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NUMBER 3
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THE CUTTING EDGE:

New Approaches to the Archaeology of Human Origins

Editors

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Stone Age Institute & Indiana University

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COVER CAPTIONS AND CREDITS

Top: Homo habilis Utilizing Stone Tools. Painting by artist-naturalist Jay H. Matternes. Copyright 1995, Jay H. Matternes. Inspired by a prehistoric scenario by K. Schick and N. Toth in Making Silent Stones Speak: Human Origins and the Dawn of Technology (1993), Simon and Schuster, New York. Pp.147-149.

Lower right: Whole flake of trachyte lava from the 2.6 million-year-old site of Gona EG-10, Ethiopia. Reported by S. Semaw (2006), "The Oldest Stone Artifacts from Gona (2.6-2.5 Ma), Afar, Ethiopia: Implications for Understanding the Earliest Stages of Knapping" in The Oldowan: Case Studies into the Earliest Stone Age, eds. N. Toth and K. Schick. Stone Age Institute Press, Gosport, Indiana. Pp. 43-75. Photo courtesy of Tim White.

Lower left: Prehistoric cut-marks from a stone tool on Sterkfontein hominin partial cranium StW 53. Reported by T. Pickering, T. White, and N. Toth (2000) in "Cutmarks on a Plio-Pleistocene hominid from Sterkfontein, South Africa". American Journal of Physical Anthropology 111, 579-584. Scanning electron micrograph by N. Toth.

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CHAPTER 4

ARCHAIC STONE INDUSTRIES FROM EAST AFRICA AND SOUTHERN EUROPE PRE-OLDOWAN AND OLDOWAN

HENRY DE LUMLEY, DEBORAH BARSKY AND DOMINIQUE CAUCHE

Over recent years, many discoveries have renewed our knowledge about the oldest stone industries and also about the behaviour and lifestyle of the hominids that made them, not only in East Africa, but also in the Near East, in Trans Caucasia and in southern Europe.

If the first tool-making hominids appear in East Africa as early as 2.55 million years ago, they are present in the Levant a little over 2 million years ago, as early as 1.81 million years ago at the gates of Europe in Trans-Caucasia, and a little over 1.4 million years ago on the Mediterranean coasts of Europe (Figures 19 and 21).

PRE-OLDOWAN OR ARCHAIC OLDOWAN

The Gona and Ounda Gona sites in Ethiopia, dated to a little over 2.5 million years old, have yielded lithics characterized largely by knapping products (Figure 1): flakes and angular fragments (de Lumley, 2006; Semaw, 2000 and 2005; Semaw et al., 1997 and 2003). Manufactured pebbles are rare. Bipolar knapping on an anvil was often practiced while hand-held knapping methods employed were sometimes unifacial, bifacial or even multifacial. Core exploitation was relatively intense, with numerous, generally small sized flakes removed from each piece. The assemblage does not include standardized small retouched tools shaped by secondary retouch modifying the edge of a flake or angular fragment.

The Lokalalei 1 and 2C sites in Kenya, in the Nachukui Formation dated to 2.340 million years old, discovered and studied by Hélène Roche and Pierre-Jean Texier, offer an industry similar to that from the Gona sites (Roche et al., 1999; Delagnes et al., 2005). The assemblages comprise mainly non-retouched flakes, angular fragments and cores (Figure 2).

Refits of flakes onto cores allowed define a systematic reduction sequence resulting in the production of numerous, generally small-sized flakes. For some cores as many as fifty pieces were refitted. As is the case for the Gona region sites, the Lokalalei assemblages do not comprise any standardized, small retouched tools on flakes or debris, with the possible exception of a few pieces.

The archaic stone tools from the Omo Valley, such as those from Omo 71 and Omo 84, dated to around 2,4 million years old, as well as those from Omo 57 and Omo 123, dated to around 2.34 million years old, discovered and studied by Jean Chevaillon, yielded very numerous small quartz flakes, with an average size of 2 to 3 cm, most often showing reduced or null striking platforms and flat inner surfaces, bearing witness to the frequent use of bipolar knapping on an anvil. However, pebble tools and percussion instruments are rare or absent. There are no small retouched tools. Yet flake edges often show irregular use retouch and chips attesting to their use.

Locally available raw materials, mainly quartz and some basalt, were used in the fabrication of the stone tool assemblage from the Fejej FJ-1 site in the southern Omo area of Ethiopia, around five kilometres from the Kenyan border (Barsky et al., 2006; de Lumley et al., 2004a and 2004b; Chapon, 2007). Pebbles used were collected from the environment immediately surrounding the site; a few hundred meters at the most. Both bipolar knapping on an anvil and hand held techniques were used during knapping reduction sequences which were mainly unifacial, sometimes bifacial and rarely multifacial.

The assemblage is mainly composed of small-sized flakes and angular fragments (Figure 3). Pebble tools are

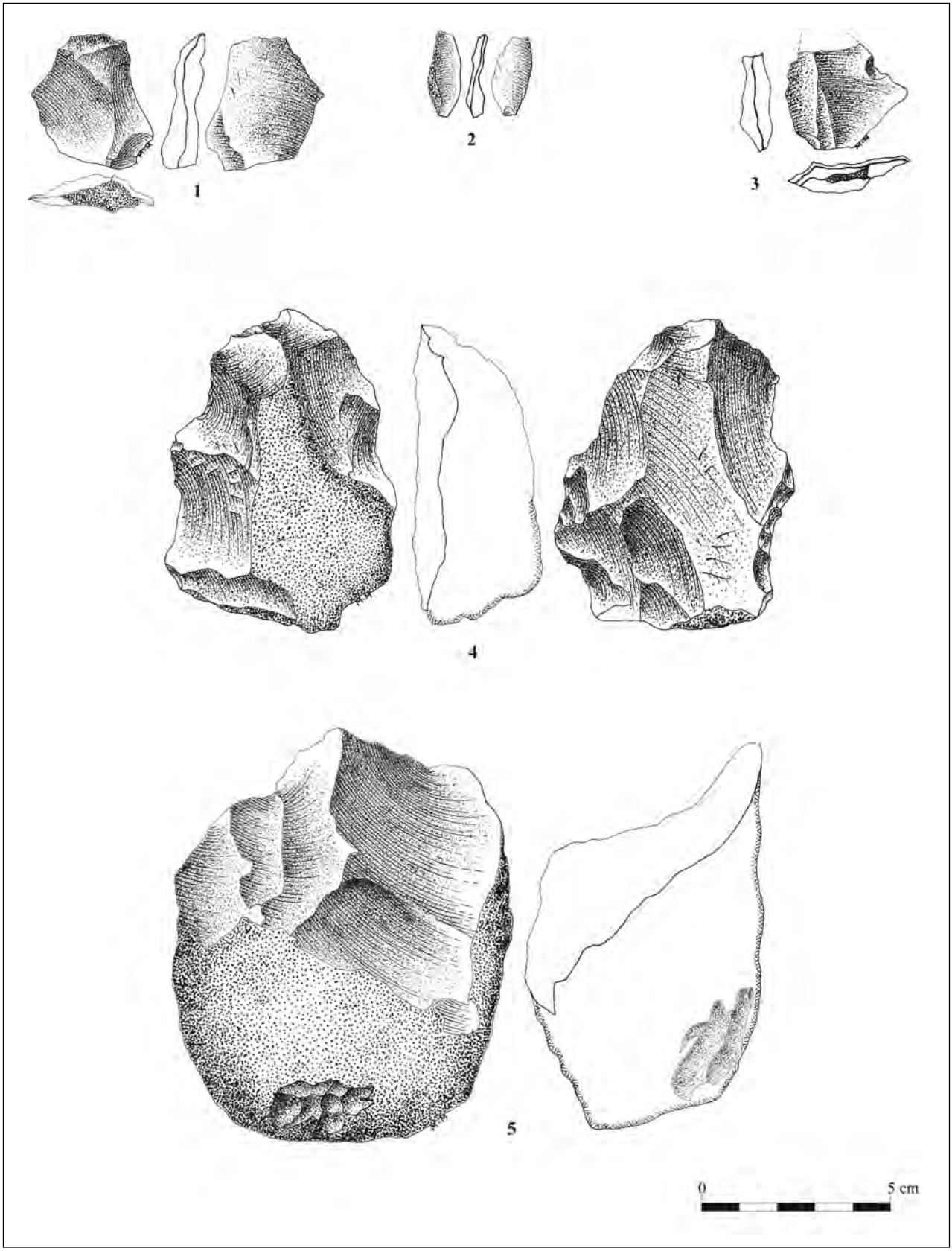

Figure 1. Gona EG 10, Hadar, Ethiopia. 2.55 million years. Pre-Oldowan *or* Archaic Oldowan*.*
1 to 3: flakes; 4: core; 5: chopper

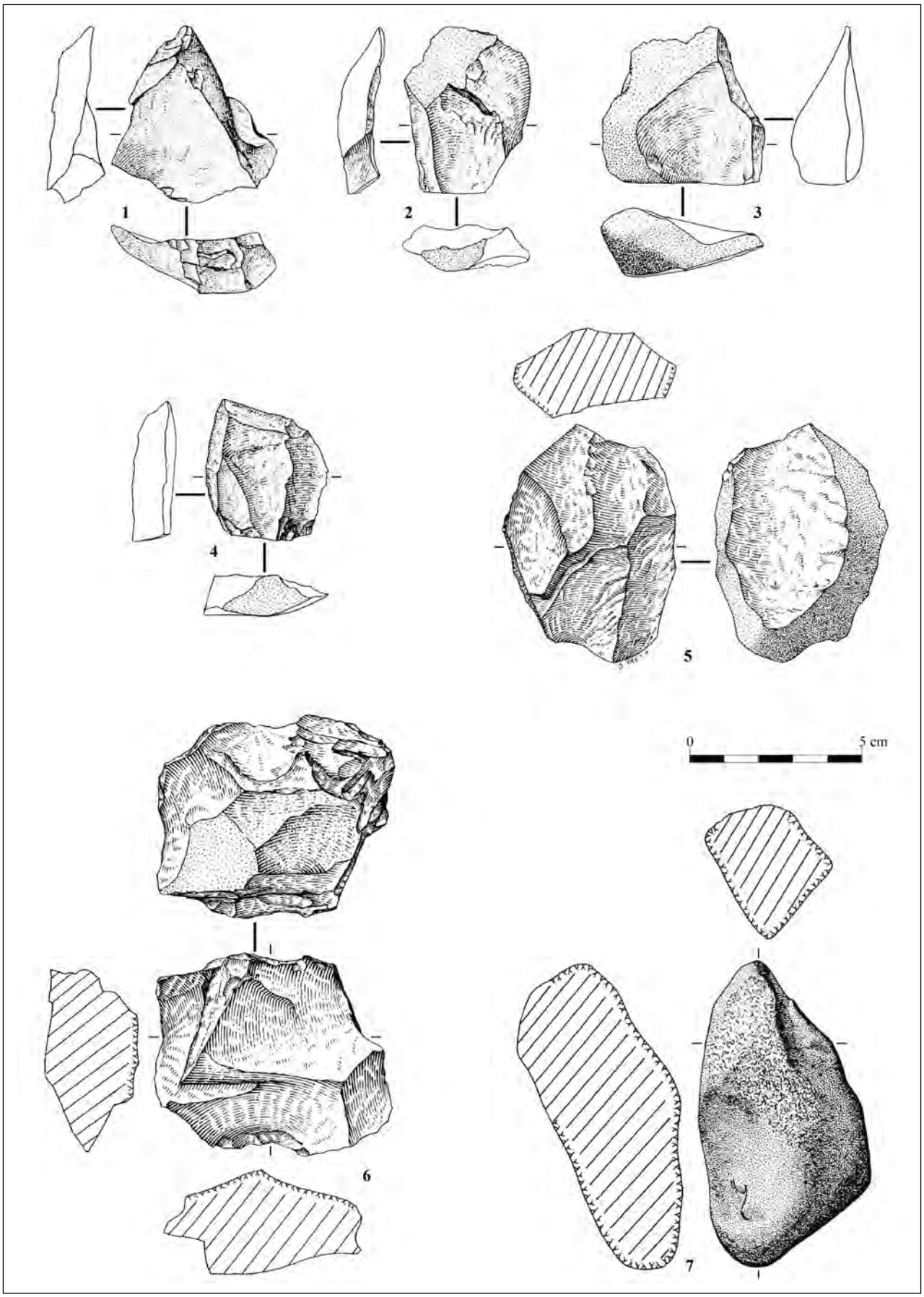

Figure 2. Lokalalei 2C, West Turkana, Kenya. 2.2 million years. Pre-Oldowan *or* Archaic Oldowan*.*
1 to 4: flakes; 5 and 6: cores; 7: percussion instrument. (from A. Delagnes et H. Roche, 2005).

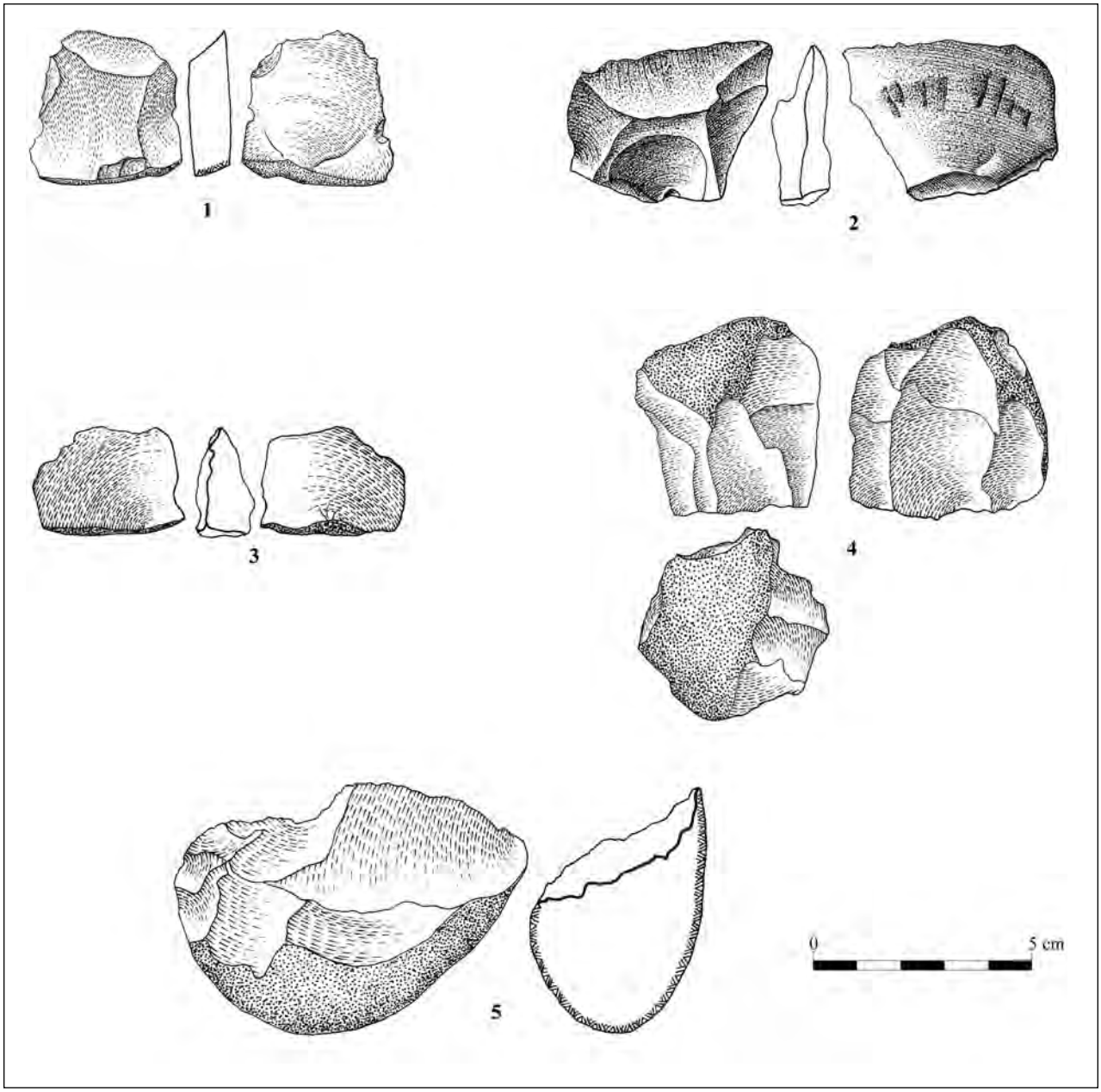

Figure 3. Fejej FJ-1, South Omo, Ethiopia. 1.96 million years. Pre-Oldowan *or* Archaic Oldowan*.*
1 to 3: flakes; 4: core; 5: chopper.

rare: choppers (pebbles showing a bevelled cutting edge shaped by one or several removals on a single face), a few core-scrapers (*rostro-carénés*; massive choppers with abrupt, narrow and convex cutting edges) and rare chopping tools (pebbles showing a bevelled cutting edge shaped by one or several removals on both faces). At this site, once again, there are no intentionally shaped small retouched tools on flakes or angular fragments.

In East Africa, presently known lithic assemblages dating to before around 1.9 million years ago show common characteristics (de Lumley, 2006; de Lumley, 2004a and 2004b). Such industries, dated to between 2.55 and 1.9 million years ago, have also been discovered in Ethiopia, in the Hadar region (AL666) and in the Omo Valley (Ftji1, 2 and 5, Omo 71, 84, 57 and 123) and at Kanjera South in Kenya (Plummer et al., 1999). The tools were essentially made from quartz or volcanic rock types collected from the area immediately surrounding the site. Knapping was generally executed using the hand held technique most often with unifacial and unidirectional removals, sometimes with multipolar or centripetal removals. Bifacial knapping was rarely practiced. Multipolar orthogonal knapping is also present. Bipolar knapping on an anvil was quite often used. It is important to underline that this type of percussion; bipolar simultaneously in two opposite directions, does not necessarily signify a poorly mastered knapping technique, but rather a very efficient way to extract flakes or sharp fragments, from small crystalline pebbles. Thus, knapping methods and techniques for flake production were chosen in ac-

cordance with the quality of raw materials and/or initial bloc or pebble morphology. It is thus that humans chose essentially cubic blocks offering natural striking platforms.

Generally cores were abandoned after the extraction of only a few flakes, especially when raw materials were of poor quality. However, when rocks were of finer quality, for example fine grained basalt, reduction sequences were systematically more intensive, as Fejej FJ-1, and even up to fifty flakes for a core at the Lokalalei 2C site (Roche et al., 1999).

Relative abundance of raw materials near each site, their nature, the morphology and size of available pebbles or blocs all had a determinant influence on the technological characteristics of each stone series.

These archaic lithic assemblages are essentially composed of non-retouched flakes, some cores or pebble tools, notably choppers and a few chopping tools. Flakes seem to have been the main objective sought out by the knappers. Their non-modified edges sometimes show chips attesting to their use. Flakes were often broken during their production probably because of violent blows with a hard hammer instrument or during bipolar on an anvil knapping technique. Flakes obtained, generally small sized, show numerous knapping accidents: longitudinal fractures along or parallel to the knapping axis, and fractures transversal or oblique to the knapping axis.

In all of these assemblages, even the oldest, as at Gona, hominids had acquired quite elaborate knapping strategies attesting to their technical prowess, and their relatively developed level of comprehension of raw material bloc geometry and of the physical parameters essential to knap hard rocks, as well as anticipatory faculties. They had acquired and mastered knapping processes according to certain constant technological principles. The invention of the tool, 2.55 million years ago, is a major cultural leap for humanity, with which begins the real history of Mankind.

We have proposed to group together these archaic industries under the name “Pre-Oldowan” or “Archaic Oldowan” in order to underline the absence or extreme scarcity of small retouched tools which characterizes them (Barsky et al., 2006; de Lumley, 2006 and 2007; de Lumley et al., 2004a and 2004b). In the case of retouched tools, an edge is modified by tiny, continuous, adjacent or overlapping removals, to obtain a predetermined shape. The term “Pre-Oldowan” is not meant to designate a single, homogenous and well defined cultural entity, but rather a cultural evolutionary stage within which there are not yet stereotyped and standardized small tools made by retouch that modified the initial form of flake, fragment or core clasts. It is a practical denomination for designating a cultural milieu wherein the technological (chaine opératoires) and typological (resulting tool types) characteristics are more archaic than in the Oldowan *stricto sensu* or Classical Oldowan. It connotes a behavioural parallelism amongst diverse human groups present in East Africa between 2.55 and 1.9 million years ago.

A drier milieu and the consecutive extension of a savannah type environment constrained some hominids to consume larger quantities of grains, thus favouring the development of large teeth (Paranthropus), while others were oriented towards ever increasing meat consumption. They were scavengers who, with the help of their primitive tools, collected meat left on large Herbivore carcasses abandoned by large Carnivores (Dominguez-Rodrigo et al., 2005; Semaw et al., 2003). They also gathered not only vegetables, but also small animals such as rodents, reptiles and amphibians.

Classical Oldowan

Although a decisive step for human evolution, these archaic tools were rudimentary. Growing sophistication in tool making was soon to accompany the progressive evolution of the human brain.

Around 1.9 million years ago in East Africa, at Olduvai in Tanzania, but also in Kenya and Ethiopia, more evolved stone industries appear. They too are characterized by a predominance of flakes, unifacial, bifacial or multifacial cores and some pebble tools (choppers, chopping-tools) (Figures 4 to 7). Small tools also make their appearance, with intentionally retouched edges modifying the initial form of the flake or fragment support. These are end scrapers, scrapers and denticulates, that is to say, flakes or fragments upon which adjacent notches were intentionally made in order to form a saw-like edge (Figures 4 to 7). Other types of tools also appear, such as polyhedrons (globular shaped tools made by small removals forming facets) (Figure 7, n° 11) and spheroids (perfectly spherical stones intentionally made but whose use remains unknown). It is this stone industry, found at Olduvai Gorge at several sites dated to between 1.9 and 1.7 million years old that Louis, and then Mary Leakey named “Oldowan” (Leakey, 1971; de la Torre et al., 2005).

Oldowan culture was to spread throughout the entire African continent: its traces are found not only in Olduvai’s Bed I between 1.9 and 1.6 million years ago, but also in Ethiopia, at the Gombore I site in Melka Kunturé, at sites dated to 1.7 million years ago, in Algeria at Ain Hanech, dated to around 1.8 million years old, and even in south Africa, at Sterkfontein 5 and at Swartkrans.

“Classical Oldowan”, dated to between 1.9 and 1.6 million years old, is characterized by the predominance of non-modified flakes, the presence of unifacial and sometimes bifacial or multifacial cores, pebble tools which are present in low but significant proportions polyhedrons and spheroids and especially small retouched tools (end scrapers, scrapers, denticulates) (de la Torre et al., 2005). These elements denote type-specialization which is progressively to become more and more standardized.

The Classical Oldowan marks the acquisition of a new stage in human cognition, within which specific

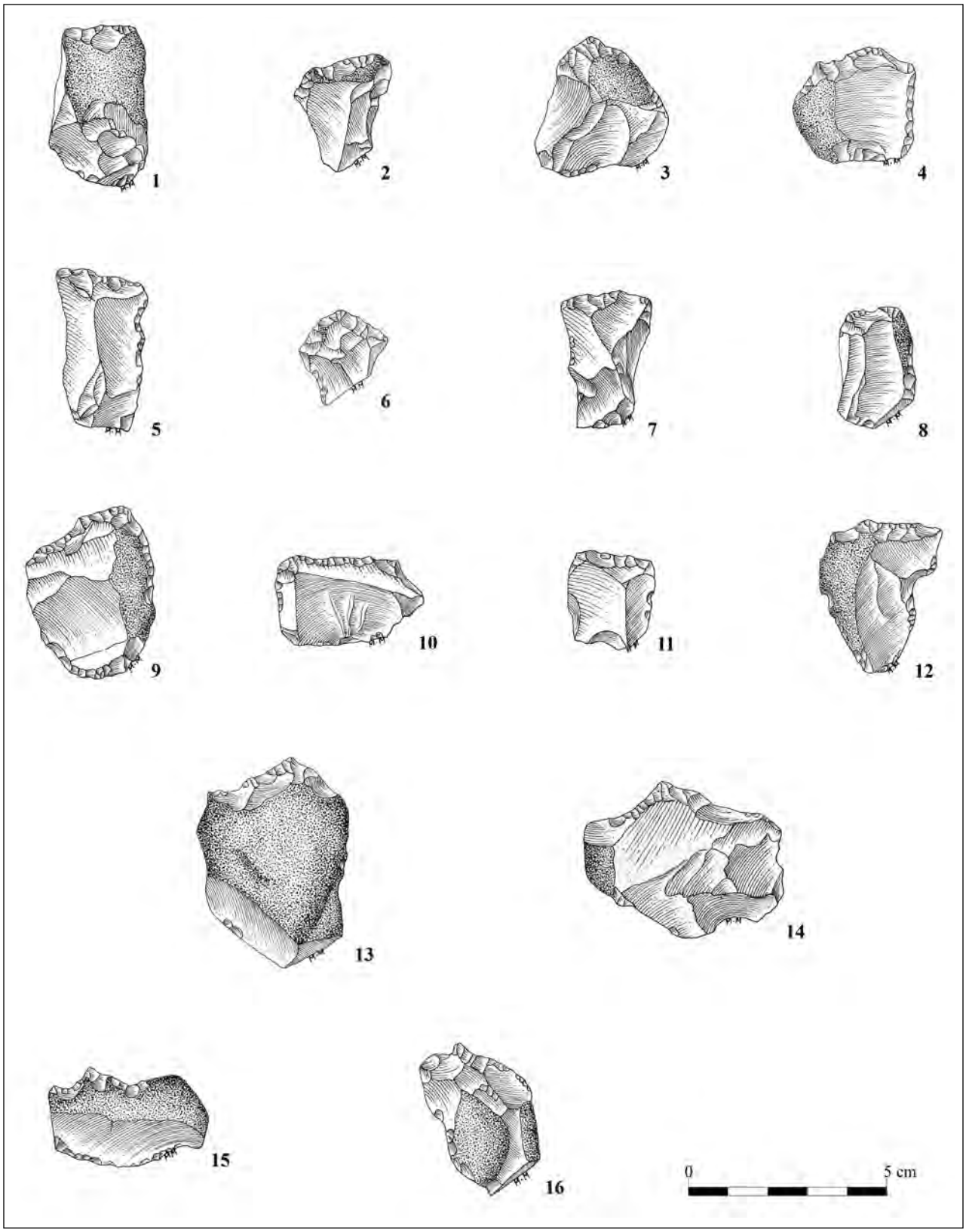

Figure 4. Olduvai, Tanzania. Bed 1, Site FLK North, Sandy Conglomerate. 1.75 million years. Oldowan sensu stricto or Classical Oldowan*. Small retouched tools on chert flakes.*
1 to 11: scrapers; 12: scraper + notch; 13 to 16: becs made from two continuous retouched notches.

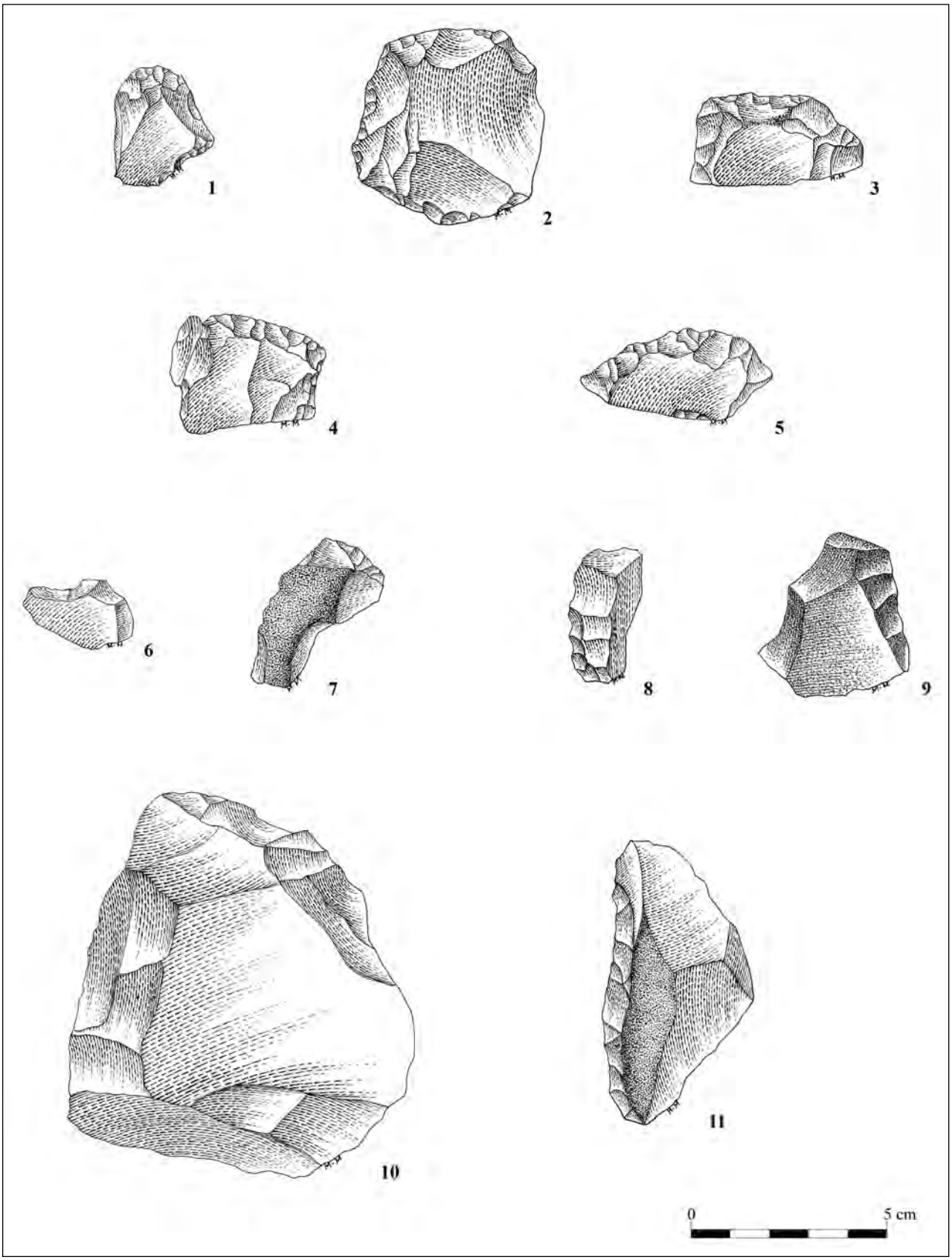

Figure 5. Olduvai, Tanzania. Bed I, site FLK NN 1. 1.75 million years. Oldowan sensu stricto or Classical Oldowan. *Small retouched tools on quartz flakes.*
1 and 7: end scrapers; 2 to 5 and 9 to 11: side scrapers; 6: notch; 8: denticulate scraper.

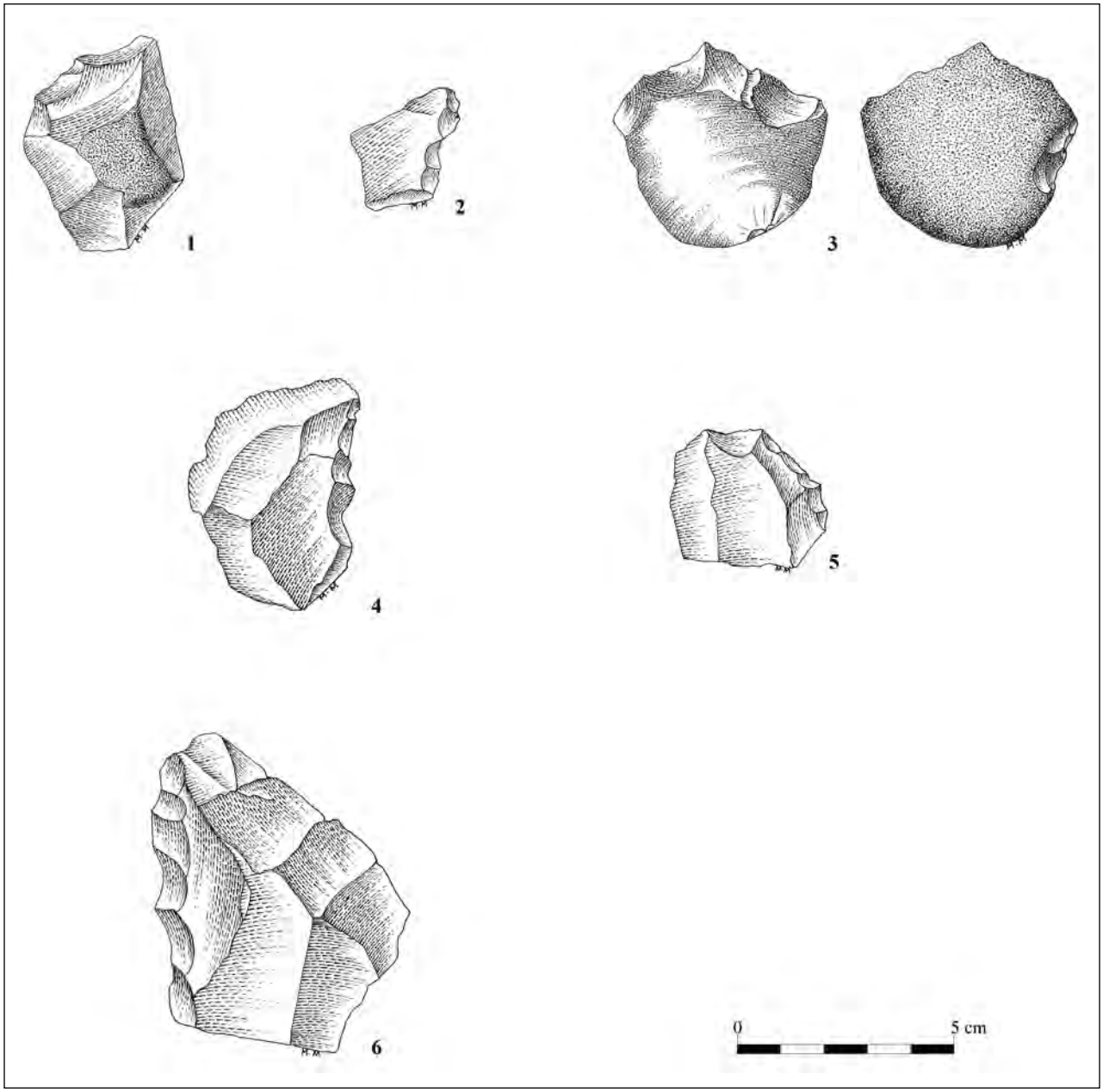

Figure 6. Olduvai, Tanzania. Bed I, site FLK North, levels 1 to 3. 1.75 million years. Oldowan sensu stricto or Classical Oldowan. *Small retouched tools on quartz flakes (n°s 1, 2 and 4 to 6) and volcanic rock (n° 5). 1, 2 and 5: scrapers; 3, 4 and 6: denticulates.*

small-sized tools were fashioned using voluntary retouch, and a certain standardization of manufactured tools is achieved.

These early artisans lived at lake edges or alongside small water sources or marshes, convenient for water supply and scavenging. Though they continued to scavenge, the desire for meatier alimentation led hominids to practice their first hunting activities. The growing diversity of their stone tool-kit denotes a specialization in their activities. Scrapers and end scrapers were probably used to work skins, thus suggesting that they began to dress themselves, denticulates and other tools with wide deep notches may have been used for wood working. But what were polydhedrons and spheroids used for? They may have served as primitive bolas for capturing large herbivores by immobilizing their legs.

The Pre-Oldowan Outside of Africa

According to our knowledge to date, australopithecines appear to have been confined to Africa. However, it was very early after their emergence that the first human tool making artisans left the African cradle of humanity (Figures 19 and 21).

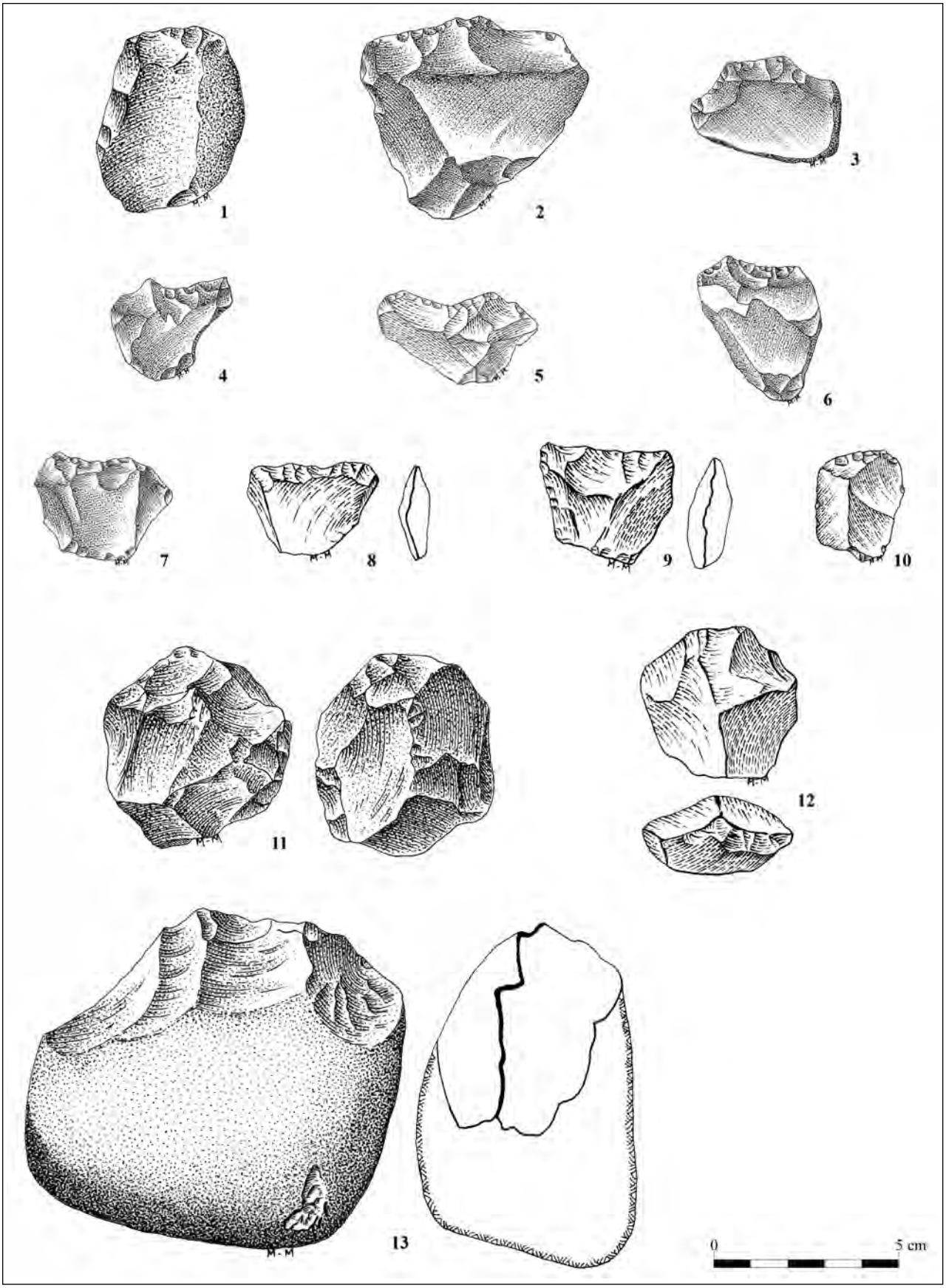

Figure 7. Olduvai, Tanzania. Bed I, site DK. 1.8 million years. Oldowan sensu stricto or Classical Oldowan. *Small retouched tools on flakes, quartz (n°s 8 to 10) and volcanic rock (n°s 1 and 4 to 7). 1: scraper adjacent to an end scraper; 2 to 9: scrapers; 10: end scraper; 11: polyhendron; 12: discoidal core; 13: chopping tool.*

Yiron, Israël

The Yiron site, located north-west of Haifa in Israel, symbolizes this large dispersion. Reported by Avraham Ronen as early as 1980, this site indicates to paleontologists that stone tool manufacturers lived in the Levant more than 2 million years ago (Ronen, 1991 and 2006; Ronen et al., 1980).

The plateau is composed of a thick layer of basalt flow covering gravels trapped in red clays. The basalt flow has been dated by potassium-argon to 2.450 million years old. Stone tools, a few flint pieces, were discovered in the gravel just beneath the basalt (Figure 8). Up to date, too few objects have been found to allow for a precise diagnostic of this industry. It is characterized by the predominance of non-retouched flakes, bifacial cores and the absence of standardized small retouched tools on flakes. It appears therefore very similar to the Pre-Oldowan industries from East Africa.

Dmanissi

At the crossroads between Africa, Asia and Europe, Georgia is situated between the Black and Caspian seas, in the prolongation of the Rift Valley and the Palestinian corridor, beyond the Zagros and Anatolian mountain ranges and the Small Caucasus. It was the launching point from which early humans migrated towards Europe and Asia.

At the Dmanissi site, 85 kilometers south of Tbilissi at an altitude of 100 meters, on the southern slopes of the Small Caucasus, a Lower Pleistocene fauna, a Pre-Oldowan stone industry and numerous hominid remains were discovered in a well dated stratigraphical context (Lordkipanidzé et al., 2007; Celiberti et al., 2004; Gabounia et al., 2000 and 2002; de Lumley, 2006; de Lumley et al., 2002 and 2005). This site attests to Man's arrival at the gates of Europe around 1.810 million years ago, thanks to the geochronological 40Ar/39Ar dating method.

Today in ruins, the medieval city of Dmanissi, near the village Patara Dmanissi, was built on a basaltic spur at the confluence of two rivers; the Mashavera, which circles it to the north-west, and the Pinezaouri, to the south-east. Constructed during the IXth and Xth centuries, the city prospered between the XIIth and XIVth centuries, before its destruction in the second half of the XIVth century by Tamerlan, a Turkish Muslim conqueror, at the head of the Golden Horde.

The prehistoric site was discovered beneath the medieval city. Excavations brought to light trash pits in the foundation basements. In 1991, a hominid mandible was found in one of these, in very ancient deposits within which it had been buried. Following this discovery, other human remains were found at Dmanissi. Excavations under the direction of David Lordkipanidzé have revealed five skulls, four mandibles and around twenty postcranial remains. They are the oldest known human remains yet to have been found in Eurasia.

The Dmanissi spur is covered by a thick volcanic lava flow composed of basalt, covering Pliocene fluvial deposits. This lava, coming from the Dzavacheti of Empeliki Mountains west of the site, flowed through the Mashavera paleo-valley. Heading towards the north-east, it constituted an obstacle against which lakes were formed. An age of 1.850 million years was obtained from the lava flow using the potassium-argon method.

A layer of volcanic ash (bed VI) covers the basalt flow. The hominid remains were found in this level, and it has been dated using the $^{40}Ar/^{39}Ar$ method to 1.810 million years old. Subsequently, river and flood silty sands covered the layer of ash. The paleomagnetic limit Olduvai-Middle Matuyama, around 1.770 million years, was identified in the deposits, 80 centimetres above the layer of ash. The archeological deposits at Dmanissi which yielded the human remains, dated to between 1.810 and 1.750 million years, thus accumulated over a period of less than 60,000 years (de Lumley et al., 2002).

Paleo-vegetation in the area may be reconstituted through the study of the rare pollens, phytoliths and carporests. It evokes a mosaic type landscape, with large, mainly grassy open spaces and dispersed forest areas, a gallery type forest along riversides and denser forest covering the nearby mountains (Messager, 2006). It is similar to that familiar to early African hominids.

The large mammalian fauna includes canids (*Cansis etruscus, Vulpes alopecoides*), bears (*Ursus etruscus, Ursus* sp.), hyenas (*Pachycrocuta perrieri, Pachycrocuta* sp.), felines (*Lynx issiodorensis, Panthera gombaszoegensis*) and notably sabre tooth tigres (*Meganteron meganteron, Homotherium crenatidens*). Among the herbivores present at the site: elephants (*Mammuthus meridionalis*), horses (*Equus stenonis, Equus* sp. aff. *altidens*), rhinoceros (*Dicerorhinus etruscus*), cervids (*Cervus perrieri*, *Cervus* sp., *Eucladoceros* aff. *senezensis*, *Cervus* (*Dama*) cf. *nestii major*), small bovids (*Paleotragus* sp., *Dmanisibos georgicus*, *Galagoral meniginii sicenbergii*, *Capra* sp., *Sorgelia* sp., *Ovibovini*), antilopes (*Gazella* sp., *Antilopini*) and even, among the birds, ostriches (*Strutho dmanisensis)*.

This faunal assemblage may be dated according to the evolutionary stage of the different species to the transition period between the Tertiary and Quaternary periods (Plio-Pleistocene boundary) dated to around 1.8 million years ago.

It comprises African species such as giraffe (*Paleotragus* sp.) and ostrich, Eurasian species such as some horses, elephants rhinoceros and deer, as well as sabre tooth tigers which were widespread during this period in Africa as in Eurasia, clearly indicating that Georgia is situated at the crossroads between two major geographical ensembles (Africa and Eurasia), with the Levant hyphenating these two large spaces.

Sedimentological, paleobotanical and paleontological data allow to reconstitute the environment within which these early humans lived at the gates of Europe: a savannah landscape with some trees and sectors of forest

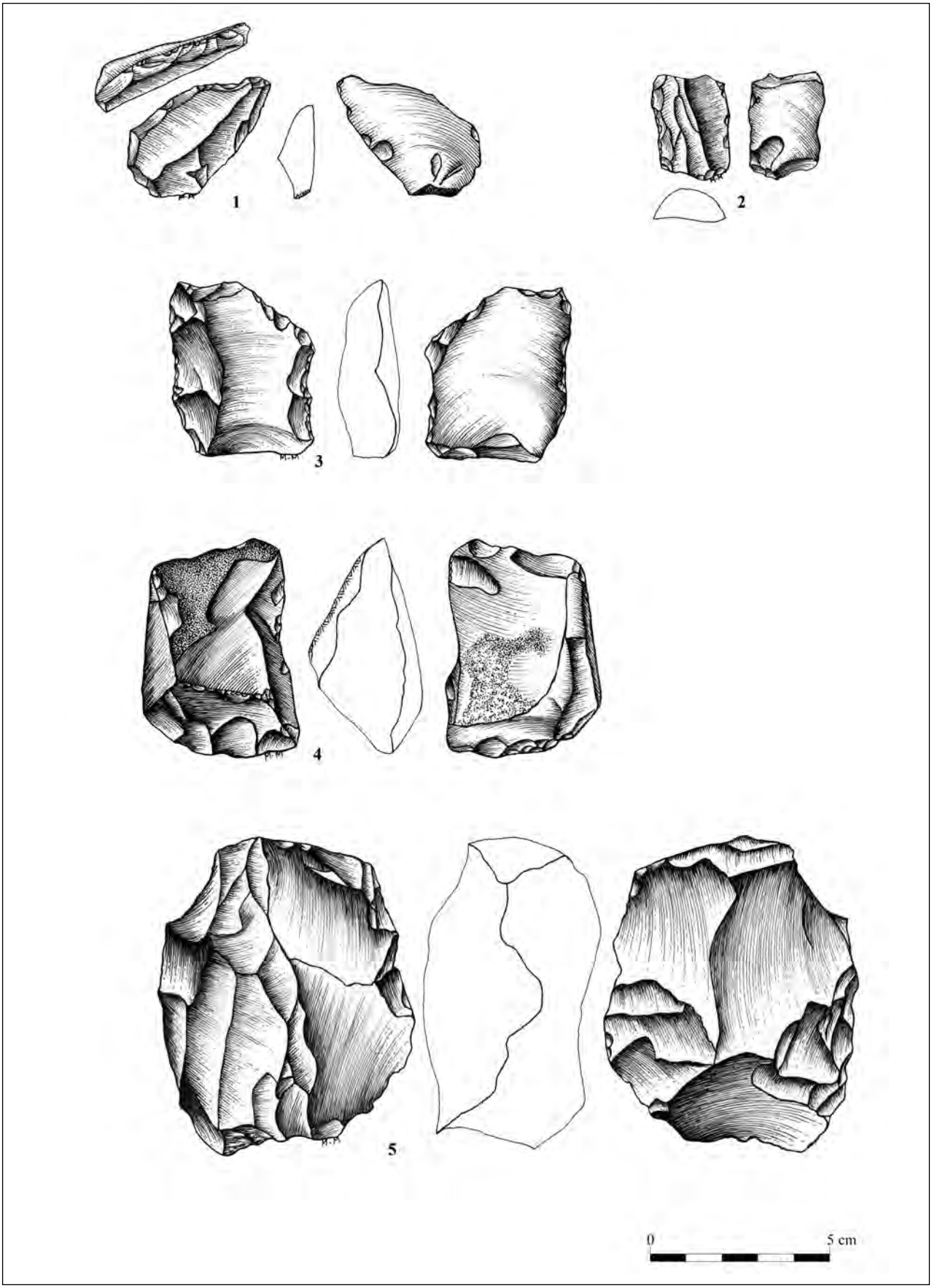

Figure 8. Yiron, Haifa Region of Israël. More than 2 million years. Pre-Oldowan or Archaic Oldowan. *Flint lithic industry. 1 to 3: flakes; 4 and 5: cores.*

cover, under a hot and humid subtropical climate. The hominids who lived on the southern slopes of the Small Caucasus 1.8 million years ago rediscovered their ancestral ecological niche. Fauna there was abundant, while in East Africa the climate grew progressively drier.

The hominid remains include, five skulls, four mandibles and around twenty post-cranial remains, belonged to at least five individuals of both sexes and of varying ages: one adolescent 13 or 14 years old, a pre-adult, two adults and one toothless elder. They were quite small, around 1.50 meters tall, with a cerebral volume of 600 to 770 cm^3 (de Lumley et al., 2006).

Their anatomical characteristics, most notably metrical, indicate that the Dmanissi hominid remains may be an intermediary form between, on the one hand, *Homo habilis-rudolfensis* and, on the other hand, *Homo ergaster* which appeared in East Africa as early as 1.8 million years ago. They do however appear closer to the former group, particularly to *rudolfensis* ER 1470 found in Kenya. Several characteristics differentiate them: their skull has a greater transverse diameter (euroneuryon), less however than that of *Homo ergaster*, a petro-tympanic disposition at the base of the skull in posterior rotation, as well as very strong canine pillars.

The relative gracility of their face, narrowness of their occipital portion and the architecture of the base of their skull clearly distinguishes them from *Homo erectus*, whose predecessors appear to have been *Homo ergaster*.

All of the anatomic characteristics of the Dmanissi hominids combined led Marie-Antoinette de Lumley to attribute the Dmanissi hominids to a new species: *Homo georgicus* (de Lumley et al., 2006).

An abundant stone industry (Figure 9) was also found at Dmanissi, among the fauna and human remains. It is very archaic (Celiberti et al., 2004; de Lumley, 2006; de Lumley et al., 2005). The raw material is essentially composed of volcanic rock pebbles, with some metamorphic rocks as well, all collected from the nearby Mashavera and Pinezaouri alluvials. Raw material supplying was strictly local–there are no rocks brought from any distance away.

Rocks selected are of fine and of varying quality, and hominids chose pebbles with angular morphology, presenting natural planes, most favourable for knapping and shaping.

The lithic assemblage is characterized by a large number of non-modified whole or broken pebbles, perhaps manuports, that is to say, objects brought to the site in their natural state. Many show angular morphology, with triangular or quadrangular sections. Their relatively modest dimensions (75×55×35 mm for the whole pebbles), less than those of the pebble tools (83×73×45 mm), may indicate a choice of larger clasts for the latter.

The assemblage is also characterized by numerous non-modified knapping and shaping products–flakes and fragments–a relative frequency of cores, alongside the larger unifacial or bifacial and more or less elaborate pebble tools. Percussion tools include pebbles showing marks from knapping blows or bone fracture, as well as pebbles with isolated convex negative scars typical of accidental removals. Small flakes less than length 20 mm long are very scarce and there are no retouched flakes. There are no standardized small tools shaped by intentional retouch.

All stages of knapping and shaping operational chains are represented at the site, from whole pebbles up to finished products (non-modified flakes or pebble tools) including knapping residues (cores and fragments) and even percussion instruments. The flakes themselves carry traces of the different knapping stages; from entirely cortical dorsal surfaces (test flakes corresponding to first removals detached from a pebble and thus conserving a cortical surface), to non-cortical flakes (flakes detached within the volume of the blocks). Their presence, as well as that of numerous cores, suggests that knapping took place on the site, *in situ*. A refit of a flake onto a chopper, both from the same layer, also shows that shaping took place on-site. The edges of broken pebbles, pebble tools, cores, fragments and flakes often show irregular use retouch.

The relatively low proportion of non-cortical flakes (less than a third) in association with numerous partially exploited cores with only a few removal scars, underlines non-intensive support exploitation. Most of the non-cortical flakes coming from within the volume of the pebbles are in fine grained tuff, a more exhaustive use of this finer quality rock type. Furthermore, a large number of flakes with cortical striking platforms also conserve, at least partially, the cortical surface of the pebble from which it was knapped on their outer side. This may be explained by the summarily knapped clasts and pebble tools most of which show a single removal negative (primary choppers) or sometimes choppers with a few removals. The orientation of removal scars conserved on the flakes' outer sides confirms the frequency of unipolar knapping. Flakes resulting from more complex knapping strategies are rare. Likewise, flakes show relatively few removal scars (average of 2.1) also underlining minimal exploitation of knapped or shaped clasts.

Knapping was done with a hard percussion instrument using mainly hand held or occasionally bipolar on anvil techniques. Cores are characterized by a dominance of unifacial knapping, few removals and the frequent use of unprepared cortical striking platforms. However, presence of bifacial, multifacial or prismatic cores indicates that the Dmanissi knappers were able to apply more complex knapping strategies and thus possessed well mastered knapping techniques. More numerous removals are visible on some cores, notably those in finer quality raw materials.

Pebble tools and percussion instruments largely dominate the assemblage. Many whole or broken pebbles show traces of their use as percussion tools, either for breaking bones or for knapping or shaping other stone artefacts. Such traces consist of chipped areas or

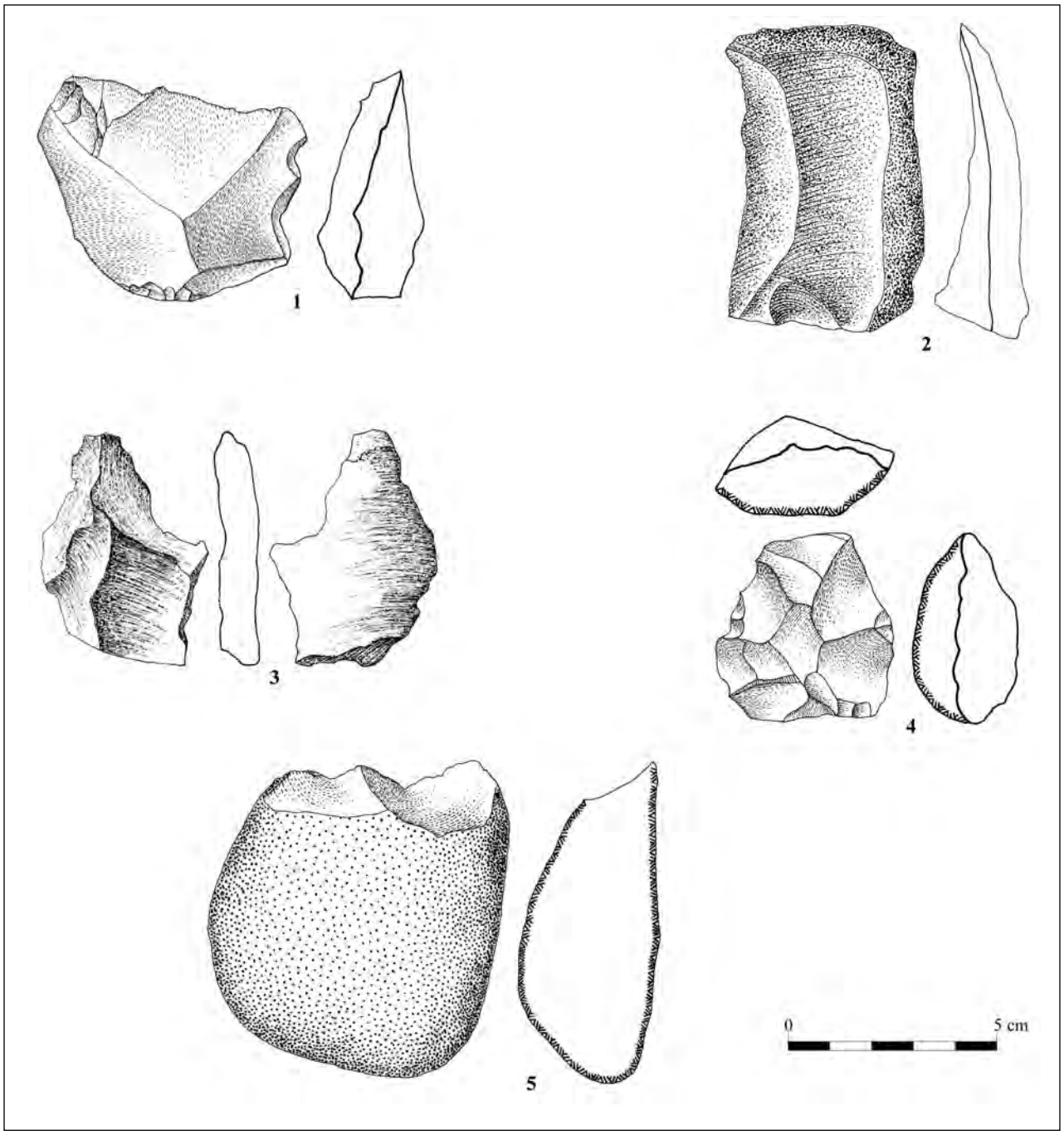

Figure 9. Dmanissi, Georgia. 1.81 million years. Pre-Oldowan or Archaic Oldowan. *Lithic industry in diverse rocks. 1 to 3: flakes; 4: core; 5: chopper.*

cupula, or, more often, accidental single convex edged removal scars. Percussion instruments are most often thick pebbles with traces typically located on the lateral edges. Isolated convex removal scars have nearly right-angled striking angles (average of 86 degrees), in other words, the knapping platform is sub parallel to the main pebble axis.

Pebble tools found in the different layers of the Dmanissi stratigraphical complex attest that the clasts were selected according to their size; favouring large pebbles; either thick and angular or flatter and angular. Nearly two thirds of the pebble tools show a single concave removal negative. These are primary choppers whose cutting edge was shaped by only one short removal, with a more acute angle (average of 79.5 degrees) than observed on pebbles with convex edged removal scars. Choppers, usually non-converging, are more elaborate; shaped by few removals (an average of only 3.3), delineating an angled cutting edge (average of 79 degrees). The few core-scrapers present in the assemblage were made on larger clasts by more numerous removals (average=4.3). Chopping-tools are rare, made from thick, large pebbles. On the average they show only five removal scars and the angle of their cutting edge is the most acute among

the pebble tools (average of 69.2 degrees).

On the other hand, small standardized tools shaped by intentional retouch on flakes or fragments were not found in the stone tool assemblage from Dmanissi. Their cutting edges do however often show irregular, marginal micro-retouch or isolated irregular retouch, such as dense notches, which may be continuous or sometimes even overlapping, localized on parts of the edges and attesting to the intensive use of these pieces.

Among pieces showing irregular retouch, isolated notches are most frequent (56.2 %). Only about a quarter of the pieces affected show continuous irregular retouch located on an edge and evoking a scraper or a sort of end scraper. Some flakes (seven pieces) show a single removal on one or the other of its faces.

In short, the Dmanissi stone assemblage (Figure 9) is characterized by the following traits :

- a strong proportion of whole or broken pebbles (manuports)
- numerous non-modified knapping products (flakes and fragments), most of which conserve a cortical surface
- cores with a limited number of scars, made from selected angular clasts (pebbles with natural planes)
- primary choppers (pebbles with single concave flake scars) dominate among the macro-tools and there are some more elaborate choppers (notably non-pointed), whereas percussion instruments are most frequent
- many pieces, especially flakes and fragments, with traces of intense use wear such as notches, or dense, continuous or overlapping irregular retouch, attesting to their intensive use
- absence of standardized small tools shaped by intentional retouch

The stone industry from Dmanissi has numerous points in common with the oldest stone industries known in Africa such as those from Kada Gona (EG 10 and EG 12, 2.550 million years old); Lokalalei 2C (2.340 million years old) and Fejej FJ-1 (1.9 million years old):

- local raw material selection
- better quality raw materials were more exhaustively knapped
- selectivity in choice of pebble morphology
- abundance of non-modified knapping products (flakes, debris, cores)
- frequent production of sharp-edged objects (essentially flakes, but also pebble tools) for cutting meat and disarticulating animal carcasses
- mastery of rock fracturing methods
- use of hand held and bipolar knapping on an anvil techniques
- parallel use of several knapping strategies
- predominance use of unidirectional, unifacial knapping strategies
- presence of pebble tools, mainly with unifacial removal scars (choppers) with little morphological standardization
- absence or extreme rarity of small tools shaped by intentional retouch
- high proportion of flakes, fragments and broken pebbles with tiny retouch or irregular retouch, notably dense notches, resulting from intensive use

Pirro Nord, Foggia Province, Southern Italy

The Pirro Nord site, also known as the Cava dell'Erba, is located in southern Italy's Foggia Province, on the Apricena Commune, northeast of the Gargano massif. The area has been known for a long time as a very rich paleontological site; its karstic cavities were brought to light during quarrying and have yielded remains of mammals characteristic of the Lower Pleistocene.

In September 2006, at the occasion of the XVth International Congress of Prehistoric and Protohistoric Sciences, Marta Arzarello and her collaborators reported the discovery, among the faunal remains, of a few stone pieces (Figure 10), attesting to the arrival of prehistoric humans on the Mediterranean coast of southern Europe as early as 1.4 million years ago.

The site is a vast karstic network of galleries and fissures, largely produced by erosion. The fauna discovered in these galleries is very rich: more than one hundred species of vertebrates have been found. Carnivores, notably felines, are dominant (*Homotherium crenatidens*, *Megantereon whitei*, *Acinonix pardinensis*, *Lycaon lycaoanoides*), bear (*Ursus etruscus*) and giant hyena (*Pachycrocuta brevirostris*). Among the herbivores there are bison (*Bison deguilii*), horse (*Equus altidens, Equus* cf. *Equus stenonis*), rhinoceros (*Stephanorhinus hundsheimensis*) and cervids (*Praemegaceros obscurus, Axis* sp.). A specimen of African monkey has also been found (*Theropithecus* sp.).

This faunal assemblage is characteristic of the Lower Pleistocene and dates the site to around 1.4 million years old. It is later than the beginning of the Lower Pleistocene, as indicated by the presence of *Stephanorhinus hundsheimensis*, and earlier than the Vallonnet site, which has been dated to 1.070 to 1 million years old and where *Ursus deningeri* and *Bison schoetensacki* have been found. Among the bird remains discovered, the coexistence of such species as the great bustard (*Otis tarda*), the bustard (*Tetrax tetrax*) and the sand grouse (*Pterocles orientalis*) suggest an open environment, arid, but with seasonally humid areas. This landscape corresponds to that favoured by large herbivores.

A few pieces knapped from flint were found in three fissures: three cores and some flakes. They were

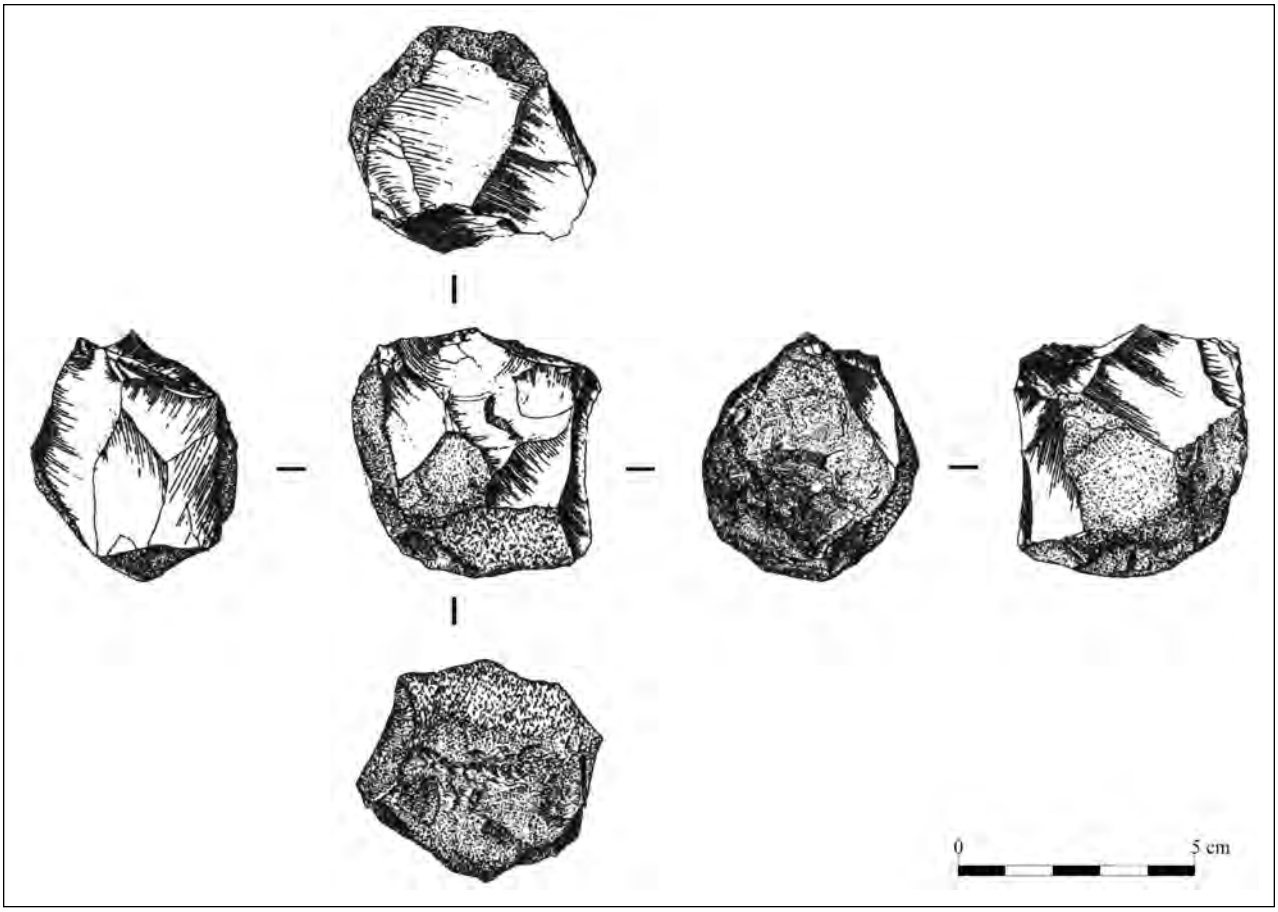

Figure 10. Pirro Nord. Foggia Province, Italy. 1.4 million years. Pre-Oldowan or Archaic Oldowan*. Flint core. (from M. Arzarello et al., 2006).*

knapped by violent percussion using the hand held technique. No small flakes with intentional retouch were found. However, the edges of some of the flakes show micro retouch attesting to their use. The industry is like other "Pre-Oldowan" industries older than Dmanissi, Yiron and some East African assemblages (Fejej, Lokalalei and Gona). The Pirro Nord assemblage is characterized by the production of non-modified flakes. Raw material is local testifying to a limited area of transport.

This recent discovery of a prehistoric site 1.4 million years old from southern Italy is a milestone for the arrival of hominids in southern Europe, on the Mediterranean shore of southern Europe.

The great Guadix-Baza paleo-lake, Orce, Andalucia

Barranco León and Fuente Nueva 3

In 1976 the team from the Miguel-Crusafont Paleontological Institute in Sabadell, near Barcelona, discovered a rich stone industry among the large mammal fossils in the Guadix-Baza Basin in Andalusia, northeast of Granada. The Barranco León and Fuente Nueva 3 sites, just 4 kilometres apart, are located to the east of the town of Orce, around 115 kilometres to the north east of the Provincial capital and 80 kilometres from the seashore (de Lumley, 2006; Martinez-Navarro et al., 2003; Toro et al., 2002, 2003a and 2003b). These two sites are of exceptional interest as examples of typical Pre-Oldowan butchery sites demonstrating, once again, that early humans made tools because they had become meat-eaters.

The Barranco León site was first made known by Jordi Agusti and excavated in 1994 by Josep Gibert. Excavations were later taken up by Isidro Toro Moyano. Fuente Nueva 3 was discovered in 1991 by Alain Bocquet and excavated from 1995 by Josep Gibert and Alain Turq. Excavations were later undertaken by Isidro Toro Moyano.

Two deeply embanked valleys cut into the Guadix-Baza basin Plio-Pleistocene formations that are over 100 meters thick. Important natural stratigraphical sections have been left by erosion. They show the evolution of an ancient lake, the Baza paleo-lake, which covered the basin from the end of the Miocene up the Middle Pleistocene, between 7 million years and 300,000 years ago, before drying up, when waters feeding this endoreic basin were captured by the Guadalquivir.

This basin, extending over around 3,000 km^2, was formed during the Miocene, about 10 million years ago (Middle Tortonian) following tectonic phenomena. Once linked to the Mediterranean Sea and the Atlantic Ocean, it was first inundated by the sea which, at the end of the

Miocene, leaving progressively thinner clayey deposits. By the Messinian, around 6 million years ago, during the Miocene-Pliocene transition, connections between the Mediterranean and the Atlantic were permanently closed and the basin became endoreic, that is to say, fed only by continental waters, and so became a lake. It was then progressively filled in by continental deposits during the Pliocene, and throughout the Lower and Middle Pleistocene.

During the middle of the Middle Pleistocene the Guadalquivir captured drainage waters and the basin was opened up once again, it became exoreic, as this Andalusian river emptied into the Atlantic Ocean to the west of Gibraltar. Its Plio-Pleistocene formations were then truncated by a glacis, and then deeply cut into by erosion, the base of the level then being lowered to 500 meters, after which the Baza paleo-lake dried up permanently.

Numerous paleontological sites have been discovered in the upper layers of this formation on the border of the paleo-lake, most notably Venta Micena, dated to 1.5 million years ago, as well as the Barranco León and Fuente Nueva 3 archeological sites, both dated to around 1.2 million years old. These last two sites have also revealed stone industries and numerous bone remains. These two Andalusian sites are very rich, not only for information they furnish about fauna, but also for their contribution to what we know about the early inhabitants of Europe on the Iberian Peninsula.

The fauna is very abundant and these sites have been dated according to the biochronology of large mammals and microvertebrates. The sites have also been dated by magnetostratigraphy. The sedimentary deposits give a negative paleomagnetic reading which, taking into account the fauna's evolutionary stage, corresponds to the Middle Matuyama inversion (1.780 to 1.070 million years), preceding the direct Jaramillo episode (1.070 million years to 984,000 years). In fact, the large and micro mammals are at the same evolutionary stage and they are very close in age. They are older than those from the Vallonnet Cave site, dated to between 1.070 million years and 980,000 years, with the appearance of the deer (*Megaceroides* cf. *verticornis*) and the archaic bear (*Ursus deningeri*), species absent from both of these Spanish sites, which may therefore be dated to around 1.2 million years old.

Fauna from Barranco León (Martinez-navarro et al., 2003) includes saber-toothed tigers (*Homotherium* sp.), giant hyenas (*Pachycrocuta brevirostris*), bears (*Ursus* sp.), an archaic wolf (*Canis mosbachensis*), foxes (*Vulpes* sp., *Alopex* cf. *praeglacialis*), badgers (*Meles* sp.), archaic elephants (*Mammuthus meridionalis*), hippopotamus (*Hippopotamus antiquus*), deer (*Megaceroides* aff. *obscurus*, *Pseudodama* sp.), bison (*Bison* sp.), small bovids (*Hemitragus* cf. *albus*), horses (*Equus altidens*, *Equus* cf. *bressanus*), rhinoceros (*Stephanorhinus hundsheimensis*), porcupines (*Hystrix* sp.), rabbits (*Oryctolagus* cf. *lacosti*), and many rodents (*Allophaiomys* aff. *lavocati*, *Allophaiomys* sp., *Castillomys crustafonti* sp., *Apodemus* aff. *mystacinus*).

The fauna from Fuente Nueva 3 (Martinez-Navarro et al., 2003) includes saber-toothed tigers (*Machairodontinae* indet.), giant hyenas (*Pachycrocuta brevirostris*), bears (*Ursus* sp.), an archaic wolf (*Canis mosbachensis*), foxes (*Vulpes* sp., *Alopex* cf. *praeglacialis*), badgers (*Meles* sp.), archaic elephants (*Mammuthus meridionalis*), hippopotamus (*Hippopotamus antiquus*), deer (*Megaceroides* aff. *obscurus*, *Pseudodama* sp.), bison (*Bison* sp.), small bovids (*Ammotragus europaeus*, *Hemitragus* cf. *albus*), horses (*Equus altidens)*, rhinoceros (*Stephanorhinus hundsheimensis*), porcupines (*Hystrix* sp.), and rodents (*Allophaiomys* aff. *lavocati*, *Allophaiomys* sp., *Mymomys savani*).

The stone industries from both sites (Figure 11) are very similar, concerning the raw materials used, and the types of pieces realized and the knapping techniques used (Toro et al., 2003a and 2003b; de Lumley, 2007). They attest to a human presence in southern Europe as early as the middle of the Lower Pleistocene.

The rocks used as clasts for these tools are mainly flint and limestone, collected in the environment immediately surrounding the sites where they are abundantly available as blocks, pebbles, nodules or plates. Different types of flint of varying quality, as well as marly limestone or limestone silicified to different degrees have been identified.

Rock exploitation apparently began at the source where the materials were collected by some initiating blows. An under-representation of flakes from the early stages of the operative schemas is seen: entirely cortical or with few removal scars on their dorsal face, suggests that this activity took place away from the sites. The scarcity of possible refits of considerable size confirms that most of the knapping was not performed in the same area where the meat was consumed.

Different types of more or less massive percussion tools–whole or broken pebbles, stones and pebbles with isolated convex removal scars–are numerous. Traces of their use are conserved on their surfaces as crush-marks, cupules, or isolated removal scars. The surfaces of the limestones are chemically altered, often impeding observation of any such traces. These implements apparently served early humans frequenting the swampy area on the edge of the Baza paleo-lake for breaking large herbivore bones and as percussion instruments for shaping and knapping stones.

Large tools on pebbles or stones are very rare in both sites among numerous knapped flakes. They are mainly pebbles with single concave removal scars ("primary choppers"), while in both sites there are few choppers with edges shaped using a series of continuous removals. Other types of choppers, irregular and of poor quality are also rare.

Flake knapping is thus the main characteristic of the Barranco León and Fuente Nueva 3 assemblages. It took place using hand held or bipolar on anvil techniques. Small series of unidirectional removal scars are

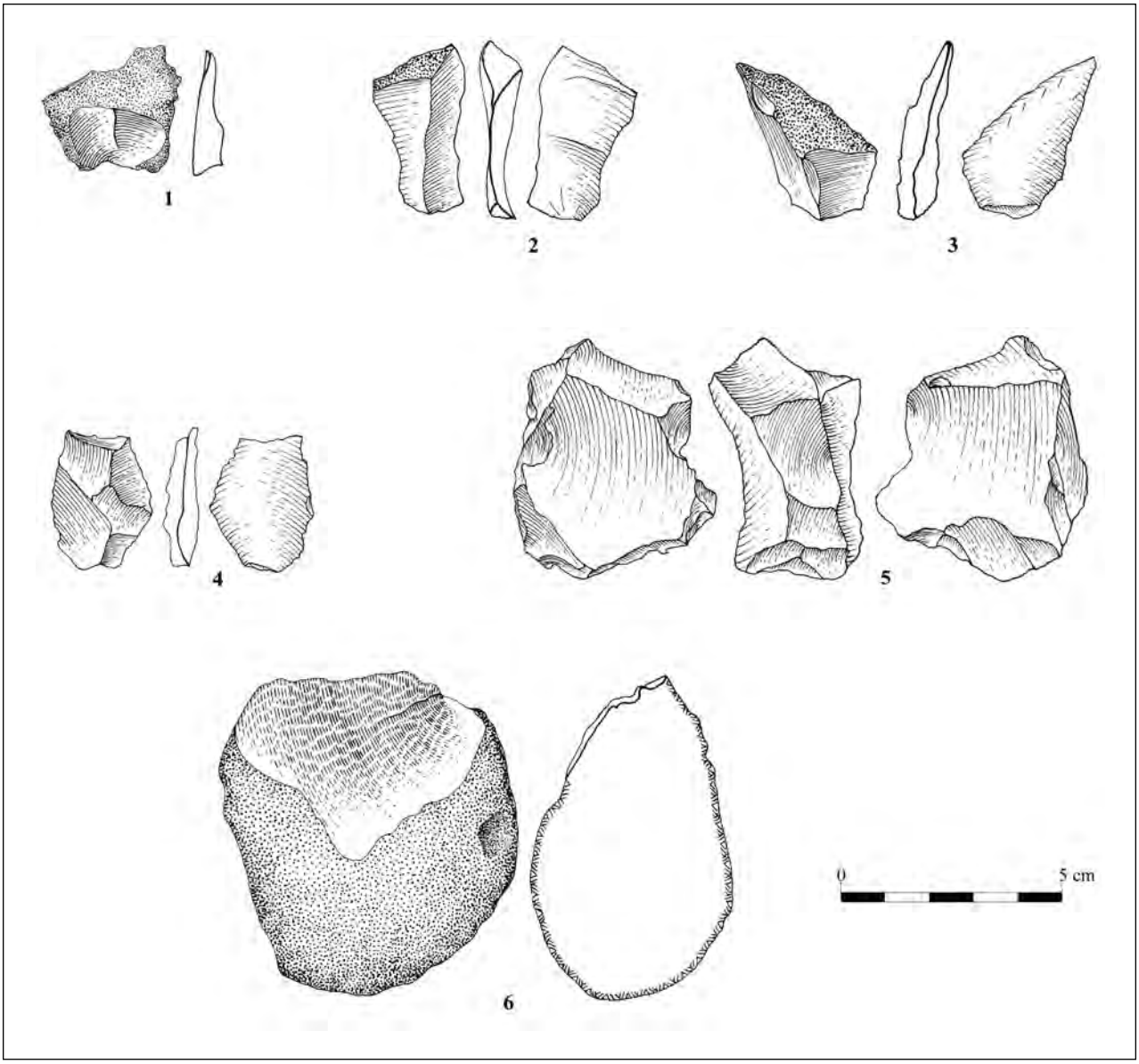

Figure 11. Barranco León and Fuente Nueva 3, Orce, Guadix-Baza basin, Andalucia, Spain. 1.2 million years. Pre-Oldowan or Archaic Oldowan.
1 to 4: flakes; 5: core; 6: pebble with an isolated concave removal negative (primary chopper).

often observed on the cores. Core scars are sometimes also centripetal or crossed, on one or two sides of a clast, or multifacial in orthogonal series, leading to the production of cores with globular or polyhedron morphology. Some of the flakes obtained were themselves subsequently knapped. The latter, as well as overall core reduction strategy, reveals a desire to optimize raw material exploitation, especially for finer quality rocks such as some of the flint.

Angular fragments are also numerous, resulting from the percussion of relatively poor quality rocks, with mineral inclusions or lithoclases transformed into planes during knapping.

Most of the flakes conserve little of the original cortical surfaces from pebbles or nodules while others were knapped from the interior of the clast and conserve no cortical surface at all. The latter were obtained from the central mass of the raw material and are often small with a low extension (length) index. The model sought after was a small, more or less square flake, on the average 2 to 3 centimetres long. The frequency of small flakes may be explained by frequent use of the bipolar on an anvil technique which produces chipping on the transversal flake edges, posed directly onto the anvil, and the detaching of small fragments.

Cores are remarkably rare compared to flakes. At Barranco León, a total of 252 flakes larger than 2 cm were counted in comparison to only 18 cores. Such a ratio (14 flakes for one core) seems impossible given the poor quality of some of the rocks used. At Fuente Nueva 3, a total of 300 flakes larger than 2 cm in comparison to 21 cores giving a ratio of around 16 flakes for each core, even less probable for poor quality rocks. It therefore appears likely that a large proportion of the non-modified

flakes, especially those larger than 2 cm, and also the cores, were transported to the site at least partially flaked.

However, numerous exhausted polyhedron, globular or cubic cores from which no further flakes could have been produced, knapped using either hand held or bipolar on an anvil techniques, as well as flake-cores from which small flakes were produced, seem to suggest that much of the knapping did take place on-site, according to needs, to carry out certain activities. There are mainly very small flakes knapped on-site from small cores (very reduced) or from other flakes. In fact, frequent irregular retouch on these small flakes show that their edges were rapidly used and they probably had to be replaced often.

However, numerous cores showing intense exploitation and from which no further flakes may be obtained are seen; polyhedrons, globular or cubic cores knapped using either hand held or bipolar flaking on an anvil, seem to indicate that a large number of pieces were obtained on the site, according to needs, for some activity.

Many pieces, be they broken or shaped pebbles, angular stones, cores, fragments or (especially) flakes, show traces on their more-or-less sharp cutting edges of irregular use retouch and micro retouch. However, intentional retouch for the elaboration of standardized small tools was not practiced by Orce's early humans.

The quasi-exclusive use at Barranco León and Fuente Nueva 3 of local raw materials can be seen; all coming from sources accessible within a range of 5 kilometres, suggest that these two sites were not habitation sites. They seem to have been areas for a specific activity for which hominids used nearby rocks.

This system of exploitation of rock resources is particularly interesting. The behaviour of these early humans is, in this respect, very opportunistic.

Quaternary conglomerates near the sites, accessible 500 meters to 5 kilometres away, furnished nodules of limestone and flint. Collection of these materials could have taken place during daily foraging in search of food.

Although this kind of exploitation of stone resources may appear simplistic or even instinctive, selective behaviour did preside in the choice of raw materials. Pebbles with summarily rolled surfaces and, consequently few fissures, seem to have been selected. Among the latter, limestone was carefully selected for the production of large tools while nodules of silicious rocks (flint and radiolarite) were reserved for flake production. This selectivity shows that hominids practiced a reasoned use of raw materials, taking into account their physical properties, in spite of their simple acquisition approach. It proves that these early humans were perfectly adapted to their environment and that they had already adopted a behavior that was efficient in its industrial enterprises.

The presence of stone artefacts among the large mammal bones, sometimes preserved in anatomical position, such as the hippopotamus at Barranco León or the elephant at Fuente Nueva 3, as well as apparently human-caused breakage and some traces of butchery on bones, leads to believe that the stone tools were destined to be used for processing the carcasses of these animals.

The relative scarcity of pebble tools and their small size precludes the idea of a site reserved for disarticulating and cutting up of large mammal carcasses killed by humans or which were bogged down in the swamps.

The predominance of non-modified flakes, most often small in size, on the average 10 to 25 mm long at Barranco León and 20 to 40 mm long at Fuente Nueva 3, seems to suggest that they were used for cutting up and scraping meat remaining on animal carcasses abandoned by large carnivores in the swampy areas around the Baza paleo-lake (Figure 12). Humans competed with hyenas for the carcasses. They practiced secondary scavenging : they followed satiated carnivores and obtained the pieces of meat still remaining on the bones using their small flakes.

The technological (operative schemas) and typological (resulting tool types) characteristics of the stone industry, as well as the behaviour of the early humans from Barranco León and Fuente Nueva 3, fit these sites within the Pre-Oldowan cultural horizon.

La Sima del Elefante, Sierra d'Atapuerca, Spain

Around 500 kilometres to the northwest of the Guadix-baza basin, the Atapuerca Sierra, near Burgos, in the Castille-León Province, is an imposing karstic massif with numerous cavities which sheltered remarkable prehistoric sites covering all periods of human history in Europe (Carbonell I Roura et al., 1995 and 2001; Carbonell I Roura et al., 2008; Cuenca-Bescos et al., 2004; Garcia et al., 2008; Huguet et al., 2007; Pares et al., 2006; Rofes et al., 2006; Rosas et al., 2001 and 2006).

Amongst these sites, La Sima de l'Elefante is a cavity opened up by the trench of an old railway track (la *Trinchera del Ferrocaril*). It is a vast cave, rich in large mammal faunal remains–such as elephants–from which comes the name of the site. It was in-filled by sandy clays rich in stones over 15 meters thick. The lower levels are very old; magneto-stratigraphical studies have established that they were deposited prior to the geomagnetic polarity change Matuyama-Brunhes, dated to 770,000 years ago. Results from the *cosmogenic nuclide* method gave a date of 1.13 ± 0.16 and 1.22 ± 0.14 million years (Carbonell et al., 2008).

Fauna from these levels includes archaic cervids, primitive bison, hippopotamus, rhinoceros, macaques, turtles, beavers and other rodents and insectivores for which numerous remains have been found. The evolutionary stage was determined by paleontological studies, particularly by the rodents, including an archaic form of *Iberomys huescarensis*, *Allophaiomys lavocati* and *Catillomys rivas*, and the insectivores, especially *Beremendia fissidens* and *Asoriculus gibberodon*, all suggest a date of Lower Pleistocene, earlier than 1 million years old.

Presence of hippopotamus, beavers and turtles sug-

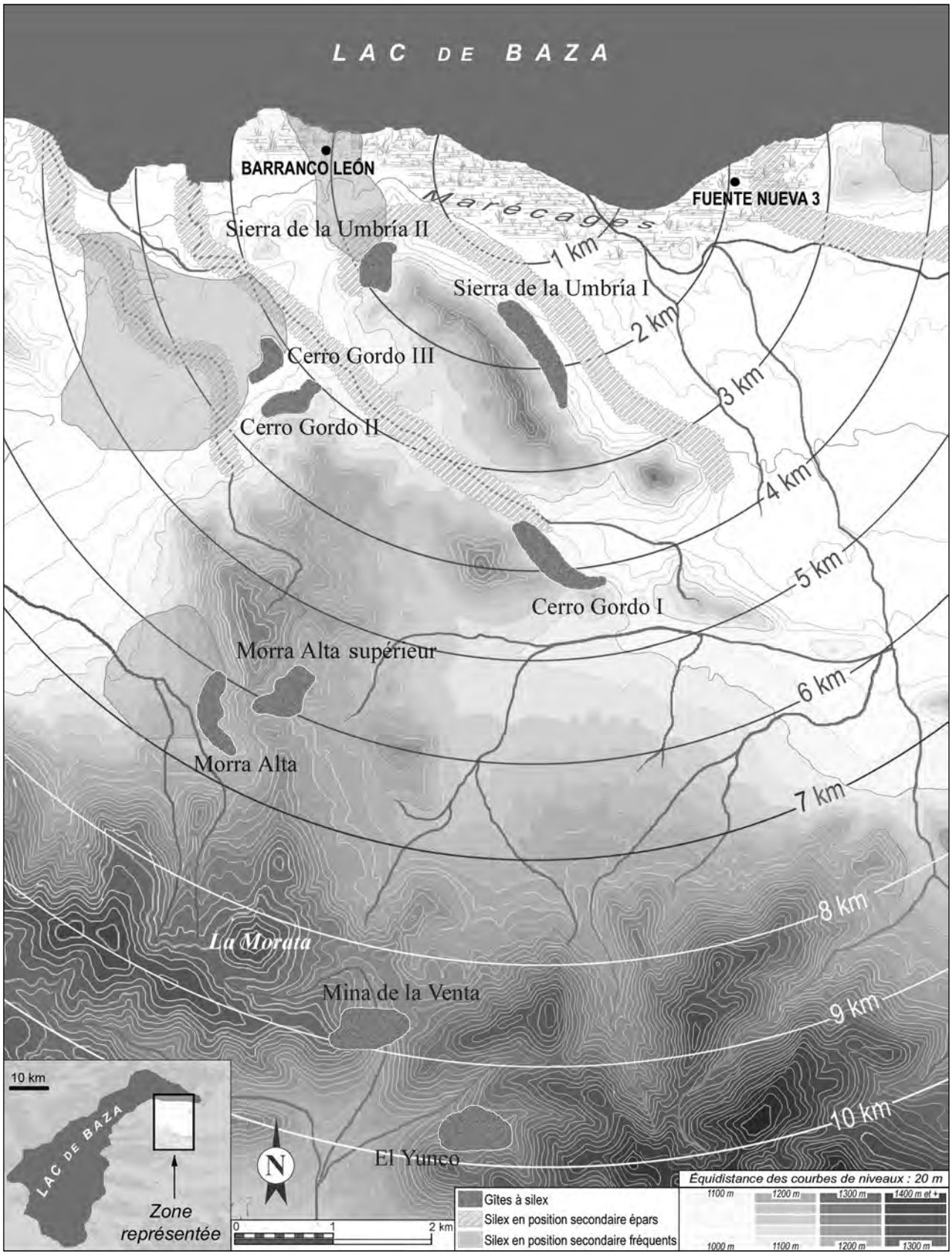

Figure 12. The Pre-Oldowan site Barranco León and Fuente Nueva 3, Orce, Guadix-Baza basin, Andalucia, Spain, were located in a swampy area between the southern edge of the large Baza paleo-lake and a Jurassic limestone massive, rich in flint.
In the swampy area, on the Baza lake-edge, prehistoric humans indulged in scavenging around 1.2 million years ago.

gest a humid landscape with rivers and swamps. During excavations in 2000, Eudald Carbonell's team brought to light the first flake knapped from flint: it is proof that hominids stayed at the Atapuerca Sierra more than a million years ago.

Since then, other non-modified knapped flint flakes have been recovered. None of these flakes had been transformed by intentional, regular retouch. They are non-modified flakes. These tools appear to correspond with those from other sites with Pre-Oldowan industries.

In July 2007 an isolated premolar and the lower portion of a hominid mandible, belonging to the same individual, was attributed to *Homo antecessor* (Carbonell et al., 2008), were discovered.

Thus, a little over 1 million years ago in the Guadix-Baza basin at Barranco León and Fuente Nueva 3 as well as at La Sima del Elefante in the Atapuerca Sierra, the earliest inhabitants of Europe lived in a humid, wooded environment, at a lake's edge in the Andalusian basin or near the rivers and swamps of the Castilian Sierra.

Who were the artisans of these primitive stone tools? Were they similar to Dmanissi's *Homo georgicus*, at the gates of Europe, or were they closer to the European forms of *Homo erectus*, *Homo heidelbergensis* that we find later at the Ceprano site in Italy (*Homo cepranensis*) or at Gran Dolina (*Homo antecessor*), another cave site in the Atapuerca Sierra, around 880,000 years ago? Ongoing excavations in the Guadix-Baza basin and the Sima d'Elefante site may soon provide answers to this question so fundamental to understanding the morphological evolution of the earliest inhabitants of Europe. The hominid remains found in June and July in the lower levels of the Sima del Elefante yield the first answers to this question.

The Vallonnet Cave site, Roquebrune-Cap-Martin, Alpes-Maritimes

The Vallonnet Cave at Roquebrune-Cap-Martin in the Alpes-Maritimes is located on the western slopes of Cap Martin, around 800 meters from the Mediterranean seashore (de Lumley et al., 1988). It opens up onto the right-hand side of a small ravine, the Vallonnet, which descends towards Menton Bay. It is a small cavity carved into a Jurassic dolomitic-limestone massif, pitched, enveloped in a Miocene conglomerate made up of pebbles and sandy concretions. The low and narrow porch joins a 5 meter long corridor which opens onto a 4 meter wide chamber. Stratigraphical and sedimentological studies of the deposits have defined five ensembles.

The base of stratigraphical ensemble I is made up of a stalagmitic floor dated to between 1.4 and 1.370 million years old. Pollen analysis in the deposits evokes a forest landscape with Mediterranean essences dominated by plane trees.

Above this level, stratigraphical ensemble II is made up of marine sands rich in foraminiferous, marine mollusc shells and fish bones amassed by a transgressing sea which dismantled the existing continental in-fill. This marine beach is slightly older than 1.070 million years. Among the fish, the presence of diodon (globe fish) and, among the molluscs, the presence of species typical of warm seas, indicate a tropical or subtropical sea. The latter data, in association with that from the fossil pollen analysis, suggests a relatively warm, dry climate with mild winters.

With a thickness of 1.5 meters, stratigraphical ensemble III is the most important of the series deposited in the cave. It is composed of continental deposits made up of clayey-silty sands rich in stones and pebbles from the conglomerate overhanging the cave. This relatively homogenous continental in-fill has been sub-divided into three main layers which were subsequently sub-divided into several human or carnivore occupation levels. Many bones brought into the cave by humans and/or by carnivores have been found in these deposits. Pollen analysis in this stratigraphical ensemble suggests an open landscape made up of composites, mainly chicories, clusters of trees, and a sort of scrubland passing gradually into deciduous-leafed oak forests dominated by white oak. The relatively dry climate observed at the beginning of this ensemble becomes more humid later on. Magneto-stratigraphical studies show that this ensemble corresponds with the Jaramillo geomagnetic polarity episode within the larger reverse polarity period of Matuyama. This episode, situated between the two reverse geomagnetic polarity events that are the Middle and Upper Matuyama, is dated to between 1.070 and 1 million years ago.

A little over 1 million years ago, the entranceway corridor's existing infill was emptied by erosion and only the deposits located deep in the chamber of the cave were preserved.

Stratigraphical ensemble IV is a thick stalagmite floor that was formed and that sealed what remained of the geomagnetically reverse deposits thus preserving them from further erosion. It was formed later than 1 million years ago (Upper Matuyama) and has been dated using electron spin resonance to between 900,000 and 890,000 years old.

Palynological analysis suggests a deciduous forest comprising a variety of species suggesting a colder and especially more humid climate than at present.

The deposits making up this upper ensemble V consist of silty-sandy plastic clays, extracted from earlier deposits and accumulated during the different humid phases of the Quaternary period.

Nearly one hundred knapped stone tools were found in the sandy-clayey-silty sediment of ensemble III (Figure 13) among Quaternary faunal remains. They are dispersed over sixteen carnivore and human occupation levels identified as different archeostratigraphical units by Anna Echassoux (2004) on computerized vertical projections allowing a view of the archeological material on profiles 25 centimetres wide.

Six units were identified in the lowest layer C, five in the middle layer B2 and five in the upper layer B1.

These archeostratigraphical units were not only human occupations. Research carried out has not revealed any particular pattern in the site. The Vallonnet Cave served as a den for large carnivores, mainly bear, and felines such as panther and saber-toothed tigers; large hyenas broke many of the bones (Essachoux, 2004). Large carnivores brought numerous herbivore carcasses into the cave: deer, bison, small bovid, rhinoceros, horse, wild boar. Apart from the carnivores, humans could have also frequented the cave, leaving their tools behind.

Large mammal fauna is very abundant and includes more than twenty-five species. Carnivores account for a third of the material which is characteristic of the end of the Lower Pleistocene and which includes some archaic species: macaque (*Macaca sylvanus florentina*), felines like the Eurasian jaguar (*Pantera gomaszoegensis*), cheetah (*Acinonyx pardensis*) or the giant hyena (*Pachycrocuta brevirostris*), southern elephant (*Mammuthus meridionalis*), rhinoceros (*Stephanorhinus hundsheimensis*, horse (*Equus stenonis*), pig (*Sus*), deer (*Cervus nesti vallonnetensis*), musk ox (*Praeovibos*).

Other, more evolved species, announce the Middle Paleolithic: an archaic wolf (*Canis mosbachensis*), an archaic fox (*Alopex praeglacialis*), the cave lynx (*Lynx spelaea*), a bovid (*Bison shoetensacki*) and thar (*Hemitragus bonali*).

The evolutionary stage of each species of this well dated fauna (from 1.070 to 1 million years old), delimits the Vallonnet stratigraphical horizon which has become a referential milestone in Europe for biochronology.

Paleoecological affinities evoke different landscapes: the numerous deer remains suggest forest areas, while bison and small bovids evoke more open spaces.

Stone tools (Figure 13) left by humans during their short stays in the cave–a hundred odd pieces–were knapped from pebbles collected in the Roquebrune Miocene conglomerate (de Lumley et al., 1988). Three pieces were knapped from translucent beige flint pebbles which come from 700 meters to the north of the cave at Ciotti, near Menton. Limestone was most often used for the manufacture of these tools, as well as a few sandstone and some rare fine quartzite and flint pebbles. The assemblage is mainly composed of pebbles used as percussion instruments (showing isolated convex removals), pebble tools, cores and non-modified flakes.

Percussion tools are by far the most numerous. Pebbles showing single concave removals (primary choppers) are frequent, although are poorly manufactured. Pebble tools showing multiple removals (choppers, chopping-tools) are significant but most of them are of poor quality and without standardization. Many cortical flakes present in the collection were produced by accidental breakage of percussion instruments with isolated convex removals. Those produced from intentional production of pebble tools are also well represented. Finally, flakes from cores are rare. A core showing multidirectional orthogonally oriented removal scars and another with bipolar unifacial scars have been unearthed. All flakes are non-modified; none were transformed by intentional retouch.

The middle portion of a bison femur (*Bison shoetensacki*) showing a series of removals and apparently having served as a percussion instrument (Figure 14), and around ten deciduous deer antlers were brought into the cave and used as tools. While tooth marks present on most of the bones attest to their transport and breakage by carnivores, characteristic spiral-type breaks resulting from intentional human percussion on fresh bone are visible on others.

Some bones show parallel, fine, short, obliquely oriented striation marks from meat cutting with a stone implement. The high proportion of percussion tools, whole or broken pebbles and pebbles with convex edged removals, gives this industry a particular character and bears witness to the dominant human activity practiced in the Vallonnet Cave. These tools may be associated with numerous intentionally broken large herbivore bones found in the cave, while a few knapped flakes, especially those in flint, bear witness to meat cutting activity.

Around one million years ago humans occasionally came to Vallonnet Cave to scavenge carcasses abandoned there by large carnivores, breaking the bones and consuming the marrow.

At sites where the presence of early humans is attested to by archaic stone industries, large herbivore bones are often associated with large feline remains such as saber-toothed tigers (*Homotherium* and *Megantereon megantereon*), or Eurasian jaguars (*Panthera gombaszoegensis*). Did early humans who had become meat eaters follow large carnivores who, once satiated, left behind carcasses of large herbivores, just like the giant hyenas did (*Pachycrocuta brevirostris*) ? There apparently was real competition between hyenas and humans for scavenging.

These humans, more scavengers than hunters, left no traces of domestic arrangement in the Vallonnet Cave. No evidence has yet been discovered to suggest that they had domesticated fire. With Pirro Nord, Barranco León and Fuente Nueva 3 and the Sima del Elefante, the Vallonnet Cave is among the oldest known evidence of a human presence in Europe in a well-dated stratigraphical context.

Ca'Belvedere di Monte Poggiolo, Emilei-Romagne, Italy

In Emilia-Romagna, on the eastern slopes of the Apennines, between Rimini and Bologna, numerous Lower Paleolithic sites were found rich in non-modified flakes, cores and pebble tools: Ca'Belvedere di Monte Poggiolo, Ca'Romanina and Rio Sanguinario. Ca'Belvedere, discovered in 1984 and studied by Carlo Peretto, is the principal site.

Stratigraphical studies of the site identify, at the base, a thick layer of greyish-blue clayey sediment deposited by a coastline sea and overlain by a level of pebbles. Nonetheless, magnetostratigraphical studies have

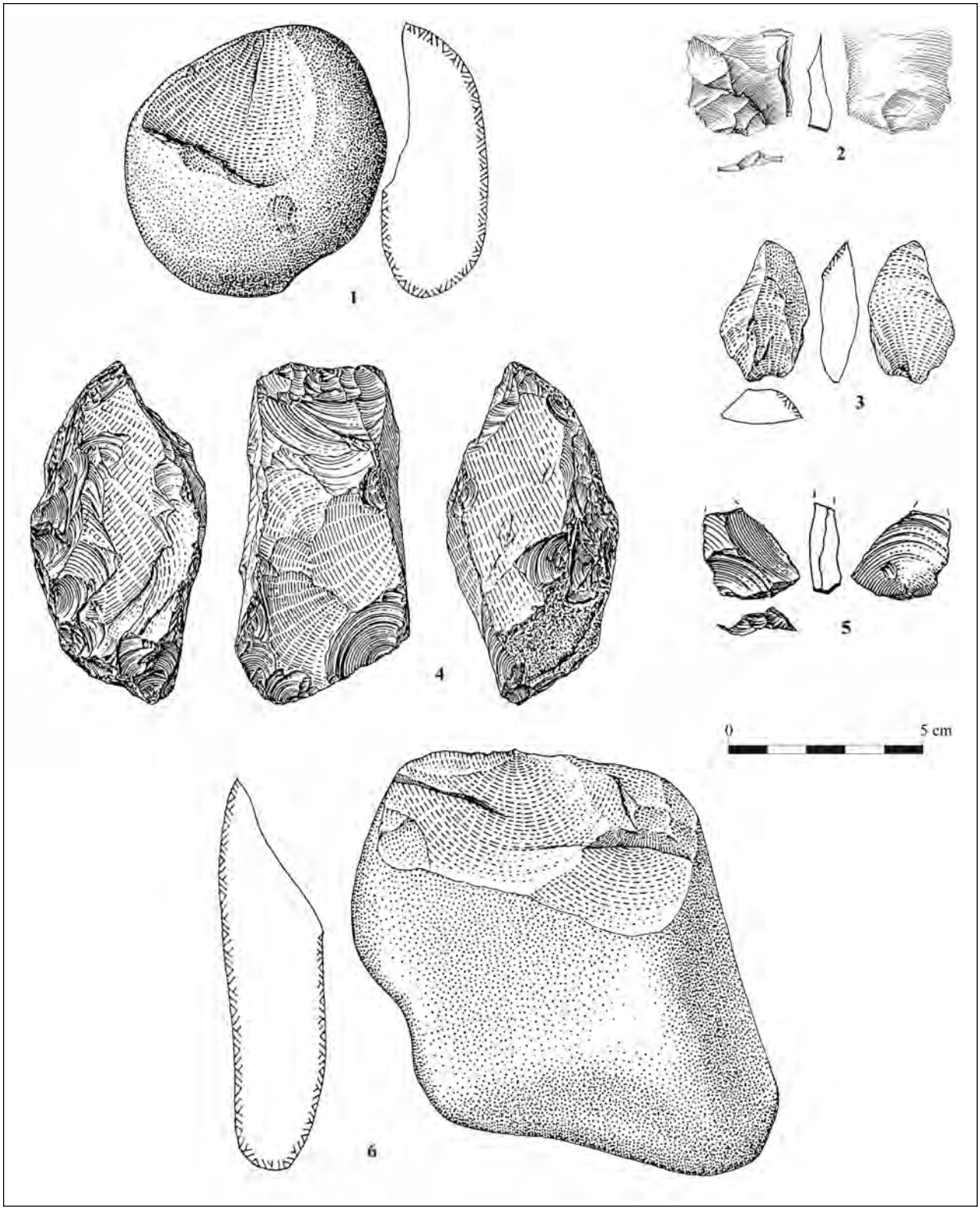

Figure 13. Vallonnet Cave, Roquebrune-Cap Martin, Alpes-maritimes, France. Between 1.7 and 1 million years. Pre-Oldowan or Archaic Oldowan*. Limestone industry.*
1: Pebble with an isolated convex edged removal negative (percussion instrument); 2, 3 and 5: flakes; 4: core; 6: chopper.

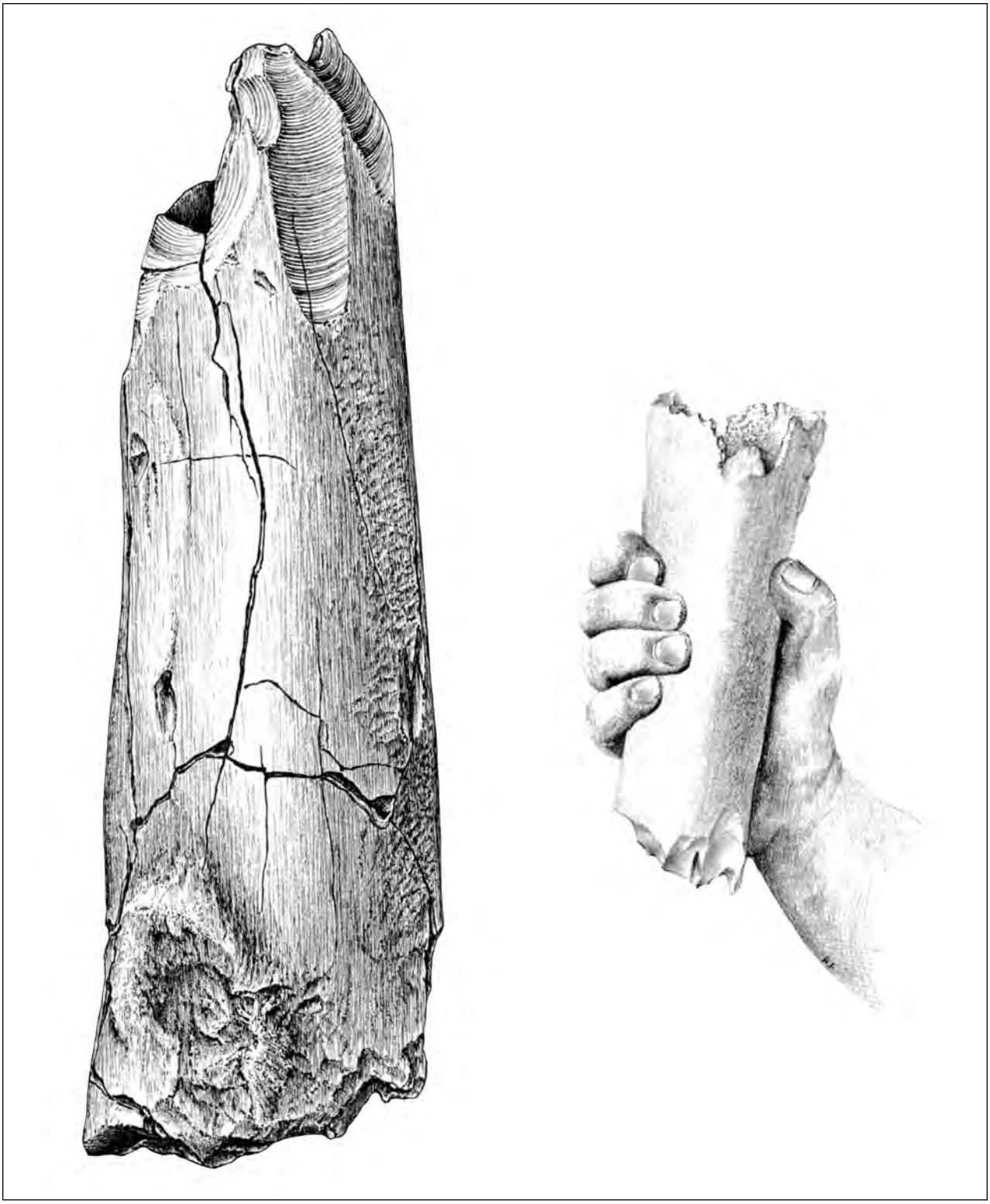

Figure 14. Vallonnet Cave, Roquebrune-Cap Martin, Alpes-maritimes, France. Between 1.7 and 1 million years. Pre-Oldowan or Archaic Oldowan.
Bison schoetensacki diaphysis fragment that served as a percussion instrument, showing a series of invasive removals.

revealed a reverse geomagnetic polarity allowing to date these deposits to the Upper Matuyama epoch, between one million and 780,000 years ago. Unfortunately, fauna was not preserved: it is therefore difficult to precisely date the site.

A very rich stone tool industry comprising thousands of pieces (Figure 15) was discovered on this shoreline. It is characterized by abundant flake production, almost all obtained from flint pebbles. Cores are numerous, showing use of mainly unifacial, sometimes bifacial and rarely multifacial knapping methods.

Large tools are represented by choppers, most of which show single removal scars, and there are some chopping-tools. Contrary to what one generally observes in archaic Pre-Oldowan industries, flakes from this site sometimes show retouch, at the limit of regular retouch, dominated by notched tools, bringing to mind non-standardized small tools which may have served for cutting meat.

Numerous flakes have been refitted onto one another or onto the cores from which they were extracted, attesting to complete on-site exploitation. These refits help in reconstituting knapping technology used by the artisans at this site. There is a very simple technique using mostly single removals; flakes obtained may sometimes show irregular use retouch. In addition, analysis of spatial distribution of the flakes shows that certain areas of the site were preferred.

The Latium Rift

In central Italy, between Rome to the north and Monte Cassino to the south, the Apennines to the east and the Lepini mountains to the west, the Latium rift was covered with large lakes during the Lower or Middle Pleistocene. Ancient volcanoes were identified along this rift by ashes deposited over time in the Quarternary formations and that allow for radiometric dating. The chemical composition of these ashes makes them characteristic chronological milestones interstratified in the Quaternary deposits.

Archaic stone tools were discovered at several locations by Italian Paleontologists, notably Italo Biddittu, Aldo Segre and Eugenia Segre-Naldini, at Colle Marino, Arce, Fontana-Liri and Castro dei Volsci (Biddittu, 1971, 1972, 1983 and 1984; Biddittu et al., 1992; Cauche et al., 2004). The levels comprising these stone tools are sandwiched between deposits containing Lower Pleistocene faunal remains below and more recent levels above which seem to correspond to eruptive activity known in the Latium. The oldest of these levels has been dated by potassium-argon to 0.7 million years.

It is difficult to date these sites. Because of the acidity of the sediment, fauna has mostly disappeared. However, at Colle Marino, a humerus fragment from a large hyena, *Pachycrocuta brevirostris*, was found, as at Vallonnnet, Barranco León and Fuente Nueva 3.

The prehistoric stone tools of the Latium are characterized by frequent percussion instruments–pebbles or blocks showing traces of percussion activity and pebble tools–as well as numerous flakes and debris. As at Ca'Belvedere, some flakes and debris show retouch that may have been intentional, especially notches.

The Oldowan in Europe

In East Africa, especially at Olduvai, humans voluntarily retouched flakes and fragments to shape them into small tools as early as 1.9 million years ago. The retouch modified the natural edges into notches, denticulates, scrapers and end scrapers. Along with polyhedrons and spheroids, these small tools characterize the Oldowan culture.

Fabrication of such small tools appears much later in Europe (Figure 21), where they appear only around 900,000 years ago. Although present at Olduvai at DK1 (Figure 7) and FLK NN1 (Figures 4 to 6) 1.9 to 1.8 million years ago, they have been identified at some southern European sites, such as at Terrassa in Catalonia around 0.9 million years ago, at Ceprano in Italy (Figure 16) and at Gran Dolina in Spain (Figure 17) only around 0.8 million years ago and again in Italy at La Pineta in Isernia (Figure 18) only around 0.62 million years ago (Figure 20).

The temporal discrepancy (Figure 21) between the emergence of this large cultural horizon in Africa and its appearance in Europe is considerable: one million years. This temporal gap leads one to believe that the spatial diffusion of these new acquisitions was extremely slow. The passage between Pre-Oldowan and Oldowan industries thus marks a new stage in the development of human cognitive capacities and represents an important cultural advancement.

Terrassa, Catalonia, Spain

The Terrassa site in Catalonia, particularly rich in stone industry and in fauna, is located 30 kilometres to the northeast of Barcelona at the edge of a small river, the Val Paradis. It was unearthed in geomagnetically reverse deposits corresponding to the Upper Matuyama. The fauna is slightly more recent than that from Vallonnet and dates the site to around 900,000 years old. It includes a Eurasian jaguar (*Panthera gombaszoegensis*), a gracile rhinoceros (*Stephanorhinus hundsheimensis*), a stenonian horse, a suid close to the one from Vallonnet, a cervid (*Pseudodama nestii vallonnetensis*) and antique elephant (*Elephas antiquus*).

The stone tools include a few poorly worked pebbles, numerous flakes and a few intentionally retouched small tools on flakes or debris.

Ceprano, Latium, Italy

The Campo Grande di Ceprano site is located in central Italy, in the Latium, around 100 kilometres southeast of Rome (Ascenzi et al., 1996 and 1997; Mallegni et al., 2003). The site is of particular interest because a human skull was discovered there in 1994 by Italo Bid-

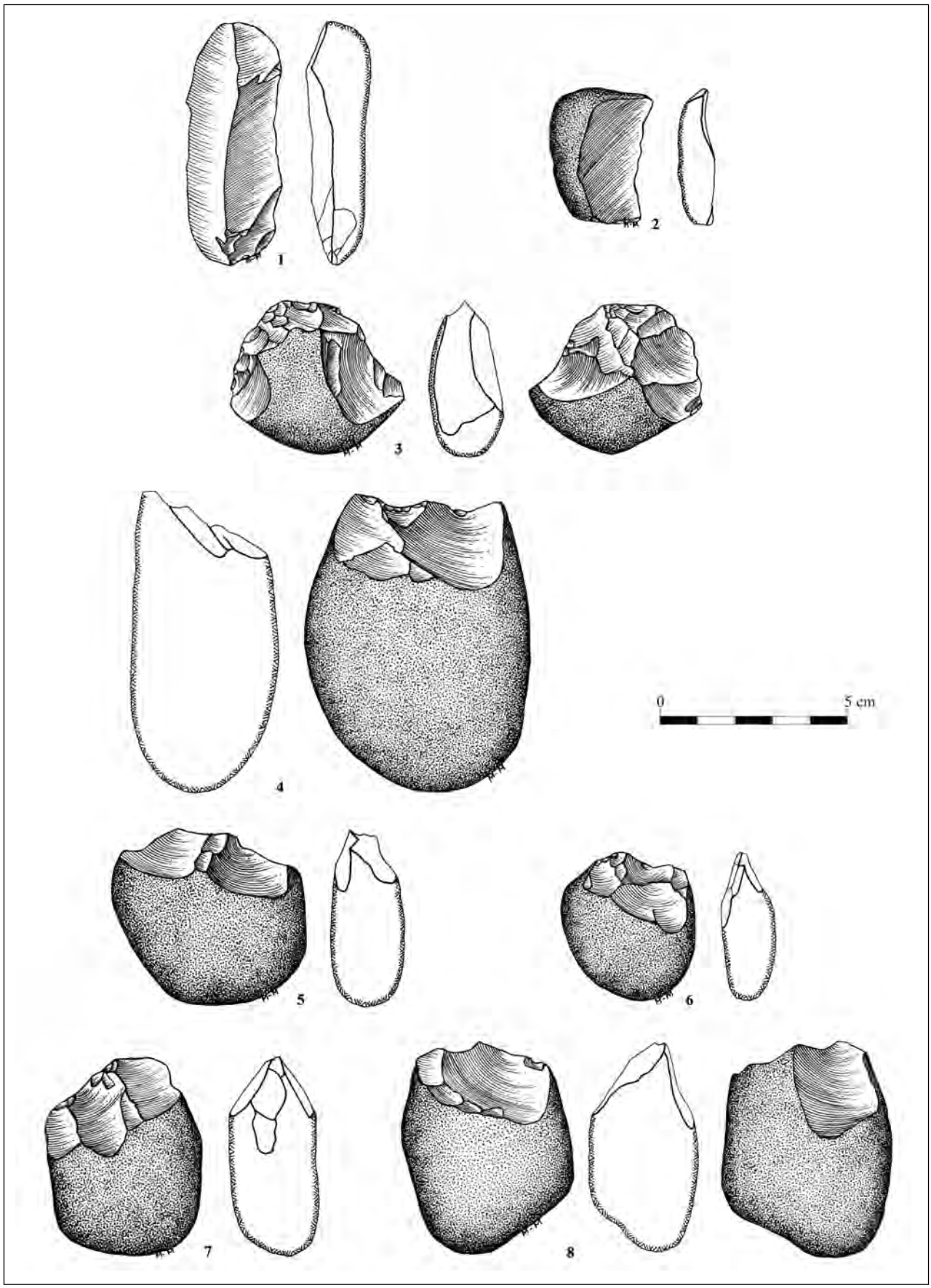

Figure 15. Ca'Belvedere di Monte Poggiolo, Emilie-Romagne, Italy. Around 1 million years. Pre-Oldowan or Archaic Oldowan. *Flint industry.*
1 and 2: flakes; 3: core; 4: chopper; 5 to 8: chopping tools.

dittu. The skullcap was found isolated in clay flows during roadwork, and is the oldest human skull presently known from Mediterranean Europe.

The skullcap was discovered during roadwork, isolated in clay flows. These clayey deposits cover fluvial sand formations, rich in fresh water molluscs. They show reverse geomagnetic polarity and appear to be slightly earlier than the Matuyama-Brunhes dated to 780,000 years ago.

The massive, low skullcap bears relief marks above the orbits and temporal crests. The latter end in a torus showing a parietal postero-inferior angle similar to that observed on most *Homo erectus*. Its morphology is very different from *Homo georgicus* who lived 1.8 million years ago. In spite of a large variability, it appears close to that of the African and Eurasian *Homo erectus*. It is close to the European Anteneandertals (*Homo heidelbergensis*), and thus has been attributed to a new species (*Homo cepranensis)* (Mallegni et al., 2003).

One million years separate *Homo georgicus* from Ceprano Man (*Homo cepranensis*). Is there an evolutionary link between them or did a new population come to Europe from Africa or Asia? The question remains to be answered.

Archaic stone tools were found in association with large mammal bones including elephant (*Elephas antiquus*), rhinoceros (*Stephanorhinus hundsheimensis*), hippopotamus (*Hippopotamus* sp.), cervis (*Pseudodama nestii vallonnensis*).

The lithics (Figure 16) were knapped from a large variety of raw materials–flint, jasper, silicified breccia, quartz, quartzite, limestone–collected as pebbles or plates, and are characterized by a large number of knapped flakes, cores and pebble tools (Cauche et al., 2004). Core reduction was intense with frequent directional changes. Most flakes show little or no cortical residue.

Some flakes or fragments were intentionally retouched into scrapers, denticulates and side scrapers or shaped into notches, becs and short thick points shaped by adjacent notches. These small tools denote a diversity of specialized activities corresponding perhaps to a higher level of cognition for Oldowan humans.

Gran Dolina, TD 6, Atapuerca Siera, Spain

The Gran Dolina site is located in the Atapuerca Sierra, Castille-León Province, near the Sima del Elefante. This huge cavity, like that of the Sima del Elefante, was opened up during railway construction work to build the Trinchera del Ferrocaril (Carbonell et al., 1995 and 2001).

The lower levels (from the base to the top) TD 4, TD 5 and TD 6, immediately underlying the polarity change limit Matuyama-Brunhes, are earlier than 780,000 years old. Level TD 6, familiarly called the "Aurora Strata" is rich in fauna including rhinoceros (*Stephanorhinus etruscus*), elephants (*Mammuthus* sp.), horse (*Equus altidens*), cervids (*Cervus nestii vallonnetensis*, *Cervus elaphus*, *Eucladoceros giulii*), bison (*Bison* cf. voigtstedtensis) and large carnivores such as saber-toothed tigers (*Homotherium latidens*), Eurasian jaguar (*Panthera gomaszoegensis*), lynx (*Lynx* sp.), as well as very numerous rodents (*Allophaiomys chalinei, Pliomys espiscopalis, Mimomys savani*). This faunal ensemble is characteristic of the end of the Lower Pleistocene (800,000 years).

Nearly a hundred human remains were discovered in this level, including a frontal, a maxillary, a mandible, a parietal and numerous teeth and post-cranial elements: ribs and vertebra. All of these bones come from six individuals; two children , two adolescents and two young adults.

Some traits allow to characterize them: they are relatively slender, there is a depression on the maxillary, their tooth relief is relatively complex with numerous cusps and deep grooves, and the molars have multiple roots. These characteristic traits led Jose Bermudez de Castro, Juan Luis Arsuage and Eudald Carbonell to name them *Homo antecessor* (Carbonell et al., 1995).

These fragmentary human remains show striation marks from meat removal and spiral-type fractures typical of fresh bone breakage. It would appear that the site was a lair for hominids who scavenged large herbivore and human remains, more specifically young individuals.

The stone industry (Figure 17) discovered among these human and faunal remains was knapped from diverse rocks: limestone, fine and coarse grained quartzite, quartz, flint and sandstone. They must have been collected as pebbles or blocks.

Flakes dominate, indicating an important knapping activity. Cores are also numerous, confirming the latter hypothesis. Knapping was almost exclusively done using hand held percussion in several directions: centripetal, orthogonal or simply unipolar. The few flakes showing intentional retouch (Figure 17, n^{os} 4 to 6) to make scrapers and denticulates or to shape notches, link this assemblage to the Oldowan.

La Pineta, Isernia, Italy

The La Pineta site, south of the town of Isernia in the Molise Province of central Italy, is located 150 kilometres to the northeast of Naples (Peretto, 1994). The natural Isernia basin constitutes a vast depression once occupied by a large lake at the beginning of the Quaternary period. A thick layer of white lacustrine clays were left by the lake and then covered by sand and gravel. Travertine is interstratified at the top of this formation. Several layers containing volcanic ash allow to precisely determine the age of this site.

In the sand and gravel layers with travertine, two archeological levels rich in fauna and stone industry were uncovered over a large area by Carlo Peretto. Radiometric dates using two argon isotopes (^{40}Ar /^{39}Ar) enable to attribute an age to these two archeological levels of between 620,000 and 604,000 years. The clayey upper levels, situated above the archeological layers, have been dated to 504,000 and 474,000 years. The very abundant

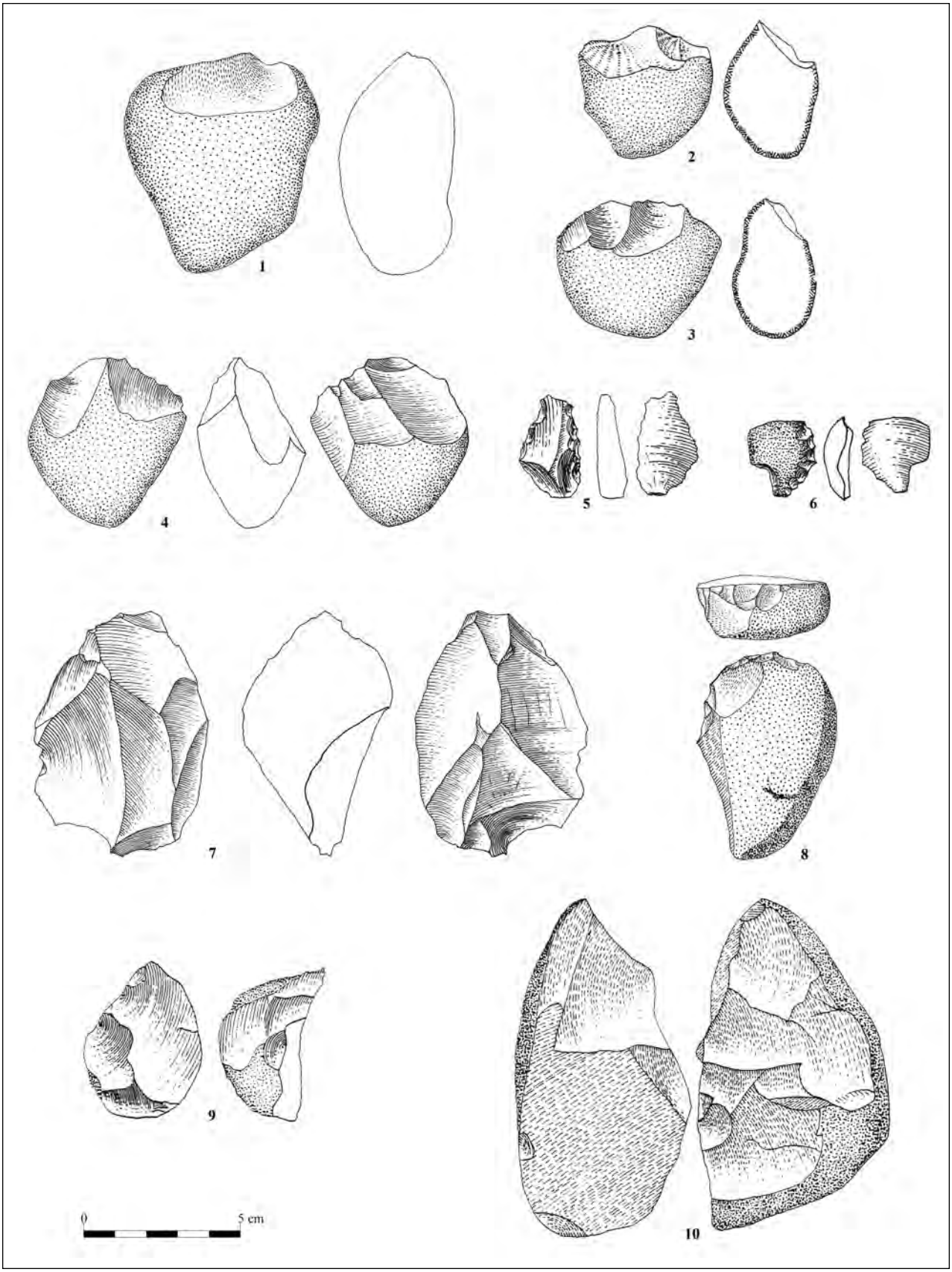

Figure 16. Campo Grande di Ceprano, Latium, Italy. Around 800,000 years. Oldowan sensu stricto or Classical Oldowan. *Industry in diverse rock types.*
1: pebble with an isolated concave removal negative (primary chopper); 2 and 3: choppers; 4: chopping tool; 5 and 6: denticulated scrapers; 8: end scraper; 7, 9 and 12: cores.

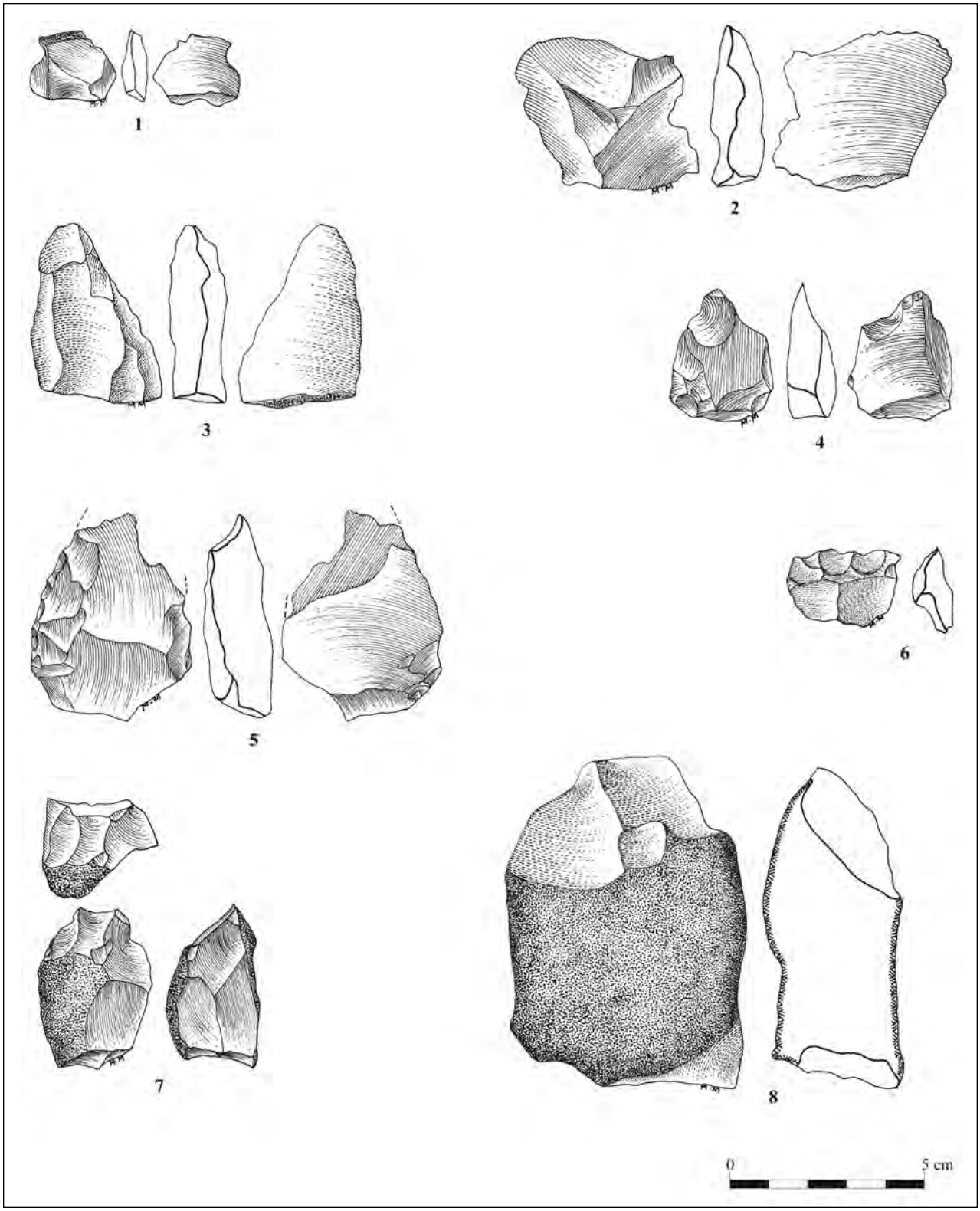

Figure 17. Atapuerca, Gran Dolina, level TD 6, Castille León, Spain. Around 800,000 years. Oldowan sensu stricto or Classical Oldowan.
1 to 3: flakes; 4 notched tool; 5: scraper; 6: denticulate; 7: core; 8: chopper.

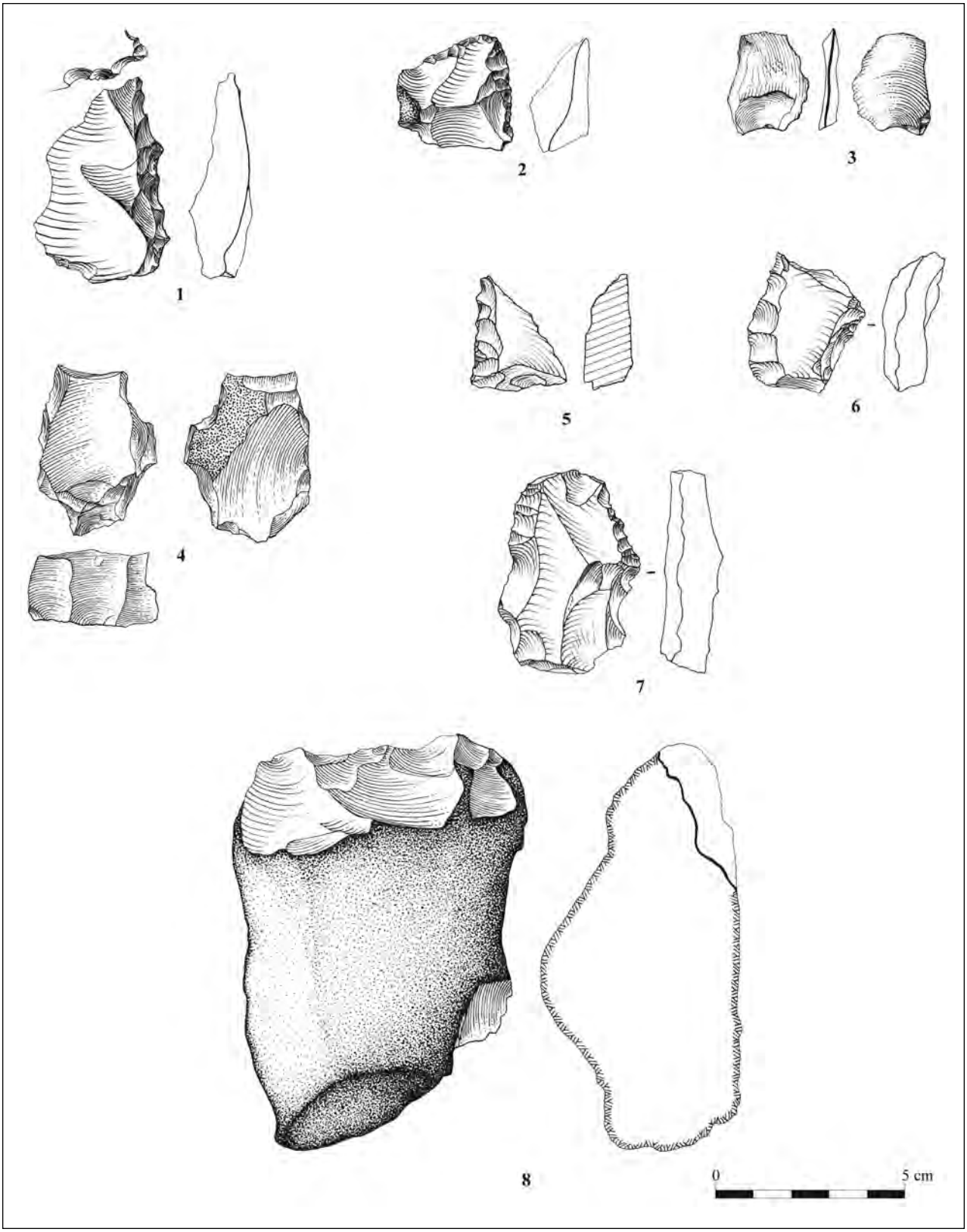

Figure 18. La Pineta, Isernia, Molise Province, Italy. 620,000 years. Flint industry.
1 and 6: denticulated scrapers; 2: double convex edged dejeté *scraper; 3: flake produced from another flake; 4: core; 5: scraper; 7: denticulate; 8: chopper.*

fauna includes bison (*Bison schoetensacki*), rhinoceros (*Stephanorhinus hundsheimensis*), elephants (*Elephas (Palaeoloxodon) namadicus*), bear (*Ursus deningeri*), hippopotamus (*Hippopotamus* cf. *antiquus*), wild boar (*Sus scrofa*), small bovids (*Hemitragus* cf. *bonali*), cervids (*Megaloceroides solilhacus, Cervus elaphus acoronatus, Dama dama* cf. *clactoniana*, *Capreolus* sp.) and a large feline, the lion (*Panthera leo fossilis*). This fauna is characteristic of the morphological species evolution at the beginning of the Middle Pleistocene.

Within this faunal assemblage, numerous cervid bones and the presence of hippopotamus remains suggest a humid forest landscape.

The stone tools from this site (Figure 18) are very numerous, with several thousand pieces. The products were essentially knapped from flint and some limestone. Two main operative schemas may be distinguished. For the shaping of pebble tools, humans chose limestone, but they preferred flint for knapping flakes. Pebble tools are relatively rare but well made. Flakes are most numerous in the assemblage. Most of the flintknapping took place using bipolar on an anvil technique but hand held knapping was also practiced. Unidirectional percussion predominates, without excluding the use of bipolar percussion. Many flakes were further reduced as cores.

This industry is characterized by intentionally retouched small tools, mainly on flint flakes. The collection includes mainly notched tools, scrapers and end scrapers. This making of small tools on flakes (Figure 18, n°s 1, 2, 5 and 7) by successive notches or continuous raised retouch, that is to say, wide, concave and sub vertical or more or less abrupt micro removals, is one of the principal traits of the la Pineta assemblage. This type of shaping is practically unknown in more archaic industries (Pre-Oldowan) but present in Classical Oldowan.

Most of the bones, dispersed over a large surface area, are broken and rarely found in anatomical connection. They often show intentional fractures (on fresh bone) for marrow extraction. Striation marks on the bones indicate that meat was cut off of them. Some bison, elephant and rhinoceros skulls were opened, suggesting that the brains of these large herbivores were consumed. It appears that this was a scavenging site where humans were attracted by the carcasses of drowned animals. The pebble tools may have served for butchery activities such as disarticulating large herbivore carcasses, while the flakes and small tools may have served to remove and cut up flesh.

No particular spatial pattern has been detected at the site. An accumulation of travertine blocks surrounded by flint flakes may suggest a natural area where hominins could have withdrawn to a dry place after having scavenged in the surrounding muddy swamps.

Conclusions

In East Africa, stone industries earlier than 1.9 million years present common characteristics. They are essentially knapped from quartz or volcanic rocks, raw materials collected close to the sites. Most of the knapping was realized by hand held technique, using unifacial, unipolar knapping, or sometimes multipolar or centripetal removals. Bifacial knapping was rare. Multipolar orthogonal knapping was also used. Bipolar knapping on an anvil was quite often used (Omo 57, Omo 123, FtJi1, FtJi2, FtJi5, Fejej FJ-1) (de Lumley et al., 2004; de Lumley, 2006 and 2007). It is important to underline that bipolar on an anvil knapping was not necessarily a poorly mastered technique but rather the best way to extract flakes or fragments from small pebbles in crystalline rocks. Methods and techniques of flake production are often tied to the quality of raw materials and to initial block or pebble morphology. Generally, cores were abandoned after the extraction of a few flakes, especially when raw materials were of poor quality. Nonetheless, when rocks were of fine quality, for example fine grained basalt, reduction sequences were longer, up to fifty flakes for a core at Lokalalei 2C. The apparent technological differences between these assemblages reflect, for a large part, differences in available raw materials. Relative availability of raw materials in the immediate environment of each site, their nature, morphology and the size of available pebbles or blocks, conditioned the technological characteristics of each lithic series.

The lithic assemblages are mainly composed of non-modified flakes, some cores and pebble tools, mainly choppers and rare chopping-tools. For these sites flake production seems to have been the main objective of the knappers. The non-modified flake edges are sometimes chipped, indicating their use. Flakes are often broken as a result of the violent blows using a hard percussion instrument, either by hand held or bipolar on anvil techniques. Flakes obtained were small and often present knapping accidents: longitudinal breaks along (Siret type accidents) or parallel to the knapping axis, or breaks that are transversal or oblique to that axis.

Industry from these sites whose age is between 2.55 to 1.90 million years old present the following common characteristics :

- local rock selection
- choice of raw materials for which the best ones were more exhaustively knapped
- selectivity in choosing pebble or block morphology
- presence of numerous percussion instruments
- well-mastered rock fracture
- use of both hand held and bipolar knapping on an anvil techniques
- presence of pebble tools, generally unifacial (choppers) and pebbles with single removals (primary

choppers) probably used for disarticulating animal carcasses

- parallel use of several well mastered knapping strategies and, mainly unifacial knapping using unidirectional removals, more rarely multipolar or centripetal and sometimes bifacial or multifacial orthogonal knapping. The methods used generally follow a least effort strategy
- dominance of unifacial cores
- abundance of non-modified knapping products (flakes, fragments and cores)
- dominance of non-modified flakes, generally small sized and without pre-determined form, probably used for cutting meat
- abundance of flakes broken from knapping with violent blows
- frequency of remnant cortex on flakes whose striking platforms are also most often cortical or non-prepared
- absence or extreme rarity of small intentionally retouched tools on flakes or fragments
- a high proportion of irregular marginal micro-retouch on flake, debris, pebble tool and broken pebble edges, especially dense notches.

We have proposed (de Lumley et al., 2004; de Lumley et al. 2005; de Lumley, 2006 and 2007) to group together these archaic industries under the name *Pre-Oldowan* (or *Archaic Oldowan*) to designate lithic assemblages which are characterized by the absence or extreme scarcity of small retouched tools. The term *Pre-Oldowan* does not designate here a single homogenous, autonomous and well defined culture, but simply a cultural evolutionary stage where standardized, stereotypical small tools on flakes and fragments with retouch that modifies the original form of their edges are not yet made while such tools are present in the Oldowan levels DK 1 (1.9 myrs.) and FLK NN (1.8 myrs.) at Olduvai, where there are a relatively significant amount of true end scrapers, scrapers and denticulates made from quartz (Figures 4 to 7), associated with polyhedrons and spheroids (Leakey, 1971; de la Torre and Mora, 2005).

In a large sense it is possible to distinguish two stages of Oldowan that are probably tied to the level of cognition attained by early humans.

1. the *Pre-Oldowan* or *Archaic Oldowan*, like at Gona EG 10 and EG 12, Ounda Gona OGS-6 and OGS-7, Lokalalei or Fejej FJ-1, sites with an age between 2.5 and 1.9 million years, where stone industries are characterized by the dominance of non-modified flakes, mostly unifacial cores, some pebble tools, numerous percussion instruments and the absence of standardized small retouched tools on flakes or debris.
2. The *Oldowan s. s. (sensu stricto)* or *Classical Oldowan*, like at Olduvai DK 1 and FLK NN 1, with an age of between 1.9 and 1.6 million years, also characterized by the dominance of non-modified flakes, presence of unifacial and sometimes bifacial cores, pebble tools, percussion instruments, and where standardized small retouched tools appear (end scrapers, scrapers, denticulates), as well as polyhedrons and spheroids.

Pre-Oldowan industries are characterized by a very strong dominance of non-modified flakes, a large proportion of cores, the presence of pebble tools, a relative abundance of percussion instruments and the absence of standardized intentionally retouched small tools. They correspond with an early stage of hominid cultural evolution whose degree of cognition did not yet allow them to realize specific small sized tools or for relative standardization in their tool manufacture.

The term *Pre-Oldowan* is a practical denomination to designate a cultural horizon whose technological and typological characteristics are more archaic than those of the Oldowan s. s. or Classical Oldowan and correspond to comparative behaviour between diverse groups of hominids living in East Africa between 2.55 and 1.9 million years ago.

Outside of Africa, archaic Pre-Oldowan industries are present at Yiron in the Levant, as early as 2 million years ago and at Dmanissi in Georgia 1.81 million years ago.

They are present in Mediterranean Europe as early as 1.2 million years ago at Barranco León and at Fuente Nueva 3 in Andalucia, as early as 1.1 million years ago at La Sima del Elefante in the Atapuerca Sierra, between 1.07 and 0.984 million years ago at the Vallonnet Cave site in the Alpes-Maritimes and at Ca'Belvedere di Montepoggiolo in Italy around 1 million years ago.

An important time-lag thus separates these assemblages from Classical Oldowan assemblages in East Africa and Mediterranean Europe where standardized small retouched tools on flakes or fragments were sometimes made, as well as spheroids: DK 1 at Olduvai around 1.9 million years ago, FLK NN 1 at Olduvai around 1.8 million years ago, Terrassa in Catalonia around 0.9 million years ago, Ceprano in Itay and Gran Dolina TD4 TD 5 and TD 6 in Spain around 0.8 million years ago and at la Pineta at Isernia around 0.65 million years ago.

The large chronological gape separating the emergence in Africa of these major cultural horizons tied to the development of cognitive capacities of hominids and their presence in Europe bring to light the very slow spatial diffusion of these new cultural acquisitions.

If all these archaic stone industries, called here Pre-Oldowan or archaic Oldowan, whose technological and typological characteristics correspond to the earliest stage of human cultural evolution tied to the attainment of a certain cognitive level, are very similar, they may nonetheless present a certain variability conditioned by the environment and human adaptation to milieu.

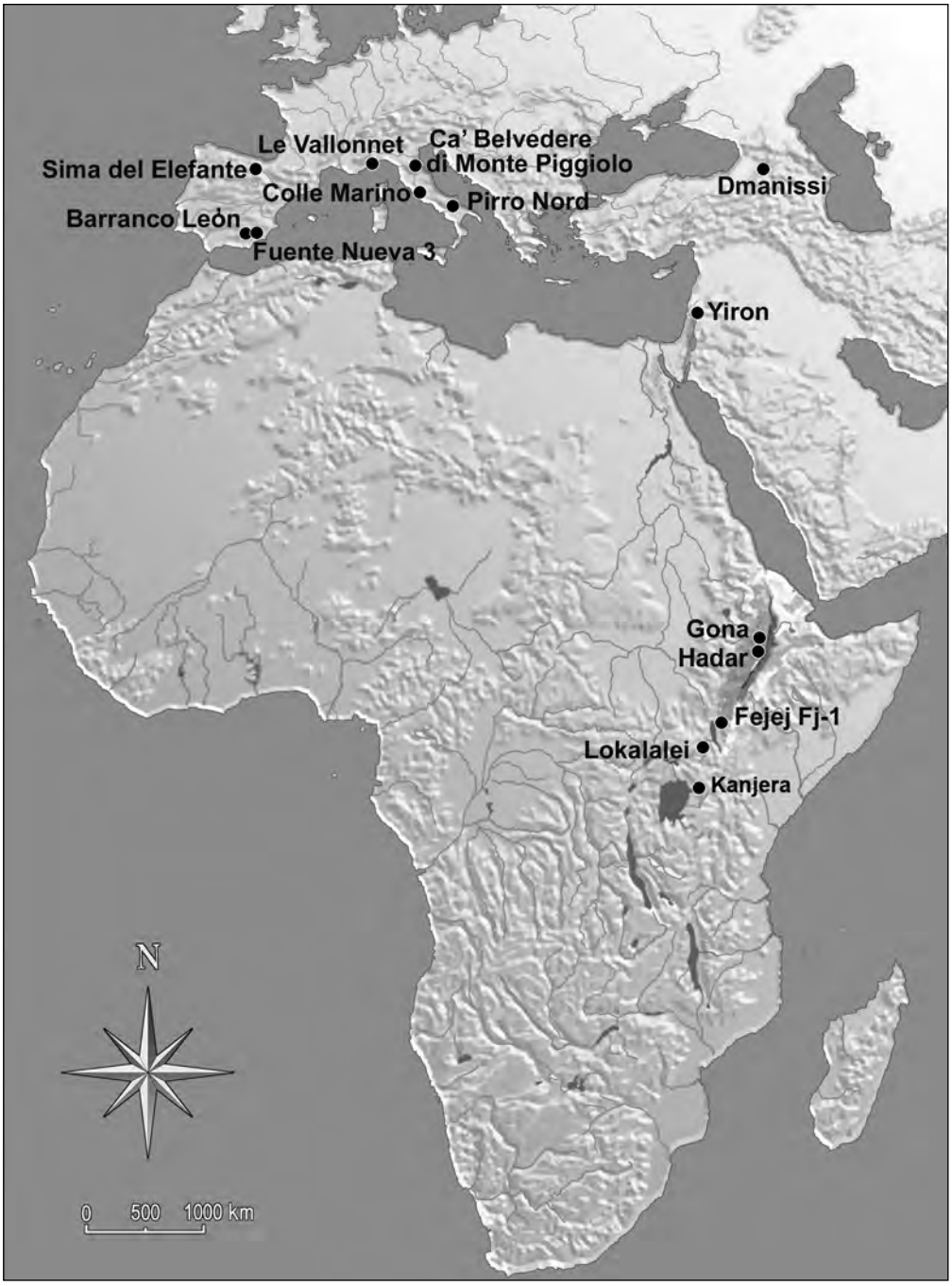

Figure 19. Sites with Pre-Oldowan *or* Archaic Oldowan *type industries, without small, intentionally retouched tools, corresponding to a behavioural and cognitive parallelism.*

Thus the industry from Gona EG 10 and EG 12 was essentially knapped from trachyte, rhyolite and basalt pebbles of excellent quality abundant in the Gona alluvials, those from Fejej FJ-1 in quartz pebbles relatively numerous in the alluvials of water courses from the Hamar mountain range, those from Dmanissi in various rock types from the Mashavera and Pinezaouri rivers, while those from Barranco León and Fuente Nueva 3 were made from flint nodules from nearby Jurassic limestone bordering the Guadix-Baza basin (Celiberti et al., 2004; de Lumley et al., 2005).

Well made pebble tools are quite well represented at Gona EG 10 and EG 12, at Fejej FJ-1 and at Dmanissi, but are very rare in the Barranco León and Fuente Nueva 3 assemblages because of the absence of alluvial layers with pebbles in the environment near the sites. Pebbles are replaced by Jurassic limestone blocks whose edges show irregular use wear attesting to their use as cutting instruments.

A common structure between lithic assemblages is tied to a specific cognitive level, where non-modified small flakes dominate, most probably used for cutting or scraping meat off bones abandoned by scavengers, and by the absence or extreme scarcity of small retouched tools on flakes or fragments, but a relative variability due to environmental constraints; thus may be viewed the ar-

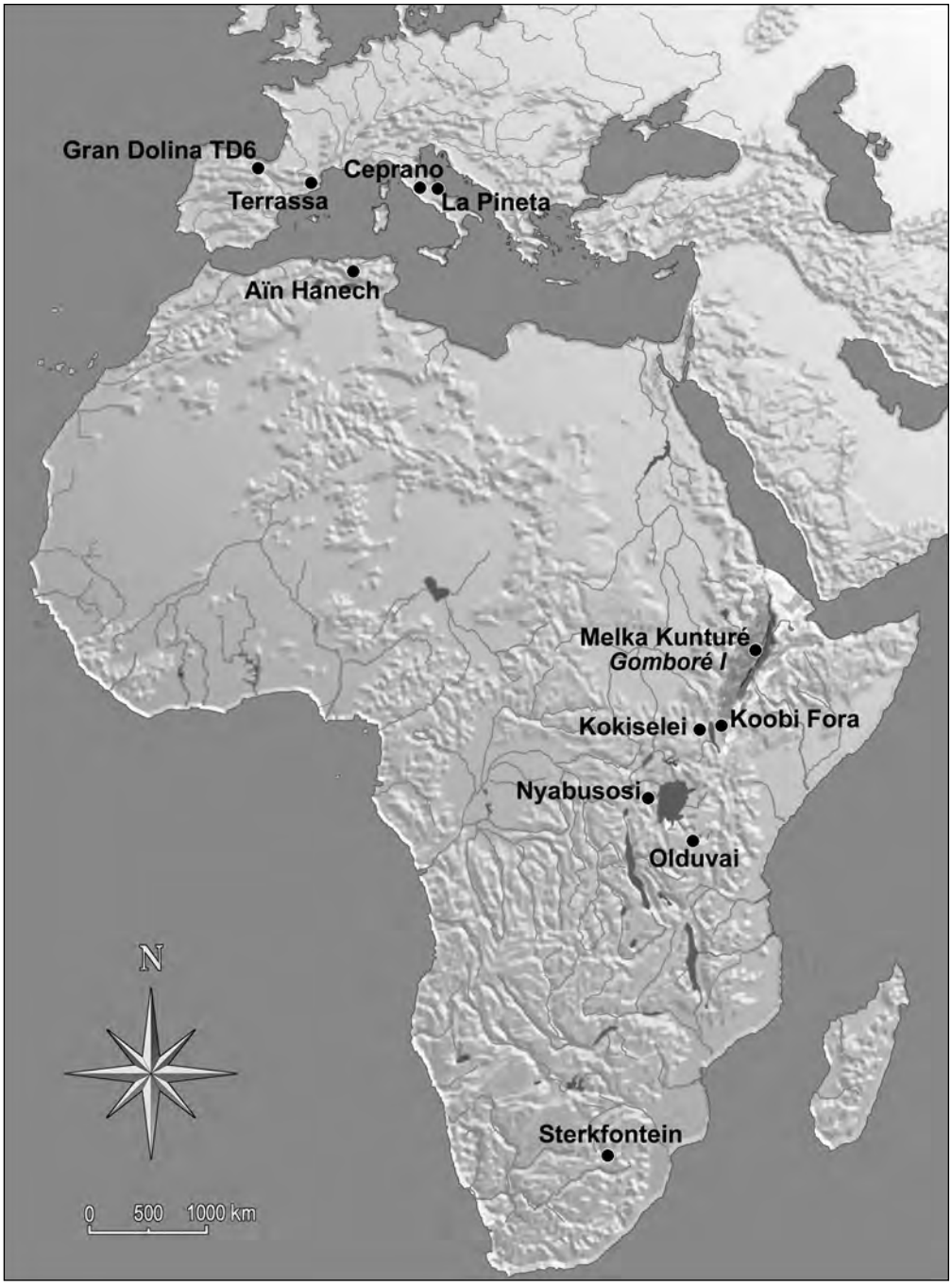

Figure 20. Sites with Oldowan sensu stricto *or* Classical Oldowan *type industries, with small, intentionally retouched tools, corresponding to an identical behavioural and cognitive stage.*

chaic stone industries from East Africa up to the shores of Mediterranean Europe.

With the emergence of conceptual thought as early as 2.55 million years ago, hominids were capable of conceiving and manufacturing a model. That model was small non-modified flakes for cutting up meat or pebble tools for slicing. With the slow conquest of the world by early humans, this cognitive capacity was to be diffused up to the gateways of Europe, at Dmanissi 1.81 million years ago and in Mediterranean Europe, in the Guadix-Baza basin at Barranco León and Fuente Nueva 3 and the Sima del Elefante at Atapuerca 1.2 million years ago.

Pre-Oldowan lithic assemblages, as well as the Oldowan lithic assemblages which followed them in time, each correspond to behavioural and cognitive parallelisms of hominids groups present in diverse regions of the world and that may be largely separated in time (Figure 21).

References

Antoniazzi, A., Cattani, L., Cremaschi, M., Fontana, L., Peretto, C., Posaneto, R., Proli, F., Ungaro, S., 1988. Le gisement du Paléolithique inférieur de Ca'Belvedere di Monte Poggiolo (Forli, Italie). Preliminary results. L'Anthropologie 92, 629-642.

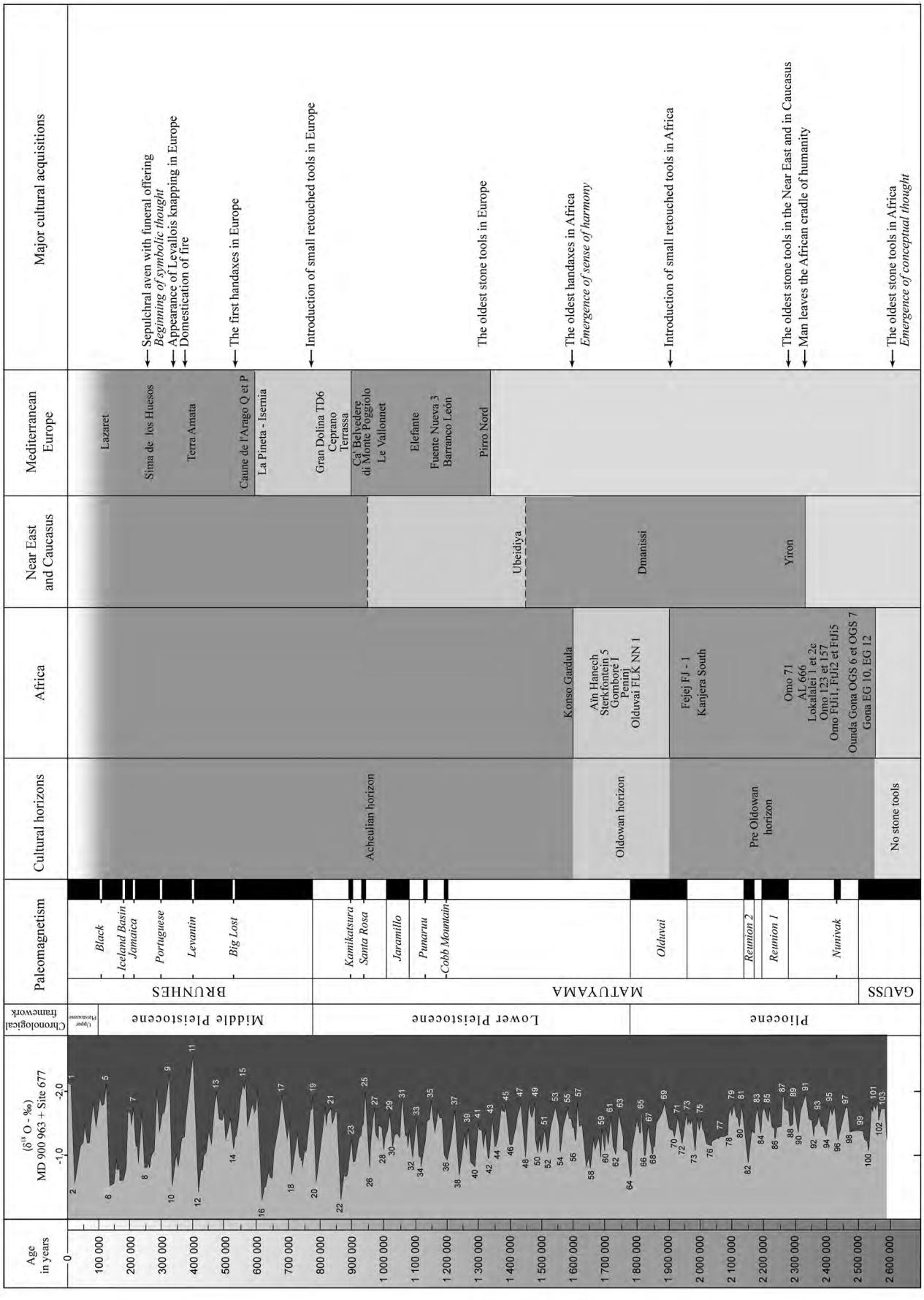

Figure 21. Main major cultural sequences in Africa, the Near East, Trans Caucasia and southern Europe in their geochronological and paleoclimatic Quaternary framework. Important temporal gaps separating the emergence of different cultures, corresponding to identical behavioural and cognitive stages tied to a certain cognitive level, may be observed in different large regions of the world.

Arzarello, M., Marcollni, F., Pavia, G., Pavia, M., Petronio, C., Petrucci, M., Rook, L., Sardella, R., 2006. Evidence of earliest human occurrence in Europe: the site of Pirro Nord (Southern Italy). Naturwissenschaften 94, 107-112.

Ascenzi, A., Biddittu, I., Cassoli, P.F., Segre, A.G., Segre-Naldini, E., 1996. A calvarium of late *Homo erectus* from Ceprano, Italy. Journal of Human Evolution 31, 409-423.

Ascenzi, A., Segre, A.G., 1997. Discovery of a Homo erectus calvarium at Ceprano, central Italy. Anthropologie 35, 241-246.

Barsky, D., Cauche, D., Celiberti, V., Pleurdeau, D., Beyenne, Y., de Lumley, H., 2006. les industries lithiques archaïques du site de Fejej, Ethiopie. XIV^{ème} Congrès de I'Union Internationale des Sciences Préhistoriques et Protohistoriques, Liege (Septembre 2001), pp.1-9.

Biddittu, I., 1971. Paleolitico inferiore di Arce e Fontana Liri (Frosinone). Archivio per I'Antropologia e la Etnologia, vol. CI, Firenze: Stamperia Editoria1e Parenti, pp. 251-254.

Biddittu, I., 1972. Pleistocene e industrie 1itiche pre-acheuleane ad Arce e Fontana Liri (Frosinone). Quaternaria 16, 35-52.

Biddittu, I., 1983. II paleolitico inferiore del Lazio, industrie archaiche. In: Atti XXIII riunione scientifica dell' Istituto italiano di Preistoria e Protostoria, Firenze.

Biddittu, I., 1984. Le piu antiche industrie del Paleolitico inferiore del Lazio. Atti della XXIV riunione scientifica dell' Istituto Italiano di Preistoria e Protostoria. 1982. pp. 31-38. Roma.

Biddittu, I., Segre, A.G., 1982. Pleistocene medio-inferiore con industria arcaica su ciottolo nel bacino di Anagni (Lazio). Atti della XXIII riunione scientifica dell'Istituto Italiano di Preistoria e Protostoria, 7-9 maggio 1980, Firenze, pp. 567-576.

Carbonell, E., Bermúdez de Castro, J.M., Arsuaga, J.L., Diez, C.J., Rosas, A., Cuenca, G., Sala, R., Mosquera, M., Rodriguez, X.P., 1995. Lower Pleistocene Hominids and artifacts from Atapuerca TD-6 (Spain). Science 269, 826-830.

Carbonell, E., Bermúdez de Castro, J.M., Parés, J.M., Pérez-Gonzalez, A., Cuenca-Bescós, G., Ollé, A., Mosquera, M., Huguet, R., van der Made, J., Rosas, A., Sala, R., Vallverdú, J., Garcia, N., Granger, D.E., Martinón-Torres, M., Rodriguez, X.P., Stock, G., Vergès, J.M., Allué, E., Burjachs, F., Cáceres, I., Canals, A., Benito, A., Diez, C., Lozano, M., Mateos, A., Navazo, M., Rodriguez, J., Rosell, J., Arsuaga, J.L., 2008. The first hominin of Europe. Nature, Letters, vol. 452/27, March 2008, doi: 10.1038/nature 06815, pp. 465 à 469.

Carbonell, E., Mosquera, M., Olle, A., Rodriguez, X.P., Sahnouni, M., Sala, R., Verges, J.M., 2001. Structure morphotechnique de l'industrie lithique du Pléistocène inférieur et moyen d'Atapuerca (Burgos Espagne). L'Anrhropologie 105, 259-280.

Cauche, D., Celiberti, V., Barsky, D., Notter, O., Biddittu, I., de Lumley, H., 2004. les plus anciennes industries lithiques du Latium, Italie. Actes du XIV^{ème} Congrès de l'UI.S.P.P., Université de Liège, Belgique, 2-8 septembre 2001, section 4, Premiers hommes et Pa1éolithique inférieur. BAR International Series 1272, 49-57.

Celiberti, V., Barsky, D., Cauche, D., Notter, O., Nioradze, M., Lordkipanidze, D., Gabunia, L., de Lumley, H., 2004. les industries lithiques archaïques du site de Dmanissi, Géorgie. Actes du XlV^{ème} Congrès de l'UI.S.P.P., Université de Liège, Belgique, 2-8 septembre 2001, section 4, Premiers hommes et Paléolithique inférieur. BAR International Series 1272, 29-36.

Cuenca-Bescós, G., Rofes, J., 2004. Insectívoros (Mammalia), clima y paisaje de los niveles inferiores de Trinchera Elefante (Pleistoceno inferior, Atapuerca). Zona Arqueológica 4, 150-156.

Delagnes, A., Roche, H., 2005. Late Pliocene hominid knapping skills: The case of Lokalalei 2c, West Turkana, Kenya (2005). Journal of Human Evolution 48, 435-472.

de Lumley, H., 2006. Il y a 2.5 million d'années… Un seuil majeur de l'hominisation. L'émergence de la pensée conceptionnelle et des stratégies maîtrisées du débitage de la pierre. *Palevol*. Comptes Rendus de l'Académie des Sciences, Paris, Paléontologie Humaine et Préhistoire, tome 5, fascicule 1-2, janvier-février 2006, n° 1-2, p. 119-126.

de Lumley, H., 2007. La grande histoire des premiers Hommes européens. Édition Odile Jacob, 269 pages.

de Lumley, H., Beyene, Yonas (Ed.), 2004a. Les sites préhistoriques de la région de Fejej, Sud-Omo, Ethiopie, dans leur contexte stratigraphique et paléontologique. Préfaces de Dominique de Villepin et de Teshome Toga. ADPF, Association pour la diffusion de la pensée française. Editions Recherche sur les civilisations. Ministère des Affaires Etrangères. Direction générale de la Coopération internationale et du développement, sous-direction des Sciences sociales et de l'Archéologie, 18 articles, 635 p.

de Lumley, H., Beyene, Y., Barsky, D., Byrne, L., Camara, A., Cauche, D., Celiberti, V., Fournier, A., Pleurdeau, D., 2004b. L'industrie lithique préoldowayenne du site de Fejej FJ-I, in «les sites préhistoriques de la région de Fejej, Sud-Omo, Ethiopie, dans leur contexte stratigraphique et paléontologique», édité sous la direction de Henry de Lumley et Yonas Beyene. Preface by Dominique de Villepin and Teshome Toga. ADPF, Association pour la diffusion de la pensee française. Editions Recherche sur les civilisations. Ministère des Affaires Etrangères. Direction générale de la Coopération intemationale et du développement, sous direction des Sciences sociales et de l'Archéologie, pp. 391-564.

de Lumley, H., Fournier, A., Krzepkowska, J., Echassoux, A., 1988. L'industrie du Pléistocène inférieur de la grotte du Vallonnet, Roquebrune-Cap-Martin, Alpes-Maritimes. L'Anthropologie 92, 501-614.

de Lumley, H., Lordkipanidze, D., Feraud, G., Garcia, T., Perrenoud, C., Gagnepain, J., Saos, T., Voinchet, P., 2002. Datation par la méthode 40Ar/39Ar de la couche de cendres volcaniques (couche VI de Dmanissi, Géorgie) qui a livré des restes d'hominidés fossiles de 1.81 Ma. Comptes Rendus Palevol 1, 181-189.

de Lumley, H., Nioradze, M., Barsky, D., Cauche, D., Celiberti, V., Nioradze, G., Notter, O., Zvania, D., Lordkipanidze, D., 2005. les industries lithiques préoldowayennes du début du Pléistocène inférieur du site de Drmanissi en Géorgie. L'Anthropologie 109, l-182.

de Lumley, M.A., Gabounia, L., Vekua, A., Lordkipanidze, D., 2006. Les restes humains du Pliocène final et du début du Pléistocène inférieur de Dmanissi, Géorgie (1991-2000). I–Les crânes, D 2280, D 2282, D 2700. L'Anthropologie, 110, 1-110.

de la Torre, I., Mora, R., 2005. Technological strategies in the Lower Pleistocene at Olduvai Beds I & II, *Erau1* 112, Etudes et Recherches Archéologiques de l'Université de Liège, 2005.

Dominguez-Rodrigo, M., Pickering, T.R., Semaw, S., Rogers, M.J., 2005. Cutmarked bones from Pliocene archeological sites at Gona, Afar, Ethiopia: implications for the function of the world's oldest stone tools. Journal of Human Evolution 48, 109-121.

Echassoux, A., 2004. Étude taphonomique, paleoecologique et archeozoologique des faunes de grands mammifères de la seconde moitié du Pléistocène inférieur de la grotte du Vallonnet (Roquebrune-Cap-Martin, Alpes-Maritimes, France). L'Anthropologie 108, 11-53.

Gabounia, L., de Lumley, M.A., Vekua, A., Lordkipanidze, D., de Lumley, H., 2002. Découverte d'un nouvel hominidé à Dmanissi (Transcaucasie, Géorgie). Comptes Rendus Palevol I, 243-253.

Gabounia, L., Vekua, A., Lordkipanidze, D., Swischer III, C.C., Ferring, R., Justus, A., Nioradze, M., Tvalchrelidze, M., Anton, S.C., Bosinski, G., Jöris, O., de Lumley, M.A., Majsuradze, G., Mouskhelishvili, A., 2000. Earliest Pleistocene hominid cranial remains from Dmanisi, Republic of Georgia: taxonomy, geological setting and age. Science 288, 1019-1025.

Garcia, N., Howell, F.C., 2008. New discovery of a large mustelid (Carnivora: Mammalia) from the early Pleistocene locality of Sima del Elefante (Sierra de Atapuerca, Spain). Palaeontographica Abteilung A 283.

Huguet, R., 2007. Primeras ocupaciones humanas en la Península Ibérica: paleoeconomia de la Sierra de Atapuerca (Burgos) y la Cuenca de Guadiz-Baza (Granada) durante el Pleistoceno Inferior. Ph.D. Dissertation, Dept. of History and History of Art, University Rovira i Virgili, Taragona, Spain.

Leakey, M.D., 1971. Olduvai Gorge. volume 3. Excavations in Beds I and II 1960-1963 Cambridge University Press.

Lordkipanidze, D., Jashashvili, T., Vekua, A., Ponce de Leon, M.S., Zollikofer, C.P.E., Rightmire, G.P., Pontzer, H., Ferring, R., Oms, O., Tappen, M., Bukhsianidze, M., Agusti, J., Kahlke, R., Kiladze, G., Martinez-Navarro, B., Mouskhelishvili, A., Nioradze, M., Rook, L., 2007. Postcranial evidence from early *Homo* from Dmanisi, Georgia. Nature 449, 305-310.

Mallegni, F., Carnieri, E., Bisconti, M., Tartarelli, G., Ricci, S., Biddittu, I., Segre, A., 2003. *Homo cepranensis* sp. novo and the evolution of African-European middle Pleistocene hominids. CR. Palevol 2, 153-159.

Martinez-Navarro, B., Espigares, M.P., Ros, S., 2003. Estudio preliminar de las asociaciones de grandes mamiferos de Fuente Nueva-3 y Barranco Leon-5 (Orce, Granada, Espana) (informe de las campanas de 1999-2002). In: Toro, I., Agusti, J., Martinez-Navarro, B. (Eds.), Excavaciones arqueologicas en los yacimientos del Pleistoceno inferior de Barranco Leon y Fuente Nueva 3, Orce (Granada). Memoria Cientifica Campanas 1999-2002. Junta de Andalucia. Consejeria de Cultura. E.P.G. Arqueologia Monografico, pp. 115-136.

Messager, E., 2006. Apports des analyses paléobotaniques à la reconstitution paléoenvironnementale du site de Dmanisi et de sa région (Géorgie). Thèse de Doctorat. du Muséum National d'Histoire Naturelle. Quaternaire: Géologie, Paléontologle humaine, Préhistoire, Institut de Paléontologie Humaine, Paris, samedi 2 décembre 2006, 243 p.

Parés, J.M., Pérez-González, A., Rosas, A., Benito, A., Bermúdez de Castro, J.M., Carbonell, E., Huguet, R., 2006. Matuyama-age lithic tools from the Sima del Elefante site, Atapuerca (northern Spain). Journal of Human Evolution, 50, 163-169.

Peretto, C. (Ed.), 1994. Le industrie litiche del giacimento paleolitico de Isernia la Pineta. Isernia Cosmo Iannone ed. Istituto Regionale per gli studi storici del Molise «V. Cuoco», 433 pages.

Peretto, C., 2000. les outillages sur galet du site de Ca'Belvedere di Monte Poggiolo (Forli, Italie). Résumé des communications. Colloque de Tautavel sur «les Premiers habitants de l 'Europe», p. 99.

Peretto, C., Amore, F.O., Antoniazzi, A., Bahain, J.J., Cattani, L., Cavallini, E., Esposito, P., Falgueres, C., Gagnepain, J., Hedley, I., Laurent, M., Lebreton, V., Longo, L., Milliken, S., Monegatti, P., Olle, A., Pugliese, N., Renault-Miskovsky, J., Sozzi, M., Ungaro, S., Vannucci, S., Verges, J.M., Wagner, J.J., Yokoyama, Y., 1998. L'industrie lithique de Ca'Belvedere di Monte Poggiolo: stratigraphie, matière première, typologie, remontages et traces d'utilisation. L'Anthropologie 102, 343-465.

Plummer, T., Bishop, L.C., Ditchfield, P., Hicks, J., 1999. Research on late Pliocene Oldowan sites at Kanjera South, Kenya. Journal of Human Evolution 36, 151-170.

Roche, H., Delagnes, A., Brugal, J.P., Feibel, C., Kibunjia, M., Mourre, V., Texier, P.J., 1999. Early hominid stone tool production and technical skill 2.34 Myr ago in West Turkana, Kenya. Nature 399, 57-60.

Rofes, J., Cuenca-Bescos, G., 2006. First evidence of the Soricidae (Mammalia). *Asoriculus gibberodon* (Petényi, 1864) in the Pleistocene of North Iberia. Rivista Italiana di Paleontologia e Stratigrafia 112, 301-315.

Ronen, A., 1991. The Yiron Gravel lithic assemblage. In: Artifacts older than 2.4 My in Israel Archeologisches Korrespondenzblatt Verlag des Romisch-germanischen Zentralmuseum, Mainz. pp. 159-164, 21.2.

Ronen, A., 2006. The oldest human groups in the Levant. Compte Rendu Palevol 5, 343-351.

Ronen, A., Inbar, M., Klein, M., Brunnacker, K., 1980. Artifacts-bearing gravels beneath the Yiron Basalt. Israelian Journal of Earth Sciences 29, 221-226.

Rosas, A., Pérez-Gonzàlez, A., Carbonell, E., van der Made, J., Sánchez, A., Laplana, C., Cuenca-Bescós, G., María Parés, J., Huguet, R., 2001. Le gisement pléistocène de la "Sima del Elefante" (Sierra de Atapuerca, Espagne). L'Anthropologie 105, 301-312.

Rosas, A., Parés, J.M., Sánchez, A., Bastir, M., Martínez-Maza, C., Benito, A., Saladie, P., Sala, R., Rodríguez, J., Martínez-Pérez, R., García, N., Allué, E., van der Made, J., Vallverdú, J., Bermúdez de Castro, J.M., Carbonell, E., Pérez-González, A., Huguet, R., 2006. The Sima del Elefante cave site at Atapuerca (Spain). Estudios Geologicos 62, 327-348.

Semaw, S., 2000. The world's oldest stone artefacts from Gona, Ethiopia. Their implications for understanding stone technology and patterns of human evolution between 2.6-1.5 million years ago. Journal of Archaeological Science 27, 1197-1214.

Semaw, S., 2005. Les plus anciens artefacts lithiques (2.6-2.5 millions d'années) des sites archéologiques du pliocène final de EG-10 et EG-12 in Gona Est, Afar, Ethiopie. In: Sahnouni, M. (Dir.), Le Paléolithique en Afrique. L'histoire la plus longue. Editions Artcom. pp. 13-52.

Semaw, S., Renne, P.R., Harris, J.W.K., Feibel, C.S., Bernor, R.L., Fasseha, N., Mowbra, Y.K., 1997. 2.5 million-year-old stone tools from Gona, Ethiopia. Nature 385, 333-336.

Semaw, S., Rogers, M.J., Quade, J., Renne, P.R., Butler, R.F., Dominguez-Rodrigo, M., Stout, D., Hart, W.S., Pickering, T., Simpson, S.W., 2003. 2.6 million-year-old stone tools and associated bones from OGS-6 and OGS-7, Gona, Afar, Ethiopia. Journal of Human Evolution, 45, 169-177.

Toro, I., Agusti, J., Martinez-Navarro, B. (Ed.), 2003a. El pleistoceno inferior de-Barranco Leon y Fuente Nueva 3, Orce (Granada). Memoria cientifica campañias 1999-2002. Arqueologia Monografias. Junta de Andalucia, Consejeria de Cultura, Direccion Général de Bienes culturales, 206 pages.

Toro, I., de Lumley, H., Barsky, D., Celiberti, V., Cauche, D., Moncel, M.H., Fajardo, B., Toro Cano, M., 2003b. Las industrias liticas de Barranco Leon y Fuente Nueva 3 de Orce. Estudio tecnico y tipologico. Las cadenas operativas. Amilisis traceologico. Resultados preliminares. In: Toro, I., Agusti, J., Martinez-Navarro, B. (Eds.), Memoria cientifica campañas 1999-2002. Junta de Andalucia. Consejeria de Cultura. E.P.G. Arqueologia Monografico. pp. 183-206.

Toro, I., Turq, A., Agusti, J., Martinez-Navarro, B., Oms, O., 2002. Los yacimientos de Barranco Leon y Fuente Nueva 3 de Orce (Granada). Contribucion al conocimiento del primer poblamiento humano de Europa. SPAL 9 (2000), 179-188.