Early Mousterian Levallois Technology in Unit IX of Tabun Cave

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ABSTRACT

Following the stratigraphic sequence described by D. Garrod in her pioneering excavations at Tabun Cave, the Levantine Mousterian is traditionally divided into three sub-stages (B, C, D) according to changes in modal forms of Levallois production. Despite the ubiquity of this terminology, none of these three stages from Tabun has been described in detail. Furthermore, our knowledge of variability in technology and chronology within the Levantine Middle Paleolithic has increased markedly in the last three decades. This variation is especially apparent in the Early Middle Paleolithic, when both Levallois and non-Levallois laminar methods appear in most sites but with different frequencies. In this paper we provide a reconstruction of the Levallois technology in the early Middle Paleolithic of Tabun Cave using assemblages from Jelinek's excavations in Unit IX (Garrod's layer D). In contrast to many other contemporary sites, where non-Levallois laminar production is strongly represented, the assemblage of Unit IX is dominated by a recurrent, unipolar Levallois technology. Understanding the specific character of the "prototype" of Tabun D is an important step towards assessing inter- and intra-assemblage variability within the Levantine Early Middle Paleolithic. Appreciating this variation is in turn essential for explaining the apparently sudden appearance of these early Mousterian assemblages between 200 and 250 kya. The method used at Tabun Unit IX is both flexible and efficient, yielding both large numbers of blanks and a range of products while reducing the waste of material involved in shaping and maintaining of the core. In these assemblages, blades, flakes and Levallois points, and a variety of other products, were produced through systematic exploitation of different parts of the core's surface. In this respect the technology of Tabun Unit IX differs from the 'laminar method' known from other early Levantine assemblages in the organization of production and in its economic features and the range of products.

INTRODUCTION

Archeological studies at Tabun Cave over the past 75 years have fundamentally shaped perceptions of the Middle and Lower Paleolithic in the eastern Mediterranean (e.g., Garrod 1956; Garrod and Bate 1937; Grün and Stringer 2000; Jelinek et al. 1973; Jelinek 1975, 1977, 1982a, b, 1990; McCown and Keith 1939; Mercier and Valladas 2003; McPherron 2006). The first phase of work at the site resulted in the standard tripartite division of the Levantine Middle Paleolithic, in which the earliest phase ('Tabun D') is characterized by the abundance of blades and elongated points (Copeland 1975; Garrod and Bate 1937: 77–78; Jelinek 1982a,b; Shea 2003 and references therein). Despite the site's significance, and despite important subsequent work by Jelinek et al. (1973), Meignen (1994) and Monigal (2002), the character of lithic production in the Early Middle Paleolithic (henceforth EMP) of Tabun has not been fully explored. In apparent contrast to many other EMP sites in this region, Tabun Unit IX (henceforth Tabun IX) is dominated by Levallois technology. Other assemblages of comparable age contain Levallois alongside other modalities of blank production—most notably the 'laminar method'—marked by a different treatment of the core volume (Delagnes and Meignen 2006; Meignen 2007a, Meignen and Tushabramishvili 2010). While this differentiation is well acknowledged in most current studies (Hovers 2009), detailed reconstructions of each of the technologies of the EMP are still lacking. Moreover, understanding the technological options available to, and technological choices made by EMP hominins is an important step toward fuller understanding of their economy, land use and cognition. It is also crucial to investigating the breaks and continuities between the EMP and earlier technologies.

In this paper we present a detailed attribute-based technological analysis of the material from Unit IX from A. Jelinek's excavations at Tabun Cave, the best preserved unit from the EMP of the site (Jelinek et al. 1973; Jelinek 1982a). Jelinek made the key observation that production throughout Tabun IX was oriented toward elongated blanks, including both blades and points (Jelinek et al. 1973: 174). This is in contrast to the work of Garrod, who places less weight on the blades from Tabun D (Garrod and Bate 1937). Meignen's more detailed study (1994, 2007a, b), emphasized the dominant use of Levallois technology in Tabun IX, contrasting it with other EMP assemblages where elongated products also were commonly obtained from non-Levallois

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cores. Meignen (1994) described the blank-production technology as unidirectional, convergent or bidirectional recurrent Levallois, in which the main objective was the removal of blades and elongated points. She mentioned that the shaping of the Levallois surface was usually not conducted by flaking from the lateral edges but rather by removing specialized *débordant* flakes and blades from the dominant striking platform. Monigal (2002) examined the material from Units VII–IX of Tabun and reached similar conclusions, observing further that bidirectional reduction was a minor component. Both Monigal's and Meignen's studies intentionally emphasized the manufacture of blades and elongated points and were less concerned with the other elements of the assemblages. Although we concur with many of these authors' basic conclusions, this study considers the full range of Levallois and non-Levallois products in order to better characterize the reduction in Tabun IX. We employ attribute analysis to examine the possible relation between products. The results indicate a dominant use of a recurrent Levallois reduction that applied unipolar/convergent removals for the co-production of a variety of products—blades, flakes, points, and other forms—through repeated series of removals. This might be one of the key differences from the laminar method that seemingly focused on a narrower range of products—mainly blades (Meginen 2000; Monigal 2002).

TABUN CAVE

Tabun Cave lies at the mouth of Nahal Me'arot (Wadi el-Mughara), facing the coastal plain ca. 20km south of Haifa, Israel. The cave was first excavated in 1929–1934 by D.A.E. Garrod (Garrod and Bate 1937:1–2). It was re-excavated in 1967–1971 by A. Jelinek (Jelinek 1982a; Jelinek et al. 1973). Excavations were continued between 1975 and 2003 by A. Ronen (Ronen and Tsatskin 1995). Garrod removed an estimated 2,000m³ of sediment from the cave (Rollefson 1978:19), leaving a stepped section approximately 24.50m deep that began in the inner chamber and ended at bedrock in the outer chamber where a swallow-hole was uncovered. Garrod divided the stratigraphic sequence into seven layers, beginning with what she called Taycian and ending with the late Mousterian (Layer B) (the uppermost Layer A was mixed and included recent material [Garrod and Bate 1937]). Jelinek's excavations concentrated on Garrod's stepped section in the intermediate chamber. The new section was 10m high, 5m to 6m wide and penetrated 2m into Garrod's section. The exposed sequence was divided into 14 'Major Stratigraphic Units' (identified with Roman numerals), each composed of multiple geological beds (Jelinek 1981, 1982b, 1990). Although the new excavations provided much better control over the stratigraphy, Garrod's simple division of the sequence is still most commonly encountered in the literature.

In all, Units II–IX from Jelinek' (1981) excavations correlate to Garrod's Layer D and the lower part of Layer C. The material examined for this paper comes from Unit IX of Jelinek's excavations, which is equivalent to the lower part of Garrod's Layer D. Unit IX is the most intact EMP deposit at Tabun: Units III–VIII show evidence of considerable erosion and re-deposition. The assemblage from this layer is most often referred to as 'Early Levantine Mousterian' or 'Tabun D-Type' in the literature (Bar-Yosef 1995; Copeland 1975, 1998; Shea 2003 and references therein). The sediments in this part of the sequence consist mainly of aeolian sand and silt (Jelinek et al. 1973). Unit IX has been dated by TL to 256±26 kyr (Mercier and Valladas 2003). Ungulate teeth from Garrod's excavations gave much younger dates, 143+41/-28 kyr, using a combination of U-Series and ESR (Grün and Stringer 2000). Discrepancies in results could be due to difference in dating techniques as well as uncertainties about the exact provenience of the teeth from Garrod's excavations.

MATERIAL AND METHODS

Unit IX consists of Beds 62–69, with a total thickness of between 1.0m and 1.5m (depending on location). It was encountered in 17 (1m²) squares of the excavation's grid, although it is only partially represented in some squares. The assemblage includes a sum of 1,651 large piece-plotted items (Jelinek 1982b: 75). The material used in this study comes from the collections housed at the University of Arizona (ca. half of the assemblage). Complete collections from eight excavation squares within Unit IX remained on loan in Tucson at the time of this publication. The material from three squares was returned to Israel and is stored at the Israel Antiquities Authority in its entirety. The assemblages from an additional six adjacent squares in the same beds are divided between Israel and Tucson. In order to avoid sampling biases due to the division of these collections, items from those squares split between Arizona and Israel are used in only a few analyses (noted below). The smallest flakes (≤ 2.5cm) were long ago separated from the rest of the assemblage and are currently under study by M. Bisson, who has courteously shared his results with us. However, these artifacts were not incorporated to the main database because they were not analyzed using the same criteria. Additionally, the data provided by Bisson refer to the entire unit, and not just to the collections at the University of Arizona. In any event, because it was so difficult to extract small objects from the cemented sediments encountered in Jelinek's excavation area, the sample of diminutive flakes is small and most likely not representative.

The finds from Tabun IX, and especially the shaped tools, have been described in several prior publications (Jelinek 1977; 1981, 1982b) so a complete description would be superfluous. Nevertheless, some of the technological categories used here—such as *débordants* and overpassed items—differ from those used in previous studies of Tabun by Jelinek and others. In addition, this study employs measurements of maximum width and thickness, and not the medial measurements used in previous studies (Jelinek 1977)[1], so some results differ. The division between blades and flakes is made here according to the standard criterion, a length/width ratio larger or smaller than 2.0/1; however, in this study the ratio is based on maximum measurements and not on mid-point measurements as in some of the previous studies of Tabun (e.g., Jelinek 1977).

Distinguishing between individual products of Levallois and non-Levallois systems of reduction is far from simple (e.g., Boëda 1995; Hovers 2009: 63; Van Peer 1992: 3). Although researchers have detected metrical and morphological differences among blades produced by Levallois and non-Levallois technology (Copeland 1983; Meignen 1998, 2000), these refer to population characteristics and do not permit reliable attribution of single items. The differentiation between non-Levallois blades and Levallois blades is more complicated than the classification of flakes, since in this case both production systems are characterized by a high degree of predetermination, with the main difference being in the organization of the core's volume (Boëda 1995). In fact, it has repeatedly been suggested that non-Levallois blade production holds many similarities with the concept of the *recurrent* Levallois production (e.g., Belfer Cohen and Goring Morris 2009; Shimelmitz et al. 2011). As such, although several studies choose to differentiate between Levallois and non-Levallois blades (e.g., Hovers 2009), we presume that in the particular case of Tabun IX, which is dominated by unidirectional reduction, such a division will be arbitrary. We do, however, consider the effects of including blades from non-Levallois cores in the analyses. As for flakes, we distinguish between 'Levallois flakes,' 'atypical Levallois flakes,' and 'simple flakes.' The Levallois flakes are characterized by a well organized scar pattern, taken as evidence of intentional predetermination, and they have a relatively flat and uniform cross-section (Debénath and Dibble 1994: 46). The 'atypical Levallois flakes' also show a complex scar pattern, but usually have irregular shape and are difficult to distinguish from flakes used in shaping the Levallois surface; that is, they may be predetermin*ing* blanks and not themselves predetermin*ed.* Due to this possibility, the 'atypical Levallois flakes' are not included among the Levallois products, as in some studies of the Levantine Mousterian (e.g., Hovers 2009: 109). The 'simple flakes' have simpler dorsal scar patterns and less regular profiles, shapes, and cross-sections. They are probably the results of both Levallois core shaping and maintenance, as well as of non-Levallois core reduction that also occurred at site. The definition of the Levallois point is much clearer, consisting of a pointed, triangular shape, usually with a well-defined "*Y-arete*" scar pattern. The division between Levallois points and elongated Levallois points follows the division between blades and flakes (length/width >2/1). This too is slightly different from Jelinek's previous study (1982b: 77) where the boundary was set at 2.75/1 but midpoint measurements were used. The distinction between elongated points and blades is not always obvious and some items could be put in either category. In this analysis, "elongated point" refers only to specimens with a triangular plan and not to every elongated blank with a pointed distal end.

In all, the assemblage is composed of a variety of forms or types of blanks. The presence of retouch on a wide range of products shows that virtually all of these could be and were used for various purposes. Because our goal is a technological reconstruction, the primary importance lies in the initial forms of the pieces, regardless of their subsequent uses, so we do not separate retouched and unretouched pieces for the purposes of technological analysis. Nevertheless, because their utilization is of importance as well, Table 1 distinguishes three categories for each type of flake or blade—blanks, shaped pieces, and 'Nahr Ibrahim Technique' (Solecki and Solecki 1970). The distinction between "blanks" and "shaped" pieces is based on the presence of secondary modification by retouch or a burin blow on the latter. The items identified as showing 'Nahr Ibrahim technique' were separated because they are assumed to represent a specific type of core ('cores on flakes;' Hovers, 2007). They were not added to the general 'core' group for two reasons. First, our emphasis is on tracking the distribution and characteristics of all products of core reduction regardless of their later use. Second, most 'cores on flakes' differ from other cores in that they yielded very few removals, usually very small flakes (e.g., Barkai et al. 2010; Dibble and McPherron 2006).

Our reconstruction is based mainly on the analysis and comparison of cores along with four product types—blades, Levallois flakes, elongated points and broad points, which constitute the majority of the assemblage. We discuss other artifact types commonly assumed to be by-products. The analysis refers to unmodified blanks as well as items that were modified by retouch or 'the Nahr Ibrahim technique.'

Although the majority of the blanks are whole, we chose to include broken items in order to increase sample sizes for some attributes. Broken segments can still provide important data for reconstructing the reduction sequence—i.e., end-termination, striking platforms, etc. (e.g., Barkai et al. 2005; Shimelmitz 2009). The numbers of complete blanks and fragments are presented in Table 1. Metrics, dorsal scar patterns, and number of scars were recorded on whole items only.

The attribute analysis used here follows several earlier studies that have demonstrated the potential of attribute-based studies for understanding lithic *chaînes opératoires* (e.g., Hovers 2009; Monigal 2002; Soriano et al. 2007; Shimelmitz et al. 2011). This approach is especially appropriate for Tabun IX because the sample contains an abundance of flakes and blades but few cores in good condition. Methods such as refitting and diacritical analysis of cores are less appropriate for assemblages collected from relatively small excavation areas and/or with few cores. We included the blades (n=46), Levallois points (n=15), elongated Levallois points (n=11), Levallois flakes (n=9), *débordants* (n=4), overpassd items (n=3), and Levallois cores (n=4) from the squares with "divided" collections in the sample for the purpose of the attribute analysis and the description of the products only. The specific attributes taken are described below. The character, orientation, and direction of dorsal scars on flakes and blades are important sources of evidence for this analysis (e.g., Boëda 1988a; Van Peer 1992). Our ability to clearly distinguish laminar scars is limited in many cases because so many dorsal scars are truncated by later removals or by the edge of the blank. Consequently

TABLE 1. THE STUDIED SAMPLE FROM UNIT IX.

		whole	proximal	medial	distal	sum	%*	% out of debitage and tools
primary element flake	blank	38	4	2	3	47	78.33	
	shaped	7	3	0	2	12	20	
	NHT	1	0	0	0	1	1.667	
	sum	46	7	2	5	60	100	8.3
primary element blade	blank	14	3	0	5	22	71.0	
	shaped	8	0	0	1	9	29.0	
	NHT	0	0	0	0	0	0.0	
	sum	22	3	0	6	31	100	4.3
simple flake	blank	43	4	3	8	58	75.32	
	shaped	10	3	0	1	14	18.18	
	NHT	2	1	0	2	5	6.5	
	sum	55	8	3	11	77	100	10.6
Naturally backed knife (flake)	blank	15	4	0	3	22	81.5	
	shaped	3	1	0	0	4	14.8	
	NHT	1	0	0	0	1	3.7	
	sum	19	5	0	3	27	100	3.7
Naturally backed knife (laminar)	blank	16	0	0	1	17	65.4	
	shaped	8	0	0	1	9	34.6	
	NHT	0	0	0	0	0	0.0	
	sum	24	0	0	2	26	100	3.6
atypical Levallois flake	blank	7	2	0	0	9	69.23	
	shaped	4	0	0	0	4	30.77	
	NHT	0	0	0	0	0	0	
	sum	11	2	0	0	13	100	1.8
pseudo Levallois point	blank	0	0	0	0	0	0	
	shaped	3	0	0	0	3	100	
	NHT	0	0	0	0	0	0	
	sum	3	0	0	0	3	100	0.4
Levallois flake	blank	37	14	1	1	53	67.95	
	shaped	19	1	0	2	22	28.21	
	NHT	1	2	0	0	3	3.8	
	sum	57	17	1	3	78	100	10.8
Levallois point	blank	24	0	0	1	25	60.98	
	shaped	16	0	0	0	16	39.02	
	NHT	0	0	0	0	0	0.0	
	sum	40	0	0	1	41	100	5.7

		whole	proximal	medial	distal	sum	%*	% out of debitage and tools
elongated Levallois point	blank	18	0	0	0	18	62.1	
	shaped	11	0	0	0	11	37.9	
	NHT	0	0	0	0	0	0.0	
	sum	29	0	0	0	29	100	4.0
blade	blank	113	9	6	23	151	67.4	
	shaped	59	6	0	7	72	32.1	
	NHT	1	0	0	0	1	0.4	
	sum	173	15	6	30	224	100	30.9
overpassed	blank	20	0	0	1	21	77.8	
	shaped	5	0	0	1	6	22.2	
	NHT	0	0	0	0	0	0	
	sum	25	0	0	2	27	100	3.7
debordant	blank	25	1	0	1	27	75.0	
	shaped	8	1	0	0	9	25.0	
	NHT	0	0	0	0	0	0.0	
	sum	33	2	0	1	36	100	5.0
crested blades	blank	1	0	0	0	1	100	
	shaped	0	0	0	0	0	0.0	
	NHT	0	0	0	0	0	0.0	
	sum	1	0	0	0	1	100	0.1
CTE-varia	blank	7	0	0	0	7	77.8	
	shaped	2	0	0	0	2	22.2	
	NHT	0	0	0	0	0	0	
	sum	9	0	0	0	9	100	1.2
burin spall	blank	1	0	0	0	1	100	
	shaped	0	0	0	0	0	0	
	NHT	0	0	0	0	0	0	
	sum	1	0	0	0	1	100	0.1

Total of debitge (including cores) and tools								
sum	blank	379	41	12	47	479	66.1	
sum	shaped	163	15	0	15	193	26.6	
sum	NHT	6	3	0	2	11	1.5	
cores						32	4.4	4.4
fragmented cores						10	1.4	1.4
debitage and tools	**sum**	**548**	**59**	**12**	**64**	**725**	100	100
% of fragmentation (excluding cores)	**sum**	80.2	8.2	1.7	8.8	100		
chunks						**37**		
total						**762**		

Division between 'blanks' and 'shaped' refers to the presence of secondary modification by retouch or burin blow on the latter (their division into percentage is presented under the %*). Items worked by the 'Nahr Ibrahim technique' (NHT) are recorded separately due to the possibility of representing cores ('core on flakes'). They were not added to the cores due to the importance of recording the type of blanks they were made on. The presented percentages are out of the debitage (including cores) and tools—i.e., all items except chunks.

we refer to *elongated* scars (L/W >2/1) and not to *laminar* scars in the following analyses.

RESULTS

GENERAL CHARACTERISTICS OF THE ASSEMBLAGE

The examined material from the designated squares of Tabun IX includes 762 items, mainly large flakes, blades, points, retouched pieces, and cores (see Table 1; the additional 92 items from adjacent squares are not included in the table). We emphasize that these are mostly large pieces with many features and attributes preserved; small flakes, chips, and chunks are not included as recovery was different for those items. The raw materials are mainly homogenous, fine-grained flints. The flints vary in colors and textures, and different "types" of flint often grade into each other. The main raw material types resemble sources No. 1–2 from Druck's (2004) study of the flint outcrops of Mount Carmel, which are located 2–3km to the east of Tabun Cave, though other raw material sources were used as well. Cortical flakes and blades and the residual cortex on cores show that the nodules exploited were usually rounded or irregular. The presence of blades more than 10cm long demonstrates that some of the exploited nodules were quite large. Cortex can be up to 1cm thick. Many items of all categories bear remnants of the denser internal part of the cortical rind while the chalkier outer surface has been removed.

The numbers and proportions of the various blank types as well as their secondary modification are presented in Table 1. The cores, core trimming elements, and products are discussed below. Some of the main attributes of the products are presented in Table 2. In all, 80.2% of the items (excluding cores) are complete. The assemblage, as expected, shows a high proportion of elongated pieces. The Ilam (including whole items only) is 50.1.

Primary element flakes or blades, which are defined by cortex covering at least 30% of their dorsal face, account for 8.3% (n=60) and 4.3% (n=31) of the assemblage, respectively. About a third of the primary element flakes are almost fully cortical. The simple flakes (n=77; 10.6%) vary in shapes and sizes. Naturally backed knives or NBKs are characterized by a sharp edge opposed by a steep cortical back oriented at an angle of at least 60º to the ventral face; laminar specimens (n=26) and flakes (n=27) are present in equal proportions.

Only 169 small flakes (≤2.5cm) were collected from Tabun IX. Of these 33 are whole. The majority of the whole small finds are simple flakes. Some of them, however, represent the flakes from the shaping and resharpening of tools (these data are provided courtesy of M. Bisson). This small assemblage probably does not reflect on the full character of production on site, because cementation of the sediments limited the number of pieces that could be collected.

Overall ,26.6% of the large blanks studied are retouched, and an additional 1.5% show the application of the 'Nahr Ibrahim technique' (see Table 1) (Hovers 2007; Solecki and Solecki 1970). Both flakes and small blades/bladelets were removed from these 'cores on flakes.' This is a high level of secondary modification for a Levantine Mousterian assemblage (e.g., Hovers 2001: 130–132, Table 1). The sample of shaped tools includes retouched blades, raclettes, scrapers, burins, retouched Levallois points, Mousterian points, points on blades (e.g., Abu Sif), denticulates, and borers (see also Jelinek 1975: 309). There are several hints that blades, Levallois flakes, points and elongated points were used in somewhat different ways.

1. For the most part, secondary modification is relatively light and did not significantly alter the shape of the blanks (Figures 1: 1, 3–4, and 2: 2, 4). Only 11.3% of the shaped items were modified by abrupt or scaled retouch that significantly changed the original shape of the blank; the frequency of abrupt and scaled retouch differs between products and is more frequent on blades and elongated points (Figure 3; Table 3).
2. There is some evidence that different blank types experienced varying intensities of reduction. There are no differences among the four most common "diagnostic" blank types—blades, Levallois flakes, short Levallois points, and elongated Levallois points—in terms of the number of retouched edges (χ^2=0.690, df=3, p=0.876). However, there are some differences in the intensity of retouch, as measured by Kuhn's (1990) t/T index. Elongated Levallois points show the most advanced reduction on average (Table 4), although the only statistically significant pairwise difference is between blades and elongated Levallois points (Mann-Whitney U statistic=250, n=83 [68, 15], p=0.002).
3. Scars typically interpreted as impact fractures[2] (e.g., Shea 1988, 1997) were found on 4.1% of the blades, 5.0% of the elongated Levallois points, and 12.5% of the Levallois points; all are present on the distal end. These are usually of the 'burin-like'/'burination' or 'flute' type (e.g., Bergman and Newcomer 1983; Crombé et al. 2001; Odell and Cowan 1986: 204). The difference between Levallois points and blades is statistically significant (χ^2=6.31, df=1, p=0.012). No potential impact fractures were observed on the Levallois flakes.

CORES

The analyzed assemblages contained 32 cores. Ten fragments too incomplete for classification for analysis were recorded separately. The 32 classifiable specimens include 16 Levallois cores, 5 discoidal cores, 6 non-Levallois cores with a single striking platform, 3 polyhedral flake cores with multiple striking platforms and 2 "tested pieces" (pebbles with one or two removals). For the following description we added four additional Levallois cores from the adjacent squares with divided collections.

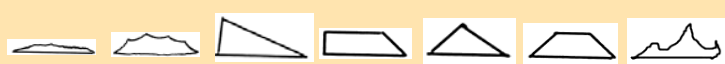
Although there is a well-known tendency toward elongated products, non-Levallois reduction in Tabun IX is

TABLE 2. MAJOR ATTRIBUTES OF THE PRODUCTS.

Metrics (mm)	length range	length mean	width range	width mean	thickness range	thickness mean	length/ width range	length/ width mean	width/ thickness range	width/ thickness mean
Levallois flake	20-88	52.5±6.5	24-56	36.3±6.0	3-17	7.0±3.1	0.5-2.0	1.4±0.2	3.1-10.5	6.3±1.7
Levallois point	34-82	56.0±8.5	20-55	32.5±6.4	2-16	7.0±1.4	1.0-1.9	1.7±0.1	3.0-12.0	4.6±0.0
elongated Levallois point	48-116	74.7±16.8	21-49	31.7±7.0	4-16	7.9±2.8	2.0-3.9	2.4±0.4	2.5-8.0	4.2±1.2
blade	42-126	78.7±17.2	13-55	25.2±6.6	3-18	8.4±2.7	2.0-6.5	3.1±0.4	1.3-8.0	3.2±0.5

Striking platforms	faceted	old faceted*	dihedral	plain	thin plain**	puncti-form	natural	mean width striking platform
Levallois flake	81.3	11.3	3.8	2.5	1.2			27.0±7.8
Levallois point	81.5	11.1	1.9	5.6				30.6±8.0
elongated Levallois point	80.0	15.0		5.0				26.1±7.8
blade	54.3	9.4	6.3	22.9	4.5	2.2	0.4	16.2±6.8

Scar pattern***	centripetal	3-way centripetal	bipolar	convergent	convergent and bipolar	convergent and prependicular	double perpendicular	straight and perpendicular	unidirectional
Levallois flake	3.1	10.9	6.3	46.9	6.3	3.1		4.7	18.8
Levallois point				72.2	14.8	7.4			5.6
elongated Levallois point			10.3	66.7	10.3	2.6		5.1	5.1
blade	1.4	2.8	16.5	19.3	4.7	3.3	0.9	9.9	41.0



Cross-section	flat	polyhedral	right angle triangular	right angle trapezoidal	triangular	trapezoidal	irregular
Levallois flake	37.7	13.0			5.2	41.6	2.6
Levallois point	14.8	9.3			1.9	64.8	9.3
elongated Levallois point	2.6	7.9			13.2	65.8	10.5
blade	0.8	9.1	0.8	3.2	34.4	34.4	17.4

% of cortex	0%	10%	20%
Levallois flake	89.6	9.0	1.5
Levallois point	96.3		3.7
elongated Levallois point	92.3	7.7	
blade	72.9	22.9	4.2

*'old faceted' refers to striking platforms that are covered by several scars; however, in contrast to faceting, none of them includes the negative of the bulb. They are most likely traces of faceting preformed at earlier removal of blanks.

**'thin plain' refers to plain striking platforms with a thickness of ≤2mm.

***the left/right position in the arrows is schematic and does not reflect a preference to a specific side.

not oriented strictly toward production of blades. Of the six non-Levallois single-platform cores, four produced only flakes and two produced both flakes and blades. The two single platform cores with blade and flake scars (size: 53*42*32mm; 73*76*54mm) show a relatively well-controlled reduction and have a roughly prismatic shape. The dominant products of these cores according to the scars were flakes (elongated scar/flake scar ratios on debitage surfaces are 2/3 and 2/5). None of these cores show evidence of preliminary shaping for controlling the reduction

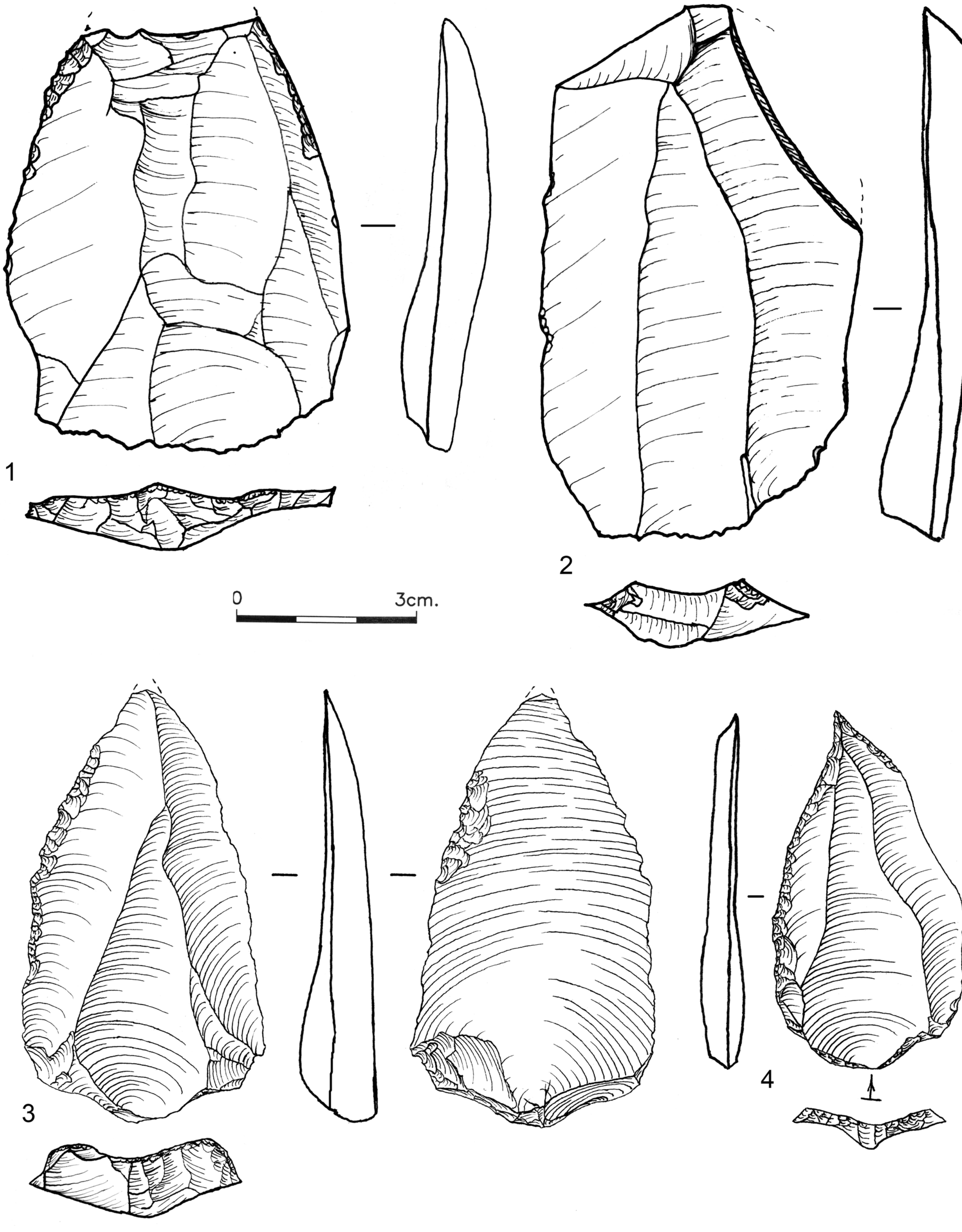


Figure 1. (1–2) Levallois flakes and (3–4) Levallois points. Items 1, 3–4 are retouched.

or providing a specific core shape. Because they would not have produced blades as regular as those commonly found in the assemblage, these kinds of cores (which also differ from the better-organized prismatic blade cores found in other EMP sites; Monigal 2002) do not seem to be source of the majority of the blades studied. It rather seems that these 'blade and flake cores' share more similarities with the 'simple' flake production exemplified by the other non-Levallois cores. Three of the non-Levallois cores have multiple striking platforms but it appears that only one

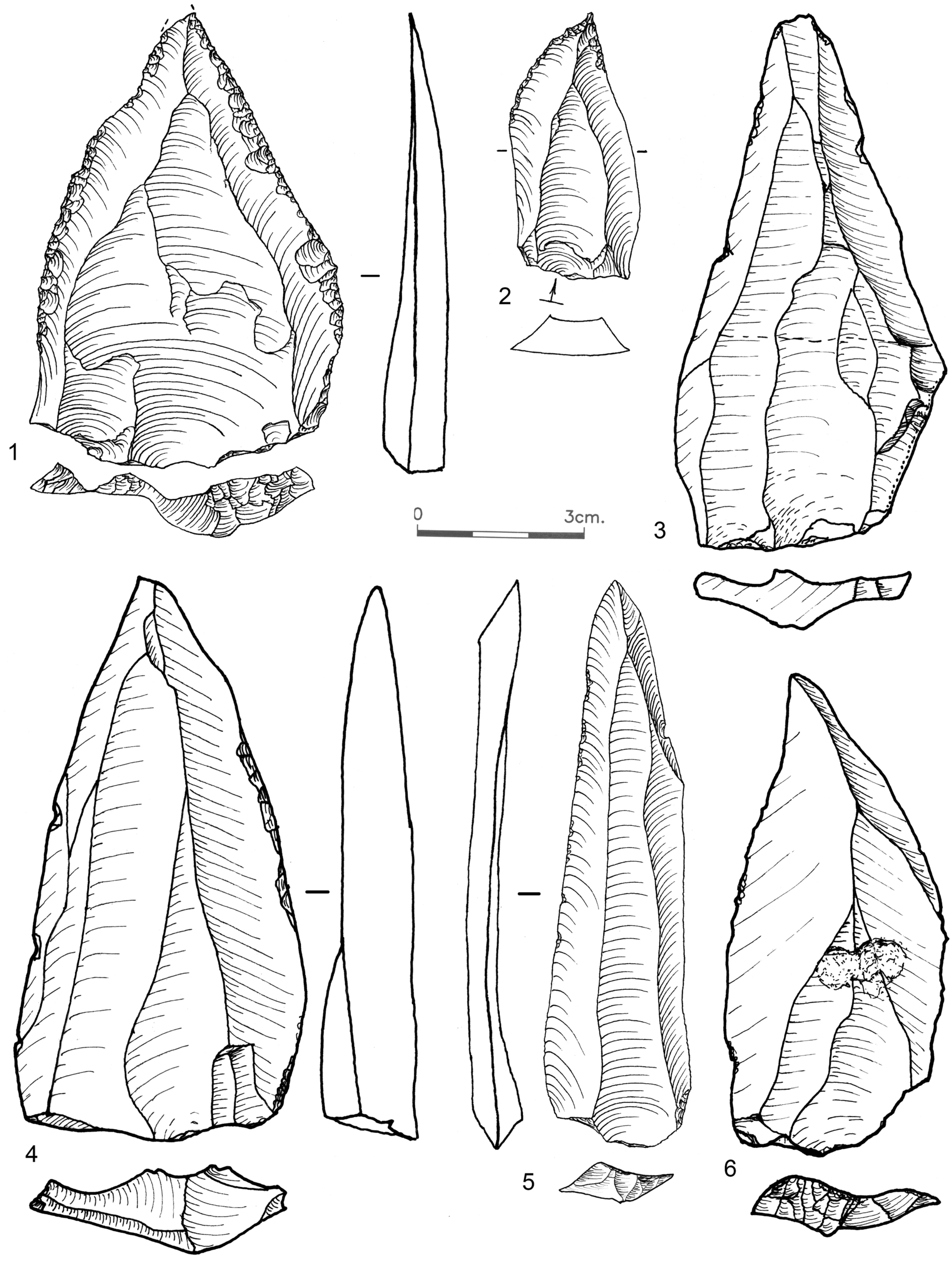


Figure 2. (1) Levallois point and (2–6) elongated Levallois points. Items 1–2 and 4 were retouched.

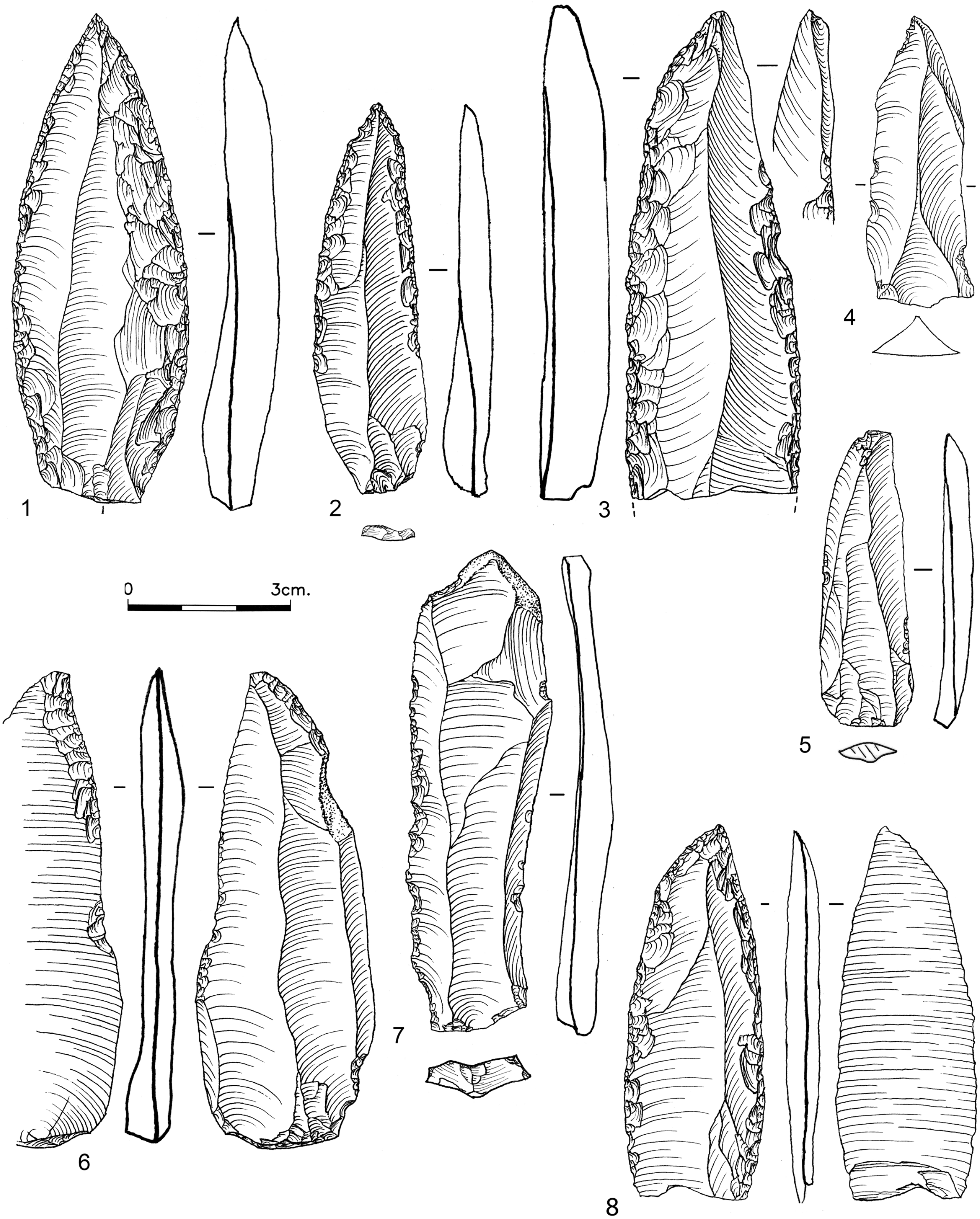


Figure 3. Blades. Items 1–3, 6–8 are retouched.

TABLE 3. PERCENTAGE OF ITEMS SHAPED BY ABRUPT OR SCALED RETOUCH.

Blank Type	n=	% secondary shaping/ retouch	% abrupt or scaled retouch out of shaped
Levallois flake	75	28.2	9.1
Levallois point	41	37.2	12.5
elongated Levallois point	29	37.9	18.2
blade	223	32.1	20.8

platform was used at a time; after one platform was abandoned the production shifted to a different platform. There is no indication that the 'simple' unipolar core reduction represents recycling of exhausted or abandoned Levallois cores. The discoidal cores could represent either a distinct trajectory of flake production or the further exploitation of discarded Levallois cores; the small numbers, however, prohibit further conclusions.

The 20 Levallois cores studied include 1 preferential and 19 recurrent cores. Of the latter, 1 is centripetal and 18 are unidirectional/convergent (Figure 4). The preferential core shows classic centripetal shaping (e.g., Boëda 1995; Hovers 2009); a single large oval flake was removed from the center of the Levallois surface. The specific character of the unidirectional/convergent Levallois cores is described in more detail below.

CORE TRIMMING ELEMENTS

Core trimming elements (CTEs) are not treated consistently in studies of Middle Paleolithic assemblages. In fact, they are usually discussed in more depth in the study of Upper Paleolithic and later assemblages (e.g., Moretensen 1970). In reports using the Bordian typological system, this group is usually absent. In more recent studies, they have been referred to as 'core management pieces' (Hovers 2009), "*piéces techniques*" (Ameloot-Van der Heijden 1994: 65), or 'technologically diagnostic artifacts' (Monigal 2002). The CTEs (n=73) from the study sample include *débordants* (n=36; 49.3% of the CTEs), overpassed items (n=27; 37.0% of the CTEs), crested blades (n=1; 1.4% of the CTEs) and varia (n=9; 12.3% of the CTEs) (numbers include both retouched and unretouched pieces) (see Table 1). For the following description we also added four *débordants* and three overpassed items from the adjacent squares with divided collections.

The *débordant* items, which removed part of the core's margin and under-surface, are very common in Tabun IX. Their major attributes are presented in Table 5. They tend to have curved or twisted profiles, some having an overpassed termination (Figure 5: 2). The evidence for lateral preparation on these items varies. In some cases a fine flat lateral ridge was prepared, while in others just a few flakes were removed. The lateral removals can appear both on the Levallois surface and the under-surface.

The overpassed items were divided into three groups: (1) relatively flat overpassed items (n=12), bearing clear flake and blade scars indicating that they were removed from the center of a Levallois debitage surface (see Figure 5: 4); (2) overpassed items with an angular cross-section covered by laminar scars (n=3) that were most likely removed from simple single striking platform cores; and, (3) overpassed items (n=15) that cannot be clearly related to any particular reduction sequence. Extensive cortex cover and the absence of clear blade and flake scars show that nine of the indeterminate pieces originated during the early stages of production. About half of the overpassed items preserve some cortex, most often on their distal ends. We did not attempt to distinguish between overpassed pieces removed intentionally or accidently.

The single crested blade is characterized by a bifacial ridge. It measures 87*20*11mm. It is of note that artifacts resembling crested blades appear in small numbers even in MP assemblages with little other evidence of blade production (e.g., Hovers 2009: 85, Table 5.10).

ASSESSING THE COMPLETENESS OF THE ASSEMBLAGE

Before going further with the analysis it is crucial to assess whether the assemblage indeed contains products *representative of* relatively complete reduction sequences or whether

TABLE 4. SUMMARY STATISTICS OF REDUCTION INDEX.

Blank Type	n =	mean	sd
Levallois flake	15	0.445	0.21
Levallois point	17	0.436	0.20
elongated Levallois point	15	0.548	0.21
blade	68	0.376	0.15

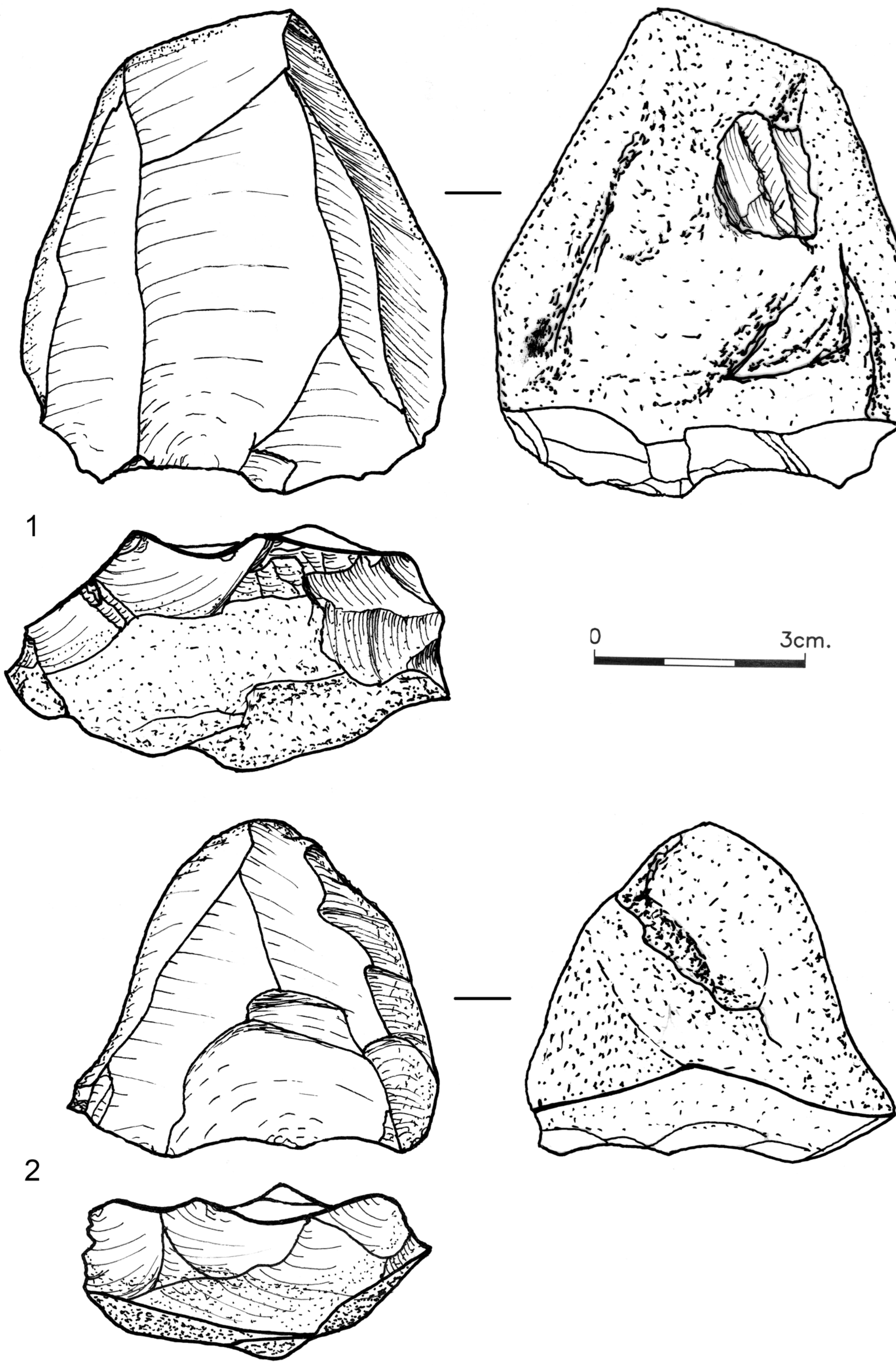


Figure 4. Levallois cores.

only certain stages took place at the site. Jelinek (1982b) argued that the assemblage from Unit IX shows evidence for selective transport of objects made somewhere else, either within the cave or outside of it. His interpretation followed from the fact that the assemblage is rich in large, well made, whole blanks (products) and contains comparatively few cores in good condition. We reconsider this question based on the presence of waste, the frequency of cortical items, and other technologically significant elements.

First, although the frequency of cores is not high, especially in light of the large number of Levallois products (see Table 1), it is similar to many Levantine MP sites, where the percentages of cores usually fluctuate around 5% (Hovers 2001: 130–132, Table 1). The abundance and variety of items characteristic of early stages of reduction as well core maintenance also is important. The presence of primary el-

TABLE 5. MAIN ATTRIBUTES OF *DÉBORDANTS*.

Metrics (mm)	range	mean	s.d.
length	34–113	70.5	24.5
width	18–75	34.0	10.6
thickness	5–31	13.6	6.6
length/width	0.9–2.8	2.1	0.6
width/thickness	1.2–4.2	2.8	0.6

Cortex Cover	%
almost all	3.2
lateral	32.3
lateral + distal	29.0
middle	3.2
distal	3.2
non	29.0

Striking Platform	%
faceted	61.5
old faceted	7.7
dihedral	11.5
plain	19.2

Cross-Section	%
right angle triangular	10.0
right angle trapezoidal	63.3
irregular	26.7

Lateral Blows	%
represented by scars	32.3
represented by scars and negatives of bulb of percussion	67.7

End-Termination	%
feather	32.3
hinged	9.7
overpass	58.1

Side of Core Removed	%
left	64.5
right	35.5

ement flakes (8.3%), of which a third are fully cortical, is another indication that some preliminary shaping of the cores took place within the area sampled by Jelinek's excavation trench. This conclusion is further supported by the fact that of the 20 primary element flakes with fully cortical surface, 8 have a natural cortical striking platform typical of "opening flakes" (Inizan et al. 1999: 141). When including all blanks with substantial cortical surfaces (primary elements and NBKs [laminar and flakes]), the percentage reaches 22.6% of the debitage and shaped items (excluding cores). Widening the view further, 39.7% of the flakes, blades and other reduction products (all but cores) bear at least *some* cortex. Although this could signify that knapping did take place in the vicinity of the excavated area, large cortical items could also have been selected for transport or modification, so that their presence does not necessarily demonstrate production on site. However, the fact that the mean length of the elongated Levallois points and blades (74.7mm [s.d. 16.8] and 78.7mm [s.d. 17.2] respectively) and that of the *débordants* and the overpassed items (70.5mm [s.d. 24.5] and 72.0mm [s.d. 15.5]) are similar indicate a correlation between products and by-products and supports manufacture *in situ*. The length of the primary element blades (73.9mm; s.d. 16.8) also is similar to that of the blades and elongated Levallois points.

The ratios of the supposed products (blades, Levallois flakes, and points) to other blank types also suggest at least some manufacture occurred in place. Although the ratio of "products" to *débordants* is high, 10.3/1, adding the NBKs, which served the same technological purpose as *débordants* (e.g., Hovers 2009: 88; Meginen 1994), reduces the ratio to 4.2/1. When accounting for all items that indicate some adjustment of cores' lateral and distal convexities (*débordants*, NBKs, primary element blades, and overpassed items), the ratio falls is 2.5/1. Only a few of these were likely removed from non-Levallois blade cores, because such cores are rare in the assemblage and the characteristics of the pieces themselves are more indicative of the Levallois method. When counting only items removed from the lateral edges (i.e., taking out the overpassed items detached from the center of the surface), the product/byproduct ratio is 2.9. This ratio is in fact close to what is predicted by reconstructions of recurrent Levallois reduction[3] (e.g., Boëda 1988b: 54, 58, Figures 6, 12, 1995: 53, Figure 4.23; Delagnes 1995: 203, Figure 14.2; Meignen 1995: 372, Figure 25:10; Moncel 1999: 403, Figure 160a). This practice of maintaining the lateral convexities by removal of items from the striking platform, typical of the unidirectional/ convergent method, can explain the fact that simple flakes are not numerous at the assemblage.

The above data, along with the presence of cores that are both lightly and heavily utilized, indicates that at least some blank production took place at or very close to the cave. It is important to remember that Jelinek's excavation sampled only a limited horizontal area. Because spatial variation in activities has been observed in many Middle Paleolithic cave sites (e.g., Alperson-Afil and Hovers 2005; Henry 1998; Wadley 2006), it is likely that some of the knap-

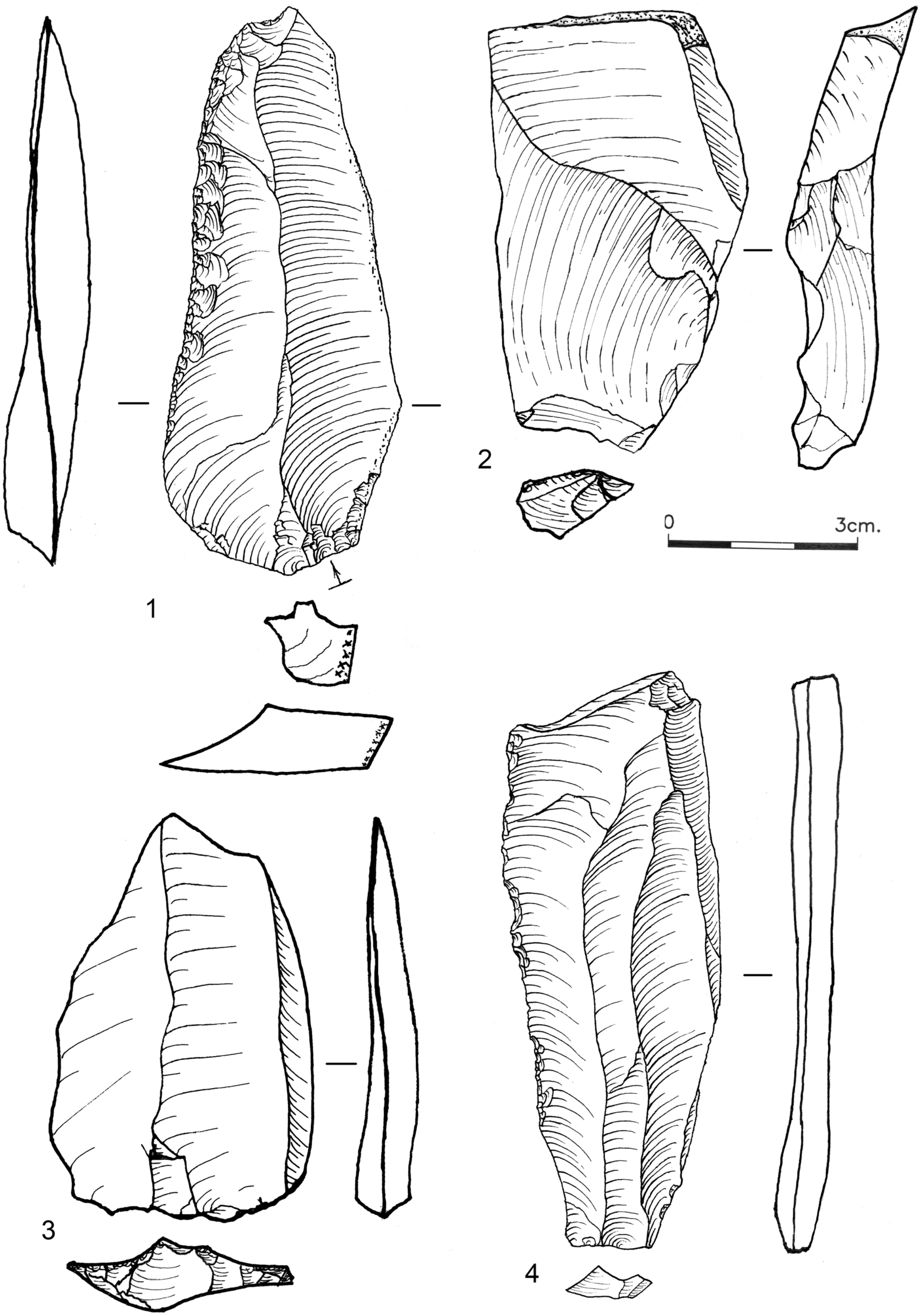


Figure 5. (1) scraper on a naturally backed knife; (2) débordant; (3) Levallois flake; and, (4) overpassed blade.

ping did not occur within the excavated area. Although we are certain that not every nodule was fully reduced in place, what is important for our analysis is that the sample contains material representative of all stages of the reduction process. This makes it appropriate for a technological analysis.

THE RELATIONSHIPS BETWEEN DIFFERENT PRODUCTS

The analyses which follow focus on Levallois technology and on its presumed products—blades, points (elongated and broad), and Levallois flakes. The relations between the different products are examined through the analysis of the unidirectional/ convergent recurrent Levallois cores and the characteristics of the products themselves. Through the analysis we mainly focus on comparing the correlation between the laminar items (blades and elongated points) to the flake items (Levallois flakes and points).

Including the sample of blades as a whole within these four products demands an explanation, since blades in many EMP sites originated from non-Levallois production as well (Meignen 2007a, b; Monigal 2002; Nishiaki 1989). In the case of Tabun IX, we assume that only a fraction of the blades came from non-Levallois blade cores. This conclusion follows from both general evidence for non-Levallois production, and from the features of the blades themselves. Non-Levallois blade production waste is scarce, limited to a single crested blade and a few overpassed items possibly derived from blade cores. Furthermore, neither of the two cores bearing blade scars represents the sort of systematic production of blades found in EMP sites (e.g., Meignen 2007a, b; Monigal 2002; Weinstein-Evron et al. 2003). The two related cores from Tabun IX instead show the combined production of irregular blades and flakes, and could not have produced long blades such as found in the assemblage. In contrast, derivation of most blades from Levallois production is evident in many characteristics presented below. The possibility that some of the blades originated in non-Levallois production elsewhere and were carried into the site must be considered as well. Although it if difficult to establish a clear-cut division between Levallois and non-Levallois blades in the case of Tabun IX, the *maximum* proportion of non-Levallois blades can be estimated by the 23% of blades having a plain striking platform or by the 34% of blades with triangular cross-section. In terms of the raw material we did not note any consistent differences between typical Levallois blades and ones that might have come from other sorts of core; to the contrary, the raw materials of the blades are very similar to the ones used to make Levallois flakes and points. As such, we assume the number of the non-Levallois blades in the assemblage is small and does not affect our general results. Both Meignen (2011: 89) and Monigal (2002: 307) express similar views.

Characteristics of the Unidirectional/Convergent Recurrent Levallois Cores.

The assemblage from Unit IX contains18 recurrent unidirectional-convergent Levallois cores (see Figure 4); one of these cores is slightly damaged and, therefore, for some attributes, n=17. The ubiquity of cortex on the lower face (20–100% of the under-surface) suggests that that most of these cores were made on nodules. The cores vary considerably in size, ranging from 44mm to 102mm in length (mean: 59.7mm, s.d. 15.5mm). The length/width ratio of the cores (index of elongation) is 0.8–1.4 with a mean of 1.0 (s.d. 0.1). In plan view, the unidirectional Levallois cores are either triangular or 'D-shaped,' having a wide striking platform with a rounded or pointed end opposite.

The striking platforms of all Levallois cores were prepared by faceting, although the intensity of the faceting varies not only among the cores but across parts of the platform on an individual core (see Figure 4: 1). In contour, the striking platforms are either straight or convex, which is typical in this kind of unidirectional recurrent technological system.

Traces of preparation of the lower surface (other than the striking platform) were observed on 13 of the unidirectional Levallois cores. This treatment, however, is mostly partial and on only two cores is the entire margin prepared. In the other cases, the preparation of the lower face is limited to one of the lateral edges (n=4), both lateral edges (n=3), one lateral edge and the distal end (n=3), or the distal end only (n=1). While the occurrence of non-cortical areas testifies to the shaping of the lower face in general, the preservation of negatives of bulbs of percussion on the under-surface indicates the renewal of the core subsequent to a series of removals from the Levallois surface. Negative of bulbs of percussion were observed on only eight of these cores. The comparative scarcity of negative bulbs of percussion on the cores' under-surfaces is a function of the fact that reshaping of the Levallois surfaces was most often accomplished by removing *débordants* and NBKs from the main striking platform rather than by flaking inward from the lateral edges.

The total number of large scars (> 2.5cm in maximal size) preserved on the Levallois (upper) surfaces of the cores ranges from 3 to 12. The number of scars originating from the striking platforms ranges from 2 to 10, and, of these, between 0 and 7 per core are elongated (blade-like). Elongated scars cover the entire flaking surface of only three of the cores, while in the other cases they are distributed along one or both edges of the surface. The scar patterns on the Levallois cores include unidirectional parallel (n=4), orthogonal (n=2), bidirectional/opposed (n=1), convergent (n=6), convergent with opposed scars (n=3), and convergent with opposed and perpendicular scars (n=1). The diversity of the scar patterns is a result of the shaping and preparation of the core face as well as of the production of the products. All cores show a single dominant striking platform. When present at all, scars originating at the end opposite the main striking platform are small and were apparently aimed at adjusting the distal convexity of the flaking surface. Considering only the largest scars, thus eliminating scars that likely represent shaping of the core, the Levallois cores are more similar, with eight showing unidirectional parallel removals and 10 showing convergent removals. None of the cores shows evidence for true bipolar production of large blanks from opposed platforms. Traces of the removal of *débordants* and NBKs—elongated scars along the margins of the Levallois surfaces—were observed on all unipolar Levallois specimens. On 12 specimens they appear on both lateral edges.

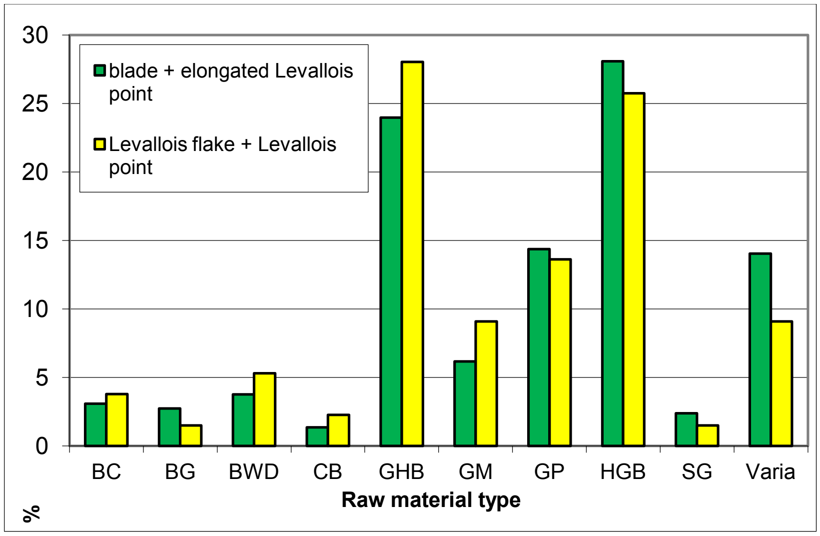


Figure 6. Raw material color and texture among the laminar and flake products (n=blades+elongated Levallois points: 292; Levallois flakes + Levallois points: 132).

Comparison of Products

In order to examine the relationships between the blades, Levallois points, and Levallois flakes, we compared them in terms of raw materials, metrics, dorsal scar patterns, and angles of skew (Jelinek 1977: 87*-88*).

In all, 10 categories of flint were discerned on the basis of color and texture[4]. The dominant colors are yellowish-light brown, dark brown, greenish gray, and gray which can appear as a single color or in different combinations. Many raw material colors and textures intergrade, sometimes on the same piece, showing that they represent just a few distinct raw material types. A few specimens are made of unusual and distinctive raw materials that are not a part of this normal range of variation; these probably came to the site as finished products. The laminar products (blades and Levallois elongated points) and the flake products (Levallois points and flakes) are made of very similar ranges of raw materials (Figure 6). Because different reduction sequences are often characterized by the use of different raw materials (Boaretto et al. 2009), the similarity of raw materials among the different item types supports the notion that they originated from the same general reduction sequence.

A particularly telling clue as to the relation between the laminar and flake products lies in the complementary angles of skew. For this purpose we grouped the blanks into three categories: (1) items with a left skew (60°–85°), (2) items with a right skew (95°–120°), and straight or unskewed items (ca. 85°–95°). Laminar products tend to be skewed significantly more often than the flake products (Figure 7) (χ^2=4.49, df=1, p=0.034). This probably relates to the fact that short, broad flake scars typically appear on cores near the center of the Levallois surface, whereas elongated scars more frequently appear along the core edges, which tend to converge toward the distal end (see Figure 4). Thus, different skews suggest that elongated and non-elongated blanks could have been detached from different sections of the same cores rather than from different kinds of cores.

The metrics demonstrate more complex results (Figure 8). The distribution of the maximum length of products shows a nearly perfect Guassian (normal) distribution, in which the laminar products, not surprisingly, tend to be longer than the flake products. The maximum width shows a similar distribution, although in this case it is the flake products that are generally wider than the laminar products. In the case of maximum thickness, the distributions for the two populations—laminar and non-laminar—are almost identical. The difference in length/width ratio between flakes and blades is of course part of their definition. However, it is notable that even the flakes from Tabun IX tend to be elongated, and the modal length/width ratio of the entire sample is actually at 1.8–1.9, close to the conventional ratio for blades (Figure 9). The width/thickness ratio also demonstrates continuity in distributions (Figure 10).

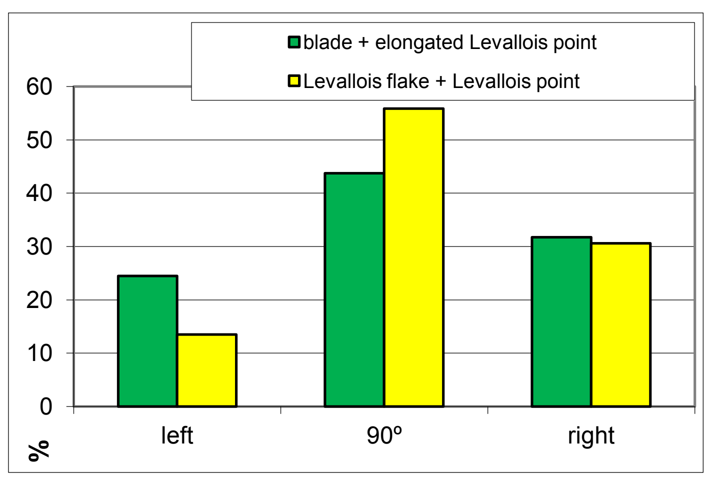


Figure 7. The direction of skew among products (n=blades+elongated Levallois points: 249; Levallois flakes + Levallois points: 111).

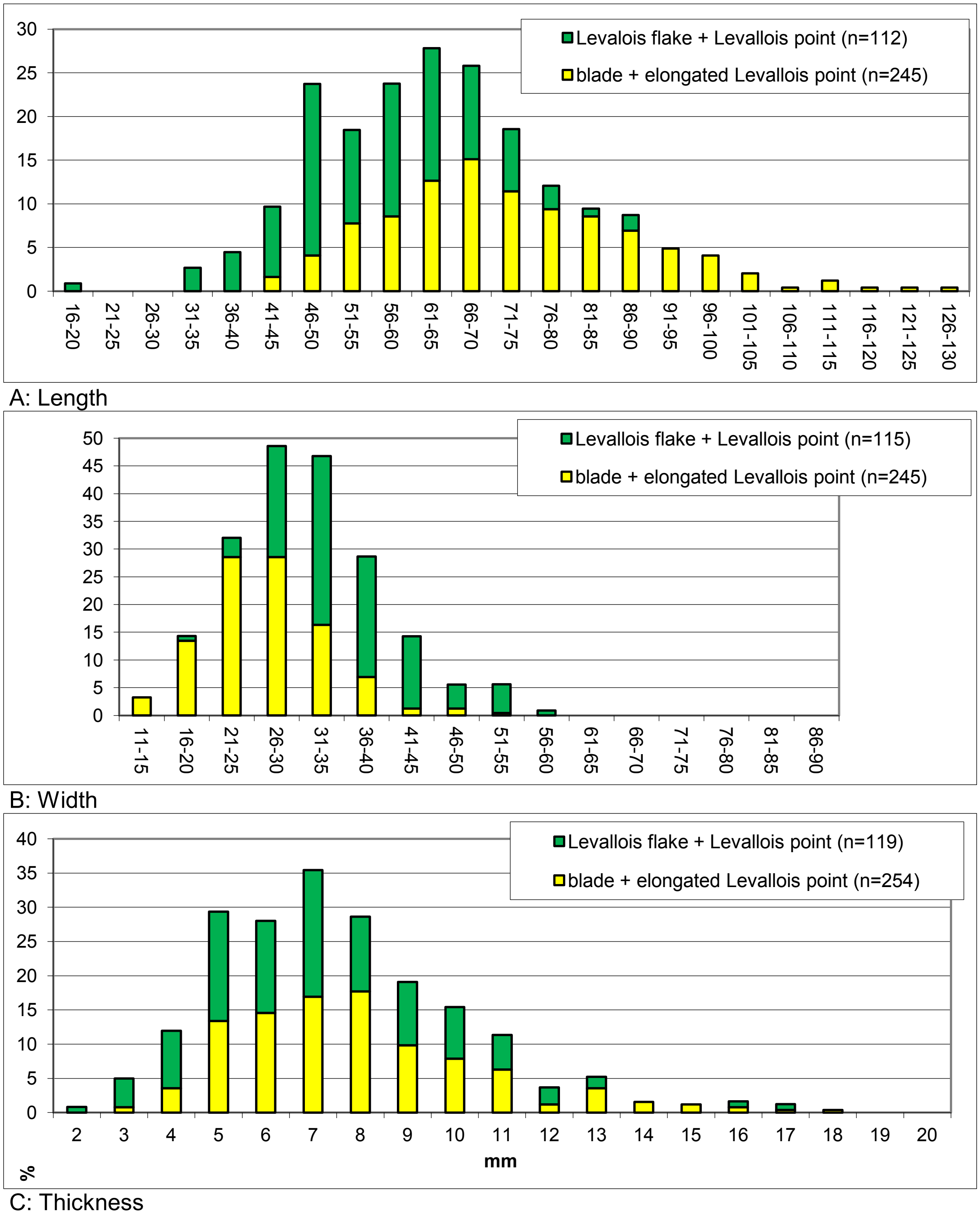


Figure 8. Maximum length, width, and thickness of products.

In this case, the flakes are relatively flatter (because they are wider than blades), but even the laminar pieces show a relatively high width/thickness ratio (3.2; s.d. 0.5). In comparison, the blades of the Amudian of Tabun Unit XI are thicker, with a mean width/thickness ratio of 2.9 (s.d. 1.1) (Shimelmitz 2009: Table 22).

It is particularly significant that elongated scars were observed on dorsal surfaces of both laminar and non-laminar products (see Figures 1 and 2). The number of elongated scars on the dorsal face of all products combined approximates a bell-shaped distribution (Figure 11) further suggesting that the different classes of item may have been part of single general *chaîne opératoire.*

Summarizing the above, the similar patterns in raw material and complementarity in angle of skew among laminar products and flake products support the notion that they were manufactured from the same core forms. The metrics show that laminar products and the flakes grade into each other, usually resulting in near-normal unimodal size distributions, consistent with the idea that they are in

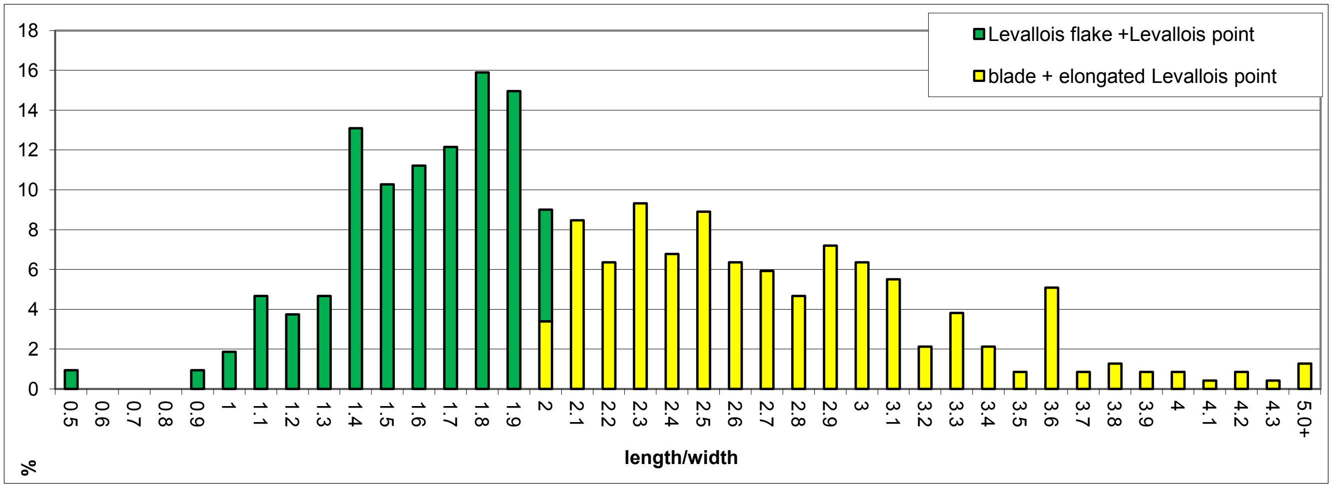


Figure 9. Length/width ratio of products (n=blades+elongated Levallois points: 236; Levallois flakes + Levallois points: 107).

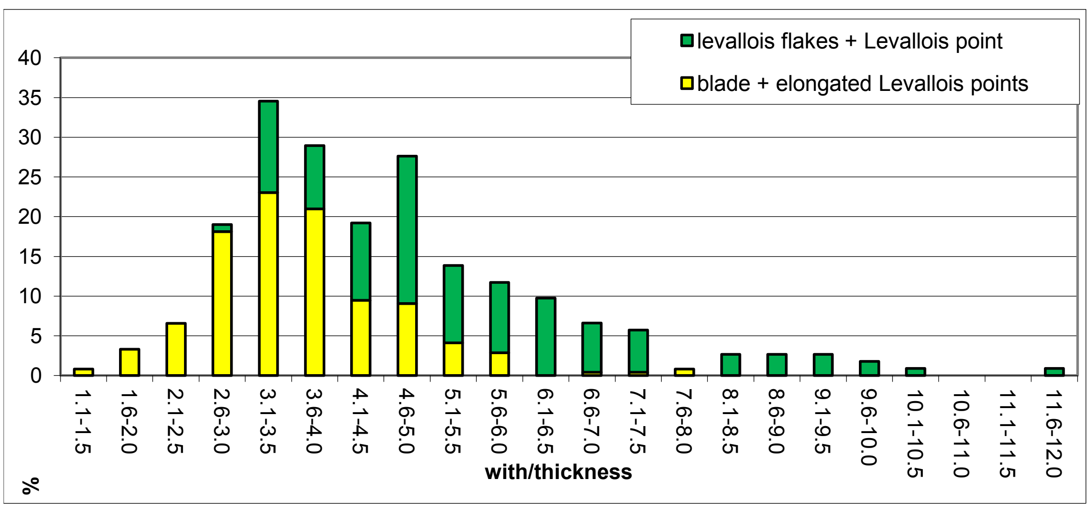


Figure 10. Width/thickness ratio of products (n=blades+elongated Levallois points: 243; Levallois flakes + Levallois points: 113).

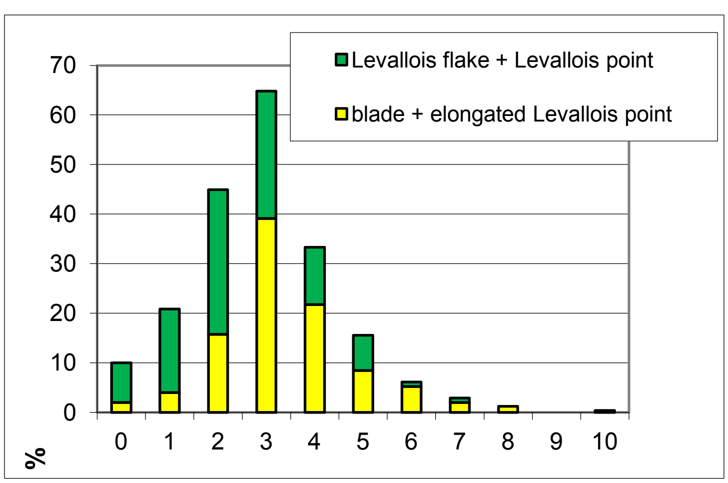


Figure 11. Number of elongated scars on products (n=blades+elongated Levallois points: 248; Levallois flakes + Levallois points: 113).

general the outcome of a single reduction sequence. The scar patterns on the products strengthen this conclusion as well. These similarities, however, do not indicate that the difference between the blades, Levallois flakes, and points (elongated or not) are meaningless. As we argue in the following section, they may be the result of calculated and repeated procedures. The platykurtic, apparently multimodal distribution of the length/width ratio might be one indication of this.

RECONSTRUCTING THE REDUCTION SEQUENCE

The data presented thus far, along with additional observations presented below, form the basis for a description of the dominant Levallois reduction sequence of Tabun IX. It is apparent that blank production from Levallois cores in Tabun IX is characterized by a specific reduction sequence that led to the combined production of Levallois blades, flakes, and points, along with a variety of other kinds of items. This is consistent with general observations made by Meignen (1994), Monigal (2002) and Jelinek (1982b). Some other methods of production clearly contributed to the variety of blanks in the Tabun IX assemblage, including non-Levallois flake and blade production, but these are numerically less important.

Production of blanks began with rounded or irregular nodules ca. 10–15cm in size, probably collected from close to the site. The presence of many products with cortex on their dorsal surfaces, and the presence of many items such as NBKs, *débordants*, and overpassed pieces with partially cortical surfaces indicate that some nodules were brought in to the site with much remaining cortex. The subsequent shaping of cores was aimed at forming the required convexities of the Levallois surface and on preparing platforms, and not on full decortication. In the case of Tabun IX, the decortication focused on removing only the outermost rind, and many flakes and blades preserve the more siliceous inner cortex over parts of their dorsal surfaces. The presence of cortical items similar in shape to Levallois products in Units IX–VII (all part of the EMP of Tabun) shows that the removal of cortex was precise and minimized loss of raw material volume prior to the removal of target products (Figure 12). Large cortical elements were in fact valued as blanks for shaped tools—20.0% and 29.0% of the primary element flakes and blades, respectively, were retouched. The utility of large cortical pieces would explain why the knappers choose to bring at least some minimally-prepared nodules into the cave.

The initial preparation of a Levallois core must result in a shape with two convex faces meeting in a clear plane of intersection; one surface is then used for removal of the Levallois products and the other for preparation of striking platforms (see Boëda [1995] for a detailed exposition). The scar patterns on the primary element flakes from Tabun IX provide clues as to the character of the preparation of the cores. In all, 37.8% of these items show removals coming from multiple directions, suggesting that initial preparation of core surfaces sometimes involved striking flakes from different parts of the core's circumference. This tactic may have been necessary to achieve the required lateral and distal convexity of the Levallois flaking surface. The lateral scars found on many of the *débordants* also indicate initial circumferential preparation. Nevertheless, the abundance of NBKs, as well as primary element blades and overpassed items that have cortex along one margin, indicates that some raw material nodules were already close to the shape needed for Levallois production. Selection of appropriately-shaped nodules for Levallois cores has been noted in other cases (e.g., Kuhn 1995).

It is difficult to reconstruct the original shape of the cores without extensive refitting and methods of exploitation could have changed as the cores were reduced (e.g., Bar-Yosef and Meignen 1992; Dibble 1995; Hovers 2009: 43). However, in the case of Tabun IX it appears that cores may have maintained similar forms over the course of reduction. One clue of this is the presence of an unusually large Levallois convergent core (102*88*35mm) which exhibits the same D-shape as many of the smaller cores. Another line of evidence is the range of sizes that characterized the *débordants* (Figure 13) which demonstrates similar treatment of cores across different stages of the reduction process. It is impossible to reconstruct the original striking platforms, but it is clear that during reduction platforms were maintained by faceting that varied in intensity along the different areas of the curved or straight striking platforms.

The removal of products from cores in Tabun IX combined the production of Levallois blades, flakes, and points. The rhythm or sequence with which these items were removed probably varied from core to core and even from series to series as sequential Levallois surfaces were exploited. The majority of blanks produced from the debitage surface were elongated; the ratio of laminar pieces (including elongated points) to non-laminar products in the assemblage is 2.1/1. Levallois points are not frequent however, and most are comparatively short; the ratio of Levallois blades and flakes to points (elongated or not) is 4.3/1, and the ratio of short Levallois points to elongated Levallois points is 1.4/1. Most products have either unidirectional parallel or convergent dorsal scar patterns; the latter, not surprisingly, is most common on pointed items.

The negative scars on the cores and the complementary angles of skew on different kinds of products show that elongated pieces were more commonly removed from the margins of the Levallois surface, while shorter flakes and points were removed from the center. This hypothesis is further supported by evidence of dorsal curvature on products. Using the width and thickness of the items, we reconstructed the arch radius of the surface from which they were detached (Figure 14). The lateral convexity of the core surface is an essential characteristic of the Levallois technology and this calculation seeks to place various products on different sectors of this side-to-side curvature. For the reconstruction of the radius, we used mid-point measurements which best represent the lateral convexity and minimize the influence of conchoidal fracture on the curvature of the ventral face. The distribution (Figure 15)

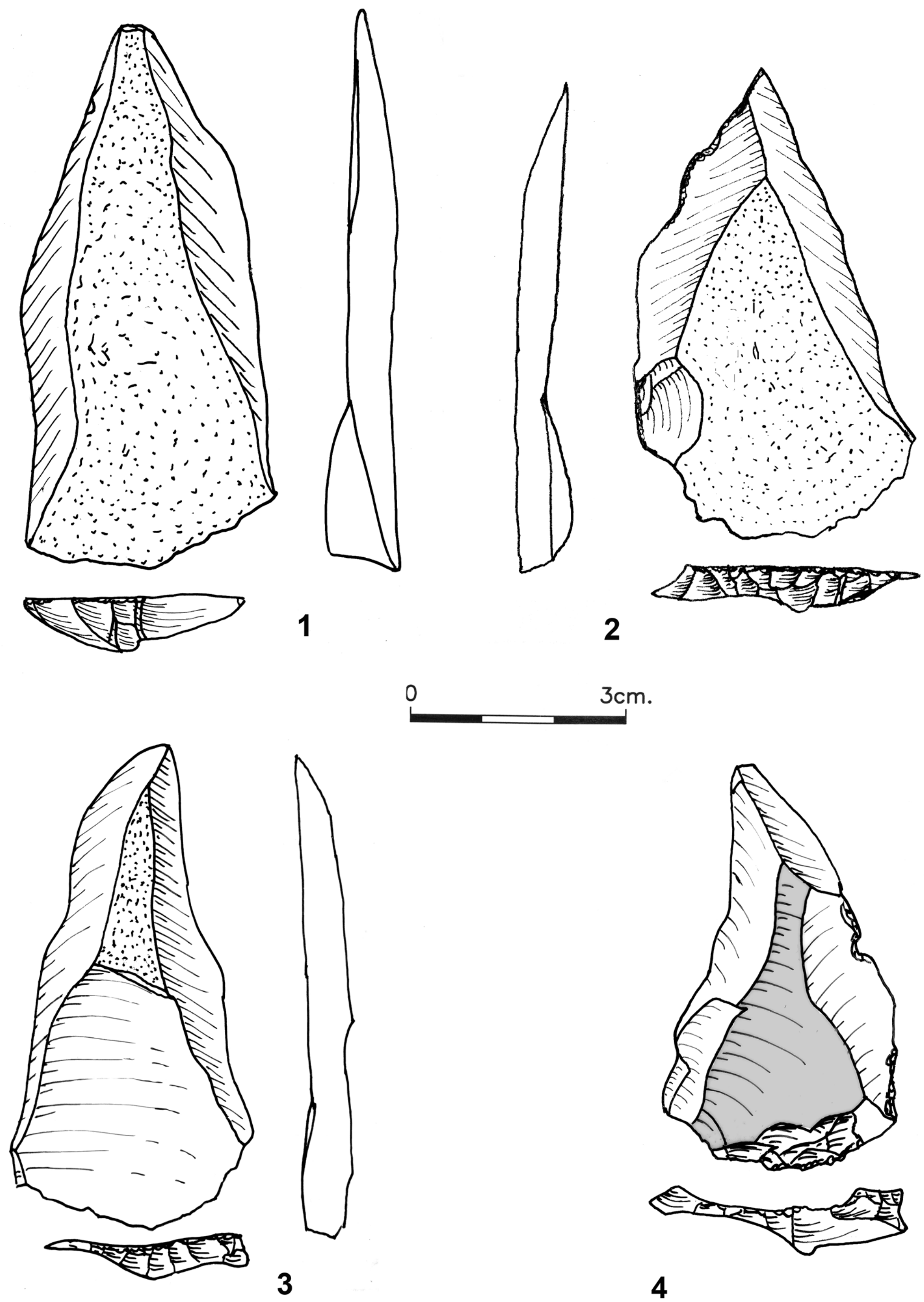


Figure 12. Cortical items from Units IX–VII. (1) Unit IX; (2–3) Unit VIII; (4) Unit VII. Raster marks old patinated surface (preceding the knapping of the item).

shows that blades were detached from arches of comparatively small radius, meaning more strongly curved surfaces. In this aspect, the blades are statistically different from the other products (Table 6). This signifies that the blades were detached from parts of the debitage surface with greater lateral convexity. Although lateral convexity could have shifted as the core was exploited, it would normally have been more pronounced along the edges of the flaking surface (see Figure 4).

As a whole, the Levallois surfaces were kept relatively flat throughout the reduction of cores, as reflected by the relatively high width/thickness ratio of the products[5]. Jelinek's (1977) study shows that relatively flat blanks are common at many other MP sites. Removing fine, flat blanks from lightly curved surfaces is not a task easily mastered and the ability to produce a series of products from a Levallois core with a relatively flat surface probably required a high degree of skill. Bidirectional reduction is one method

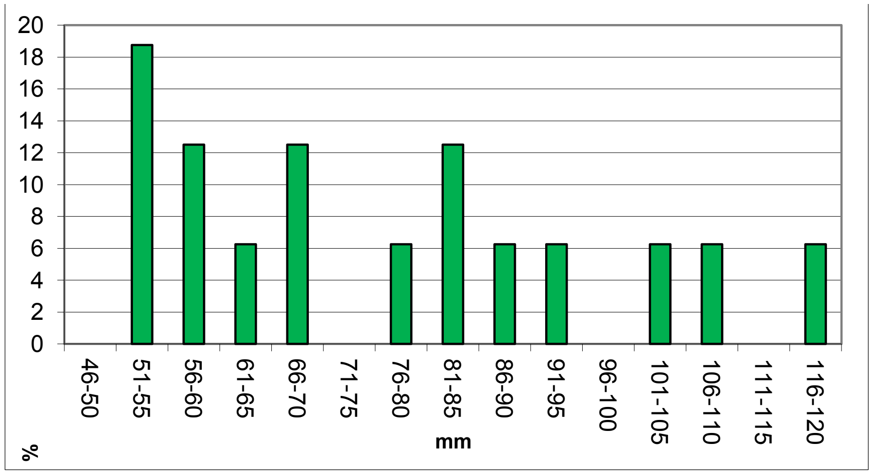


Figure 13. The length of débordants, including only items with an overpassing end termination (n=16) that best correlate to core length.

for maintaining a recurrent production of blades from a flat Levallois surface, and it was commonly used in some other regions (Boëda 1995; Bordes 1961). Bidirectional reduction provides more options in selecting the specific points for striking off blanks, and the production of blanks from the opposite end helps to maintain necessary surface convexities. Although unidirectional production of a series of blades is possible, the approach described for Tabun IX is more suitable to the production of several types of products that exploit the varying morphologies of different parts of the Levallois surface. In this way, knapping errors are less likely to occur and a larger part of the core's mass can be potentially converted into usable blanks.

Faceting was the main method used to prepare striking platforms in Tabun IX. As is typical of Levallois, striking platforms are generally thick and indicate of the use of hard hammer percussion. Faceting served three goals: (1) adjusting the angle between the debitage surface and the strik-

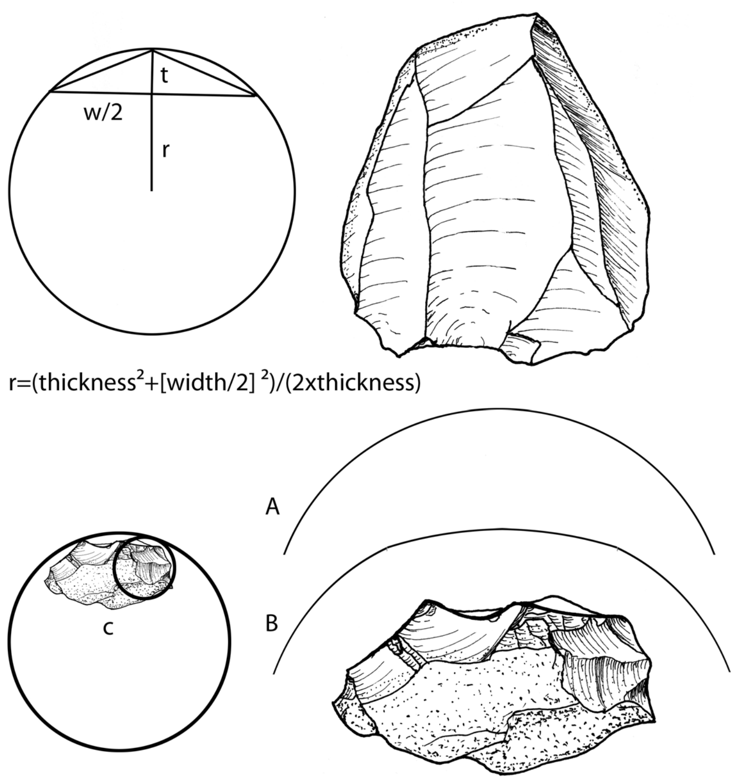


Figure 14. A schematic representation of calculating the arch radius from products. The item's width (cord) and thickness (height) represent the arch by which the radius is geometrically calculated. (A) an homogenous arch; (B) an arch with varying convexities; (C) an example of the varying convexities on the same surface.

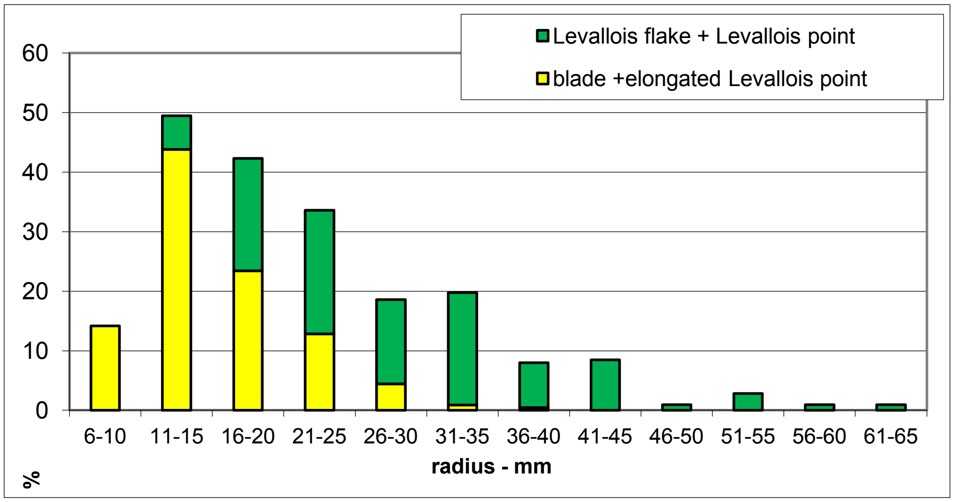


Figure 15. The reconstructed radius according to width and thickness (mid measurements)(n=blades+elongated Levallois points: 226; Levallois flakes + Levallois points: 106).

ing platform, (2) channeling the force of the blow between two ridges (parallel or converging); and, (3) directing the specific orientation of the detached items, especially important with pattern of convergent reduction. The striking platforms of the products differ, in that faceting was more often used on flakes and points than on blades (see Table 2). This is not surprising because faceting is more common on larger striking platforms, and the mean width and surface size of the platforms of the flakes and points are larger than those of blades (Table 7). We note however that the inclusion of some blades from non-Levallois cores probably does inflate the number of blades with plain, un-faceted butts. At the same time, while faceting is not a necessity for producing blades by hard hammer (e.g., Monigal 2002; Shimelmitz et al. 2011), it is important in the production of wide and thin blanks (Dibble 1981; Van Peer 1992: 59). Out of the four types of product, the blades indeed have the lowest average width/thickness ratios (Table 8; see also Table 2).

In fact, EMP knappers purposefully prepared different kinds of platforms in order to remove products from different areas of the core. As would be expected, *chapeau de gendarme* butts appear more often on Levallois points (18.9%) and elongated Levallois points (7.7%), less commonly on Levallois flakes (1.3%) and blades (1.4%) (Table 9). 'Half' *chapeau de gendarme* butts appear with about equal frequency on Levallois points (13.2%), elongated Levallois points (17.9%), and Levallois flakes (18.8%), but this type of platform is rare on blades (2.8%) (see Table 9). These differences in platform preparation suggest minor but important adjustments of technique in the manufacture of each of the four products.

The blades, flakes, and points of Tabun IX do not show a perfect symmetry or specific repeated shapes that would indicate a high level of standardization. This feature of the assemblage also was noted by Meignen (1994). For example, only 37.5% of the points and 22.5% of the elongated points show a clear '*Y-arrete*' pattern. The fact that many of the points were retouched might also be a function of this lack of symmetry, as retouch could have served to correct their shape (Bordes 1961: 24; Debénath and Dibble 1994: 50). This situation reflects a kind of compromise between the possibilities of achieving products with perfectly predetermined shape, and achieving large numbers and a wider range of products. Lineal or preferential Levallois manufacture shows a clear hierarchy between predetermined blanks and predetermining blanks, leading to a high level of control over the precise shape of the products, achieved by carefully shaping the Levallois surface. In the recurrent Levallois, many products served both as predetermin*ed* blanks and as predetermin*ing* blanks (e.g., Boëda 1995; Pelegrin 2005), and so the potential for control over the convexities is limited. In the case of Tabun IX, it seems that achieving specific shapes of blanks (i.e., a perfectly symmetrical Levallois point) was less important than was

TABLE 6. COMPARISONS OF THE CALCULATED ARCH RADIUS OF THE PRODUCTS (t-test).

	***t* value**	***df***	***p* value**
blades (n=190) vs. elongated Levallois points (n=36)	5.54	243	<0.0001
blades (n=190) vs. Levallois flakes (n=56)	11.76	73.9	<0.0001
blades (n=190) vs. Levallois points (n=50)	9.27	60.38	<0.0001

TABLE 7. COMPARISONS OF STRIKING PLATFORM WIDTH (A) AND SURFACE AREA (B) (t-test).

	n=	width (mm)	surface: width*thickness
blade	217	16.2±6.8	92.5±68.1
elongated Levallois point	40	26.1±7.8	174.0±115.8
Levallois flake	80	27.0±7.8	172.7±104.3
Levallois point	54	30.6±8.0	185.9±136.0

	t value	*df*	*p* value
A: Width			
blades vs. elongated Levallois points	8.29	255	<0.0001
blades vs. Levallois flakes	11.34	295	<0.0001
blades vs. Levallois points	13.08	269	<0.0001
B: Surface of Striking Platform			
blades vs. elongated Levallois points	4.15	40.74	<0.0001
blades vs. Levallois flakes	5.73	79.39	<0.0001
blades vs. Levallois points	4.67	54.05	<0.0001

TABLE 8. COMPARISONS OF WIDTH/THICKNESS RATIO (t-test).

	t value	*df*	*p* value
blades (n=208) vs. elongated Levallois points (n=37)	3.81	243	<0.0001
blades (n=208) vs. Levallois flakes (n=62)	9.09	74.2	<0.0001
blades (n=208) vs. Levallois points (n=53)	7.34	59.39	<0.0001

TABLE 9. COMPARISONS OF THE FREQUENCIES OF *CHAPEAU DE GENDARME* BUTTS (Chi-square).

	χ^2	*df*	*p* value
chapeau de gendarme			
Levallois points (n=53) vs. Levallois flakes (n=80)	13.04	1	<0.0001
Levallois points (n=53) vs. blades (n=218)	28.56	1	<0.0001
Half *chapeau de gendarme*			
blades (n=218) vs. elongated Levallois points (n=39)	15.91	1	<0.0001
blades (n=218) vs. Levallois flakes (n=80)	22.87	1	<0.0001
blades (n=218) vs. Levallois points (n=53)	10.21	1	<0.001

TABLE 10. SIDE OF LATERAL EDGE REMOVED FROM THE CORE.

	n=	left %	right %
débordants	39	66.7	33.3
NBK-laminar	30	43.3	56.7
NBK-flake	31	54.8	45.2
all NBKs	61	49.2	50.8
primary element blade*	26	42.3	57.7
SUM	**126**	**53.2**	**46.8**

*Primary element blades include only specimens with a clear tendency toward a specific side.

making a larger number and variety of products.

An important element in Levallois technology is maintenance of lateral and distal convexities of the Levallois surface. Dorsal scar patterns on products and cores from Tabun IX suggest that lateral shaping was not always employed in the latter stages of production. The relatively infrequent negative of bulbs of percussion on the under-surface of the Levallois cores also support this. Instead, the debitage surface was most often maintained by removing *débordants*, NBKs, primary element blades, and overpassed flakes by striking them from the main platform. The removal of these items was not always symmetrical and *débordants* were more commonly struck from one edge of the cores. These differences diminish when all blanks struck from the edges of the core are taken together (Table 10), but the fact that the skew of the elongated items is slightly biased toward the right side further supports a non-symmetrical exploitation of the debitage surface (see Figure 7). Although the removal of NBKs, *débordants*, and primary element blades served to reshape the convexities of the Levallois surface, these items were also highly useful cutting implements or blanks for secondary modification (see Table 1). In fact, some of the highest frequencies of retouch in the assemblage are observed on blanks such as elongate cortical elements or naturally backed knives, forms typically considered by-products or waste (see Table 1). Maintaining the core's distal convexity through intentionally striking overpassing flakes and blades is a delicate business. In some cases, small flakes also were removed from the end of the core opposite the main striking platform to help maintain the required distal convexity of core faces.

The sizes of cores inevitably diminish throughout the reduction process. The length decreases due to the frequent re-faceting of platforms and the occasional maintenance of the distal end by flaking or overpassing. The removal of the *débordants* and NBKs gradually diminish the cores' widths as well. Length probably decreased more rapidly as indicated by the length/width ratio of the discarded cores (mean: 1.0; s.d. 0.1). The influence of core geometry on the shapes of blanks has been observed in several cases (e.g., Hovers 2009: 44; Van Peer 1992: 38). A gradual shift from elongated to squarish cores might affect the quantities of different kinds of items that could be produced. Elongated cores are more suitable for the production of blades and elongate points, shorter, while broader cores are more suitable for production of flakes and broad points. It is thus not surprising that the discarded Levallois cores do not all show laminar scars. However, while some may have been transformed into discoid or polyhedral cores at the ends of their use lives, this was apparently not always the case.

DISCUSSION

The analysis of the material from Tabun IX offers a detailed perspective on the particular form of the Levallois technology practiced in the Levantine EMP at this site. Similar studies of other EMP sites, hopefully encompassing both the Levallois and the laminar methods, are needed to track and translate the variability in lithic technology during the earliest Mousterian, as has been done through the more thorough studies of material from the later phases of the Levantine MP (e.g., Henry 1995; Hovers 2009; Meignen and Bar-Yosef 1992) and many other studies of Levallois technology of the Middle Paleolithic elsewhere (e.g., Baumler 1995; Boëda 1995; Boëda et al. 1990; Chabai 1997; Delagnes and Meignen 2006; Porraz 2009). One contribution of this study is in demonstrating how at Tabun IX, the "prototype" of 'Tabun D' phase, blades, Levallois flakes, and points were all generated in a single reduction sequence utilizing different areas of the Levallois surface, all the while keeping a recurrent, unidirectional/convergent pattern. This observation demonstrates the weakness of the common practice of diagnosing Levallois technological systems from the "products" alone. It also departs somewhat from the general view of the EMP that emphasized the production of points and blades and downplayed the importance of other components (e.g., Bar-Yosef 1998; Monigal 2001, 2002). It is of note that while Meignen (1994) clearly stated that blades, points, and flakes could have been manufactured as part of a single reduction sequence, in her general syntheses she repeatedly emphasizes the production of blades and elongated points (e.g., Meginen 1998, 2000, 2007a, 2007b) and it is this impression that dominates the current literature.

While the data presented above clearly support the complementary production of several blank types from the same Levallois surface in Tabun IX, some might argue that we are not dealing with a set of end products but rather with a system of manufacture characterized by a hierarchy of blanks in which some are predetermin*ed* (products) and some are predetermin*ing* (by-products) (e.g., Pelegerin 2005). The removal of blades as predetermining items for the shaping of Levallois points has been described in several papers, mainly in connection with the later Levantine Mousterian (e.g., Demidenko and Usik 2003; Hovers 2009: 99; Monigal 2002: 459–460). We, however, argue that this is not the case of Tabun IX for the following reasons:

1. Many of the blades of Tabun IX are characterized by fine edges, trapezoidal cross section and previous elongated scars on their dorsal face. This indicates the repeated removal of blades (alongside other products) and not just the removal of two lateral blades for shaping the Levallois surface convexities.
2. While the removal of blades can be useful in some cases for configuring the '*Y-arrete*' scar pattern and the required convexities of the Levallois surface for the production of points, the removal of *débordants* usually provides a more secure result if the only target is a point. *Débordants* tend to show twisted profiles and to remove a larger portion from the distal end, by this adjusting both the lateral and distal convexities; in fact, specimens produced as by-products of point manufacture have this twisted morphology (Demidenko and Usik 2003). The blades from Tabun IX, on the other hand, tend to be straight rather than twisted so that their removal will aid in controlling the lateral convexity but not the distal convexity. Furthermore, the removal of blades is risky in term of keeping the debitage surface uniform since it occasionally leads to hinge scars. In all, the removal of *débordants* that are usually thicker and wider (e.g., see Tables 2 and 5) is not only "safer" but will result in a more clear classic '*Y-arrete*.'
3. Evidence of core shaping and maintenance from the Tabun IX assemblage shows a bias towards a specific side, and treatments of core margins are generally not symmetrical (e.g., one edge maintained by lateral flaking and the other by *débordant*). Were points the exclusive target we would have expected shaping and shape maintenance to be more symmetrical.
4. The lengths of the blades (see Table 2) show they were more commonly made while the cores were relatively large. When the cores were reduced in size in the course of reduction, blade removal decreased. If the target of blade removal was only to create the '*Y-arrete*' needed to make a Levallois point, we would have expected them to be removed also from the latter stages of core reduction and there should be many small (bladelet-sized) specimens. Their absence (the limit of the collection was 2.5cm so collection bias is not a factor here) indicates that their removal was not only about core geometry but rather a technological choice performed only when fairly large blades could be removed.
5. The ratio of blades and other elongated products (*débordants*, elongated NBKs) to points is roughly 3.3/1, greater than the predicted ratio of 2/1 if these were used just to shape the Y-*arete* pattern for points. Of course, some points could have been carried away from the site, but, as discussed above, it more likely that large, "finished" items were carried in.

As others have observed, even though it is often used as a prototype for all EMP assemblages in the Levant, the assemblage from Tabun IX is actually unusual in being dominated by a particular type of Levallois technology. An interesting question now is whether the Levallois reduction from other EMP sites followed the scheme reported in this study, although it has been argued that this is the case *grosso modo* (Meignen 2007a, b; Monigal 2001, 2002). Moreover, in other EMP Levantine sites, such as Abu-Sif, Rosh Ein Mor, Hayonim, Douara IV, and Ain Difla, blades also were produced from non-Levallois cores of various morphologies (Marks and Monigal 1995; Meignen 2007a, b and references therein; Monigal 2002; Nishiaki 1989). It is also unclear whether non-Levallois blade manufacture in other EMP assemblages had similar characteristics in terms of ranges of products. Future studies should clarify the true range of technological options and the scale of behavioral flexibility among early Mousterian hominins in the Levant. At present, however, it appears that the laminar, non-Levallois methods reconstructed by Meginen (2000) and Monigal (2002) and the recurrent Levallois appearing in Tabun IX, are more than alternatives for achieving similar ends. There may be significant differences especially in the variety of items produced. While both systems encompass predetermination and serial production (or punctuated serial production), it would appear that laminar method generally focused on the repeated production of the *same* blank type, whereas the recurrent Levallois technique described resulted in a *range* of blank types. This difference urges us to extend our discussion of Middle Paleolithic technology from "modal" tendencies and the frequent emphasis on predetermination to broader considerations of technological decisions and the flexibility or rigidity of alternative methods for making tools.

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ENDNOTES

[1]We use maximal measurements of width and thickness and not medial because this is important for an accurate identification of the laminar items (length/width ratio >2/1) within the assemblage; medial measurements might be misleading for points that tend to narrow from base to end.

[2]Although the fact that the Tabun assemblage has been kept in drawers for the last 40 years raised some doubts over the origins of these impact fractures, several observations suggest that post-collection damage is not a significant source of apparent impact fractures. Fresh scars are usually easily detectable due to a minor difference in color/patination and this is not the case here. Furthermore, the fact that these fractures appear in different frequencies on various blank types is significant. Apparent impact scars usually appear on the tips and not on the corners of the Levallois points, suggesting that they are not simply related to the presence of fragile pointed projections.

[3]This is based on the schematic reconstructions provided by the various authors cited above. In these reconstructions, the amount of products for Levallois surface varies from three to eight, in which the Levallois surfaces were reshaped by the reduction of two *débordants*—i.e., a ratio of 1.5/1–4/1 products is expected. We note however that most reconstructions show the production of only three products for each Levallois surface.

[4](1) BC: yellowish-light brown flint, medium grain size; (2) BG: brown-gray flint, medium grain size; (3) BWD: brown with white dots, fine grained; (4) CB: a mixture of caramel-brown and dark brown colors, fine grained; (5) GHB: a mixture of greenish-gray and dark brown, fine grained; (6) GM: gray color with varying shades, fine grained; (7) GP: a mixture of gray and light pink, fine grained, (8) HGB: a mixture of greenish gray, dark brown, and yellowish-light brown, fine grained; (9) SG: homogeneous gray, fine grained; (10) varia. The Munsell color system was not used due to the high variation even on a single item.

[5]The blades of the Amudian are characterized by 2.9±1.1 width/thickness ratio. The ratios from other Middle Paleolithic sites of the Levant show a similar range to Tabun IX with means of 3.3–4.0 (Monigal 2002: 561, Appendix E).

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