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S.L. KUHN, G. ARSEBÜK and F. CLARK HOWELL

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Key-words : *Turkey, Lower Paleolithic, Middle Pleistocene, lithic technology, raw material exploitation.*
Mots clefs : *Turquie, Paléolithique ancien/moyen, Pleistocène moyen, technologie lithique, exploitation de la matière première.*

INTRODUCTION

Yarımburgaz cave is situated in Thrace (western or European Turkey), a short distance west of the modern city Istanbul (fig. 1). The archaeological potential of this large site has been known to the scientific community for decades, and small excavations have been carried out there since the late 1950s [1]. Prior to 1986, however, the later prehistoric (Chalcolithic) and historic (Greek and Byzantine) occupations of the cave had received greatest attention. From 1988 to 1990, a joint Turkish-American project, directed by Prof. Güven Arsebük (Istanbul University) and Prof. F.C. Howell (University of California, Berkeley), conducted extensive investigation of more ancient Paleolithic deposits within Yarımburgaz. Their excavations produced large samples of artifacts and animal bones from stratified Pleistocene context. Their probable Middle Pleistocene age places these assemblages among the oldest well-documented archaeological remains from Turkey.

GEOLOGICAL AND ARCHAEOLOGICAL BACKGROUND

Yarımburgaz cave is cut into a limestone ridge forming one edge of the Sazlıdere river valley, which empties into a small lagoon and eventually into the Marmara (fig. 2). For most of its length, the cave is a long, narrow, debris-choked gallery, but at its southern end the cave widens into two broad, vaulted alcoves up to 14 m high (fig. 3), termed the "upper" and "lower" chambers, respectively. These two expansive chambers, which are connected by a broad passage near their openings, were the primary focus of human (and animal) activities within the cave.

1. KANSU, 1972.

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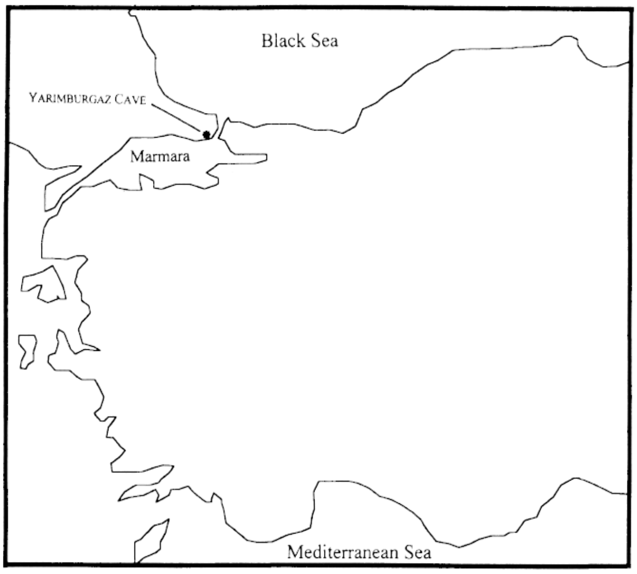

Fig. 1 : *Map of western Turkey, showing location of site.*

Fig. 2 : *Map of Yarımburgaz cave and surrounding area. "LE" = entrance to lower chamber; "UE" = entrance to upper chamber.*

The most recent and most comprehensive program of excavations at Yarımburgaz cave commenced in 1986, when Prof. M. Özdoğan (Istanbul University) began excavating a series of trenches within the upper chamber. The primary goal of this project was to establish the stratigraphy of the significant Chalcolithic deposits[2] concentrated in that part of the cave. Like previous investigators, Özdoğan noted the presence of Middle and Upper Paleolithic artifacts in the upper chamber. However, a test trench opened in the lower chamber yielded large numbers of obviously ancient lithic artifacts as well as the bones of extinct Pleistocene vertebrates in apparent primary context[3]. These discoveries prompted the next major phase of excavation. Between 1988 and 1990 Professors Arsebük and Howell conducted three seasons of excavations in the lower chamber of Yarımburgaz[4]. In all, they excavated a total of nine large trenches or blocks, amounting to just over 130 square meters, to depths of between two and five meters. The layout of their excavations in the lower chamber is shown in figure 3.

The upper chamber at Yarımburgaz contains about 3 m of sediments, extending from the Byzantine period back through Pleistocene times. Unfortunately, Pleistocene levels in the upper chamber have been reworked by the activities of more recent (post Pleistocene) inhabitants. Some of the most extensive disturbance occurred during the Byzantine period, when the upper chamber was actually remodeled into a chapel : niches and other features cut into the limestone of the cave walls are clearly visible (fig. 3). In contrast, recent activities have had much less destructive impact on deposits in the lower chamber. Some recent (Byzantine ?) pits are present, especially near the cave opening, but Pleistocene sediments were observed to be comparatively free of recent disturbance. The majority of the lower chamber sequence – which extends to a depth of 5 m or more – appears to date to the Middle Pleistocene or earlier. These sediments yielded the samples of Paleolithic artifacts and Pleistocene faunal remains discussed in this paper.

Based on findings from the 1988-1990 excavations, sediments within the lower chamber at Yarımburgaz have been divided into three main sedimentary cycles (fig. 4). The following descriptions have been abstracted from reports by William Farrand[5].

Cycle 1 : The lowest units excavated (layers R and S) consist of stratified sands, gravels, and pebbles indicative of a relatively high-energy depositional environment. These layers were probably deposited by a stream flowing outwards towards the present cave mouth. Sediments grade to silt near the top of the cycle, suggesting that the rate of water flow

2. ÖZDOĞAN, 1985.
3. ÖZDOĞAN and KOYUNLU, 1986.
4. ARSEBÜK *et al.*, 1990, 1991.
5. FARRAND, 1994; see also HOWELL *et al.*, 1990.

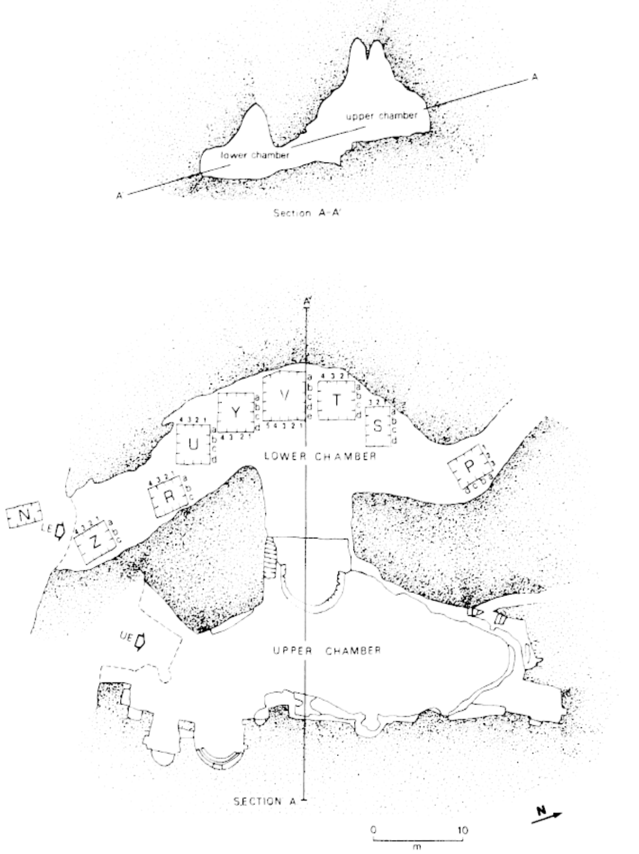

Fig. 3 : *Map of upper and lower chambers, showing locations of trenches.*

had decreased significantly. Of interest from an archaeological perspective is the fact that flint, quartz and quartzite pebbles occur naturally within the larger-size fraction of this first sedimentary cycle.

Cycle 2 : The second major sedimentary cycle (consisting of layers T, U, and V) sits atop an erosional unconformity with cycle 1. Cycle 2 consists primarily of dark clay loams, also containing scattered flint, quartz and quartzite pebbles. The uppermost sediment (layer V), a dark reddish brown loam, is vertically fissured, suggesting a marked drying out of the cave : layer V also contains many large bones and some artifacts.

Cycle 3 : The uppermost sedimentary cycle (layers W, X and Y) differs radically from underlying sediments. Cycle 3 contains quantities of angular limestone, with relatively little fine-grained sediment between the large fragments. It is quite clear that these materials were not deposited by water, which had long since ceased flowing through the cave. The large blocks spalled off the cave roof, possibly as a result of seismic activity. The densest concentrations of Pleistocene fauna and Paleolithic artifacts occur in layers W and X within this third sedimentary cycle. At the top of Cycle 3 are more recent (Pleistocene and Holocene) deposits (stratum Z).

Summary of Non-Lithic Archaeological Findings

In addition to the lithic assemblage discussed in this paper, Yarımburgaz has yielded a large and diverse fauna. At least 20 genera of large terrestrial vertebrate are represented, including both typical European and Asian taxa[6]. Despite its diversity, the fauna is heavily dominated by the remains of single species, the early cave bear *Ursus deningeri*, which accounts for about 93 % of the identifiable specimens. Bones of other large carnivores comprise about 3 % of the sample, and remains of ungulates make up the remainder. By and large, the bear remains are in excellent condition. A full range of anatomical parts is represented, although there has been some attrition attributable to bears and other large carnivores[7]. There are no traces of hominid-caused damage on the bear bones, which appear to be the results of natural deaths during the denning period[8]. The sparse evidence for hominid modification of bones is confined to the remains of large ungulates.

One might expect humans and bears to have used different parts of the cave, but preliminary analyses reveal no major spatial separation between bear bones, stone artifacts, and other archaeological and paleontological finds. Densities of all classes of finds are highly correlated both horizontally and vertically (stratigraphically), and the weakest spatial associations overall are those between stone tools and ungulate bones[9]. Although it is possible that some degree of spatial and/or stratigraphic disjunction between stone tools and bear remains may be detected by more powerful statistical techniques, the fact remains that the distributions overlap substantially. The nature of the hominid presence, and its relation to the use of the cave by denning bears, remains highly ambiguous but intriguing. Of relevance is the fact that no hearths or other constructed features were identified during the excavation. Given the broad exposures and large volume of sediment removed, it is unlikely that the excavations simply missed such features. It is also noteworthy that few, if any, artifacts show traces of burning.

6. HOWELL *et al.*, 1990.
7. STINER *et al.*, 1996.
8. *Ibid.*
9. *Ibid.*

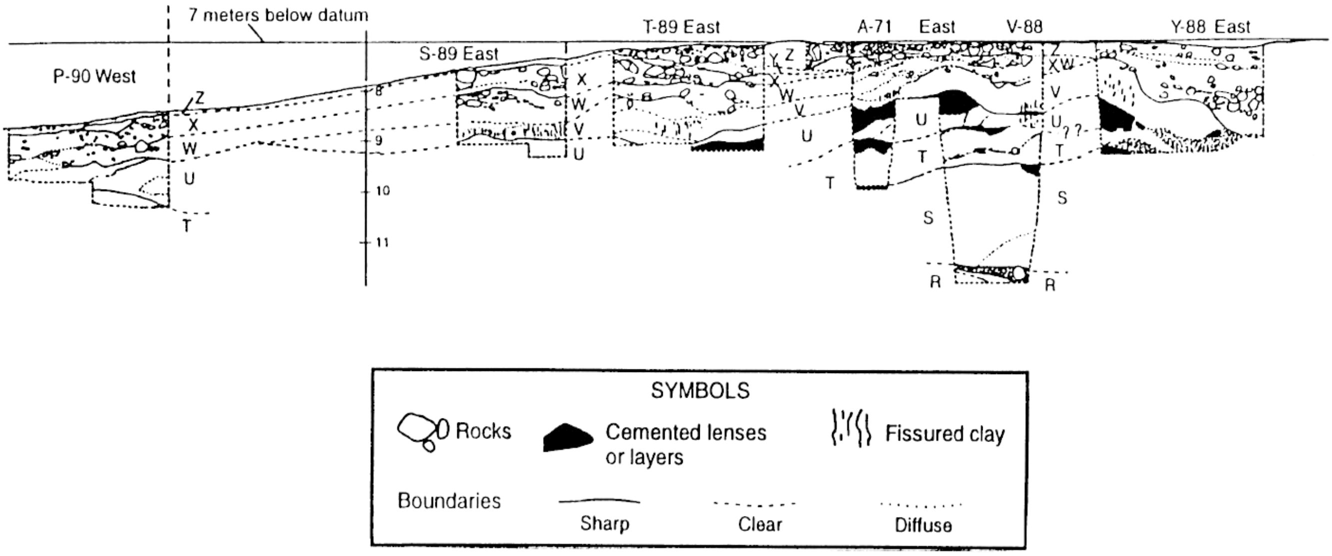

Fig. 4 : *Partial schematic stratigraphy of the lower chamber of Yarımburgaz Cave (courtesy of Dr. William Farrand).*

Establishing absolute dates for the Pleistocene archaeological levels at Yarımburgaz has proven difficult. A series of ESR (Electron Spin Resonance) dates on bear teeth range from Oxygen Isotope stage 6 back through stage 9[10]. However, cave bear teeth do not possess the thick, convoluted enamel surfaces best suited for ESR dating, and these dates must be considered with caution. Paleontological assessments of cave bears[11] are consistent with some of the ESR dates, in that they indicate that the site should be assigned to the second half of the Middle Pleistocene. Despite the problems with dating, it would appear that Yarımburgaz is the oldest *in situ* archaeological site in northwestern Turkey.

THE MIDDLE PLEISTOCENE ARTIFACT ASSEMBLAGE

All available artifacts from the 1986 through 1990 excavations in the "lower chamber" of Yarımburgaz cave are included in this analysis, with the exception of small samples of stone tools on public display at the University of Istanbul and the Istanbul Archaeological Museum. The study sample comprises 1675 artifacts, including cores, retouched tools, and unmodified flakes and debris. Pre-Chalcolithic materials from the upper chamber are not discussed in this paper.

10. BLACKWELL *et al.*, 1990.
11. STINER *et al.*, 1996.

The entire lower chamber collection is treated as a single assemblage in the following discussions. The majority of lithic artifacts come from the lower cave layers W, X, and to a lesser extent Y, within sedimentary cycle 3. In some trenches, stone tools were also recovered from the upper part of sedimentary cycle 2 (layer V). It is not clear whether the materials recovered from layer V represent an early phase of human occupation, or whether these elements have intruded into the lower stratum through reworking of the sediments by denning bears or as a result of falling into fissures in drying sediments. Comparisons of sub-assemblages from different layers have revealed very few statistically significant differences in artifact forms or raw materials among the assemblages from the various layers. It therefore seems reasonable to treat the entire collection as a homogeneous unit. Nonetheless, it is possible that subtle stratigraphic or horizontal variability may be revealed in future studies.

Raw Materials

Three principal raw materials were used in the manufacture of artifacts at Yarımburgaz. In order of abundance, these are flint, quartz, and quartzite. Artifacts of jasper, silicified wood, and unidentified metamorphic rocks are also present in small quantities. These less-common materials are grouped under the heading of "other" in all tabulations that follow.

The flint appears to be of high quality. The texture is somewhat variable, and many specimens are fossiliferous. It is possible that more than one type of raw material is represented within this category, but it is difficult to determine the original appearance of most of the flint specimens. More than 95 % of the flint artifacts are heavily patinated, and a great many are almost completely desilicified. This extreme chemical weathering is probably the product of long-term exposure to highly alkaline ground-water. The quartz used by Yarımburgaz toolmakers is a semi-translucent, milky-white crystalline variety. It shows a marked tendency towards angular cleavage rather than conchoidal fracture. Unlike some types of quartz, the stone used at Yarımburgaz does appear to be relatively tough, and it is suitable for producing robust and quite regular working edges. The most common variety of quartzite is relatively coarse grained, but it is also well indurated and quite homogeneous in texture. Large, comparatively thin flakes could be struck from quartzite cobbles without hinging or transversal fracture.

Little is known about the natural distribution of raw materials in the vicinity of Yarımburgaz cave. All archaeological specimens that retain some portion of the cortical surface appear to be derived from heavily rolled stream cobbles. None of the flint artifacts preserves unaltered nodular or tabular cortex. At least some, if not all, of the raw materials, may have been found quite close to the site in the past. Unworked quartz, quartzite, and chert or flint pebbles are found in the deposits underlying the archaeological strata within the cave (sedimentary cycles 1 and 2).

It does appear that some raw materials were available in larger "packages" than others. Unbroken quartzite cores and core tools average 9.8 cm in length, with a maximum of 17.1 cm. In contrast, flint cores average 6.3 cm (maximum = 16.2 cm), and quartz cores 5.8 cm in length (maximum = 11.3 cm). Even considering the less extensive exploitation of quartzite cores and core tools (see below), it is probable that unmodified pebbles of quartzite were originally somewhat larger than pebbles of the other two frequently used materials.

The extreme chemical weathering of flint artifacts notwithstanding, the lithic assemblage from Yarımburgaz appears comparatively fresh. Tool edges are sharp and show none of the rounding and battering typically associated with water transport (i.e., "rolling"). Evidence for *in situ* abrasion of artifacts by water-borne sediments is also lacking. The bones from the site are also in an excellent state of preservation[12].

12. *Ibid.*

Table 1 : *Basic assemblage composition.*

	Flint	Quartz	Quartzite	Other	Total
Cores	60	41	35	3	139
Core tools	10	5	48	1	64
Flake tools	398	94	40	6	538
Whole flakes	147	22	32	12	213
Broken flakes	111	16	20	6	153
Debris	373	119	62	14	568
Total	1099	297	237	42	1675

Assemblage Composition and Artifact Morphology

Table 1 shows the basic composition of the lithic assemblage from the lower chamber at Yarımburgaz. The dominant shaped elements are retouched flake tools : these outnumber core tools by a ratio of nearly 9 to 1. One notable feature of the assemblage is the high frequency of intentionally modified or utilized pieces. Modified flake tools far outnumber unbroken, unretouched flakes, and modified tools of all sorts comprise about one-third of the total assemblage. Even though sediments were sieved, quantities of small flaking debris are relatively limited. This may indicate that much primary stone flaking was done outside of the cave itself. Alternately, the paucity of small debris could be a byproduct of the particular methods of flake production employed by Middle Pleistocene hominids.

Consistent with the high frequency of retouched artifacts, many flake tools have been extensively modified (e.g., fig. 5 : 1-3). Edges tend to be quite steep, and the mean angle of retouch is approximately 70° for all types of flake tool and raw material. Flake tools with multiple retouched edges are also relatively common, accounting for nearly 24 % of all retouched pieces. The majority (61.3 %) of the retouched flake tools are modified using simple, scalar retouch. Stepped, undercut (14.9 %), abrupt (11.6 %), and Clactonian retouch (8.9 %) are the next most abundant forms of edge modification : the Clactonian technique was most often used to make notched pieces (fig. 5 : 6). A small number of flake tools exhibit a type of modification resembling Quina retouch. Some artifacts also exhibit scattered, flat, highly invasive flake scars on their ventral surfaces (fig. 5 : 13). This ventral modification – which does not necessarily coincide with retouch on the dorsal face – could represent intentional thinning of tool blanks. Alternatively, it might mark the use of large flakes as casual cores.

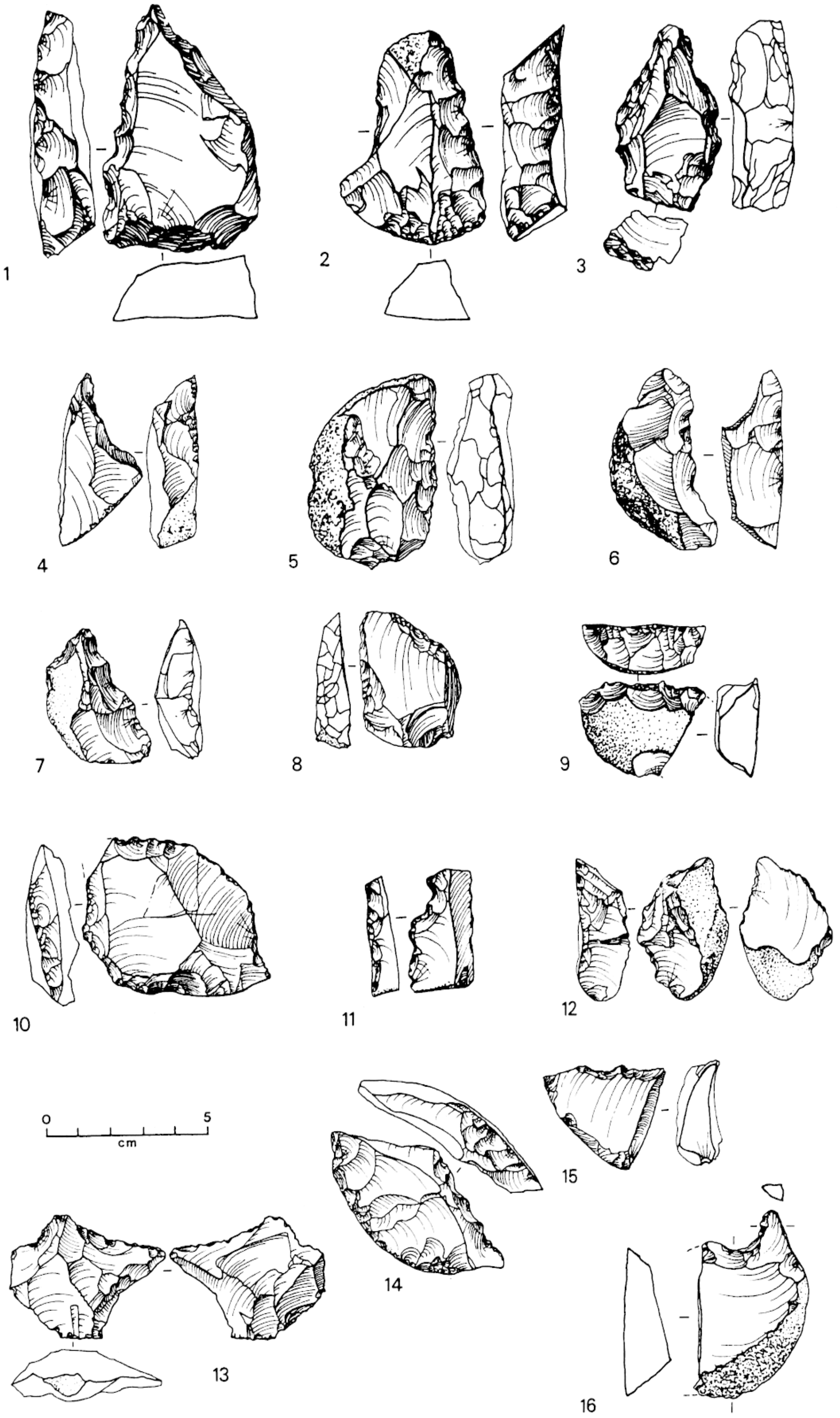

Fig. 5 : *Retouched flake tools from Yarımburgaz Cave. 1-3, 9, 10, 15 – denticulate scrapers; 5, 8 – scrapers; 4, 6 – notched pieces; 7, 11, 12, 14 – denticulates; 13, 16 – becs/perçoirs. (Illustrations by J. Ogden).*

Table 2 : *Artifact Type Frequencies, retouched flake tools.*

	Flint	Quartz	Quartzite	Other	N	Percent
Sidescraper	83	30	7	1	121	22.5 %
Denticulate	162	17	11	4	194	36.1 %
Notch	38	6	6	0	50	9.3 %
Bec/Perçoir	26	15	1	0	42	7.8 %
Burin	2	1	0	0	3	0.6 %
Combination	25	5	2	0	32	6.0 %
Rabot	2	1	4	0	7	1.3 %
Partially ret'd	60	19	9	1	89	16.5 %
Total retouched	398	94	40	6	538	100.1 %

Table 3 : *Indices of flake tool reduction.*

Edge Form	mean	standard deviation	N
denticulate	0.52	0.24	286
smooth	0.42	0.23	239
pointed/convergent	0.44	0.26	48

(Results of t test comparing denticulate with smooth edges : $t = -4.706$, $df = 523$, $p<0.001$)

In the assemblage as a whole, denticulate tools, and irregular or denticulate edges in general (e.g., fig. 5 : 6, 7, 11), are somewhat more common than sidescrapers with regular retouched edges (e.g., fig. 5 : 4, 8) (Table 2). However, for tools made of quartz, regular "scraper" edges outnumber denticulates. This reversal of the general trend probably stems from the tendency of the variety of quartz used at Yarımburgaz to fracture along straight cleavage planes : it is simply more difficult to produce saw-tooth edges on this raw material. The bec/perçoir group (fig. 5 : 12, 13, 16) – artifacts with pointed edges formed either by the intersection of two retouched margins, or by the intersection of a retouched margin with a fracture or steep natural flake margin – are considerably less abundant than denticulates and scrapers.

Even the very simple of typological distinctions used in Table 2 seem somewhat arbitrary when applied to the Yarımburgaz materials. The differences between "scraper" and "denticulate" edges are not nearly so clear cut as in some later Mousterian assemblages. Instead, there seems to be a continuous range of variation in edge profiles from deeply notched or serrated to regular and evenly retouched. Denticulates, notches and becs/perçoirs especially seem to grade into one another. A tool with a single retouched concavity may be classed as a notch if the modified area is located near the center of a flake margin, but may resemble a bec/perçoir if the notch is adjacent to a fracture or steep natural edge (e.g., fig. 5 : 16). Similarly an artifact with two or more adjacent notches might be called a notch, denticulate, or bec/perçoir, depending on the breadth and depth of the concavities.

Table 4 : *Platform Types, Retouched Tools and Unretouched Flakes.*

	Flint	Quartz	Quartzite	Other	N	Percent
No platform	139	56	19	6	220	NA
Cortical	284	20	55	6	365	53.9 %
Plain	167	41	13	9	230	34.0 %
Dihedral	28	4	2	0	34	5.0 %
Faceted	10	0	1	0	11	1.6 %
Collapsed/crushed	24	10	2	1	37	5.5 %
Total (with platforms)	513	75	73	16	677	100.0 %

Somewhat unexpectedly, irregular, denticulate or notched tool edges appear to have been more extensively reduced than smooth, regular "scraper" edges. Comparisons based on an index of edge reduction[13] show that denticulate edges as a group have significantly heavier retouch/modification than either smooth (scraper) or pointed tool edges (Table 3). Much of the difference is accounted for by greater invasiveness of retouch on denticulate edges. The situation at Yarımburgaz can be contrasted with that in many European Mousterian assemblages, where denticulates tend to be less extensively modified than sidescrapers[14]. One possibility is that the jagged edges on many of the flake tools are the result of unsuccessful resharpening (and subsequent abandonment) of implements.

Flakes and tool blanks in the assemblage tend to be thick and blocky, with relatively steep natural edges, and most preserve at least some dorsal cortex. The largest number of flakes and tool blanks have with either cortical or plain butts, and faceted platforms are extremely rare (Table 4). Although end-struck flakes outnumber side-struck pieces by almost four to one, the degree of elongation is very restricted. The length/width ratios of both flakes and tool blanks average around 1.2/1, and only four specimens can be characterized as formal blades. Flakes and flake tools average between four and five centimeters in length. The forms of flakes and tool blanks of different raw materials do differ somewhat, as is discussed in greater detail below. There are no Levallois flakes (typical or atypical) in the Yarımburgaz assemblage, and typical biface-thinning flakes are completely absent as well.

13. KUHN, 1990.
14. ROLLAND and DIBBLE, 1991.

Table 5 : *Forms of Core Tools.*

	Side	End	Side and End
Choppers	27	22	1
Chopping tools	5	3	0
Total	32	25	1

(Note that three specimens were too fragmentary to categorize).

Table 6 : *Core Forms.*

Core Form	Flint	Quartz	Quartzite	Other	Total
Tested (1-3 scars)	4 (6.8 %)	7 (17.1 %)	32 (91.4 %)	3 (75.0 %)	46 (33.1 %)
Radial	37 (62.7 %)	3 (7.3 %)	3 (8.6 %)	0 –	43 (30.9 %)
1-2 Platforms	5 (8.5 %)	7 (17.1 %)	0 –	0 –	12 (8.6 %)
Globular	6 (10.2 %)	5 (12.2 %)	0 –	0 –	11 (7.9 %)
Bipolar	0 –	8 (19,5 %)	0 –	1 (25.0 %)	9 (6.5 %)
Amorphous	7 (11.9 %)	11 (26.8 %)	0 –	0 –	18 (12.9 %)
Total	59	41	35	4	139

Core tools make up a relatively small component of the Yarımburgaz collection, comprising only 10.6 % of the modified tools. Of the 64 core tools, 61 are choppers (fig. 6). Two of the remaining specimens were classed as "proto-bifaces". Both of these are relatively thin, ovoid pointed artifacts with irregular, flat, invasive retouch along both lateral margins : one is made on a flake, the other on a flat cobble. In reality, they resemble true Acheulean bifaces only superficially, as both "proto-bifaces" are minimally modified. One very large, round cortical flake of quartzite with bidirectional retouch or use-damage at the distal end could be classified as an atypical cleaver flake, as a chopping tool on a flake, or simply as a very large utilized flake.

Unifacially-retouched choppers are significantly more common than bifacially-flaked specimens (Table 5). Aside from the preponderance of unidirectional modification, there is little morphological standardization among the core tools. The modal length for choppers and chopping tools is between 8.0 and 10.0 cm, but they vary considerably in size. The smallest specimen is only 3.3 cm long, while the largest chopper is 17.1 cm in maximum dimension. Edge angles of core tools display a somewhat bimodal distribution, with one peak at 70-75 degrees, and a second at 80-85 % (fig. 7).

A wide variety of core forms were recovered at Yarımburgaz (Table 6, fig. 8). The largest single category is that of "tested pebbles", natural cobbles with between one and three removals. The most abundant formal cores are centripetally-worked or discoid specimens (fig. 8 : 1-3). The discoid cores tend to have relatively flat faces of detachment, and the majority have been worked on one face only. Platforms may be either plain or cortical. Consistent with the scarcity of faceted platforms on flakes and tool blanks, few of the cores preserve any traces of platform faceting. Other, less abundant forms include globular cores (fig. 8 : 4 and 5), informal cores with one or two platforms, bipolar (splintered) cores, and amorphous pieces. Although some of the cores are generally polyhedral in form, there are no typical polyhedrons or spheroids in the Yarımburgaz assemblage. Eleven "hammerstones", unflaked pebbles with localized percussion damage, were also recovered.

TECHNOLOGY AND EXPLOITATION OF RAW MATERIALS

In discussing raw material economy and flake production technology at Yarımburgaz cave, it is useful to treat the three principal raw materials – flint, quartz, and quartzite – separately. Although there is a certain degree of overlap, prehistoric toolmakers employed distinct ranges of technological options in working different types of stone. Quartzite was worked mainly in a manner which resulted in the production of choppers and chopping tools. Flint and quartz were preferred for retouched flake tools, but flake blanks were obtained by somewhat different methods from these very dissimilar types of stone.

Overall, quartzite appears to have been the least commonly used and least intensively exploited raw material. Quartzite artifacts are significantly less abundant than specimens of flint and quartz (Table 1), and artifacts made of quartzite were not modified or consumed to any great extent. The great majority of quartzite cores are simple tested cobbles, with a small number of unsystematic removals. Cores of flint and quartz are consistently smaller than those of quartzite, preserving significantly less cortex and larger numbers of removals (Tables 7a, 7b). Flakes and blanks of quartzite were not retouched as often as those made of either flint or quartz : of the three common raw materials, quartzite is the only one for which there are more unretouched flakes (broken and whole) than retouched flake tools (Table 1). However, if unretouched

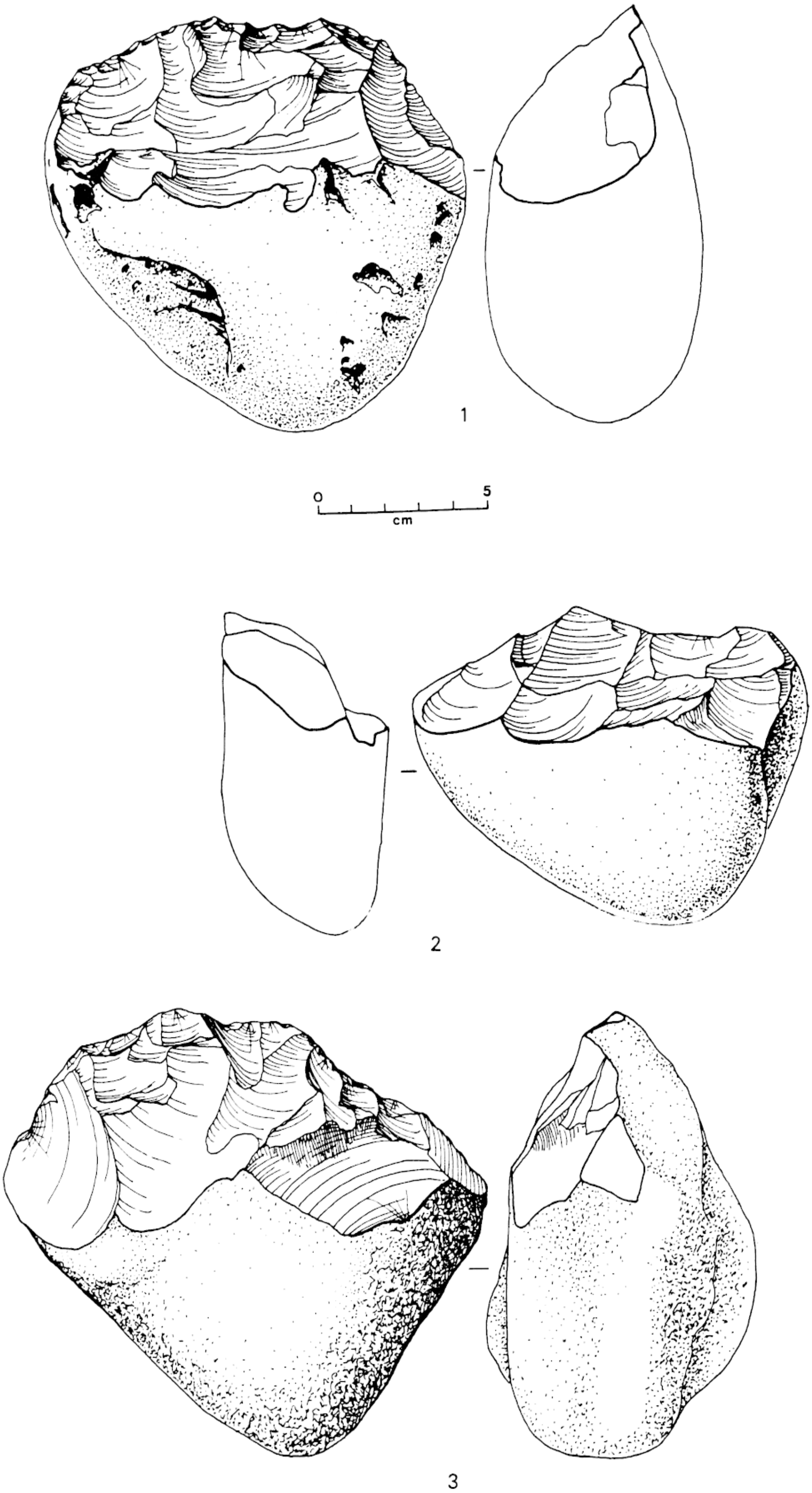

Fig. 6 : *Choppers from Yarımburgaz Cave. (Illustrations by J. Ogden).*

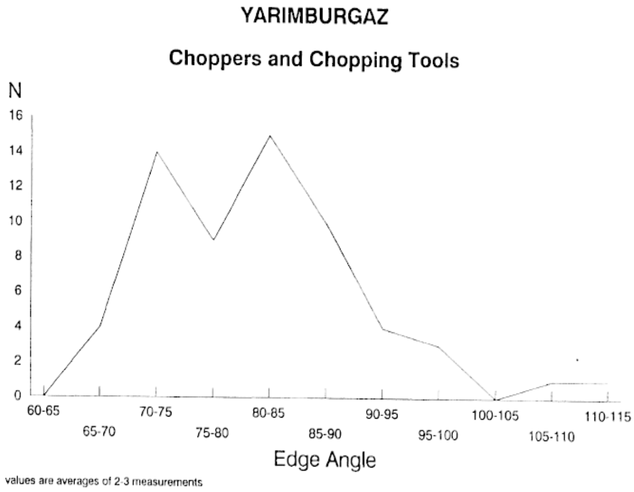

Fig. 7 : *Edge angles of choppers and chopping tools.*

Table 7a : *Median Number of Flake Removal Scars per Core.*

	Flint	Quartz	Quartzite
Choppers and chopping tools excluded	8	7	2
Choppers and chopping tools included	8	7	4

Table 7b : *Mean Quantity of Cortex per Core.*

	Flint	Quartz	Quartzite
Choppers and chopping tools excluded	32.9 %	30.4 %	77.9 %
Choppers and chopping tools included	35.4 %	34.9 %	75.5 %

flakes showing macroscopic use-damage are considered, flakes of all three materials appear to have been **used** with about the same frequency.

Manufacture Technology : Quartzite

The working of quartzite most often resulted in the production of cores or "core tools" that would be described as unifacial choppers. Fully 75 % of the core tools from the site are made of quartzite, even though this material only accounts for about 14 % of the total lithic assemblage (Table 1). Most quartzite flakes have forms typical of byproducts from chopper manufacture. On average, quartzite flakes have fewer than two dorsal scars, and almost 1/3 have no dorsal scars at all. More than 84 % of flakes preserve at least some cortex on their dorsal faces, and most have a considerable amount : on average, cortex covers 75 % of the dorsal surfaces of quartzite flakes and blanks. When dorsal scars are present they most commonly originate at the proximal (platform) end of the flake. The majority of all quartzite flakes and tools also have cortical platforms (Table 8). The existence of a variety of platform and dorsal scar patterns demonstrate that not all

Table 8 : *Platforms and Dorsal Scar Patterns, Quartzite Flakes and Tool Blanks.*

	Origin of Dorsal Scars								
Platform	No scars	Proximal	Bipolar	Lateral	1 Side + Proximal	Multi-direct.	Indet.	N	Percent
No plat.	8	2	1	4	0	0	5	20	NA
Cortical	13	21	7	4	6	1	5	57	74.0 %
Plain	5	1	5	1	1	0	1	14	18.1 %
Dihedral	0	1	0	0	0	1	0	2	2.6 %
Faceted	2	0	0	0	0	0	0	2	2.6 %
Collapsed/crushed	2	0	0	0	0	0	0	2	2.6 %
Total	30 34.9 %	25 29.0 %	13 15.1 %	9 10.5 %	7 8.1 %	2 2.3 %	11 NA	97	99.9 %

Note : Row percentages calculated using only specimens with identifiable platforms.
Column percentages calculated using only specimens with "legible" dorsal scar patterns.

Fig. 8 : *Cores from Yarımburgaz Cave. 1, 3 – unifacial discoids; 2 – discoid core; 4 – globular core; core with two opposed platforms; 6 – "truncated pebble" or unifacial discoid; 7 – centripetal core converted to unidirectional exploitation. (Illustrations by J. Ogden).*

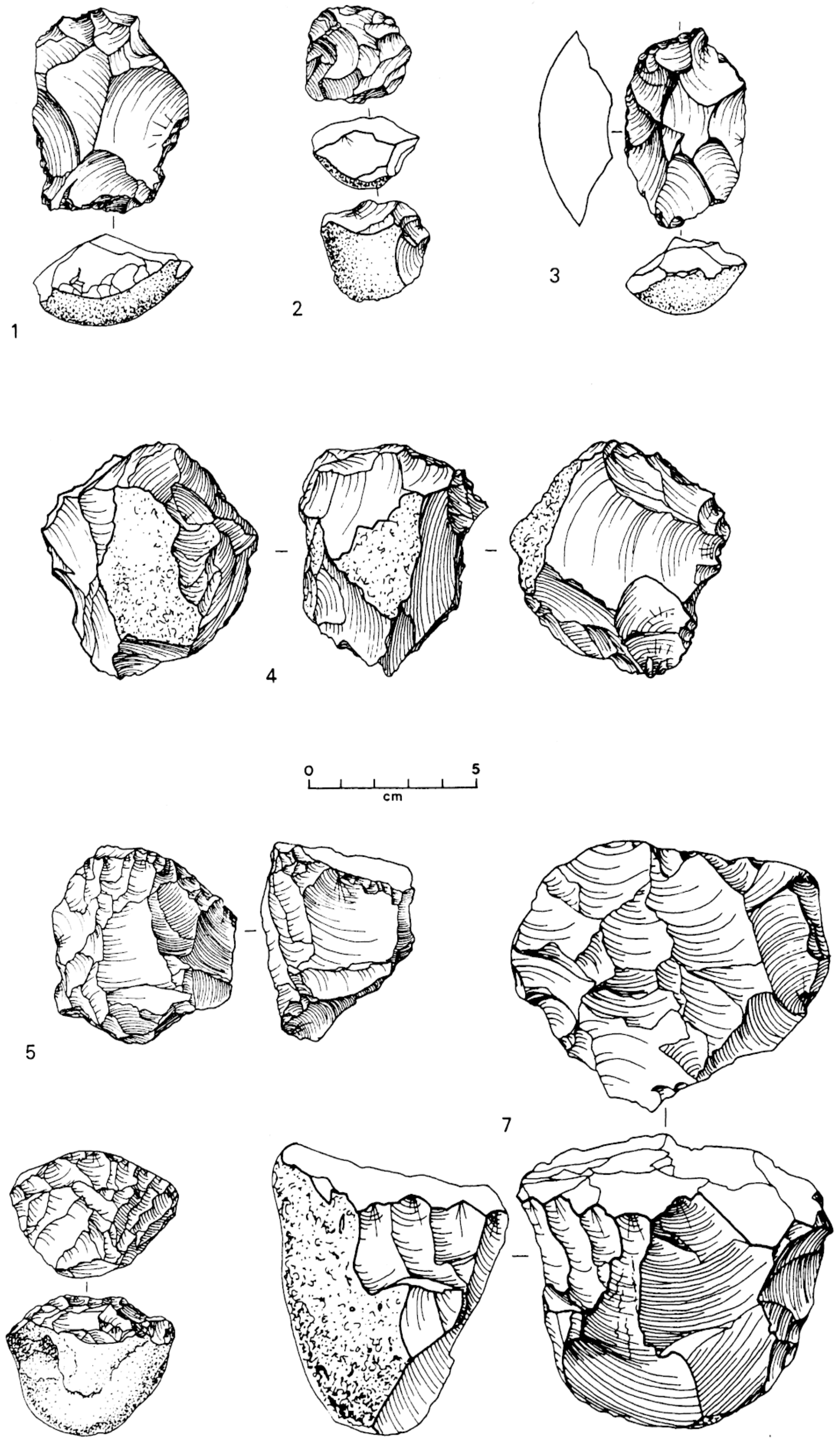
1
2
3
4
0 5
cm
5
7
6

Table 9 : *Platforms and Dorsal Scar Origins, Quartz Flakes and Tool Blanks.*

	Origin of Dorsal Scars								
Platform	No scars	Proximal	Bipolar	Lateral	1 Side + Proximal	Multi-direct.	Indet.	N	Percent
No plat.	12	4	10	2	0	2	36	66	NA
Cortical	2	2	7	6	1	1	5	24	27.9 %
Plain	1	16	10	2	2	4	12	47	54.6 %
Dihedral	0	0	1	0	1	1	1	4	4.6 %
Collapsed/crushed	0	3	4	0	0	0	4	11	12.8 %
Total	15 16.0 %	25 26.6 %	32 34.0 %	10 10.6 %	4 4.2 %	8 8.5 %	58 NA	152	99.9 %

Note : Row percentages calculated using only specimens with identifiable platforms.
Column percentages calculated using only specimens with "legible" dorsal scar patterns.

quartzite flakes were produced from choppers and chopping tools. Nonetheless, it is reasonable to infer that a great many were the results of such manufacture.

Referring to choppers and chopping tools as "core tools" implies that these items were manufactured intentionally to be used as tools. Although many choppers appear suitable for use as heavy-duty cutting tools, we should be cautious about making such a functional inference. Researchers have suggested that "choppers" in a number of Lower Paleolithic assemblages are cores for the production of flakes, rather than implements themselves[15]. However, several lines of evidence indicate that the choppers from Yarımburgaz could have served as "heavy duty" implements as well as a source of flakes. First, a variety of other methods were used to produce flakes from flint, quartz, and sometimes even quartzite. There is no reason to believe that a technique yielding "chopper-like" cores was the only practical means for working quartzite, and we might ask why this particular method might have been employed predominantly on this raw material, if the only object were to make usable flakes. Second, unlike Oldowan "chopper cores", many quartzite choppers from Yarımburgaz have relatively acute edge angles (fig. 7). On the other hand, quartzite flakes were retouched and/or utilized as frequently as flakes of other raw materials. Thus, even though the chopper tools could have served as tools themselves, they were clearly also exploited as sources of flakes and tool blanks.

15. ASHTON *et al.*, 1992; TOTH and SCHICK, 1986.

Manufacture Technology : Quartz

As Table 1 shows, quartz was most frequently employed for the manufacture of flake tools : quartz flakes show evidence of retouch nearly as frequently as do flakes of flint. In fact, the true frequency of retouch and utilization may be somewhat underestimated for this raw material. The variety of quartz used varies from translucent to nearly transparent, making it quite difficult to recognize very subtle modification of the edge due to either use or intentional modification. Quartz was also used occasionally to make choppers and chopping tools, but not nearly as often as quartzite.

Despite the rather small sample, quartz exhibits the widest variety of core forms of any of the three principal raw materials used at Yarımburgaz. In fact, no single core form accounts for more than 30 % of the total. The most abundant cores are "amorphous" specimens, with two or more platforms in a variety of orientations (Table 5). The second most abundant form is bipolar cores, pieces with splintered or wedge-shaped platforms of detachment that appear to have been worked by hammer-and-anvil technique. Like the cores, the forms of quartz flakes are highly varied. However, a large proportion of quartz flakes and blanks seem to have been derived from bipolar, hammer-and-anvil percussion. Many flakes (more than 40 %) have no recognizable platforms, a common occurrence when bipolar percussion is used (Table 9). In marked contrast to other raw materials, the great majority of remaining specimens have either plain (single facet) or crushed/collapsed platforms. Because of the difficulty of discerning flake scar directions on translucent materials like quartz, dorsal scar patterns could not be accurately determined for many specimens. Of those pieces with "legible" scars, however, more than 60 % have scars originating

Table 10 : *Platforms and Dorsal Scar Origins, Flint Flakes and Tool Blanks.*

	Origin of Dorsal Scars								
Platform	No scars	Proximal	Bipolar	Lateral	1 Side + Proximal	Multi-direct.	Indet.	N	Percent
No plat.	13	18	10	8	21	30	77	177	NA
Cortical	6	73	36	9	68	60	68	320	54.0 %
Plain	4	53	19	11	42	30	40	199	33.6 %
Dihedral	0	9	2	0	9	4	7	31	5.2 %
Faceted	0	4	0	1	2	2	3	12	2.0 %
Collapsed/crushed	0	5	7	2	8	1	7	30	5.1 %
Total	23 4.0 %	162 28.5 %	75 13.2 %	31 5.5 %	150 26.4 %	127 22.4 %	202 NA	769	 99.9 %

Note : Row percentages calculated using only specimens with identifiable platforms.
Column percentages calculated using only specimens with "legible" dorsal scar patterns.

either at the proximal end or both the proximal and distal ends (Table 9), also consistent with hammer-and-anvil technique.

The range of core forms and flake morphologies seen in the quartz artifacts from Yarımburgaz cave probably reflects the unpredictable working properties of the raw material itself. Quartz is capable of yielding flakes with sharp, very durable edges, but the material exhibits somewhat unpredictable fracture patterns. Often, a core will break unexpectedly along a cleavage plane rather than in the expected direction of percussion. A core may thus begin with one form, but an accidental fracture may necessitate changing the strategy of exploitation for subsequent removals. While such "surprises" occur with even the most homogeneous of raw materials, they are especially common in working quartz. Thus, the diversity of core forms in this material may not represent use of several distinct strategies for making flakes, but the outcome of a series of decisions made by tool makers in response to unexpected fractures. Bipolar, hammer-and-anvil percussion has been a favored technique for working quartz pebbles in a variety of cultural contexts and time periods, including at Yarımburgaz. This technique may be especially appropriate for working quartz because it is less likely to be disrupted by the material's natural tendency to break along flat planes.

Manufacture Technology : Flint

Choppers and chopping tools were infrequently manufactured of flint, although the few specimens recovered are quite "typical" in form. Like quartz, flint was frequently used for the manufacture of retouched flake tools (Table 1). It also appears that the production of flint flakes and tool blanks was often achieved by means of a distinctive method of core preparation and flake detachment. Although flint cores exhibit a variety of forms, the majority (62.7 %) show evidence of centripetal or multi-directional patterns of flake detachment (Table 5). As noted above, the centripetal cores tend to be relatively flat, and the faces of detachment are either flat or slightly convex. As such, they are quite distinct from the steeply-angled, "conical" or "biconical" forms of disc-core described from many Lower and Middle Paleolithic sites[16]. They are not classical centripetal Levallois cores either, in that platforms were never extensively prepared and "preferential" removals are not represented. In general form, many of the Yarımburgaz centripetal cores resemble what are sometimes termed "unifacial discoids"[17].

The centripetal working of cores is clearly reflected in dorsal scar patterns on flint flakes and tool blanks, in which multidirectional (centripetal) patterns predominate (Table 10). Nonetheless, the flint flakes and tool blanks from Yarımburgaz show an unusual mixture of attributes. Given the high frequencies of centripetal and multidirectional dorsal scar patterns, one might expect to find little dorsal cortex, and this is indeed the case : while almost half of flint pieces preserve traces of cortex, the median coverage of the dorsal surface is only 5.0 %. However, more than half of the flint flakes and tool blanks were struck from unprepared cortical cobble surfaces. Where the platform type can be identified, 54 % of all flint flakes and tool blanks, and about 51 % of specimens with centripetal or multidirectional dorsal scar patterns, have cortical butts (Table 10). A number of illustrative specimens are shown in figure 9.

16. ISAAC, 1977 : 175.
17. SCHICK and TOTH, 1993.

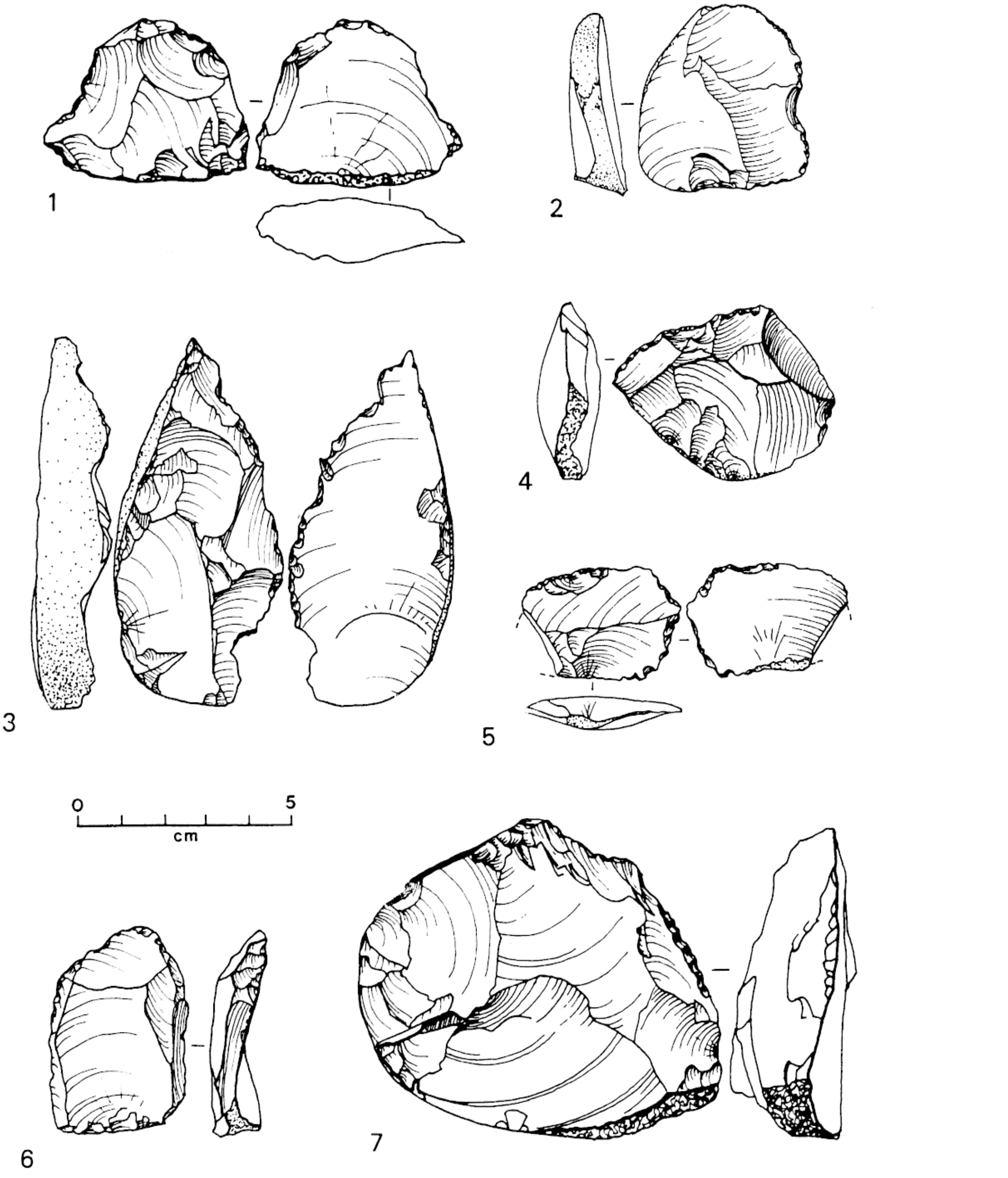

Fig. 9 : *Flint flakes and tools with cortical butts and multidirectional dorsal scars. All show sporadic retouch and/or use damage. (Illustrations by J. Ogden).*

While it is clear that some centripetal scheme of flake letachment was employed to work flint at Yarımburgaz, the general forms of flakes and tool blanks do not conform vith products of better known Middle Paleolithic techniques of core exploitation, such as Levallois and classic bifacial discoid methods[18]. As discussed above, there are no true Levallois flakes in the Yarımburgaz assemblage. Pseudo-levallois points and similar flat, triangular flakes typically

18. BOËDA, 1993.

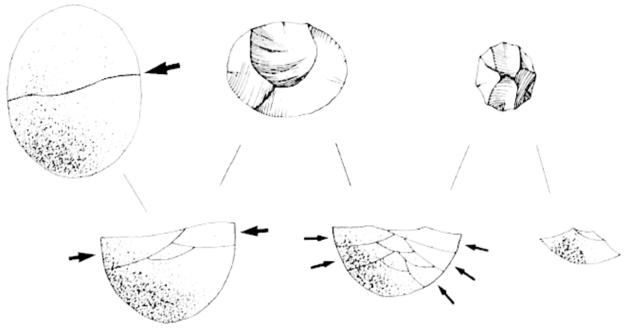

Fig. 10 : *Schematic illustration of unifacial centripetal method used to work flint at Yarımburgaz.*

produced from typical discoid cores[19] are also essentially absent from the collection. Some flakes do appear to have been detached as the result of blows struck tangentially to the center of the core, as in classic discoid reduction (i.e., fig. 9 : 2 - 4) but these are not in the majority. From the abundance of cortical platforms, it is also clear that the variety of centripetal flake production used to work flint involved little systematic preparation or adjustment of the platform.

A schematic illustration of one possible means of producing the observed patterns is shown in figure 10. The reconstructed sequence of operations begins with the splitting of a flint pebble into two more-or-less hemispherical sections. Flakes were subsequently detached from the newly created surface by blows directed at the cortical margins of the core, either directly towards or at a tangent to the core's center. If detached early in the sequence, the resulting flakes would be relatively flat (e.g., fig. 9 : 4 and 5), while pieces struck off later in the sequence may be more wedge-shaped in longitudinal section (fig. 9 : 1). The presence of single-facet, dihedral, or even a few faceted butts on some flint flakes suggest that platforms were shaped and even prepared on occasion. Since some residual cores bear traces of at least minor platform modification (compare fig. 8 : 1-3, 7), it may be that platforms were often adjusted late in the reduction of a core.

The mode of flake manufacture used on flint at Yarımburgaz cave is distinctive but not unique. An apparently similar pattern of flake production is represented at a number of Middle or late Lower Paleolithic localities in France, including sites on the terraces of the Tarn River[20], and sites such as Coudelous and Mauran in the Garonne river basin, where it has been termed the "unifacial discoid" method[21]. In the Tarn River sites, assemblages of flakes with cortical platforms are associated with residual cores called *épannelé* or "truncated cobbles"[22], which appear to be a logical residue of the kind of centripetal core reduction technology illustrated in figure 10. While a few similar specimens were found at Yarımburgaz (i.e., fig. 8 : 6), they are not especially common. Instead, it appears that as cores were reduced, they often took on a more classic radial/disc form, or else were transformed into other core forms. Figure 8 : 7 shows one example in which the face of detachment of a centripetally-exploited core was subsequently transformed into a striking platform shortly before the core was abandoned.

19. BREZILLON, 1968 : 95.
20. TAVOSO, 1978.

DISCUSSION

An obvious question concerns the similarities (and possible relationships) between the Yarımburgaz assemblage and other industries of similar age, and how such relationships pertain to geographic patterning and technological variability during the Middle Pleistocene. Due to the predominance of heavily retouched flake tools with steep, irregular, denticulate edges, the presence of well-made choppers and chopping tools, and the absence of both true bifaces and Levallois technology, the industry from Yarımburgaz cave most closely resembles the "Tayacian" and related assemblages from southern Europe[23], or the chopper and small tool industries of eastern and central Europe[24]. Similar Middle Pleistocene industries composed of heavily-modified flake tools and choppers have also been found in central Asia[25]. Thus, the closest affiliations of this assemblage would seem to be with eastern Europe and/or central Asia, rather than with south-central Anatolia or the Levant, where more classic Acheulean assemblages predominate[26], and where the significance of the few early non-handaxe assemblages – such as that from layer G at Tabun[27] – remains a subject of debate[28].

Although some investigators have identified geographically and chronologically restricted typological variants of these "handaxe-free" Middle Pleistocene core and flake tool assem-

21. JAUBERT, 1994; JAUBERT and FARIZY, 1995.
22. TAVOSO, 1978.
23. E.g., FERRARI *et al.*, 1991 ; LUMLEY, 1976a, 1976b; ROLLAND, 1985.
24. SVOBODA, 1987, 1989.
25. CLARK, 1993 : 163; DAVIS *et al.*, 1980.
26. E.g., BAR-YOSEF, 1994; BOSTANÇI, 1961 ; CLARK, 1968, 1975; MINZONI-DEROCHE et SANLAVILLE, 1968; YALÇINKAYA, 1981.
27. E.g., GARROD and BATE, 1937; HOWELL, 1959; KIRKBRIDE *et al.*, 1983.
28. BAR-YOSEF, 1994.

blages[29], we place no great weight on detailed typological comparisons with the retouched artifacts from Yarımburgaz. The main point of similarity with the other industries noted above derives from the preponderance of heavily modified, irregular and somewhat unstandardized flake tools, along with the dominance of choppers among the core tools. We suspect that comparisons based on finer typological distinctions, and especially comparisons between assemblages classified by different investigators, may be less reliable.

There is little local comparative context for the lithic industry of Yarımburgaz cave, which represents one of a small handful of well documented Middle Pleistocene assemblages from western Turkey. It is significant that Karain Cave on the southwest Anatolian coast[30], the only other recently-excavated Lower Paleolithic cave site in western Turkey, also contains a Tayacian– or Clactonian-like Lower Paleolithic industry[31]. However, the presence of flake tool assemblages and the scarcity of bifaces may also be tied in part to the fact that both Yarımburgaz and Karain are deep caves, a type of locality which does not commonly yield abundant Acheulean materials[32]. It should be noted that a few bifacial handaxes have been found in surface context along the terraces of the Bosphorous and elsewhere[33]. Given the current state of knowledge, it is impossible to be sure whether western Turkey, like southwestern Europe, contains both Acheulean and "flake tool and chopper" industries, or whether the non-handaxe assemblages are strongly predominant, as in east Asia and central and eastern Europe. Future research in the region should help to resolve this important issue.

The data from Yarımburgaz do have some bearing on explanations for the absence of classic Acheulean industries in some parts of Eurasia. Citing the fact that eastern European core and flake tool assemblages are often made from small pebbles[34], some researchers have argued that the scarcity of biface and Levallois technology in the Middle Pleistocene of these regions reflects an adaptation to the use of small and/or poor– quality raw materials[35]. Essentially, the contention is that Middle Pleistocene tool makers lacked stones large and fine-grained enough to manufacture good handaxes, so that biface technology was quickly abandoned or forgotten as hominids moved into, and ultimately through, the area. The assemblage from Yarımburgaz cave, located on the easternmost fringe of Europe, is inconsistent with a simplistic raw material-based explanation for regional variation in Middle Pleistocene technology. First, the pebbles used at the site are not especially small. Worked flint and quartzite cobbles range up to 17 cm in length, more than large enough to have been made into bifaces (or Levallois cores). Thus, there is no reason to assume that Middle Pleistocene tool makers would have been unable to produce an acceptable Acheulean assemblage using local stones. Second, the site is located at the extreme eastern margin of Europe, on or near to one possible route of migration from western Asia. Assuming that the primary direction of migration was south to north, it would be difficult to argue that the technological knowledge needed to produce handaxes and Levallois had been lost long before hominids first reached northwestern Turkey.

It must also be recognized that the steep-edged flake tools and simple choppers characteristic of Tayacian and similar assemblages do not have the same functional and economic properties as the bifaces typically associated with classic Acheulean assemblages[36]. Although a model based on presumed differences in raw material size and quality may not explain the distributions of Acheulean and "non-biface" assemblages, other functional and economic factors cannot and should not be excluded *a priori*. For example, it is a well-documented fact that large bifacial tools frequently occur in localities with little or no small flake debris[37] in the African Acheulean, suggesting that bifaces were regularly carried away from the locus of manufacture. If large bifaces frequently served as transported heavy-duty implements, used perhaps in processing carcasses of megafauna, as some have suggested[38], then their absence from certain areas or certain assemblages might well be related to the kinds of foraging opportunities available to Middle Pleistocene hominids. This hypothesis might be evaluated by comparing faunal inventories of sites with differing artifact assemblages, where the faunas could be shown to be the result of hominid activities.

Although one cannot easily argue that the Yarımburgaz assemblage differs from classic Acheulean assemblages simply because of a scarcity of appropriate raw materials, it is no simple task to interpret the apparent similarities between this and other Middle Pleistocene core and flake tool industries. The fact that flake tool and chopper industries are found

29. LUMLEY, 1976a, 1976b; SVOBODA, 1989.
30. OTTE *et al.*, 1995; YALÇINKAYA, 1988; YALÇINKAYA *et al.*, 1993.
31. OTTE *et al.*, 1995; O. BAR-YOSEF, pers. comm., 1995.
32. N. GOREN, pers. comm., 1996.
33. JELINEK, 1980; M. ÖZDOĞAN, pers. comm., 1992.
34. E.g., SVOBODA, 1989 : 46-50.
35. See discussions *In* : KLEIN, 1989 : 255; ROLLAND, 1985.
36. Cf. CLARK, 1993 : 162.
37. BINFORD, 1987; KLEINDIENST, 1962.
38. E.g., SCHICK and TOTH, 1993 : 259-260.

over a contiguous area stretching from southern Europe to central (and ultimately eastern) Asia could indicate the presence of a distinctive and widespread "technological tradition". However, the vast geographic distribution and long temporal span of Tayacian and similar industries represent a phenomenon unlike any sort of ethnic unit known from later time periods. It is also important to consider the limited framework within which comparisons between industries are often made. Our perception of the uniformity of the chopper and flake tool industries may reflect very limited exploration of variation within this group. Such assemblages are more often described in terms of what they lack – bifaces and Levallois – than in terms of their own distinctive features[39]. Extensive comparisons of flake production technologies or *chaînes opératoires* may reveal more profound contrasts among some assemblages, as well as closer similarities between others, than have been described to date.

One of the most striking features of the Yarımburgaz assemblage relates to the manner in which different raw materials were exploited. Quartzite was used primarily for the manufacture of "core tools", whereas flint and quartz were preferred for making flake tools. Moreover, different methods were used to produce flakes of the latter two materials. Some of the associations between technology and raw material – most notably the use of bipolar, hammer-and anvil percussion on quartz – may reflect the working properties of specific types of stone. On the other hand, there is no clear and obvious reason why choppers should almost always be made of quartzite and not flint, for example.

In fact, Middle and Lower Pleistocene assemblages frequently exhibit this sort of sharply differentiated use of raw materials[40]. Moreover, associations between raw materials and tool forms are not consistent among sites. At the lower Pleistocene locality of 'Ubeidiya, for instance, choppers and chopping tools were made almost exclusively on flint[41], while at Yarımburgaz they almost never were. The distinctive method of flake production used to work flint at Yarımburgaz may be linked to the exploitation of river cobbles, since their smooth cortical surfaces would provide excellent striking surfaces[42]. However, a very similar "unifacial discoid" method was apparently applied with success to quartz cobbles in the Tarn river terrace sites[43] and in the Garonne valley[44], suggesting that the intrinsic physical properties (graininess, hardness, fracture quality) of different types of stone were not themselves the determining factors.

The explanation for these locally rigid but globally variable patterns of raw material exploitation remains elusive but intriguing. One possibility is that apparent contrasts in the treatment of different varieties of stone reflect the application of a limited range of technological options to pebbles of varying size, shape, and raw material. Many early core and flake tool assemblages appear to have been oriented towards producing flakes quickly and efficiently from whatever stones happened to be at hand. This would certainly seem to apply to the various modes of flake production used at Yarımburgaz, all of which entailed a minimum of core preparation or shaping. In marked contrast to some later Acheulean technologies[45], there was very little "predetermination" of products. These core and flake tool technologies may not have been entirely "expedient", but they were quite opportunistic, in that Middle and Lower Pleistocene hominids seldom failed to take advantage of the raw materials available to them. If flakes were produced rapidly and without elaborate preparation of cores, it is likely that the shapes of the pebbles or nodules toolmakers began with would have had a great deal of influence on how core reduction proceeded : in fact, the shapes of nodules even influenced the forms of more extensively-worked Acheulean bifaces[46]. The relationships between pebble forms and the shapes of tools and cores in the Middle Pleistocene may not have been as direct and simple as those suggested for the Plio-Pleistocene industries[47]. Nonetheless, differently-shaped cobbles would have provided distinct "paths of least resistance". Given the finite range of technological options hominids had at their disposal, a flat pebble would have afforded different opportunities and limitations than a spherical one. Similarly, a chunk of lava provided one ready pathway to making flakes, a rolled and rounded cobble another. If this is the case, the associations between raw materials and core technology may be more or less fortuitous, hinging on the shapes of pebbles of different types of stone and not on the properties of the various rock types themselves. Hopefully, broad inter-assemblage comparative studies will help to address the causes of this intriguing set of patterns.

39. Rolland, 1985 : 144; Villa, 1983 : 237-238.
40. E.g., Bar-Yosef and Goren-Inbar, 1993; Clark, 1975; Goren-Inbar, 1988; Leakey, 1975; Svoboda, 1989; Villa, 1983.
41. Bar-Yosef and Goren-Inbar, 1993; Goren-Inbar, 1988.
42. L. Meignen, pers. comm., 1996.
43. Tavoso, 1978.
44. Jaubert and Farizy, 1995.
45. Texier and Roche, 1994.
46. Sampson, 1978.
47. Schick and Toth, 1993 : 130.

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