

AN ANALYSIS OF THE BY-PRODUCTS OF EXPERIMENTAL MANUFACTURE OF CLASSICAL LEVALLOIS FLAKES

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Introduction

The term "Levallois technique" derives from the type site near Paris, Levallois-Perret, where an industry characterised by this technique (Fig.1) was discovered around 1879 by Reboux [Wymer, 1968: p.72].

It was Commont who presented a detailed description of the technique as early as the beginning of this century [Commont, 1909: p.122, cited in Brézillon, 1977: p.79], seemingly for the first time in the Palaeolithic study. According to Commont, the raw material is first roughed out to remove its irregular parts, making it into a multilateral disc-shaped core. The core is then finely modified in order to regularize the ridge allocation on its flaking surface. Finally, the core is held in such a way that its flaking surface is sloped somewhat downwards, and the majority of the surface is detached with a proficient blow, aimed at a right angle to the selected portion of a faceted striking platform, producing a very large flake with centripetal flake scars.

It is noteworthy that there has appeared no technological study radically differing from that of Commont in some eighty years since this Levallois description.

In the 1950s through 1970s, Bordes focused his Palaeolithic research on the Levallois technique. *Typologie du Paléolithique ancien et moyen* published in 1961 is the comprehensive compilation of his works on this subject. In this publication, he described the Levallois technique as a special flaking process, in which an important flake (with the butt faceted or unfaceted) with a predetermined shape prepared on a core prior to its detachment is removed from the core with a final blow [p.14]. The flakes thus produced were grouped into three categories according to different shapes and different processes of their production: a flake category with parallel, crossed and centripetal dorsal scars; a blade category or flakes with the length equal to or more than twice the width continuously detached from a same core; and a point category or triangular flakes, with the flake axis dividing the distal end into two, detached from a specially prepared core [pp.17-18].

In the mean time, West and McBurney rejected uncritical acceptance of Bordes' Levallois definition, stating "*Does an examination of the flakes and cores reveal anything which can be confidently termed Levalloisian or Mousterian in the current acceptance of these terms?*" [1954: p.147] and "*Using rather more restricted connotation than that favoured by some authors (for example F. Bordes) the writer intends only flakes showing evident traces of multiple preparation of the dorsal surface*

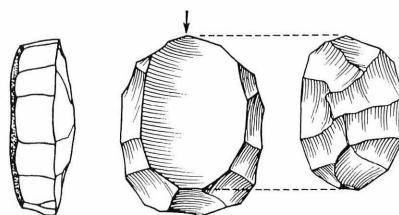


Fig.1 Scheme of Production of a Levallois
Flake [Bordes, 1968: p.30]

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together with the use of a true faceted platform" [McBurney, 1967: p.77].

In fact, Bordes' Levallois definition was so broad that it could be applied to discoidal cores and the Upper Palaeolithic prismatic blade cores, which also produced flakes and blades specially predetermined their shapes prior to their detachment.

Thus in 1980, Bordes put his Levallois ideas into shape in *Le Débitage Levallois et ses variantes*, responding to questions raised by scholars represented by McBurney as to the vagueness of the definition. This work, however, was essentially the same as that seen in the 1961 publication, and it seems that Bordes failed to establish a common standard on which researchers base their analyses of lithic assemblages with Levallois features.

From 1967 onward, Tixier has been proposing the term "Levallois method" instead of "Levallois technique" [Tixier, 1967: p.813; Tixier et al., 1980]. This terminology was a great advance on the Levallois research; too much attention had been paid to Levallois cores and flakes that were nothing but the products of the core reduction sequence, and the term "Levallois method" better connotes the whole process of Levallois flaking, starting with the initial rough-out of raw material and ending with the final detachment of a flake with a predetermined shape.

In *Préhistoire de la Pierre taillée: 1: terminologie et technologie* published in 1980, Tixier, Inizan, and Roche attempted to explain the difference between Levallois blades and the Upper Palaeolithic blades, which Bordes had not demonstrated convincingly. In this publication, the authors defined Levallois blades in a stricter sense than Bordes; the Levallois blades were defined as having non-parallel dorsal ridges and being continuously detached from a Levallois core with a rectangular outline and two opposed striking platforms [p.46, p.50], whereas the Upper Palaeolithic blades were defined as being removed following a crested blade detached to facilitate the continuous removal of regular blades [p.50].

In spite of the experiment-based persuasive Levallois definitions, especially that of a blade category proposed by Tixier and his colleagues in the 1980 publication, "Levallois" is still a difficult problem, and we see a confusion in which there is no clear definition of it, with each author making their own interpretations.

Regarding this confusion, Copeland [1983] emphasized an importance to reassess Levallois problems, especially those associated with the Levantine Mousterian.

At present, Boëda is proposing a classification system of the Levallois flaking methods consisting of two kinds: *méthode linéale* in which a single end product (flake or point) is detached from a core and *méthode récurrente* in which a series of end products (flakes, blades or points) are detached from a single core [1988a; 1988b]. The *méthode récurrente* is further sub-classified into *méthode récurrente unipolaire*, *méthode récurrente bipolaire*, and *méthode récurrente centripète*.

This concludes the introductory summary of the literature concerned with the Levallois flaking methods. As Bordes emphasized himself, it is always difficult to determine whether a given flake is Levallois or not; the determination relies mainly upon experience of observation of archaeological specimens and their experimental manufacture [1961: p.17], thereby leading to different definitions according to various degrees of experience of each researcher.

Through the experimental studies, described below, the present author was able to obtain raw data on the features of the by-products of the manufacture of classical Levallois flakes, which he may take into consideration in analysing material with Levallois features.

Replications and analytical study

In October 1989, experimental manufacture of classical Levallois flakes was undertaken in order to investigate several typological and metrical features of the by-products and to compare them with the features of the Levallois flakes removed as the end products.

The term “classical Levallois” is used here after Bordes [1980]: core reduction in which a single Levallois flake, short or elongated, is detached with a final blow after centripetal preparation to predetermine the shape of the flake to be detached [p.45].

Four blocks of siliceous shale, generally of a fine grain, were used as the raw material for the replications. The blocks were collected on the banks of the Tsukinuno river at the village of Tsukinuno, Sagae-city, Yamagata-prefecture, Japan. They vary in colour from light to dark brown.

Located some 14 km east of the Tsukinuno village is the Takaseyama site, where a bifacial tortoise-shaped core with a Levallois-like appearance, made on the similar raw material to that used for the replications, had been found (Fig.2). The core was described by Abe concerning its reduction process [1976: pp.246-251].

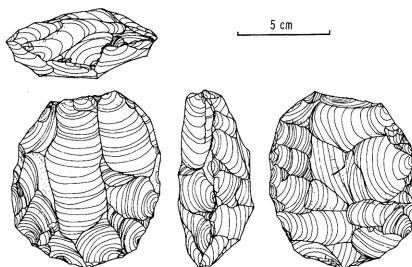


Fig.2 Levallois-like Core from Takaseyama, Yamagata-prefecture, Japan [Abe, 1976: p.246]

Three hammerstones were used for the replications: a basalt hammerstone (Fig.3: left), largest of the three and weighing 930 g, for initial rough-out of the blocks to make rough shapes of cores as well as for detaching large flakes from the blocks to make core blanks; a hammerstone of basalt-like material (Fig.3: middle) weighing 290 g for core preparation and final blows; and a hammerstone of chert-like material (Fig.3: right), smallest of the three and weighing 120 g, used delicately to modify the surfaces and sides of the cores and to facet the striking platforms of the cores.

Flaking technique used was hand-held non-marginal direct percussion, with points of percussion well on to the striking platforms, except for the initial rough-out of the blocks, in which the blocks were struck with the largest hammerstone swung down with the right hand while being rested and stabilized on the ground with the left hand (Fig.4).

The tangential percussion, illustrated by Bordes as a very efficient way to detach a Levallois flake [1961: p.14, Fig.3-5A] (Fig.5), was practised at the final stages of the core reductions, using



Fig.3 Hammerstones Used for the Replications: Scale in 5 cm



Fig.4 Rough-out of Core Blank Rested on the Ground

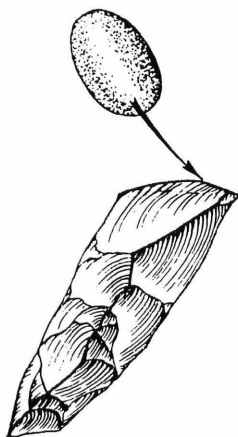


Fig.5 Tangential Percussion Illustrated by Bordes [1961: p.15]

the medium-sized hammerstone being aimed at an oblique angle to the striking platforms, though not in a marginal way, and detached five Levallois flakes as the end products from the largest portions of the core surfaces.

When the removal of a classical Levallois flake with the final blow failed, the surface, sides, and striking platform of the core were modified again to make a core shape good enough to accomplish the purpose. Once the final blow succeeded in detaching a flake which satisfied the requirements of the end product, the core reduction was discontinued even when it was possible to detach more Levallois flakes continuously after modifying the core again.

Very tiny by-products were excluded from the analysis; the aim of the analysis was to compare the Levallois flakes detached as the end products with the by-products of their manufacture in terms of typological and metrical attributes, and was not to describe in detail how all the pieces produced were conjoined.

Each piece of débitage¹⁾, large enough for the analysis, was numbered immediately after it had been removed from the core.

The numbered pieces were classified into four main débitage categories: cortical²⁾, partially-cortical³⁾, naturally-backed⁴⁾, and non-cortical débitage⁵⁾.

The non-cortical débitage was sub-divided into non-Levallois flakes⁶⁾, pseudo-Levallois points [Bordes, 1961: p.22], non-Levallois blades⁷⁾, Levallois flakes⁸⁾, levallois points [Bordes, 1961: p.18], elongated Levallois points⁹⁾, and Levallois blades¹⁰⁾.

All of the numbered débitage pieces were analysed on the following attributes:

1. Features of butt: 1) Cortex, 2) Plain, 3) Convex dihedral faceted, 4) Straight multiple faceted, 5) Convex multiple faceted, 6) in *Chapeau de gendarme*, and 7) Broken [Bordes, 1947: pp.7-8; 1961: p.5]
2. Butt width
3. Butt thickness at the point of percussion [Wilmsen, 1968: p.984]
4. Maximum length from the point of percussion to the point of last detachment [Jelinek, 1975: p.304]
5. Maximum width measured perpendicular to the maximum length [Bordes, 1961: p.6]
6. Maximum thickness measured anywhere along the length excluding bulbar area [Munday, 1976: p.121]
7. *Angle de chasse* formed between dorsal surface and butt [Barnes and Cheynier, 1935: p.289]
8. Dorsal scar patterns (Fig.6): 1) Unidirectional [Bordes and Crabtree, 1969: pp.2-3], 2)

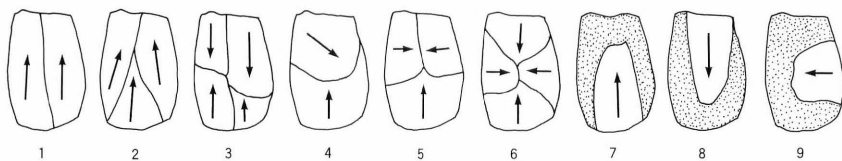


Fig.6 Patterns of Dorsal Scars

1~2: Unidirectional; 3: Bidirectional opposed; 4~5: Crossed;
6: Centripetal; 7~9: A single flake scar

- Bidirectional opposed [Bordes and Crabtree, 1969: pp.2-3], 3) Crossed [Tixier, 1963: p.43], 4) Centripetal [Crew, 1975: p.429], and 5) A single flake scar
9. Number of dorsal scar(s)
 10. Dorsal shapes: 1) Parallel, 2) Converging, and 3) Expanding [Marks, 1976: p.372]
 11. Distal shapes: 1) Blunt and 2) Pointed [Marks, 1976: p.372]
 12. Lateral profiles: 1) Flat, 2) Incurvate, and 3) Twisted [Marks, 1976: pp.372-373]

Replication 1: The raw material used in Replication 1 was a block of finely-grained siliceous shale, light brown in colour and with the cortex patinated dark brown. A large flake (with maximum length 117 mm, width 126 mm, and thickness 50 mm) was detached from the block to make a core blank (Fig.7: flake conjoined on the left).

The three hammerstones were used during the core reduction: the largest one for detaching the core blank, the medium-sized one for core preparation and the final blow, and the smallest one for delicate modification of the core sides and surface and for faceting the striking platform for the final blow.

The core reduction started with the side preparation, and then the centripetal preparation of the flaking surface was carried out, alternatively with the side preparation in accordance with the shape of the core under preparation. During this preparation, the striking platform for the final blow was located, and a classical Levallois flake (Fig.8-5) was detached successfully after the striking platform had been faceted delicately.

The core in the final form is 90 mm long, 90 mm wide, and 34 mm thick (Fig.8-6). The core surface retains centripetal flake scars which were left by its preparation. The striking platform for the final blow remains convex multiple faceted.

The numbered débitage pieces total 31, of which 3 are cortical, 3 are partially-cortical, 1 is naturally-backed, 22 are non-cortical, and 2 are broken and therefore unclassifiable (Table 1). Seven of these 31 pieces came from the side preparation, 18 came from the surface preparation, 5 came from the faceting of the striking platform, and 1 came from the final blow as the end product (Table 2).

Aside from the finally-detached Levallois flake, the non-cortical débitage consists of 14 non-Levallois flakes, 1 pseudo-Levallois point, and 6 non-Levallois blades. Most of them were produced during the surface preparation (Table 2).

The typological and metrical features presented in Tables 3 to 8 show that the Levallois flake is bigger than most of the by-products in butt width, butt thickness, length, and width. The biggest difference between them, however, lies in the number of flake scars on their dorsal surfaces; the scars on the Levallois flake are far more numerous than on the by-products.

For the reason that the core was made on a flake and that the flaking surface of the core was the ventral surface of the flake, most of the side preparation pieces are cortical or partially-cortical débitage with plain butts, while the surface preparation pieces are neither cortical nor partially-cortical débitage, with many of their butts being cortex or plain (Tables 2 and 6). Many of the

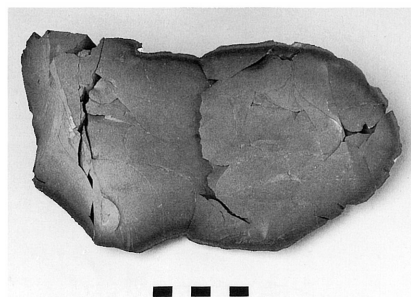


Fig.7 Conjoined Large Flakes Used as the Core Blanks for Replications 1 (Left) and 2 (Right): Scale in 5 cm

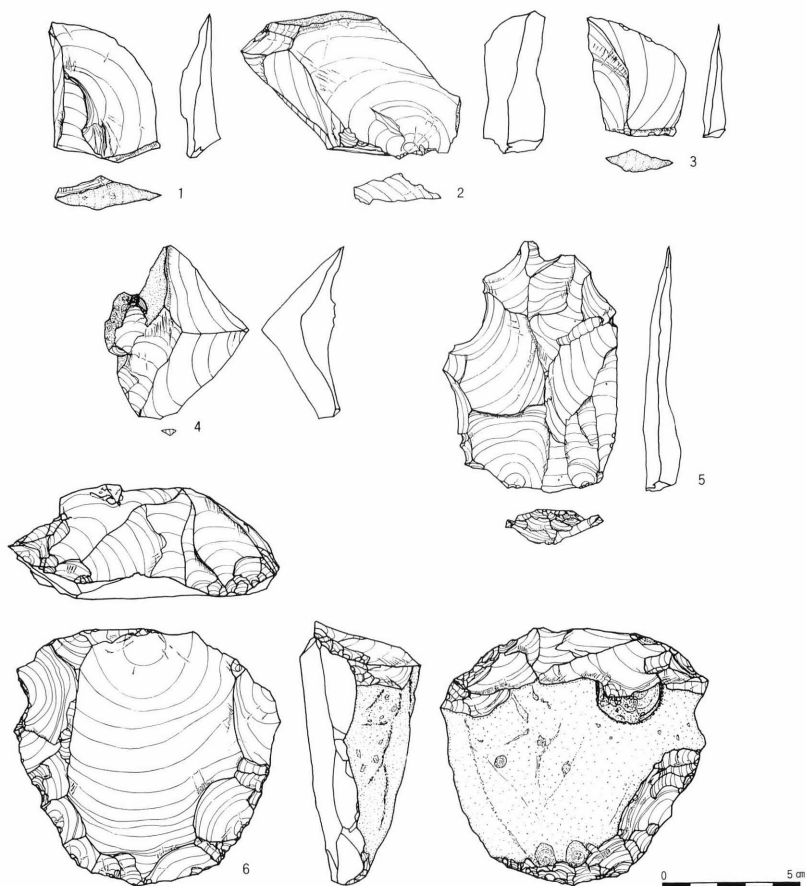


Fig.8 Products from Replication 1

surface preparation pieces have crossed dorsal scars, but the side preparation pieces tend to have a single flake scar (Table 7). As to the shapes of the débitage pieces, the dorsal shapes are parallel, converging, and expanding, and the distal shapes are mostly blunt (Table 8). The lateral profiles of the side preparation pieces are mostly incurvate, while those of the surface preparation pieces are mostly flat (Table 8).

No Levallois flakes other than the end product were accidentally detached during the core reduction.

Replication 2: In Replication 2, a large flake (with maximum length 112 mm, width 112 mm, and thickness 39 mm) was detached as the core blank from the same block of siliceous shale that was used for Replication 1 (Fig.7: flake conjoined on the right).

The largest hammerstone was used for detaching the core blank, and the medium-sized hammerstone was used for core preparation and the final blow.

The core reduction started with the centripetal preparation of the flaking surface. The side

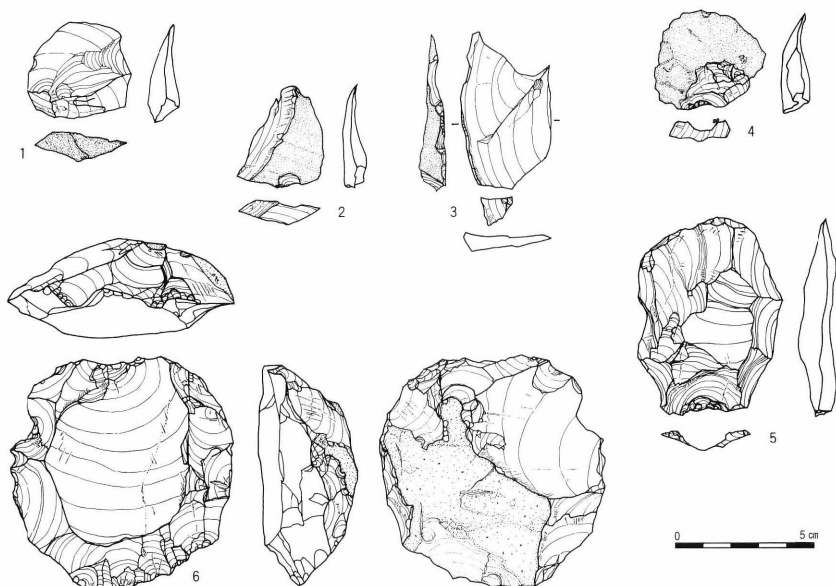


Fig.9 Products from Replication 2

preparation followed, alternating with the surface preparation. The striking platform for the final blow was located when the preparation of the core sides and surface had been finished, and a classical Levallois flake (Fig.9-5) was detached with the final blow after modifying the selected portion of the striking platform.

The core in the final form is 80 mm long, 80 mm wide, and 28 mm thick (Fig.9-6). The core surface retains centripetal flake scars left by its preparation, and the striking platform for the final blow remains straight multiple faceted.

The numbered *débitage* pieces total 30, of which 1 is cortical, 6 are partially-cortical, 3 are naturally-backed, 17 are non-cortical, and 3 are broken and unclassifiable (Table 10). Seven of these 30 pieces were from the side preparation, 21 were from the surface preparation, and 1 was from the final blow as the end product (Table 11).

The non-cortical *débitage* other than the end product consists of 14 non-Levallois flakes and 1 pseudo-Levallois point. All of them were from the surface preparation (Table 11).

The Levallois flake is bigger than most of the by-products in butt width, length, width, and thickness (Table 12), but the most remarkable difference is in that it has far more dorsal scars than the by-products (Table 14).

Because the core was made on a flake as in Replication 1 and the flaking surface of the core coincided with the ventral surface of the flake, the side preparation pieces are either cortical or partially-cortical *débitage* with plain butts, whereas the surface preparation pieces are either naturally-backed or non-cortical *débitage*, mostly with cortex or plain butts (Tables 11 and 15). Most of the surface preparation pieces have crossed dorsal scars, and the side preparation pieces usually have a single flake scar (Table 16). The dorsal shapes are parallel, converging, and expanding, with the expanding shape being seen more often in the surface preparation pieces than in the side preparation pieces, and the distal shapes are blunt (Table 17). The lateral profiles

of the side preparation pieces are either flat or incurvate, and those of the surface preparation pieces are mainly flat (Table 17).

As in Replication 1, no Levallois flakes but the end product were accidentally detached during the core reduction.

Replication 3: The raw material for this replication was a pear-shaped block of siliceous shale (with maximum length 202 mm, width 128 mm, and thickness 99 mm) of a rather coarse quality, brown in colour and with the cortex patinated orange (Fig.10).

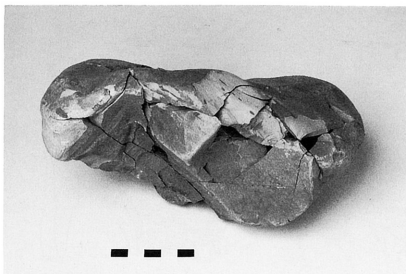


Fig.10 Conjoined Core Blank for Replication 3: Scale in 5 cm

Most probably due to the coarse quality of the raw material, hinging and plunging often occurred during the core reduction, and core size was decreased to a great extent at the stage when the core preparation had been finished.

Only the medium-sized hammerstone was used at all of the stages of the core reduction.

The core reduction started with the centripetal surface preparation, and then the sides were prepared alternating with the surface preparation. The striking platform for the final blow was located when the surface and side preparation had

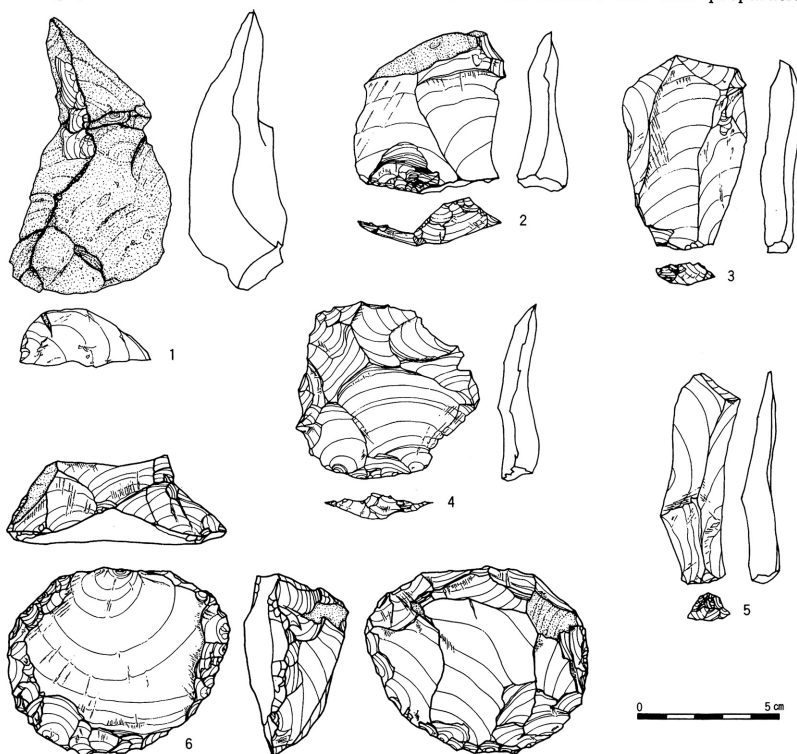


Fig.11 Products from Replication 3

been finished, and the final blow detached a classical Levallois flake (Fig.11-4).

The core in the final form is 65 mm long, 77 mm wide, and 26 mm thick (Fig.11-6). Its surface retains centripetal preparation scars, and the striking platform for the final blow remains convex multiple faceted.

The numbered débitage pieces total 65, of which 10 are cortical, 17 are partially-cortical, 34 are non-cortical, and 4 are broken and unclassifiable (Table 19). Twenty-four of these 65 pieces were from the side preparation, 38 were from the surface preparation, and 1 was from the final blow as the end product (Table 20).

Excluding the finally-detached Levallois flake, the non-cortical débitage consists of 29 non-Levallois flakes and 3 non-Levallois blades. Most of them were from the surface preparation (Table 20).

The most remarkable difference between the finally-detached Levallois flake and the by-products is that the Levallois flake has much more dorsal scars than the by-products (Table 23).

The side preparation pieces tend to be cortical or partially-cortical with plain butts, while the surface preparation pieces tend to be non-cortical débitage with plain or convex dihedral faceted butts (Tables 20 and 24). Many of the surface preparation pieces have crossed dorsal scars, and the side preparation pieces usually have unidirectional or crossed dorsal scars (Table 25). The dorsal shapes are parallel, converging, and expanding (especially for the surface preparation pieces), and the distal shapes are predominantly blunt (Table 26). The lateral profiles of the side preparation pieces are either flat or incurvate, and those of the surface preparation pieces are mainly flat (Table 26).

Aside from the end product, 1 Levallois flake and 1 Levallois blade were accidentally detached during the core reduction. They were from the surface preparation, and have crossed dorsal scars.

Replication 4: The raw material for Replication 4 was a hemispherical block of siliceous shale (with maximum length 205 mm, width 170 mm, and thickness 104 mm), very finely grained, which was dark brown in colour and had the cortex patinated yellowish brown (Fig.12).

The largest hammerstone was used for the rough-out of the block, and the medium-sized hammerstone was used for the core preparation and re-modification as well as for the final blows. The smallest hammerstone was used for delicate modification of the sides and flaking surface of the core and of the striking platforms for the final blows.

The core reduction started with the side preparation. This was followed by the centripetal preparation of the surface, which alternated with the side preparation. The striking platform for the final blow was located when the core preparation had been finished, but the final blow failed and detached a broken Levallois flake with centripetal dorsal scars (Fig.13-4). The core surface and sides were modified again in the same manner as in the preparation prior to the failed blow, and the second final blow succeeded in detaching a classical Levallois flake (Fig.13-7).

The core in the final form is 99 mm long, 88 mm wide, and 37 mm thick (Fig.13-8). The core surface retains centripetal flake scars left by its re-modification, and the striking platform for



Fig.12 Conjoined Core Blank for Replication 4: Scale in 5 cm

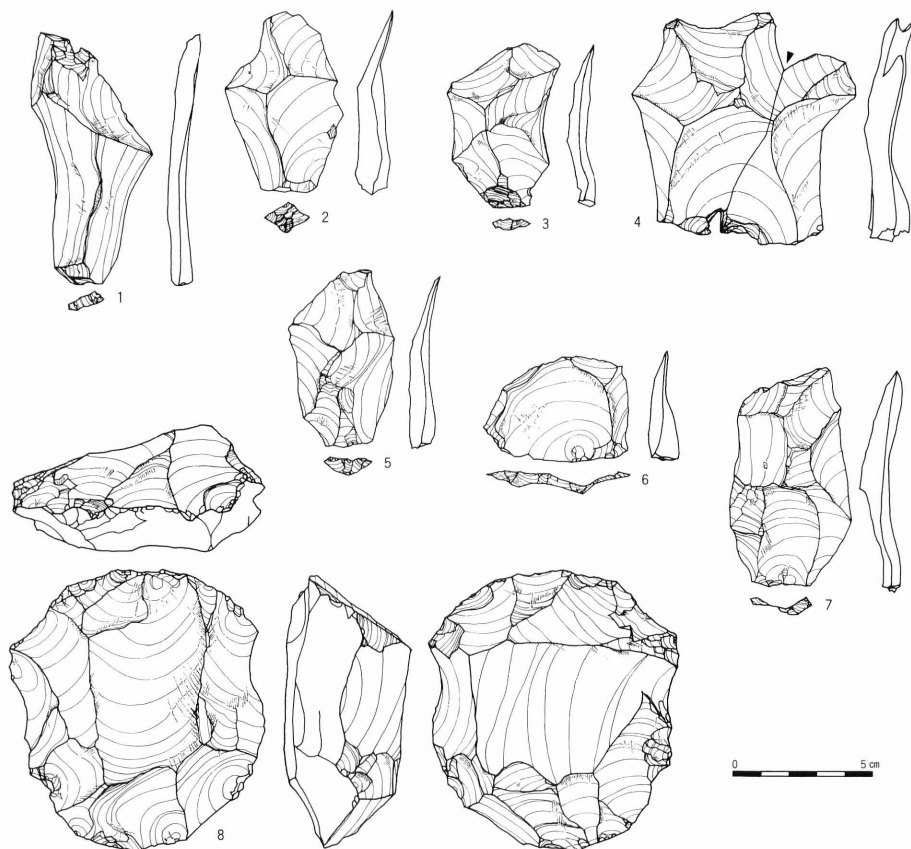


Fig.13 Products from Replication 4

the second final blow remains convex dihedral faceted.

The numbered débitage pieces total 64, of which 4 are cortical, 11 are partially-cortical, 46 are non-cortical, and 3 are broken and unclassifiable (Table 28). Twenty of these 64 pieces came from the core side preparation, 17 came from the surface preparation, 1 broken end product came from the failed first final blow, 20 came from the core surface re-modification, 3 came from the core side re-modification, and 1 unbroken end product came from the successful second final blow (Table 29).

The non-cortical débitage other than the two end products consists of 33 non-Levallois flakes, 1 pseudo-Levallois point, 6 non-Levallois blades, and 3 classical Levallois flakes. They were from the preparation and re-modification of the core surface and sides. All of the pieces from the re-modification are non-cortical (Table 29).

The Levallois flake from the successful second final blow has the dorsal scars far more numerous than on any of the by-products and the broken Levallois flake (Table 32).

The side preparation pieces are cortical, partially-cortical, and non-cortical with plain butts, and the surface preparation pieces are mainly non-cortical with plain butts (Tables 29 and 33).

Many of the surface preparation pieces have a single and crossed dorsal scars, and the side preparation pieces have a single as well as unidirectional and crossed dorsal scars. The dorsal scars on the remodification pieces of the core surface are mostly crossed, though centripetal in some cases (Table 34). The dorsal shapes of the preparation and remodification pieces are parallel, converging, and expanding, and the distal shapes are predominantly blunt (Table 35). The lateral profiles are mainly incurvate (Table 35).

Aside from the two Levallois flakes from the two final blows, 12 pieces of Levallois débitage were accidentally detached during the core reduction, of which 9 have crossed dorsal scars and are non-Levallois in terms of the classical category with centripetal preparation. These by-products Levallois consist of 3 flakes and 1 blade with crossed dorsal scars, derived from the initial preparation of the flaking surface of the core, as well as 5 flakes with crossed dorsal scars and 3 flakes (Table 37) with centripetal scars, both derived from the re-modification of the core surface.

Replication 5: The raw material used in Replication 5 was a tabular block of siliceous shale of a rather fine quality (with maximum length 188 mm, width 133 mm, and thickness 72 mm), which was light brown in colour and had the cortex patinated grey (Fig.14).

Only the medium-sized hammerstone was used for the core reduction.

The core reduction started with the centripetal preparation of the flaking surface, and the side preparation followed it, alternating with the surface preparation. Because breakage direction of the raw material, in which flaking was better controlled, was known during the core preparation, the striking platform for the final blow was located with this breakage mechanism in mind, and the final blow detached a classical Levallois flake (Fig.15-3) after the striking platform had been delicately faceted.

The core in the final form is 107 mm long, 108 mm wide, and 28 mm thick (Fig.15-5). The core surface retains centripetal flake scars left by its preparation, and the striking platform for the final blow remains convex multiple faceted.

The numbered débitage pieces total 45, of which 5 are cortical, 13 are partially-cortical, and 27 are non-cortical débitage (Table 38). Eleven of these 45 pieces came from the side preparation, 33 came from the surface preparation, and 1 was from the final blow as the end product (Table 39).

Excluding the finally-detached Levallois flake, the non-cortical débitage consists of 19 non-Levallois flakes, 5 pseudo-Levallois points, 1 non-Levallois blade, and 1 Levallois blade. Most of them were produced during the surface preparation (Table 39).

The finally-detached Levallois flake is longer than the by-products (Table 40), but the biggest difference between them is seen in that the former has more dorsal scars than any of the latter (Table 42).

The side preparation pieces tend to be cortical or partially-cortical débitage with plain butts, and the surface preparation pieces tend to be non-cortical débitage with plain or convex dihedral faceted butts (Tables 39 and 43). Most of the surface preparation pieces have crossed dorsal scars, while the side preparation pieces have a single flake scar as well as unidirectional or

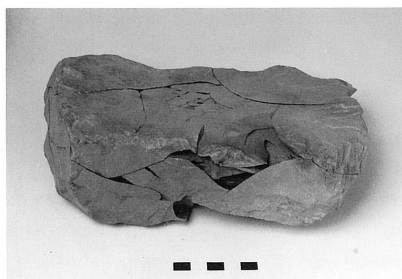


Fig.14 Conjoined Core Blank for Replication 5: Scale in 5 cm

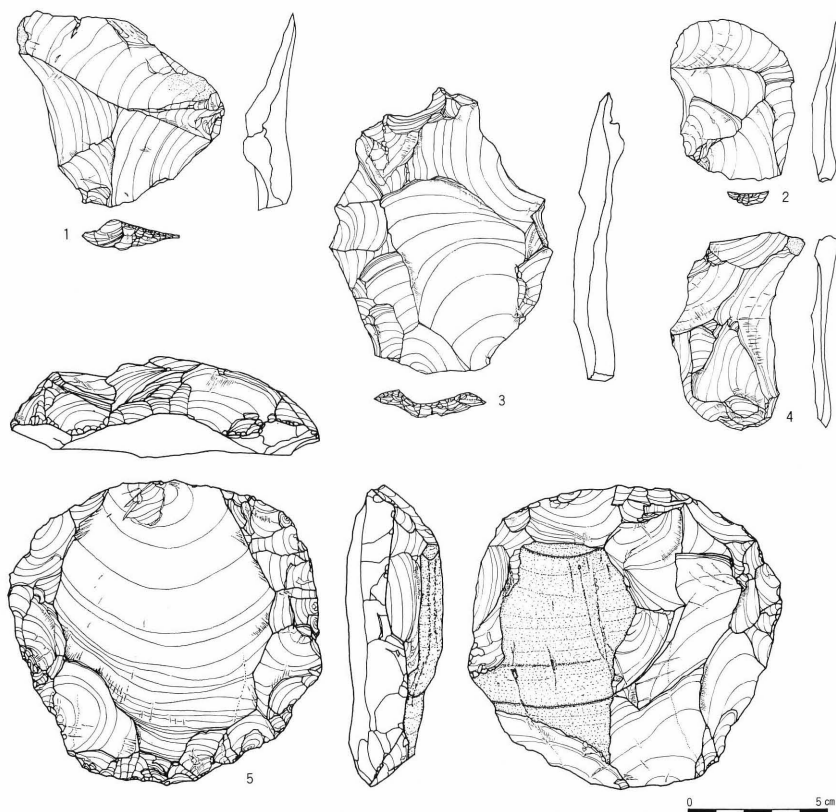


Fig.15 Products from Replication 5

crossed dorsal scars (Table 44). The dorsal shapes are mainly expanding, but are also parallel and converging, and the distal shapes are blunt in nearly all cases (Table 45). The lateral profiles of the side preparation pieces are mainly incurvate, while those of the surface preparation pieces are mainly flat (Table 45).

Four pieces of Levallois débitage other than the end product were accidentally detached during the core reduction: 3 flakes with crossed dorsal scars, which may be described as non-Levallois in terms of the classical Levallois definition, and 1 classical Levallois blade with centripetal dorsal scars. All of them were derived from the surface preparation.

Summary of analysis

In each of the replications, the non-cortical débitage was the most frequent category of the by-products. The partially-cortical débitage took the second place, and the cortical débitage was least frequent. Most of the non-cortical débitage pieces were from the preparation of the flaking surfaces of the cores. All of the four naturally-backed pieces were produced in the reduction of the cores on flakes (Replications 1 and 2), and were produced in the preparation of the flaking surfaces of the cores, which were the ventral surfaces of the flakes.

The sizes of the by-products from the five replications suggest that a size of raw material decides

sizes of preparation pieces, especially those of pieces produced at earlier stage of core reduction.

In a core reduction as Replications 1 and 2 using raw material or core blank originally shaped ideal for the reduction of a classical Levallois core, total number of detachment in the whole reduction sequence may be less numerous than in reductions using raw material shaped otherwise. When a core blank is well fitted originally, the striking platform for the final blow can be located at an early stage of its reduction. It may be very rare that striking platform for the final blow remains cortical; in order to detach a Levallois flake with its butt left cortical, a certain cortical portion of a core, originally shaped and angled favourable for the striking platform, should be extremely carefully selected at the very beginning of the reduction.

As is clearly seen in Replications 1 and 2 which used large flakes as the core blanks, which portion of a core on flake, side or surface (being the ventral surface of the flake), is detached at the very onset of the reduction may schematically decide types of the butts of initial preparation pieces: side preparation pieces with plain butts and surface preparation pieces with cortex butts in the case of a core reduction starting with surface preparation.

The débitage pieces from the core side preparation are mainly cortical and partially-cortical with plain butts, whereas the pieces from the surface preparation are mainly non-cortical with cortical, plain, and convex dihedral faceted butts, although varying in scar numbers on their dorsal surfaces.

Many of the side preparation pieces have a single as well as unidirectional flake scars, but the surface preparation pieces mainly have crossed dorsal scars.

There is seen no strong relationship between the converging dorsal shape and pointed distal shape of the débitage pieces (Tables 9, 18, 27, 36, and 46). It seems that in reductions of classical Levallois cores the distal shapes of débitage are not pointed even when the dorsal shapes happen to be converging, for it may be rare that the overall shapes of the cores are converging [see Bergman (1981: p.320) and Marks (1983: p.64) for the strong connection between core shapes and shapes of débitage pieces].

With regards the lateral profiles of the débitage pieces, the side preparation pieces tend to be incurvate, while the surface preparation pieces are generally flat. In a case of core reduction such as Replication 4, even the surface preparation pieces may be often incurvate, most probably due to the quality of raw material.

The Levallois flakes detached as the end products are bigger than most of the by-products. The biggest difference between them, however, is in the numbers of the flake scars on their dorsal surfaces, with the scars on the Levallois flakes being far more numerous than those on the by-products.

In Replications 3 to 5, 14 pieces of Levallois débitage with crossed dorsal scars, which may not be described as the classical Levallois with centripetal dorsal scars, as well as 4 pieces of classical Levallois débitage were produced accidentally during the core reductions. Although the former Levallois pieces were derived from both the initial preparation of the core surfaces and the re-modification of the core surface after the failed blow, all of the latter Levallois pieces but one (from the initial core surface-preparation) were produced in the surface re-modification.

It is believed that classical Levallois débitage is detached unintentionally (or intentionally in the *méthode Levallois récurrente centripète* of Boëda [1988a]) during re-modification of core surface after successful or failed detachment of the end product; at this stage of core reduction the core surface is expected to have no cortex and to have more or less centripetal flake scars (Fig. 16).

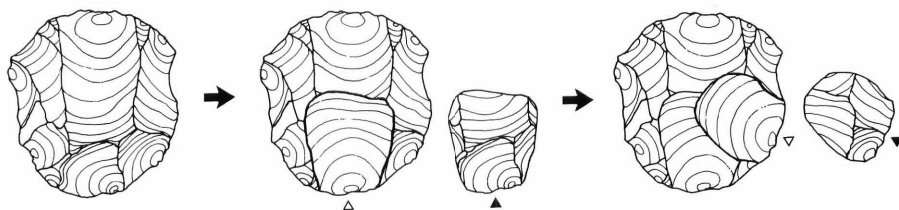


Fig.16 Scheme of Accidental Detachment of Classical Levallois Flakes during Core Surface Re-modification

Examining both the end products Levallois and the by-products Levallois, the former pieces are bigger than most of the latter, and have more dorsal scars than the latter. The ratios of the scar numbers on the end products Levallois to the by-products Levallois (with crossed dorsal scars) are 1) 13 to 4 (2 cases), 5 (3 cases), 6 (2 cases), and 9 (2 cases), 2) 14 to 4 and 7, and 3) 15 to 4, 5, and 6. The scar number ratios of the end products Levallois to the by-products Levallois with centripetal scars are 1) 13 to 6, 7, and 8 (3 cases from the re-modification) and 2) 15 to 8 (from the initial preparation).

Needless to say, it was easy for the present author, who had undertaken the replications, to differentiate between the end products Levallois and the by-products Levallois, but many analysts might have defined these by-products as typical Levallois end products. It may be actually difficult to distinguish between these two kinds of products in facing a given lithic assemblage with Levallois features, unless they are altogether conjoined to cores. A possible good basis for differentiating between them may be the numbers of flake scars on their dorsal surfaces.

Typical pseudo-Levallois points illustrated by Bordes [1961: pp.22-23, Fig.3-7] (Fig.17) were not produced very often in the replications: 8 of the 235 pieces or 3.4% of the total débitage pieces are classifiable as such. This rather small percentage seems to suggest that typical pseudo-Levallois points are not produced very often during the classical Levallois core reduction [see Matsuzawa (1987a: p.19) for a similar conclusion based on the observation of the untruncated and mint shapes of the dorsal scars on a classical Levallois flake from le Tillet].

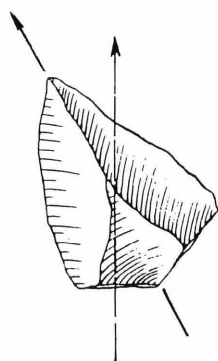


Fig.17 Pseudo-Levallois Point Illustrated by Bordes [1961: p.15]

It may be difficult to distinguish between the reduction of a Levallois core, with a series of end products removed, and that of a discoidal core. It seems likely in this connection that in the former reduction the end products differ from the by-products in some features such as the numbers of flake scars on their dorsal surfaces, whereas in the latter reduction many of the products are end products themselves and are similar to each other.

Conclusion

The experimental reductions of classical Levallois cores reported in the present paper followed the reduction schemes established by modern lithic technologists. Due to an inevitable limit of imitation, the pertinent experiments should have been more or less different from the reductions carried out by prehistoric peoples.

As a result of the analysis of the by-products from the experiments, however, the present author was able to put several Levallois questions, which he had been asking vaguely, into order in the preceding summarizing section.

In the beginning of this century, Commont described the whole process of the classical Levallois flaking, starting with the rough-out of raw material and ending with the final detachment of a large flake with centripetal flake scars left by the core preparation [1909: p.122].

Commont's description still holds for the classical Levallois definition of today, which describes careful preparation without any failure up to the final blow to obtain only a single end product, thereby describing neither the re-modification of the core after a failed blow nor the characteristic features of the by-products from the re-modification.

Except for some mention in the 1961 publication [p.17, plate 3-2], Bordes did not state explicitly as to a possibility that several classical Levallois flakes were produced from a single core. It seems, therefore, that he regarded the classical Levallois as a single detachment of end product rather than production of more than one. In this connection, Bordes ascribed the considerable scarcity of discoidal cores in the Mousterian assemblages with Levallois elements to the abundance of raw material [1961: p.73]. It seems more than probable, however, that the reduction of a Levallois core continued after a failed blow even in places where raw material was available in abundance, if the failed core still remained good enough in size and shape for its further modification to obtain the end product in the form intended at the very onset of the reduction.

Currently, Boëda [1988a; 1988b] is proposing a classification system of the Levallois flaking methods made up of two different ideas of core reduction: *méthode linéale*, equivalent to the classical Levallois, and *méthode récurrente*. This classification is quite promising in that it certainly is to present a key to solve several Levallois problems, proposing various types of models that can be used to analyse lithic assemblages with Levallois features from many parts of the world, some of which may not apply to the European Levallois definitions.

As was pointed out by Bradley and Sampson [1986: p.30], the substantiality of end products of core reductions may have been conditioned by several factors such as traditional reduction schemes, sizes and shapes of raw material, and knapper's ability to accomplish the scheme. It is also believed that the failures in flaking which occurred during the reduction led to the change of the initial scheme to a different one.

Because knapping failure, due to the quality of raw material or the knapper's insufficient control of flaking, should have happened frequently in the prehistoric times, though seemingly much less often than today, re-modification of core shapes after failed blows and the features of the by-products from the re-modification should be considered more seriously.

As the concluding remarks of the present study, two questions are raised as follows:

1) In the replications, 18 pieces of Levallois débitage (7.7% of the total débitage pieces amounting to 235), consisting of 14 with crossed dorsal scars and 4 with centripetal scars, were produced accidentally during the core preparations and re-modification. Here arises a question how we distinguish between classical Levallois flakes produced as the end products and those derived from core preparation and re-modification. In this regard, it seems problematic to count unretouched Levallois flakes for a quantitative analysis on the same level as tools with clear traces of retouch, for the identification and quantification of Levallois flakes as end products may be different according to different researchers. Is it not more reasonable to analyse Levallois flakes qualitatively as a means to see the flaking technique consistent in a given lithic assemblage

altogether with cores found associated?

2) The replications did not produce any débitage pieces which can be Levallois with unidirectional or bidirectional opposed dorsal scars. It seems highly likely as Boëda [1988a; 1988b] suggests that such kinds of Levallois flaking methods were proceeded intentionally and quite differently from the classical Levallois flaking. What, then, is a technological significance of the Levallois method with elaborate parallel preparation? This question may interestingly link with that concerning the Levantine Lower Mousterian, modelled by Tabun D, with parallel Levallois preparation and laminar débitage, which is said to be technologically distinct from the overlying Mousterian modelled by Tabun C and B said to have the classical Levallois features [see Copeland (1975: pp.329-335) for the tripartite scheme of the Levantine Mousterian].

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Notes

- 1) The term débitage is meant here for various types of flakes other than debris, although this term was originally designated for intentional action of breaking a piece of hard rock in order to use the products as they are or after retouch modification as well as for all of the products from this action [Tixier, 1963: p.32].
- 2) The cortical débitage is a category which has more than 80% cortex.
- 3) The partially-cortical débitage is a category which is neither the cortical nor non-cortical débitage.
- 4) The naturally-backed débitage is partially cortical, and has cortex or natural surface which makes almost right angles with the ventral surface [Bordes, 1961: p.33].
- 5) The non-cortical débitage is a category which has cortex up to 20%.
- 6) Flakes with the length less than twice the width and without the Levallois features are defined as non-Levallois flakes [Bordes, 1961: p.6].
- 7) Elongated non-Levallois flakes with the length equal to or more than twice the width are defined as non-Levallois blades [Bordes, 1961: p.6].
- 8) The standard, on which the determination whether or not a given flake is Levallois is based, is that of Bordes [1961: p.17]; if the flake retains dorsal scars, which may be parallel or convergent (crossed and centripetal), left by careful preparation on the core to predetermine its shape prior to its removal, the flake is defined as Levallois. In 1980, Bordes [p.45] particularly defined a Levallois flake with centripetal dorsal scars as the classical type.
- 9) Levallois points with the length equal to or more than twice the width are defined as elongated Levallois points [Bordes, 1961: p.18].
- 10) Elongated Levallois flakes with the length equal to or more than twice the width are defined as Levallois blades [Bordes, 1961: p.18].

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Explanation of Figures 8, 9, 11, 13, and 15

Fig.8 Products from Replication 1

- 1: Core surface preparation piece with cortical butt and bulb of percussion of the core on flake
- 2: Non-Levallois flake with plain butt from core side preparation
- 3: Non-Levallois flake with cortical butt from core surface preparation
- 4: Partially-cortical débitage with incurvate lateral profile from core side preparation
- 5: Classical Levallois flake from the final blow
- 6: Core in the final form

Fig.9 Products from Replication 2

- 1: Core surface preparation piece with cortical butt and bulb of percussion of the core on flake
- 2: Partially-cortical débitage with plain butt and incurvate lateral profile from core side preparation
- 3: Naturally-backed débitage from core surface preparation
- 4: Partially-cortical débitage with plain butt and incurvate lateral profile from core side preparation
- 5: Classical Levallois flake from the final blow
- 6: Core in the final form

Fig.11 Products from Replication 3

- 1: Cortical débitage with incurvate lateral profile from core side preparation
- 2: Non-Levallois flake from core surface preparation
- 3: Levallois flake with crossed dorsal scars from core surface preparation
- 4: Classical Levallois flake from the final blow
- 5: Levallois blade with crossed dorsal scars from core surface preparation
- 6: Core in the final form

Fig.13 Products from Replication 4

- 1: Levallois blade with crossed dorsal scars from core surface preparation
- 2: Levallois flake with crossed dorsal scars from core surface preparation
- 3: Classical Levallois flake from core surface re-modification
- 4: Classical Levallois flake, obliquely split (▼), from the failed first final blow
- 5: Classical Levallois flake from core surface re-modification
- 6: Classical Levallois flake from core surface re-modification
- 7: Classical Levallois flake from the second final blow
- 8: Core in the final form

Fig.15 Products from Replication 5

- 1: Pseudo-Levallois point from core surface preparation
- 2: Levallois flake with crossed dorsal scars from core surface preparation
- 3: Classical Levallois flake from the final blow
- 4: Classical Levallois blade from core surface preparation
- 5: Core in the final form

Abbreviations in Tables

Ave. : Average; S.D. : Standard deviation;
N: Number of samples

Tables 2, 11, 20, 29, and 39

C.D. : Cortical débitage; P.C.D. : Partially-cortical débitage; N.B.D. : Naturally-backed débitage;
N.L.F. : Non-Levallois flakes; P.L.P. : Pseudo-Levallois points; N.L.B. : Non-Levallois blades;
C.L.F. : Classical Levallois flakes; C.L.B. : Classical Levallois blades

Tables 3, 12, 21, 30, and 40

Max. : Maximum value; Min. : Minimum value

Tables 4, 13, 22, 31, and 41

Max. : Maximum angles; Min. : Minimum angles

Tables 5, 14, 23, 32, and 42

Max. : Maximum number; Min. : Minimum number

Tables 6, 15, 24, 33, and 43

C. : Cortical; Pl. : Plain; C.D.F. : Convex dihedral faceted; S.M.F. : Straight multiple faceted;
C.M.F. : Convex multiple faceted; *Chap.* : in *Chapeau de gendarme*; B. : Broken

Tables 7, 16, 25, 34, and 44

Uni. : Unidirectional; B.O. : Bidirectional opposed; Cr. : Crossed; Cent. : Centripetal; Same : Single detachment in the same direction as débitage axis; Side : Single detachment from sideway of débitage axis; Opp. : Single detachment from opposite end of percussion point

Tables 8, 17, 26, 35, and 45

Pa. : Parallel; Co. : Converging; Ex. : Expanding; Bl. : Blunt; Po. : Pointed; Fl. : Flat;
In. : Incurvate; Tw. : Twisted

Table 1 Main Categories of Débitage Pieces from Replication 1

	Frequency
Cortical débitage	3
Partially-cortical débitage	3
Naturally-backed débitage	1
Non-cortical débitage	22
Unclassifiable débitage	2
Total	31

Table 2 Frequency of Débitage Categories of Different Types of Preparation Pieces from Replication 1

	C. D.	P. C. D.	N. B. D.	N. L. F.	P. L. P.	N. L. B.	C. L. F.
Core side preparation pieces (N=7)	3	3		1			
Core surface preparation pieces (N=18)			1	10		5	
Pieces from striking platform faceting (N=5)				3	1	1	
Finally-detached Levallois flake							1
Total	3	3	1	14	1	6	1

Table 3 Measurements (mm) of Butts, and Lengths, Widths and Thicknesses of Débitage Pieces from Replication 1

	Butt width				Butt thickness				Length				Width				Thickness			
	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.
Core side preparation pieces (N=7)	44	6	25.4	12.5	17	2	8.7	4.6	68	15	43.1	20.2	65	15	41.3	14.9	39	5	14.3	11.7
Core surface preparation pieces (N=18)	51	6	21.6	13.1	20	2	7.0	5.5	75	13	37.9	16.9	50	10	25.9	11.7	12	1	4.9	3.7
Pieces from striking platform faceting (N=5)	18	5	11.6	5.4	11	1	4.0	3.6	46	30	37.2	6.0	27	13	23.2	5.3	9	2	5.0	2.4
Finally-detached Levallois flake	35				12				86				61				10			

Table 4 Angle de chasses (°) of Débitage Pieces from Replication 1

	Max.	Min.	Ave.	S.D.
Core side preparation pieces (N=7)	90	35	65.6	19.0
Core surface preparation pieces (N=18)	84	45	68.9	9.7
Pieces from striking platform faceting (N=5)	83	81	82.3	0.9
Finally-detached Levallois flake	80			

Table 5 Dorsal Scar Numbers of Débitage Pieces from Replication 1

	Max.	Min.	Ave.	S.D.
Core side preparation pieces (N=7)	5	0	2.3	1.6
Core surface preparation pieces (N=18)	4	1	3.1	0.9
Pieces from striking platform faceting (N=5)	7	3	4.2	1.5
Finally-detached Levallois flake	14			

Table 6 Frequency of Butt Types of Débitage Pieces from Replication 1

	C.	Pl.	C. D. F.	S. M. F.	C. M. F.	Chap.
Core side preparation pieces (N=7)	7					
Core surface preparation pieces (N=18)	5	2	3	4	1	1
Pieces from striking platform faceting (N=5)	3	1				
Finally-detached Levallois flake					1	
Total	5	12	4	4	2	1

Table 7 Frequency of Dorsal Scar Patterns of Débitage Pieces from Replication 1

	Uni.	Cr.	Cent.	Side	Opp.
Core side preparation pieces (N=7)	1	1		2	1
Core surface preparation pieces (N=18)	1	11		2	
Pieces from striking platform faceting (N=5)	1	4			
Finally-detached Levallois flake			1		
Total	3	16	1	4	1

Table 8 Frequency of Dorsal/Distal Shapes and Lateral Profiles of Débitage Pieces from Replication 1

	Dorsal shapes			Distal shapes		Lateral profiles		
	Pa.	Co.	Ex.	Bl.	Po.	Fl.	In.	Tw.
Core side preparation pieces (N=7)	4	1	2	7		6	1	
Core surface preparation pieces (N=18)	7	6	4	17	1	15	1	1
Pieces from striking platform faceting (N=5)	1	4		3	2	1	3	1
Finally-detached Levallois flake	1			1		1		
Total	13	11	6	28	3	17	10	3

Table 9 Interrelationship between Dorsal Shapes and Distal Shapes of Débitage Pieces from Replication 1

Dorsal shapes	Distal shapes		Total
	Blunt	Pointed	
Parallel	13		13
Converging	8	3	11
Expanding	6		6
Total			30

Table 10 Main Categories of Débitage Pieces from Replication 2

	Frequency
Cortical débitage	1
Partially-cortical débitage	6
Naturally-backed débitage	3
Non-cortical débitage	17
Unclassifiable débitage	3
Total	30

Table 11 Frequency of Débitage Categories of Different Types of Preparation Pieces from Replication 2

	C. D.	P. C. D.	N. B. D.	N. L. F.	P. L. P.	C. L. F.
Core side preparation pieces (N=7)	1	6				
Core surface preparation pieces (N=21)			3	14	1	
Finally-detached Levallois flake						1
Total	1	6	3	14	1	1

Table 12 Measurements (mm) of Butts, and Lengths, Widths and Thicknesses of Débitage Pieces from Replication 2

	Butt width				Butt thickness				Length				Width				Thickness			
	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.
Core side preparation pieces (N=7)	36	9	24.3	8.5	22	2	8.8	6.5	47	24	32.9	6.7	39	17	29.6	7.5	14	2	7.7	3.7
Core surface preparation pieces (N=21)	56	8	22.7	11.4	14	2	7.1	3.2	50	19	31.4	8.1	74	17	34.8	11.4	8	3	5.1	1.8
Finally-detached Levallois flake	31								67				52				11			

Table 13 *Angle de chasses* (°) of Débitage Pieces from Replication 2

	Max.	Min.	Ave.	S.D.
Core side preparation pieces (N=7)	69	42	57.0	9.6
Core surface preparation pieces (N=21)	85	55	69.9	8.7
Finally-detached Levallois flake				

Table 14 Dorsal Scar Numbers of Débitage Pieces from Replication 2

	Max.	Min.	Ave.	S.D.
Core side preparation pieces (N=7)	3	1	1.3	0.7
Core surface preparation pieces (N=21)	6	1	3.8	1.9
Finally-detached Levallois flake	16			

Table 15 Frequency of Butt Types of Débitage Pieces from Replication 2

	C.	Pl.	C. D. F.	S. M. F.	C. M. F.	B.
Core side preparation pieces (N=7)	6					1
Core surface preparation pieces (N=21)	4	9	2	3	1	2
Finally-detached Levallois flake						1
Total	4	15	2	3	1	4

Table 16 Frequency of Dorsal Scar Patterns of Débitage Pieces from Replication 2

	Cr.	Cent.	Side	Opp.
Core side preparation pieces (N=7)	1		3	3
Core surface preparation pieces (N=21)	12	1	3	1
Finally-detached Levallois flake		1		
Total	13	2	6	4

Table 17 Frequency of Dorsal/Distal Shapes and Lateral Profiles of Débitage Pieces from Replication 2

	Dorsal shapes			Distal shapes		Lateral profiles	
	Pa.	Co.	Ex.	Bl.	Po.	Fl.	In.
Core side preparation pieces (N=7)	3	3	1	7		4	3
Core surface preparation pieces (N=21)	6	3	9	18	1	14	7
Finally-detached Levallois flake	1			1		1	
Total	10	6	10	26	1	19	10

Table 18 Interrelationship between Dorsal Shapes and Distal Shapes of Débitage Pieces from Replication 2

Dorsal shapes	Distal shapes		Total
	Blunt	Pointed	
Parallel	11		11
Converging	5	1	6
Expanding	10		10
Total			27

Table 19 Main Categories of Débitage Pieces from Replication 3

	Frequency
Cortical débitage	10
Partially-cortical débitage	17
Non-cortical débitage	34
Unclassifiable débitage	4
Total	65

Table 20 Frequency of Débitage Categories of Different Types of Preparation Pieces from Replication 3

	C. D.	P. C. D.	N. L. F.	N. L. B.	C. L. F.
Core side preparation pieces (N=24)	6	9	7	1	
Core surface preparation pieces (N=38)	4	8	22	2	
Finally-detached Levallois flake					1
Total	10	17	29	3	1

Table 21 Measurements (mm) of Butts, and Lengths, Widths and Thicknesses of Débitage Pieces from Replication 3

	Butt width				Butt thickness				Length				Width				Thickness			
	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.
Core side preparation pieces (N=24)	47	3	24.8	12.8	20	1	8.0	5.1	85	19	48.2	16.8	82	19	37.6	15.5	35	3	14.2	8.5
Core surface preparation pieces (N=38)	50	6	22.4	10.9	17	1	6.0	3.4	102	18	43.9	16.7	62	19	36.9	11.8	26	3	9.7	5.2
Finally-detached Levallois flake			37				10				60				62				10	

Table 22 *Angle de chasses* (°) of Débitage Pieces from Replication 3

	Max.	Min.	Ave.	S.D.
Core side preparation pieces (N=24)	89	50	70.1	12.3
Core surface preparation pieces (N=38)	85	45	70.5	9.9
Finally-detached Levallois flake			77	

Table 23 Dorsal Scar Numbers of Débitage Pieces from Replication 3

	Max.	Min.	Ave.	S.D.
Core side preparation pieces (N=24)	9	0	3.1	2.1
Core surface preparation pieces (N=38)	10	0	3.8	2.2
Finally-detached Levallois flake			14	

Table 24 Frequency of Butt Types of Débitage Pieces from Replication 3

	C.	Pl.	C. D. F.	S. M. F.	C. M. F.	B.
Core side preparation pieces (N=24)	1	15	4			1
Core surface preparation pieces (N=38)	3	14	8	4	2	6
Finally-detached Levallois flake					1	
Total	4	29	12	4	3	7

Table 25 Frequency of Dorsal Scar Patterns of Débitage Pieces from Replication 3

	Uni.	B.O.	Cr.	Cent.	Same	Side	Opp.
Core side preparation pieces (N=24)	7		9		1	2	
Core surface preparation pieces (N=38)	4	1	22	1	2	4	1
Finally-detached Levallois flake				1			
Total	11	1	31	2	3	6	1

Table 26 Frequency of Dorsal/Distal Shapes and Lateral Profiles of Débitage Pieces from Replication 3

	Dorsal shapes			Distal shapes		Lateral profiles		
	Pa.	Co.	Ex.	Bl.	Po.	Fl.	In.	Tw.
Core side preparation pieces (N=24)	8	6	10	21	3	11	9	4
Core surface preparation pieces (N=38)	7	9	21	36	1	25	12	1
Finally-detached Levallois flake			1	1			1	
Total	15	15	32	58	4	36	22	5

Table 27 Interrelationship between Dorsal Shapes and Distal Shapes of Débitage Pieces from Replication 3

Dorsal shapes	Distal shapes		Total
	Blunt	Pointed	
Parallel	16		16
Converging	11	4	15
Expanding	31		31
Total			62

Table 28 Main Categories of Débitage Pieces from Replication 4

	Frequency
Cortical débitage	4
Partially-cortical débitage	11
Non-cortical débitage	46
Unclassifiable débitage	3
Total	64

Table 29 Frequency of Débitage Categories of Different Types of Preparation Pieces from Replication 4

	C. D.	P. C. D.	N. L. F.	P. L. P.	N. L. B.	C. L. F.
Core side preparation pieces (N=20)	3	6	8	1	1	
Core surface preparation pieces (N=17)	1	4	6		5	
Failed Levallois flake						1
Core surface re-modification pieces (N=20)			16			3
Core side re-modification pieces (N=3)			3			
Finally-detached Levallois flake						1
Total	4	10	33	1	6	5

Table 30 Measurements (mm) of Butts, and Lengths, Widths and Thicknesses of Débitage Pieces from Replication 4

	Butt width				Butt thickness				Length				Width				Thickness			
	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.
Core side preparation pieces (N=20)	51	4	30.6	12.4	20	1	11.2	5.4	125	38	71.1	22.5	102	27	60.0	22.1	38	7	20.3	9.9
Core surface preparation pieces (N=17)	62	11	28.5	17.8	19	3	9.1	4.9	130	33	63.7	24.5	95	13	45.3	25.5	35	2	11.3	9.3
Failed Levallois flake	60								80				74				9			
Core surface re-modification pieces (N=20)	46	13	27.7	10.3	16	3	6.6	3.2	72	22	43.3	12.5	58	25	38.7	10.6	13	3	6.5	2.4
Core side re-modification pieces (N=3)	50	9	25.0	17.9	18	3	8.3	6.8	50	48	49.0	0.8	60	30	42.3	12.8	12	5	8.3	2.9
Finally-detached Levallois flake									77				44				10			

Table 31 *Angle de chasses* (°) of Débitage Pieces from Replication 4

	Max.	Min.	Ave.	S.D.
Core side preparation pieces (N=20)	90	57	67.9	8.3
Core surface preparation pieces (N=17)	85	57	72.3	8.2
Failed Levallois flake				
Core surface re-modification pieces (N=20)	84	49	73.8	8.2
Core side re-modification pieces (N=3)	78	65	72.3	5.4
Finally-detached Levallois flake			87	

Table 32 Dorsal Scar Numbers of Débitage Pieces from Replication 4

	Max.	Min.	Ave.	S.D.
Core side preparation pieces (N=20)	7	0	2.7	1.9
Core surface preparation pieces (N=17)	9	0	3.5	2.1
Failed Levallois flake			7	
Core surface re-modification pieces (N=20)	9	2	4.6	2.0
Core side re-modification pieces (N=3)	6	3	5.0	1.4
Finally-detached Levallois flake			13	

Table 33 Frequency of Butt Types of Débitage Pieces from Replication 4

	Pl.	C. D. F.	S. M. F.	C. M. F.	B.
Core side preparation pieces (N=20)	15	1	1		1
Core surface preparation pieces (N=17)	6	3	2	1	3
Failed Levallois flake					1
Core surface re-modification pieces (N=20)	1	8	3	5	2
Core side re-modification pieces (N=3)	1	2			
Finally-detached Levallois flake					1
Total	23	14	6	6	8

Table 34 Frequency of Dorsal Scar Patterns of Débitage Pieces from Replication 4

	Uni.	B. O.	Cr.	Cent.	Same	Side
Core side preparation pieces (N=20)	4	1	6		1	5
Core surface preparation pieces (N=17)			8	1	1	5
Failed Levallois flake				1		
Core surface re-modification pieces (N=20)			14	4		2
Core side re-modification pieces (N=3)	1		2			
Finally-detached Levallois flake				1		
Total	5	1	30	7	2	12

Table 35 Frequency of Dorsal/Distal Shapes and Lateral Profiles of Débitage Pieces from Replication 4

	Dorsal shapes			Distal shapes		Lateral profiles	
	Pa.	Co.	Ex.	Bl.	Po.	Fl.	In.
Core side preparation pieces (N=20)	2	6	11	18	1	10	9
Core surface preparation pieces (N=17)	6	3	7	15	2	5	11
Failed Levallois flake	1			1			1
Core surface re-modification pieces (N=20)	8	5	7	18	2	7	12
Core side re-modification pieces (N=3)	1	1	1	3			3
Finally-detached Levallois flake	1			1			1
Total	19	15	26	56	5	22	37

Table 36 Interrelationship between Dorsal Shapes and Distal Shapes of Débitage Pieces from Replication 4

Dorsal shapes	Distal shapes		Total
	Blunt	Pointed	
Parallel	19		19
Converging	10	5	15
Expanding	28		28
Total			62

Table 37 Features of By-products Levallois Classical from Replication 4

	Butt width	Butt thickness	Length	Width	Thickness	Angle de chasse	Dorsal scar number	Butt type
Sample 1	46 mm	9 mm	37 mm	52 mm	8 mm	81°	6	Straight multiple faceted
Sample 2	18 mm	6 mm	60 mm	38 mm	7 mm	66°	8	Straight multiple faceted
Sample 3	13 mm	3 mm	58 mm	36 mm	7 mm	84°	7	Convex dihedral faceted

Table 38 Main Categories of Débitage Pieces from Replication 5

	Frequency
Cortical débitage	5
Partially-cortical débitage	13
Non-cortical débitage	27
Total	45

Table 39 Frequency of Débitage Categories of Different Types of Preparation Pieces from Replication 5

	C. D.	P. C. D.	N. L. F.	P. L. P.	N. L. B.	C. L. F.	C. L. B.
Core side preparation pieces (N=11)	2	5	3	1			
Core surface preparation pieces (N=33)	3	8	16	4	1		1
Finally-detached Levallois flake						1	
Total	5	13	19	5	1	1	1

Table 40 Measurements (mm) of Butts, and Lengths, Widths and Thicknesses of Débitage Pieces from Replication 5

	Butt width				Butt thickness				Length				Width				Thickness			
	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.	Max.	Min.	Ave.	S.D.
Core side preparation pieces (N=11)	57	8	37.4	15.2	23	4	9.4	5.8	88	37	59.4	14.8	83	29	56.8	16.4	38	2	15.4	9.4
Core surface preparation pieces (N=33)	83	5	27.7	17.4	17	1	6.6	4.1	81	20	50.3	15.6	120	16	47.4	19.5	23	2	8.9	5.4
Finally-detached Levallois flake	42				5				100				78				10			

Table 41 *Angle de chasses* (°) of Débitage Pieces from Replication 5

	Max.	Min.	Ave.	S. D.
Core side preparation pieces (N=11)	86	61	78.4	9.6
Core surface preparation pieces (N=33)	90	37	69.8	12.8
Finally-detached Levallois flake	78			

Table 42 Dorsal Scar Numbers of Débitage Pieces from Replication 5

	Max.	Min.	Ave.	S. D.
Core side preparation pieces (N=11)	6	0	3.0	2.3
Core surface preparation pieces (N=33)	10	0	4.1	2.4
Finally-detached Levallois flake	15			

Table 43 Frequency of Butt Types of Débitage Pieces from Replication 5

	C.	Pl.	C. D. F.	S. M. F.	C. M. F.	B.
Core side preparation pieces (N=11)		5	2		1	1
Core surface preparation pieces (N=33)	2	13	9	1	2	4
Finally-detached Levallois flake					1	
Total	2	18	11	1	4	5

Table 44 Frequency of Dorsal Scar Patterns of Débitage Pieces from Replication 5

	Uni.	B. O.	Cr.	Cent.	Side
Core side preparation pieces (N=11)	2		4		3
Core surface preparation pieces (N=33)	3	1	19	3	6
Finally-detached Levallois flake				1	
Total	5	1	23	4	9

Table 45 Frequency of Dorsal/Distal Shapes and Lateral Profiles of D bitage Pieces from Replication 5

	Dorsal shapes			Distal shapes		Lateral profiles	
	Pa.	Co.	Ex.	Bl.	Po.	Fl.	In.
Core side preparation pieces (N=11)	2	2	7	11		3	7
Core surface preparation pieces (N=33)	8	11	13	32	1	26	7
Finally-detached Levallois flake			1	1			1
Total	10	13	21	44	1	29	15

Table 46 Interrelationship between Dorsal Shapes and Distal Shapes of D bitage Pieces from Replication 5

Dorsal shapes	Distal shapes		Total
	Blunt	Pointed	
Parallel	10		10
Converging	12	1	13
Expanding	21		21
Total			44