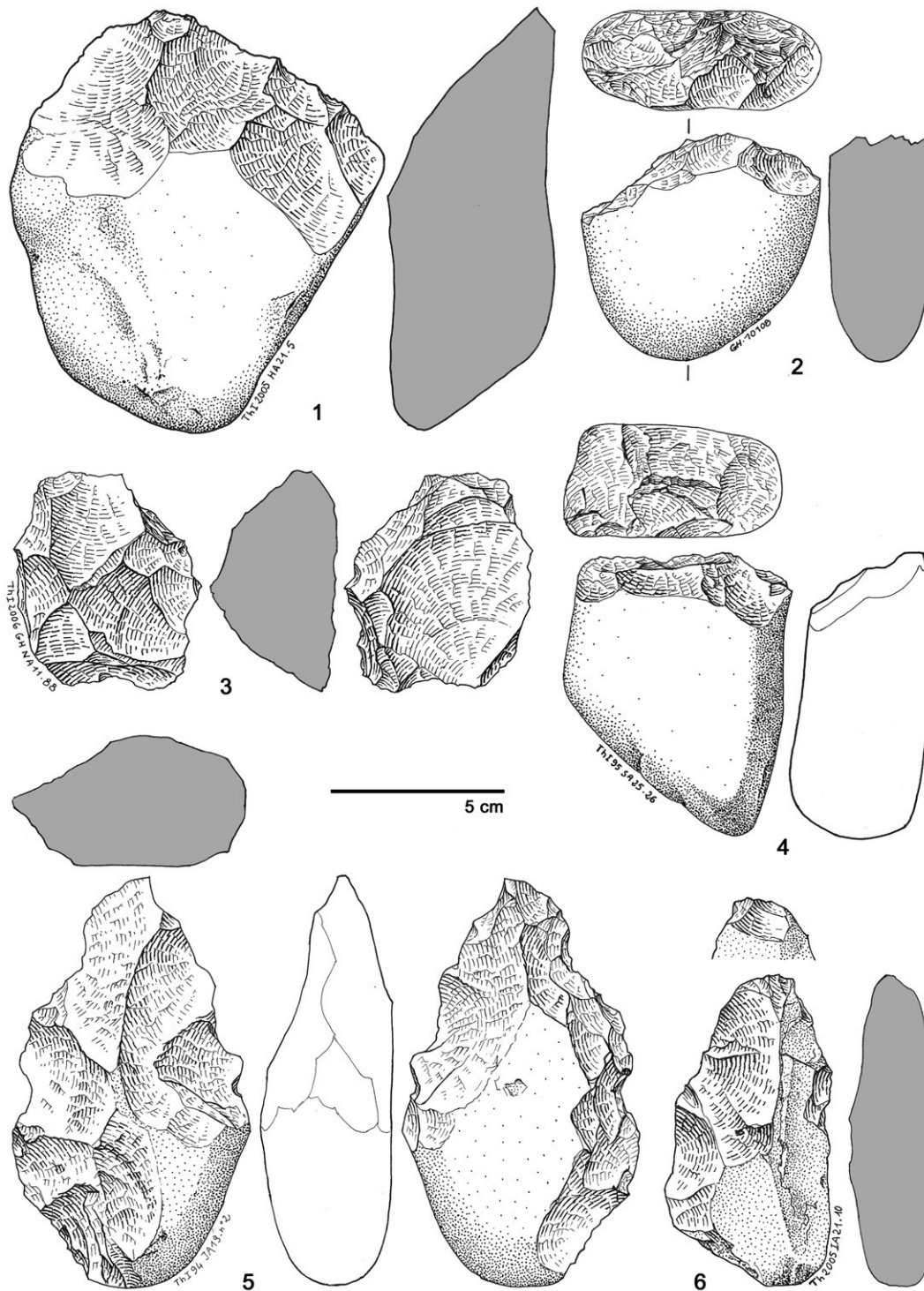


Fig. 7. Thomas I, Hominid Cave, lithic assemblage, quartzite. 1 and 4: chopper-cores. 2: bipolar truncated pebble. 3: core with preferential flake removal. 5: handaxe on cobble. 6: handaxe like core. Drawings by M. Hirbec-Raynal.

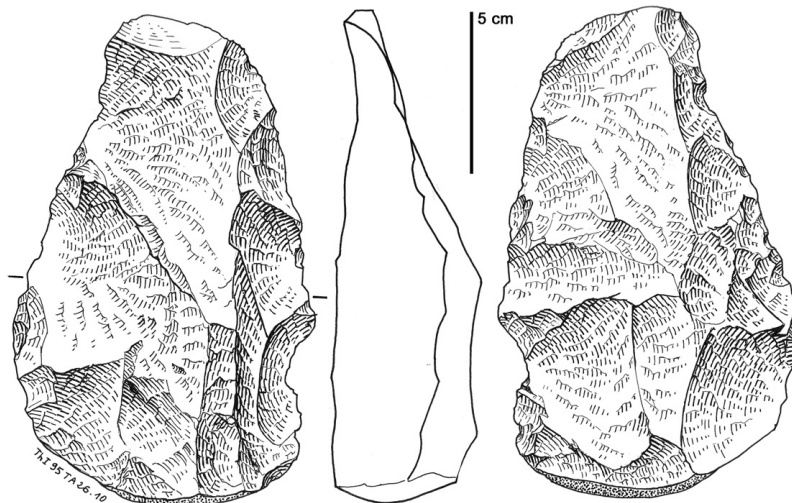


Fig. 8. Thomas I, Hominid Cave, lithic assemblage, quartzite. Large cutting bifacial tool on flake. Drawing by M. Hirbec-Raynal.

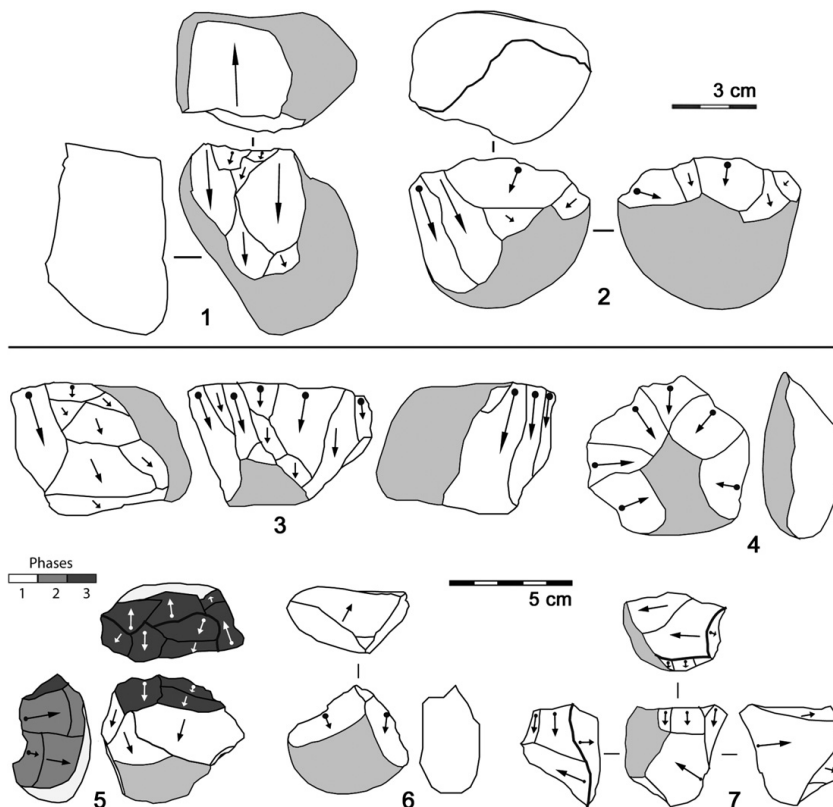


Fig. 9. Thomas I, Hominid Cave, lithic assemblage, cores. 1: Unifacial unidirectional flaking, quartzite. 2: Bifacial flaking, quartzite. 3: Peripheral unidirectional flaking, quartzite. 4: Unifacial centripetal flaking, quartzite. 5: Mixed flaking, quartzite. 6: Unifacial unidirectional flaking, flint. 7: Multifacial multidirectional flaking, flint. Drawings by R. Gallotti.

Category	Quartzite	Flint
Cores	122	6
Debris of cores	3	-
Flakes	25	-
Small flakes > 3cm	13	12
Bifaces	2	-
Debris	24	19
Hammerstones	27	-
Total	213	37

Table 1. Components of the lithic assemblage.

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:

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 bibersoni - bear

Monachus sp. - seal

Artiodactyls

Kolpochoerus sp.

Phacochoerus africanus - warthog

Bovini - aurochs or long-horned buffalo

Hippotragini - oryx?

Alcelaphini cf. *Parmularius* - antelope

Connochaetes taurinus prognus - 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

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 Eurasiatic 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 Tighenif. 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 africanus* 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 (2005e2009) 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 sidestriped 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%); *Ceratotherium* sp. (1.0%); *Equus* sp. (0.6%); *Phacochoerus africanus* (0.2%) and *Kolpochoerus* sp. (0.2%); for carnivores: *U. bibersoni* (1.9%), *Hyaena hyaena* (1.1%), *Panthera* sp. (0.2%), *Felis* cf. *libyca* (0.2%), *Monachus* sp. (0.2%) and *M. capensis* (0.2%); for rodents: *Hystrix cristata* (4.8%) and for primates: *Homo* sp. (0.6%) and *T. oswaldi* (0.5%).

Taxa (GHTh105-09)	MNI	%MNI	NISP	%NISP
<i>Hystrix cristata</i>	3	5.8%	30	4.8%
RODENTS	3	5.8%	30	4.8%
<i>Felis</i> cf. <i>libyca</i>	1	1.9%	1	0.2%
<i>Panthera</i> sp.	1	1.9%	1	0.2%
<i>Hyaena hyaena</i>	2	3.8%	7	1.1%
“ <i>Canis</i> ” sp. nov.	8	15.4%	179	28.6%
<i>Ursus bibersoni</i>	2	3.8%	12	1.9%
<i>Mellivora capensis</i>	1	1.9%	1	0.2%
<i>Monachus</i> sp.	1	1.9%	1	0.2%
CARNIVORES	16	30.8%	202	32.3%
PROBOSCIDIANS	1	1.9%	1	0.2%
<i>Ceratotherium mauritanicum</i>	1	1.9%	6	1.0%
<i>Equus</i> sp.	1	1.9%	4	0.6%
PERISSODACTYLA	2	3.8%	10	1.6%
<i>Kolpochoerus</i> sp.	1	1.9%	1	0.2%
<i>Phacochoerus africanus</i>	1	1.9%	1	0.2%
Bovini	5	9.6%	39	6.2%
Hippotragini	1	1.9%	1	0.2%
Reduncini	1	1.9%	1	0.2%
Alcelaphini	7	13.5%	123	19.5%
<i>Gazella</i> cf. <i>atlantica</i>	11	21.2%	210	33.3%
ARTIODACTYLA	27	51.9%	376	60.1%
<i>Homo</i> sp.	2	3.8%	4	0.6%
<i>Theropithecus oswaldi</i>	1	1.9%	3	0.5%
PRIMATES	3	5.8%	7	1.1%
Total	52	100.0%	626	100.0%
NISP (included anatomical identified remains)	921			
NR > 2 cm	1296			
Isolated teeth	349			
Bone destruction Index	37.9%			
Complete bones	153			
Completeness bone Index (postcranial remains)	31.7%			

Table 2. 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).

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, Suids, *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 activity of scavengers, to which can be added direct predation for middle-sized prey, like gazelles and antelopes, with 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 underrepresentation that may be due to *in situ* differential preservation (Brain, 1976, 1981; Binford, 1978, 1984; Hill, 1980; Richardson, 1980; Potts, 1983; Klein and Cruz-Urbe, 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 scars 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-Urbe, 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.

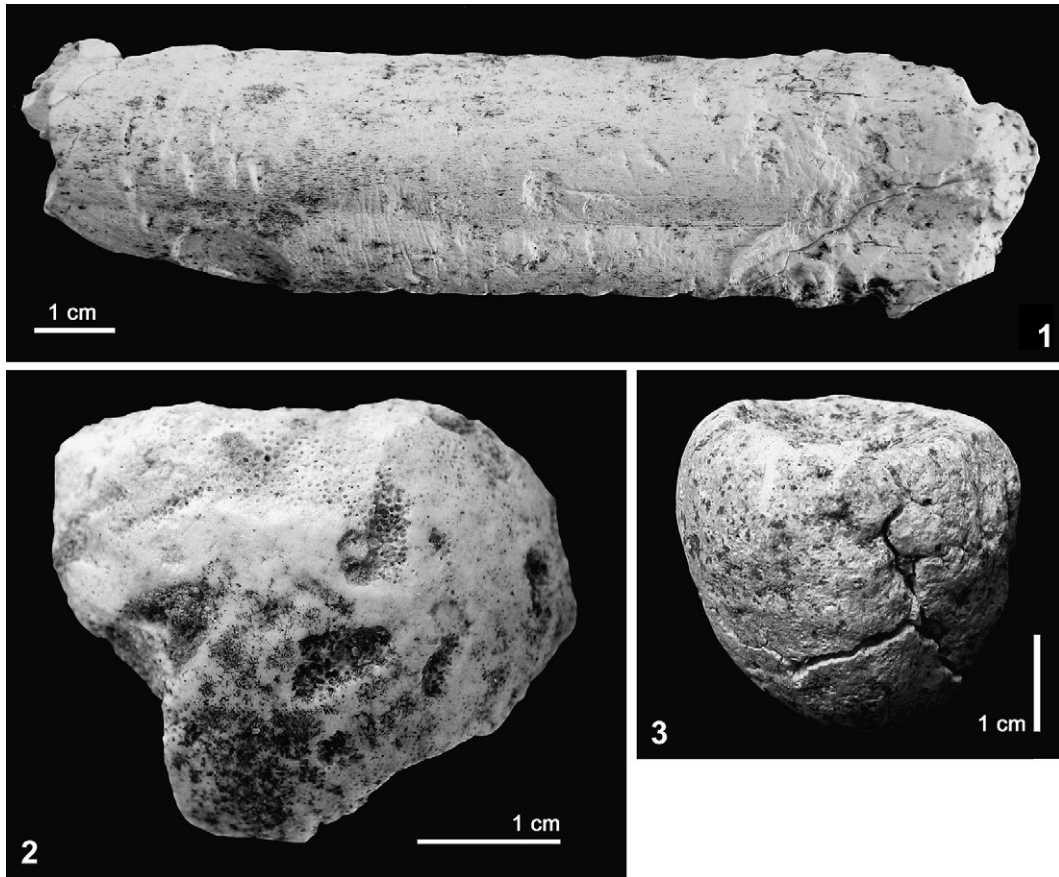


Fig. 10. 1: Carnivore tooth marks and notch on a Bovini metacarpal. 2; Large carnivore tooth marks on a proximal humerus of a young large herbivore. 3; Large carnivore coprolite (scale $\frac{1}{4}$ 1 cm). Photos C. Daujeard.

	Epiphyses			Diaphysis extremities			Median diaphysis			Total		
	NZc	NZtot	%NZc	NZc	NZtot	%NZc	NZc	NZtot	%NZc	NZc	NZtot	%NZc
Bovini indet.	2	5	40.0%	0	1	0.0%	1	2	50.0%	3	8	37.5%
Alcelaphini indet.	7	16	43.8%	3	10	30.0%	4	13	30.8%	14	39	35.9%
<i>Gazella</i> sp.	7	15	46.7%	6	19	31.6%	7	22	31.8%	20	56	35.7%
Total	16	36	44.4%	9	30	30.0%	12	37	32.4%	37	103	35.9%

Table 3. Distribution of tooth marks along the long bone shafts for the three main ungulates (NZ $\frac{1}{4}$ Number of observable zones).

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 humans, carnivores and porcupines have already been described in the Mediterranean area (Monchot, 2005; Monchot and Aouraghe, 2009; Mashkour et al., 2009). However, the studied assemblage comes from inside the cave, whereas any human occupation may well have been concentrated closer to the entrance. Geological studies have demonstrated that the unit containing the assemblage has been partly reworked by physical processes that mixed human 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 (ThI 94 OA 23e24), another right third upper premolar (ThI 95 SA 26 n 89), a first left upper incisor (ThI 95 SA 26 n 90) and a left fourth upper premolar (ThI 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.

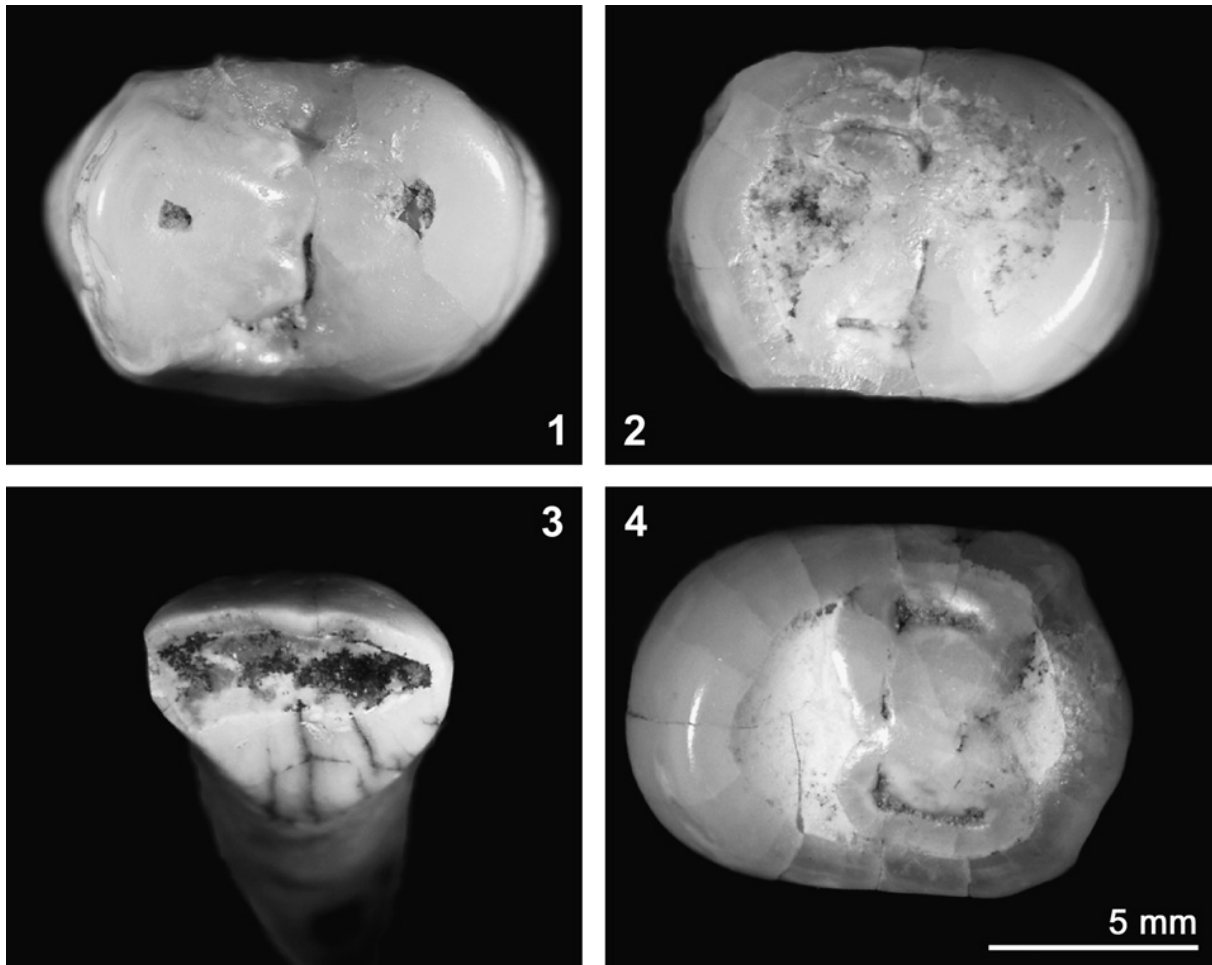


Fig. 11. 1: Thomas I 94 OA 23e24 upper right third premolar. 2; Thomas I 95 SA 26 # 89 upper right third premolar. 3; Thomas I 2006 PA 24 # 107 upper left fourth premolar. 4; Thomas I 95/96 SA 26 # 88 left upper central incisor. Photos T. Smith.

A fragment of the upper third premolar OA 23e24, 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 mA) 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 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 ($x \frac{1}{4} 17.69$, range $\frac{1}{4} 14.04$ – 22.58 , $n \frac{1}{4} 19$) (Smith et al., 2008).

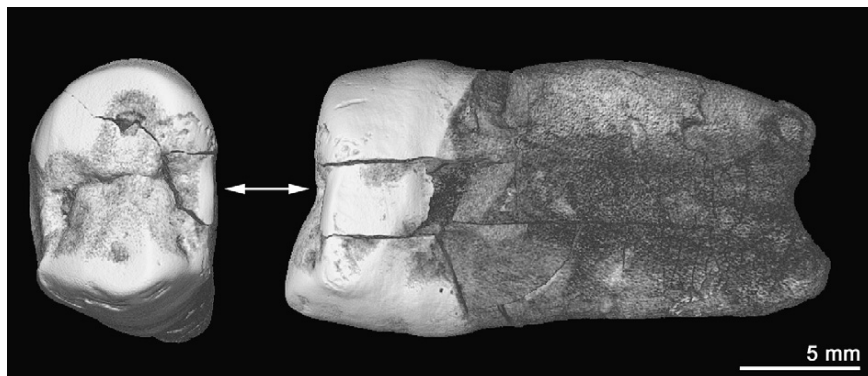


Fig. 12. Virtual model of Thomas I 94 OA 23e24 upper third premolar. The original fragment used for dating is indicated with an arrow. Photos T. Smith.

Potential furrow-type hypoplastic defects (Hillson and Bond, 1997) were noted on the buccal surface of the crown (Fig. 13 1). 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. 13 2).

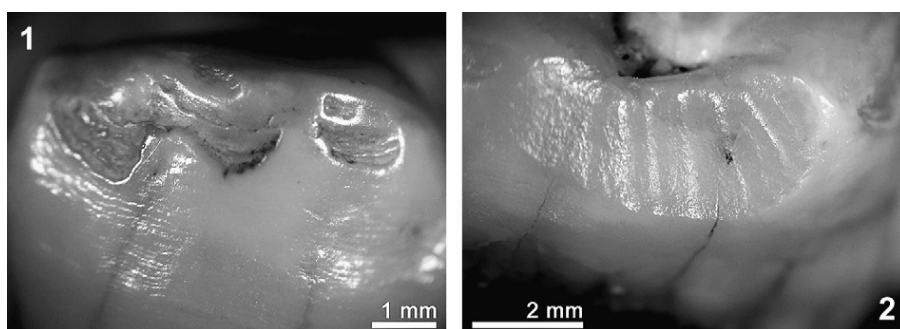


Fig. 13. Thomas I 94 OA 23e24 upper right third premolar crown. 1; Potential furrow-type hypoplastic defects on the buccal surface. 2; sub-vertical grooves on interproximal facet. Photos T. Smith.

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 23e24) 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 $^{234}\text{U}/^{238}\text{U} = 1.090 \pm 0.005$ and $^{230}\text{Th}/^{234}\text{U} = 0.69 \pm 0.02$, corresponding to an apparent U-series age of 124^{+7}_{-6} 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 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 $0.29 \pm 0.03\%$ 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 $^{230}\text{Th}/^{234}\text{U}$ distribution that was measured in situ on the enamel of Thomas III, which had an average $^{230}\text{Th}/^{234}\text{U}$ activity ratio that was 10% lower than that extrapolated to the enamel surface. As a consequence, a $^{230}\text{Th}/^{234}\text{U}$ ratio of 0.62 ± 0.2 was assumed for the enamel (corresponding to an apparent age of 103^{+6}_{-5} 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^{+94}_{-76} 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 semiarid conditions were responsible for complex sedimentation and post-depositionnal processes in the cave. The absolute dates obtained first by OSL placed the stratigraphic unit 4 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 techniques, 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

- Aguirre, E., Carbonell, 2001. Early human expansions into Eurasia: The Atapuerca evidence. *Quaternary International* 75, 11e18.
- Bar-Yosef, O., Belfer-Cohen, A., 2001. From Africa to Eurasia e Early dispersals. *Quaternary International* 75, 19e28.
- Bartram, L.E., Marean, C.W., 1999. Explaining the “Klasies patterns”; Kua ethnoarchaeology, the die kelders middle stone age archaeofauna, long bone fragmentation, and carnivore ravaging. *Journal of Archaeological Science* 26, 9e29.
- Biberson, P., 1961a. Le cadre paléogéographique de la Préhistoire du Maroc atlantique. *Publications du Service des Antiquités du Maroc* 16, 235.
- Biberson, P., 1961b. Le Paléolithique inférieur du Maroc atlantique. *Publications du Service des Antiquités du Maroc* 17, 544.
- Bernoussi, R., 1997. Contribution à l'étude paléontologique et observations archéozoologiques pour deux sites du Pleistocène moyen du Maroc atlantique; grotte à Hominidés de la carrière Thomas I et grotte des Rhinocéros de la carrière Oulad Hamida 1 (Casablanca, Maroc). Thèse de l'Université de Bordeaux 1, 1711, 263 p., unpublished.
- Binford, L.R., 1978. *Nunamiut Ethnoarchaeology*. Academic Press, New-York, 508 pp.
- Binford, L.R., 1984. *Faunal Remains from Klasies River Mouth*. Academic Press, NewYork, 283 pp.
- Blumenshine, R.J., 1986. Carcass consumption sequences and the archaeological distinction of scavenging and hunting. *Journal of Human Evolution* 15, 639e659.

Blumenshine, R.J., 1988. An experimental model of the timing of hominid and Carnivore influence on archaeological bone assemblages. *Journal of Archaeological Science* 15, 483e502.

Blumenshine, R.J., Selvaggio, M.M., 1988. Percussion marks on bone surfaces as a new diagnostic of hominid behaviour. *Nature* 333, 763e765.

Blumenshine, R.J., Selvaggio, M.M., 1991. On the marks of marrow bone processing by hammerstones and hyenas; their anatomical patterning and archaeological implications. 1987. In: Desmond Clark, J. (Ed.), *Cultural Beginnings e Approaches to Understanding Early Hominid Life-ways in the African Savanna*. UISPP, Mainz, pp. 17e32.

Brain, C.K., 1976. Some principles in the interpretation of bone accumulations associated with man. In: Isaac, G.L., Mc Cown, E.R. (Eds.), *Human Origins; Louis Leakey and the East African Evidence*. W.A. Benjamin, Menlo Park, pp. 97e116.

Brain, C.K., 1981. *The Hunters or the Hunted? an Introduction to African Cave Taphonomy*. University of Chicago Press, Chicago, 365 pp.

Carbonell, E., Bermudez de Castro, J.M., Arsuaga, J.L., Diez, J., Rosas, A., CuencaBescos, G., Sala, R., Mosquera, M., Rodriguez, X., 1995. Lower Pleistocene hominids and artifacts from Atapuerca-TD6 (Spain). *Science* 269, 826e830.

Carbonel, E., Bermudez de Castro, J.M., Arsuaga, J.L., Allue, E., Bastir, M., Benito, A., Caceres, I., Canals, A., Diez, C., van der Made, M., Mosquera, M., Ollé, A., PérezGonzales, A., Rodriguez, J., Rodriguez, X.P., Rosas, A., Rosell, J., Sala, R., Vallverdu, J., Vergés, M., 2005. An early Pleistocene hominin mandible from Atapuerca-TD6, Spain. *Proc. Natl Acad. Sci. USA* 102, 5674e5678.

Carbonell, E., Bermudez de Castro, J., Pares, J., Perez-Gonzalez, A., Cuenca-Bescos, G., Olle, A., Mosquera, M., Huguet, R., Made, J.v.d, Rosas, A., Sala, R., Vallverdu, J., Garcia, N., Granger, D., Martinon-Torres, M., Rodriguez, X., Stock, G., Verges, J., Allue, E., Burjachs, F., Caceres, I., Canals, A., Benito, A., Diez, C., Lozano, M., Mateos, A., Navazo, M., Rodriguez, J., Rosell, J., Arsuaga, J., 2008. The first hominin of Europe. *Nature* 452, 465e470.

Chaid-Saoudi, Y., Geraads, D., Raynal, J.P., 2006. The fauna from the early Pleistocene site of Mansourah (Constantine, Algeria), and its implications on the age of associated lithic industries. *Comptes Rendus Palevol* 5, 963e971.

Coumont, M.-P., 2006. *Taphonomie préhistorique; mammifères fossiles en contexte naturel, les avens-pièges, apport pour l'étude des archéofaunes*. Thèse de Doctorat, Université Aix-Marseille 1, 513 p., unpublished.

Coumont, M.-P., 2008. Les avens-pièges. Taphonomie et paléoécologie d'accumulations naturelles fossiles de faune. Apports pour la compréhension des archéofaunes. *Bulletin de la Société Préhistorique Française* 105, 691e707.

Coumont, M.-P., 2009. Proposition d'un référentiel taphonomique fossile de faunes issues d'avens-pièges. *Annales de Paléontologie* 95, 1e20.

Coumont, M.-P., Castel, J.-C., 2007. Etude taphonomique d'un aven-piège du Tardiglaciaire, l'Igue-du-Gral (Sauliac-sur-Célé, Lot). In: XXVIème Congrès de la Société Préhistorique française, Avignon, 21e25 Septembre 2004, vol. 3, 499e514.

Cruz-Uribe, K., 1991. Distinguishing hyaena from hominid bone accumulations. *Journal of Field Archaeology* 18, 467e488.

Eggins, S., Grün, R., Pike, A., Shelley, A., Taylor, L., 2003. 238U, 232Th profiling and Useries isotope analysis of fossil teeth by laser ablation-ICPMS. *Quaternary Science Reviews* 22, 1373e1382.

Eggins, S., Grün, R., McCulloch, M., Pike, A., Chappell, J., Kinsley, L., Shelley, M., Murray-Wallace, C., Spötl, C., Taylor, L., 2005. In situ U-series dating by laserablation multi-collector ICPMS: new prospects for Quaternary geochronology. *Quaternary Science Reviews* 24, 2523e2538.

El Graoui, M., 1994. Contribution à l'étude des formations littorales Quaternaires de la région de Casablanca (Maroc); sédimentologie, microfaciès et minéraux lourds. Thèse de l'Université de Bordeaux 1, n 1100, 263 p., unpublished

Ennouchi, E., 1969. Découverte d'un Pithécantropien au Maroc. *C.R. Acad. Sci. Paris., Series D* 763.

- Fosse, P., 1996. La grotte n 1 de Lunel-Viel (Hérault, France); repaire d'hyènes du Pléistocène moyen e Etude taphonomique du matériel osseux. *Paleo* 8, 47e79. Fosse, P., 1997. Variabilité des assemblages osseux créés par l'hyène des cavernes. *Paléo* 9, 15e54.
- Geraads, D., 1980. La faune des sites à *Homo erectus* des carrières Thomas (Casablanca, Maroc). *Quaternaria* 22, 65e94.
- Geraads, D., 1994. Rongeurs et Lagomorphes du Pléistocène moyen de la "Grotte des Rhinocéros", carrière Oulad Hamida 1, à Casablanca, Maroc. *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen* 191, 147e172.
- Geraads, D., 1997. Carnivores du Pliocène terminal de Ahl Al Oughlam (Casablanca, Maroc). *Geobios* 30, 127e164.
- Geraads, D., 2008. Plio-Pleistocene Carnivora of northwestern Africa: a short review. *Comptes Rendus Palevol* 7, 591e599.
- Geraads, D., 2002. Plio-Pleistocene mammalian biostratigraphy of atlantic Morocco. *Quaternaire* 13, 43e53.
- Geraads, D., 2006. The late Pliocene locality of Ahl al Oughlam, Morocco: vertebrate fauna and interpretation. *Transactions of the Royal Society of South-Africa* 61, 97e101.
- Geraads, D., Beriro, P., Roche, H., 1980. La faune et l'industrie des sites à *Homo erectus* des carrières Thomas (Casablanca, Maroc). Précisions sur l'âge de ces Hominidés. *Comptes Rendus de l'Académie des Sciences D* 291, 195e198.
- Geraads, D., Raynal, J.P., Eisemann, V., 2004. The earliest human occupation of North Africa: a reply to Sahnouni et al. (2002). *Journal of Human Evolution* 46, 751e761.
- Geraads, D., Amani, F., Raynal, J.-P., Sbihi-Alaoui, F.Z., 1998. La faune de Mammifères du Pliocène terminal d'Ahl al Oughlam, Casablanca, Maroc. *Comptes Rendus de l'Académie des Sciences, Sciences de la Terre et des Planètes* 326, 671e676.
- Grün, R., Schwarcz, H.P., Chadam, J.M., 1988. ESR dating of tooth enamel: coupled correction for U-uptake and U-series disequilibrium. *Nuclear Tracks Radiation Measurements* 14, 237e241.
- Grün, R., Maroto, J., Eggins, S., Stringer, C., Robertson, S., Taylor, L., Mortimer, G., McCulloch, M., 2006. ESR and U-series analyses of enamel and dentine fragments of the Banyoles mandible. *Journal of Human Evolution* 50, 347e358.
- Grün, R., 2002. ESR dose estimation on fossil tooth enamel by fitting the natural spectrum into the irradiated spectrum. *Radiation Measurements* 35, 87e93.
- Grün, R., Joannes-Boyau, R., Stringer, C., 2008. Two types of O-2 radicals threaten the fundamentals of ESR dating of tooth enamel. *Quaternary Geochronology* 3, 150e172.
- Grün, R., Katzenberger-Apel, O., 1994. An alpha irradiator for ESR dating. *Ancient TL* 12, 35e38.
- Guadelli, J.-L., 1989. Etude taphonomique du repaire d'hyènes de Camiac (Gironde, France). Eléments de comparaison entre un site naturel et un gisement préhistorique. *Bulletin de l'AFEQ* 38, 91e100.
- Hill, A., 1980. A modern hyaena den in Amboseli National Park, Kenya. In: R.E. Leakey, B.A. Ogot (Eds.), *Proceedings of the 8th Panafrikan Congress of Prehistory and Quaternary Studies*. Nairobi, 137e138.
- Hillson, S., 1996. *Dental Anthropology*. Cambridge University Press, Cambridge.
- Hillson, S., Bond, S., 1997. Relationship of enamel hypoplasia to the pattern of tooth crown growth: a discussion. *American Journal of Physical Anthropology* 104, 89e103.
- Hossini, S., 2002. La faune d'Anoures marocains du Miocène au Pléistocène et ses rapports avec celle de la même époque au sud-ouest européen; hypothèse sur l'origine des Anoures au Maroc. Thèse d'Etat. Université Moulay Ismail, 243 p., unpublished
- Hublin, J.-J., 2001. Northwestern African Middle Pleistocene hominids and their bearing on the emergence of *Homo sapiens*. In: Barham, L., Robson-Brown, K. (Eds.), *Human Roots. Africa and Asia in the Middle Pleistocene*. CHERUB, Western Academic and Specialist Press Ltd, Bristol, pp. 99e121.
- Keiser, A., 1990. *Human Adult Odontometrics*. Cambridge University Press, Cambridge, 194 pp.
- Klein, R.G., Cruz-Urbe, C., 1984. *The Analysis of Animal Bones from Archaeological Sites*. University of Chicago Press, 265 pp.

Lefèvre, D., 2000. Du continent à l'océan. Morphostratigraphie et paléogéographie du Quaternaire du Maroc atlantique. Le modèle casablançais, vol. 3. Université de Montpellier III, Mémoire HDR, IIème partie, p 99e299, 45 fig., 2 pl.

Lefèvre, D., Raynal, J.-P., 2002. Les formations plio-pléistocènes de Casablanca et la chronostratigraphie du Quaternaire marin du Maroc revisitées, in Paléorivages de Casablanca. Stratigraphie et Préhistoire ancienne au Maroc atlantique. Quaternaire 13 (1), 9e21.

Lefèvre D., Raynal, J.-P., Vernet, G., Piperno, M., 2002. Volcanisme et premiers peuplements en Italie méridionale: l'exemple de Notarchirico (Venosa, Italie). In: Hommes et volcans, de l'éruption à l'objet, ss la dir. de J.P. Raynal, C. AlboreLivadie, M. Piperno, Les dossiers de l'Archéo-Logis n2, CDERAD éd., 67e76.

Lefèvre, D., Texier, J.P., Raynal, J.P., Occhietti, S., Evin, J., 1994. Enregistrements réponses des variations climatiques du Pleistocène supérieur et de l'Holocène sur le littoral de Casablanca (Maroc). Quaternaire 5, 173e180.

Lumley, H., de Barsky, D., 2004. Evolution of the technological and typological characteristics of the stone tool assemblage from the Caune de l'Arago Cave. L'Anthropologie 108, 185e237.

Lyman, R.L., 1994. Vertebrate Taphonomy. Cambridge University Press, Cambridge (MA), 524 pp.

Marsh, R.E., 1999. Beta-gradient isochrons using electron paramagnetic resonance: towards a new dating method in archaeology. Master's Thesis, McMaster University, Hamilton, Ont., Canada.

Martin, L.M., 1985. Significance of enamel thickness in hominoid evolution. Nature 314, 260e263.

Mashkour, M., Monchot, H., Trinkaus, E., Reyss, J.-L., Biglari, S., Bailon, S., Heydari, S., Abdi, K., 2009. Carnivores and their prey in the Wezmeh cave (Kermanshah, Iran): a late Pleistocene refuge in the Zagros. International Journal of Osteoarchaeology 19, 678e694.

Monchot, H., 2005. Un assemblage original au Paléolithique moyen: le repaire à hyènes, porcs-épics et hominidés de la grotte Gueula (Mont Carmel, Israël). Paléorient 31, 27e42.

Monchot, H., Aouraghe, H., 2009. Deciphering the taphonomic history of an upper Paleolithic faunal assemblage from Zouhrah cave (El Harhoura 1, Morocco).

Quaternaire 20, 239e253.

Occhietti, S., Raynal, J.-P., Pichet, P., Texier, J.-P., 1993. Aminostratigraphie du dernier cycle climatique au Maroc atlantique, de Casablanca à Tanger. Comptes Rendus de l'Académie des Sciences 317 (série II), 1625e1632.

Occhietti, S., Raynal, J.-P., Pichet, P., 2002. Aminostratigraphie des formations littorales pléistocènes et holocènes de la région de Casablanca, Maroc. Quaternaire 13, 55e64.

Olejniczak, A.J., Smith, T.M., Feeney, R.N.M., Macchiarelli, R., Mazurier, A., Bondioli, L., Rosas, A., Fortea, J., de la Rasilla, M., García-Taberner, A., Radovic, J., Skinner, M.M., Toussaint, M., Hublin, J.-J., 2008. Dental tissue proportions and enamel thickness in Neandertal and modern human molars. Journal of Human Evolution 55, 12e23.

Parés, J.M., et al., 2006. Matuyama-age lithic tools from the Sima del Elefante site, Atapuerca (northern Spain). Journal of Human Evolution 50, 163e169.

Pei, W.C., 1938. Le rôle des animaux et des causes naturelles dans la cassure des os. Palaeontologica Sinica, D 7, 60.

Potts, R., 1983. Foraging for faunal resources by early hominids at Olduvai Gorge, Tanzania. In: Clutton-Brock, J., Grigson, C. (Eds.), Animals and Archaeology. Hunters and Their Prey, British Archaeological Reports International Series, S163, vol. 1, pp. 51e62.

Prescott, J.R., Hutton, J.T., 1994. Cosmic ray contributions to dose rates for luminescence and ESR dating: large depths and long-term time variations. Radiation Measurements 23, 497e500.

Raynal, J.-P., Texier, J.-P., 1984. Les "limons rouges" du Maroc atlantique: production, transport, transformation et chronologie. In: 10ème Réunion Annuelle des Sciences de la Terre, Société Géologique de France éd., Paris, 472.

Raynal, J.-P., Texier, J.P., 1989. Découverte d'Acheuléen ancien dans la carrière Thomas I à Casablanca et problème de l'ancienneté de la présence humaine au Maroc. Comptes Rendus de l'Académie des Sciences 308 (série II), 1743e1749.

Raynal, J.-P., Texier, J.P., Geraads, D., Sbihi-Alaoui, F.Z., 1990. Un nouveau gisement paléontologique plio-pléistocène en Afrique du Nord; Ahl Al Oughlam (ancienne carrière Déprez) à Casablanca (Maroc). *Comptes Rendus de l'Académie des Sciences* 310 (série II), 315e320.

Raynal, J.-P., Geraads, D., Magoga, L., El Hajraoui, A., Texier, J.P., Lefevre, D., SbihiAlaoui, F.Z., 1993. La grotte des Rhinocéros (Carrière Oulad Hamida 1, anciennement Thomas III, Casablanca), nouveau site acheuléen du Maroc atlantique. *Comptes Rendus de l'Académie des Sciences* 316 (série II), 1477e1483.

Raynal, J.-P., Magoga, L., Sbihi-Alaoui, F.Z., Geraads, D., 1995. The earliest occupation of Atlantic Morocco: the Casablanca evidence. In: Roebroeks, W., van Kolfschoten, T. (Eds.), *In the Earliest Occupation of Europe*. University of Leiden, pp. 255e262. 1996.

Raynal, J.P., Lefevre, D., Geraads, D., El Graoui, M., 1999. Contribution du site paléontologique de Lissasfa (Casablanca, Maroc) à une nouvelle interprétation du Mio-Pliocène de la Méseta. *Comptes Rendus de l'Académie des Sciences. Sciences de la terre et des planètes* 329, 617e622.

Raynal, J.P., Sbihi-Alaoui, F.Z., Geraads, D., Magoga, L., Mohib, A., 2001. The earliest occupation of North-Africa: the moroccan perspective. *Quaternary International* 75, 65e75.

Raynal, J.P., Sbihi-Alaoui, F.Z., Magoga, L., Mohib, A., Zouak, M., 2002. Casablanca and the early occupation of north-atlantic Morocco. *Quaternaire* 13, 65e77.

Raynal, J.P., Sbihi-Alaoui, F.Z., Mohib, A., Geraads, D., 2009. Préhistoire ancienne au Maroc atlantique: bilan et perspectives régionales. *Bulletin D'archéologie Marocaine* 21, 9e54.

Raynal, J.-P., Amani, F., Geraads, D., El Graoui, M., Magoga, L., Texier, J.-P., SbihiAlaoui, F.-Z., 2008. La grotte des Félines, site paléolithique du Pléistocène supérieur à Dar Bouazza (Maroc). *L'Anthropologie* 112, 182e200.

Rhodes, E.J., Raynal, J.-P., Geraads, D., Sbihi-Alaoui, F.Z., 1994. Premières dates RPE pour l'Acheuléen du Maroc atlantique (Grotte des Rhinocéros, Casablanca). *Comptes Rendus de l'Académie des Sciences* 319 (série II), 1109e1115.

Rhodes, E.J., Singarayer, J.S., Raynal, J.-P., Westaway, K.E., Sbihi-Alaoui, F.Z., 2006. New age estimations for the Palaeolithic assemblages and Pleistocene succession of Casablanca, Morocco. *Quaternary Science Reviews* 25, 2569e2585.

Richardson, P.R.K., 1980. Carnivore damage to antelope bones and its archaeological implications. *Paleontologia Africana* 23, 109e125.

Sahnouni, M., 2006. Les plus vieilles traces d'occupation humaine en Afrique du Nord: perspective de l'Ain Hanech, Algérie. *Comptes Rendus Palevol* 5, 243e254.

Sahnouni, M., Hadjouis, D., Van Der Made, J., Derradji, A., Canals, A., Medig, M., Belahrech, H., Harichane, Z., Rabhi, M., 2002. Further research at the Oldowan site of Aïn Hanech, north-eastern Algeria. *Journal of Human Evolution* 43, 925e937.

Smith, T.M., Olejniczak, A.J., Reh, S., Reid, D.J., Hublin, J.-J., 2008. Enamel thickness trends in the dental arcade of humans and chimpanzees. *American Journal of Physical Anthropology* 136, 237e241.

Stearns, C.E., 1978. Pliocene-Pleistocene emergence of the moroccan Meseta. *Geological Society of American Bulletin* 89, 1630e1644.

Tafforeau, P.T., Smith, T.M., 2008. Nondestructive imaging of hominoid dental microstructure using phase contrast X-ray synchrotron microtomography. *Journal of Human Evolution* 54, 272e278.

Terradas, X., 2003. Discoid flaking method; Conception and technological variability. In *Discoid lithic Technology. Advances and implications*, M. Peresani. BAR International Series 1120, 19e31.

Texier, J.-P., Raynal, J.-P., Lefevre, D., 1985. Nouvelles propositions pour un cadre chronologique raisonné du Quaternaire marocain. *Comptes Rendus de l'Académie des Sciences* 301 (série II), 183e188.

Texier, J.-P., Raynal, J.-P., Lefevre, D., 1987. Essai de chronologie du Quaternaire marocain. *Bulletin D'Archéologie Marocaine* 16, 11e24.

Texier, J.-P., Lefevre, D., Raynal, J.-P., 1994. Contribution pour un nouveau cadre stratigraphique des formations littorales Quaternaires de la région de Casablanca (Maroc). *Comptes Rendus de l'Académie des Sciences* 318 (series II), 1247e1253.

Texier, J.-P., Lefevre, D., Raynal, J.-P., El Graoui, M., 2002. Lithostratigraphy of the littoral deposits of the last one million years in the Casablanca region (Maroc). *Quaternaire* 13, 23e41.

Tong, H.W., Zhang, S., Chen, F., Li, Q., 2008. Rongements sélectifs des os par les porcs-épics et autres rongeurs: cas de la grotte Tianyuan, un site avec des restes humains fossiles récemment découvert près de Zhoukoudian (Choukoutien).

L'Anthropologie 111, 353e369.

Villa, P., Bartram, L., 1996. Flaked bone from a hyena den. *Paléo* 8, 143e159.

Villa, P., Mahieu, E., 1991. Breakage patterns of human long bones. *Journal of Human Evolution* 21, 27e48.