Man is a learner: transmission of technical know-how among knappers. The development of simple productions in post-Linear Pottery cultures in the German Rhineland

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Abstract – This paper focuses on the Rhine-Meuse region, with particular attention to the lithic industries of six archaeological sites located on the Aldenhoven Plateau and its surrounding areas. These sites represent a continuous chronological sequence, spanning from the late Grossgartach phase to the late Rössen culture. Through detailed technological analysis, two main production systems have been identified at the post-LBK sites of the Cologne Bay: blade production and what is referred to as *"simple production."* The latter is a broad category encompassing diverse practices such as the use of debris, blocks or cores, the production of flakes, and the activities of inexperienced knappers. The appearance of dedicated flake production marks a significant departure from the earlier LBK blade-based tradition and represents a notable technological innovation. This change in lithic organization is closely associated with the Rössen culture and may also reflect interactions with Blicquy / Villeneuve-Saint-Germain communities, influencing developments in the Rhineland.

Key words – archaeology; Neolithic; lithic industry; Post-Linear Pottery Cultures; Rhineland; lithic technology; simple productions

Titel – Der Mensch ist ein Lernender: Über die Weitergabe von technischem Wissen unter Steinschlägern – Die Entwicklung einer einfachen Produktionsweise in den post-linearbandkeramischen Kulturen im Rheinland

Zusammenfassung – Dieser Aufsatz fokussiert auf die Rhein-Maas-Region und die lithischen Industrien von sechs archäologischen Fundstellen auf der Aldenhovener Platte und ihrer Umgebung. Diese Fundstellen bilden eine kontinuierliche chronologische Abfolge, die von der späten Grossgartach-Phase bis zur späten Rössener Kultur reicht. Durch eine detaillierte technologische Analyse konnten an den post-LBK-Fundstellen der Kölner Bucht zwei Hauptproduktionssysteme identifiziert werden: die Klingenproduktion und die sogenannten *„einfachen Produktionen"*. Letztere bilden eine weit gefasste Kategorie, die verschiedene Praktiken beinhaltet, wie z.B. die Nutzung von Abschlagsmaterial, unbearbeiteten Blöcken oder Kernen, die Herstellung von Abschlägen sowie die Aktivitäten unerfahrener oder junger Feuersteinschläger. Das Auftreten einer gezielten Abschlagproduktion stellt einen bedeutenden Bruch mit der vorhergehenden, auf Klingen basierenden LBK-Tradition dar und markiert eine bemerkenswerte technologische Neuerung. Dieser Wandel in der Organisation der Steinartefaktherstellung steht in engem Zusammenhang mit der Rössener Kultur und könnte auch durch Interaktionen mit Gemeinschaften der Blicquy- / Villeneuve-Saint-Germain-Gruppe beeinflusst worden sein, die Entwicklungen im Rheinland mitgeprägt haben.

Schlüsselworte – Archäologie; Neolithikum; Lithik; Post-Linearbandkeramik; Rheinland; Aldenhovener Platte; lithische Technologie; einfache Produktion

Introduction: archaeological context

The Central European Neolithic develops with the Linear Pottery Culture (hereafter LBK), which emerges in Transdanubia (Hungary) on a Starčevo culture substratum (Balkan Early Neolithic) around the 54th century BCE (Jakucs et al., 2016). From there, the bearers of the Linear Pottery culture spread the agro-pastoral way of life, rapidly colonizing territories stretching from the Paris Basin in the west to Ukraine in the east. However, a historical break in this colonisation is evident in the 6th and 5th millennia BCE. The LBK broke up into a mosaic of cultural entities. These cultural entities are mostly defined by the stylistic homogeneity of their material culture. On this Danubian substratum, the post-LBK cultural fragmentation resulted in the emergence of numerous archaeological cultures throughout Central and Western Europe, sharing an LBK heritage and their own characteristics. Our study focuses on the German Rhineland and Belgium. Here, these new post-LBK ensembles are embodied by:

- the Blicquy/Villeneuve-Saint-Germain (BQY/VSG) culture in the northern half of France and Belgium (Constantin & Demarez, 1984) (4950/4900 – 4700/4650 BC; Dubouloz, 2003);
- the Hinkelstein (HST), Grossgartach (GG), Planig-Friedberg (PF) and Rössen (Rö) sequence in western Germany. The Hinkelstein emerges around the Middle/Upper Rhine and the Neckar and Main valleys (Meier-Arendt, 1975). The Grossgartach culture is divided into three stages and it seems that it is during the middle stage that a significant geographical extension is observed, especially to the north. The Aldenhoven Plateau (North Rhine-Westphalia) was probably only reoccupied at this time, following the clear depopulation highlighted at the end of the LBK (Zimmermann,

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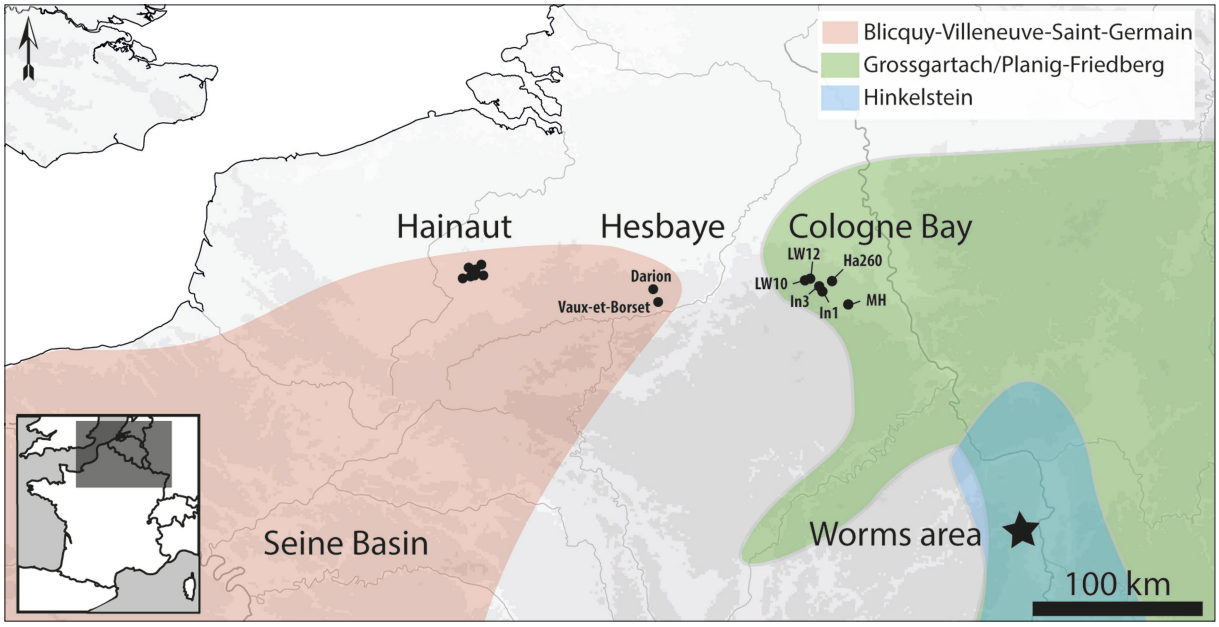

Fig. 1 Map of the chrono-cultural entities of the studied area and regions mentioned within the text from Denis et al. 2019 modified. LW10: Langweiler 10; LW12: Langweiler 12; In1: Inden 1; In3: Inden 3; MH: Müddersheim. These abbreviations will be employed in the other figures and tables. The black stars indicate the locations of the sites in the Worms area (Worms, Monsheim, Alzey) which are used for comparison purposes.

2009), which could result from the mobility of these groups towards Dutch Limburg (Balkowski, 2017) (in the Rhineland, GG/PF: 4950 – 4750 BC; Rö: 4750 – 4600 BC, according to Gehlen & Schön, 2007).

We focus on the area located in the Rhine/Meuse area, where, after the LBK, the populations belonged to these two different cultural entities (**Fig. 1**). In the westernmost part of the area, a cluster of BQY/VSG sites has been discovered in the Hainaut. Some 100 km to the East – i.e. in the Hesbaye region in Belgium –, two sites have been also attributed to the Blicquy/Villeneuve-Saint-Germain culture. In the eastern part – i.e. the Cologne Bay in Germany – a cluster of settlements was created by Grossgartach, Planig-Friedberg then Rössen populations (hereafter Rhineland cultures). The two entities were partially contemporaneous and various strands of evidence have been used to highlight inter-cultural exchanges (Gehlen & Schön, 2007):

- the discovery of Blicquy sherds at Langweiler 10 and 12 (Spatz, 1991);
- the identification of specific tools, such as transversal arrowheads, related to BQY/VSG contexts (Gehlen & Schön, 2009b, 597); *burin, quartier d'orange* or *tranchet* (Gehlen & Schön, 2009b, 600);
- personal ornaments like the schist bracelet discovered at Inden 3 (**Fig. 2**) (Gehlen & Schön, 2007, 637);
- exogeneous siliceous raw materials from Belgium: Campanian flint from Hesbaye and Obourg flint from Hainaut (Gehlen & Schön, 2007; 2009a). The latter is probably not a raw material that originated in Belgium (Denis, Gjesfjeld & Moreau, 2019). But a blade of Ghlin flint, similar to a core discovered on the BQY site of Vaux-et-Borset, was also identified at Hambach 260, confirming the existence of exogenous materials from Belgium (Denis, 2020).

The analysis of raw material circulation has highlighted that the inter-cultural links seem more significant with Eastern Belgium (Denis, 2020; Denis et al., 2019). In this paper, we suggest that these contacts may also have been at the root of a shift in the production organization of these Rhineland cultures.

Material and Method

The material selected for this study comes from six sites. Five are located along the Merzbach valley, covering the entire chronological sequence from late Grossgartach to late Rössen (**Fig. 3**). We also include the site of Müddersheim as a point of comparison due to its eastern location compared to the others. Unfortunately, we were not able to find the material from the earliest post-LBK site of Hasselsweiler 1. These sites have been broad-

Fig. 2 Photo of the schist bracelet discovered at Inden 3. Picture: S. Denis.

ly described elsewhere and we invite interested readers to refer to these publications for more information (synthesis in Gehlen, Langenbrink & Gaffrey, 2009; Gehlen & Schön, 2009a; Nowak, 2013, 182-183). For comparison purposes, we will refer to data from the Hesbaye BQY sites (mostly Vaux-et-Borset, according to Denis, 2017) and the HST core area of the Worms region (Worms, Alzey and Monsheim locations, where, at least in the case of the latter, non-burial pits have been identified; Denis, in prep.).

The studied selection of lithics represents a total of 2,220 pieces (**Fig. 4**). These collections are part of the research area explored in connection with lignite mining and exploitation which led to the development of the *Siedlungsarchäologie auf der Aldenhovener Platte* (SAP) project in the 1970s. Most of the siliceous material has been recorded under the SAP system (see Zimmermann, 1988) within the framework of the *Recording of lithic materials from Early and Middle Neolithic complexes* project, funded by the *"Foundation for the Promotion of Archaeology in the Rhine Lignite Basin"*. The project was supervised by Prof. Dr. Andreas Zim-

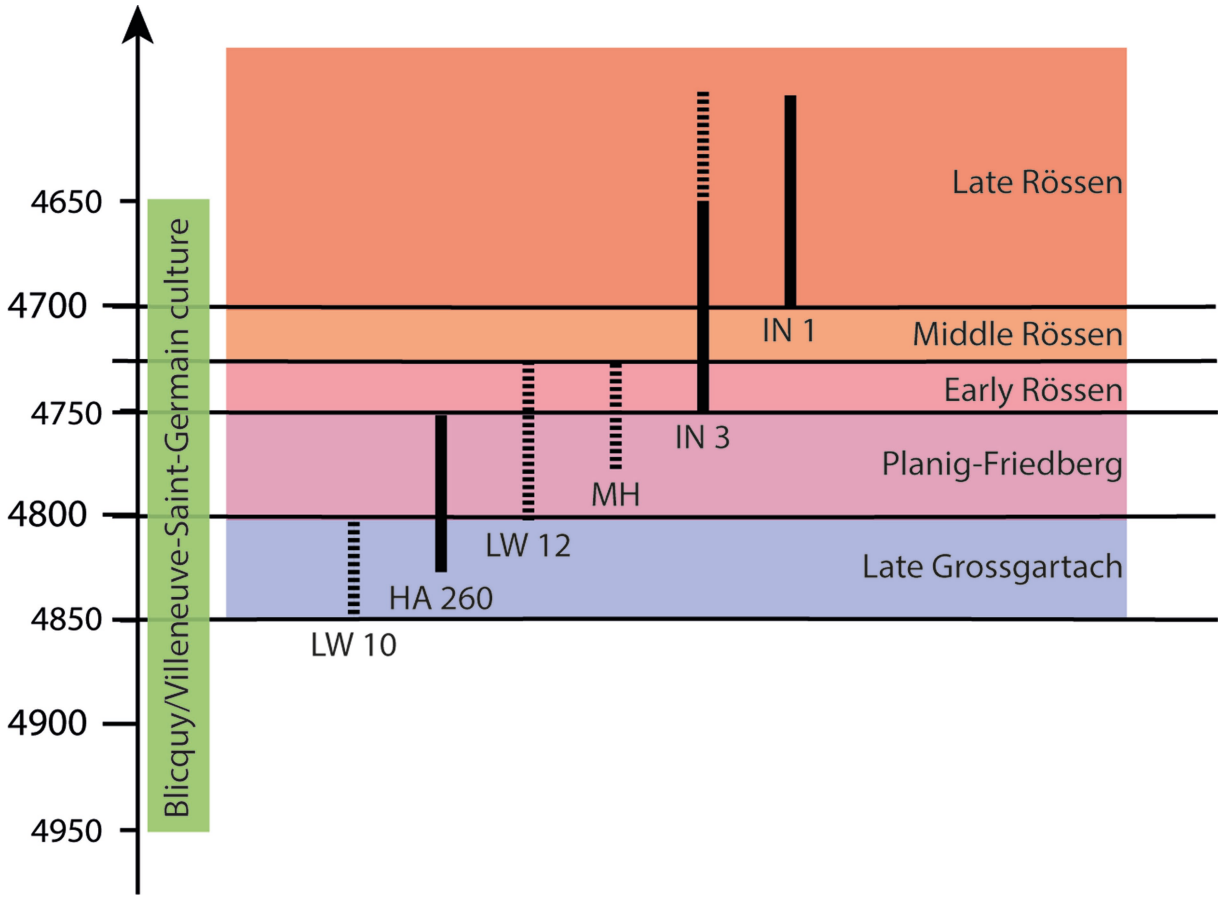

Fig. 3 Chronological attribution of the studied sites, according to Gehlen & Schön (2007). Dotted lines refer to chronologies established without absolute dates.

sites	nbre	weight (en g)
LW10	108	486
LW12	117	1595
HA260	213	1654
MH433	556	2955
IN3	221	1944
IN1	1005	9865
total	**2220**	**18499**

Fig. 4 Table presenting the collections under study for this paper, in numbers and weight.

mermann and conducted by B. Langenbrink(†) and subsequently by B. Gehlen and W. Schön (Gehlen, 2009a; 2009b; Gehlen et al., 2009; Gehlen & Schön, 2009b; 2009a; Langenbrink, 1996; Schön, 2009; Zimmermann & Gehlen, 2002).

Here, a different approach is used. The method relies on the technological analysis of stone tool production. The difference with the SAP system is the introduction of qualitative observations to identify the *chaîne opératoire* of the production (see Scharl et al., 2021 for a discussion regarding both approaches). The technological approach to lithic analysis emerged in France in the 1960s with the development of the methodological concept of the *chaîne opératoire* by A. Leroi-Gourhan (Leroi-Gourhan, 1964). The *chaîne opératoire* divides the technical process into different steps that allows a strategic and rigorous reading of the technical action, which is then deciphered from two angles: method and technique. Defined by Jacques Tixier (1967), the term "*method*" describes the arrangement (order and combination) of the various gestures involved, whereas the "*technique*" concerns the mode of action on the material. The Neolithic assemblages (notion from Binder, 1998) under study are characterized by an admixture of waste from different productions, almost devoid of any refitting. This involves the use of mental refitting, which requires the systematic realisation of diacritical sketches to establish the *chaînes opératoires*. The understanding of the *chaîne opératoire* allows us to estimate the place of each piece within the process. Here, the focus is on the distinctions between the different kinds of productions within the assemblages. The first step is to distinguish between waste and products resulting from blade production and those attributable to other types of production. While blade cores and blades are relatively easy to identify, assigning flakes to specific production sequences can be more challenging, which explains the presence of indeterminate artefacts in the tables.

The identification of blade-production waste relies on two main criteria: analysis of diacritical sketches and the percussion technique employed. Indeed, most flakes produced beyond the initial phase of the blade *chaîne opératoire* — including those from crest preparation — are struck using indirect percussion. This technique is not used in the other *chaînes opératoires* identified at the sites, which instead are carried out using direct percussion with a hard hammerstone. Indirect percussion can be clearly distinguished from hard-hammer percussion on the basis of several features: the absence of an impact point, the frequent concavity of the butt, the possible presence of a lip or a half-moon (see Allard & Denis, 2022), and the general absence of pronounced fracture features such as fissures or bulb scars (*étoilures* for example, see Inizan et al., 1995).

This technological diagnosis must be combined with analysis of diacritical sketches, which allows the identification of specific flake types:

- Flakes from crest preparation: these generally display an S profile, may retain remnants of cortex on the distal part, and exhibit unipolar parallel negatives. A characteristic feature is the frequent presence on the butt of counter-bulbs from earlier removals.
- Flakes from platform maintenance: these often preserve the proximal parts of the previous blades on the butt and sometimes on the lateral edges. The angle between these preserved surfaces and the striking platform, which forms the dorsal face of the flake, tends to be close to 90°. Negatives of removals from previous rejuvenation phases often appear convergent.
- Flakes from convexity maintenance: these are morphologically diverse. The base of the core is often used for this purpose (especially for working on the longitudinal convexities), resulting in flakes that bear dorsal blade negatives in the opposite direction to the flake's removal axis. The proximal part is generally thicker than the distal part, allowing convexities to be re-established upon removal. The same pattern is observed when flakes are detached from the main platform, particularly along the lateral edges of the core, to reconfigure transversal convexities. These flakes are short, do not cover the entire blade surface, but tend to be thin toward the distal part and do not disrupt the overall core morphology.
- Flakes from accident correction: these are used to address errors in the *débitage*, such as the for-

mation of hinged terminations. These flakes can often be recognised by the presence of a portion of the hinged surface removed along with the flake itself. Hinges can also be removed using flakes struck from the base of the core, in which case the dorsal negatives are opposed in direction. Additionally, new crests — or neo-crests — may be established during blade production to correct such problems or maintain convexities. These flakes are easily identified by their transverse blade negatives.

— Rare large flakes reflect certain stages of core reshaping. These can sometimes be difficult to distinguish from flakes removed to produce new blanks or to reconfigure the core for further production sequences during a phase of recycling/reuse.

Once all elements related to blade production have been separated, it becomes easier to assess the status of the remaining artefacts. These pieces bear traces characteristic of direct percussion with a hard hammer stone (especially characterised by prominent bulbs of percussion, well-developed impact points, waves and ripples on the lower face, see Pelegrin, 2000), or in some cases, split fractures (no bulb, strong waves, crushed butt or proximal part, flat and straight profile).

They comprise various debris, flakes and flake cores (or *"faceted pieces"* when the intentions are unclear, see Denis, 2019). The technical features of these artefacts do not indicate any predetermined *chaîne opératoire*. Instead, they reflect non-standardised production methods that contrast with the structured and formalised *chaîne opératoire* associated with blade manufacture. The quality of the raw materials employed in these *"simple"* productions is often lower than that used for blade production. The raw materials exploited by these Grossgartach, Planig-Friedberg and Rössen populations have been studied in depth (Gehlen et al., 2009; Gehlen & Schön, 2009a; Nowak, 2013; 2014). Most of the materials can be identified as cretaceous flint belonging to the *"Lanaye Member"* and originating from the Belgian and Dutch Limburg (de Grooth, 2011, 110-111). A distinction is made between two types of Lanaye flint: the Rullen type and the Rijckholt type (Löhr, Zimmermann & Hahn, 1977, 162-163; Zimmermann, 1988, 606-608). A detailed description of these types is provided by M. Th. de Grooth (2011, 121-123), who also offers a further classification of the Lanaye flint. Sources of these flint types can be found at distances of about 30 to 40 km from the research area (Albers & Felder, 1999; Löhr et al., 1977). They largely dominate the entire collection under examination. In addition, some local gravels have also been exploited but this material is of low quantity. Other pieces seem to originate from more distant sources, some probably from elsewhere in Belgium (e.g. Campanian flint from Hesbaye). However, it has to be stressed that a great deal of work remains to be done to better differentiate raw materials from Belgium and Dutch Limburg (Scharl et al., 2021).

Results

The classification of blank types reveals a high degree of variability between sites (**Fig. 5**), which is not related to sampling biases as the corpus from

site	LW10		Ha260		LW12		MH		IN3		IN1	
	nb	%	nb	%	nb	%	nb	%	nb	%	nb	%
blade/ elet	14	13,0	87	40,8	24	20,5	31	5,6	66	29,9	233	23,2
flake	49	45,4	91	42,7	55	47,0	392	70,5	87	39,4	434	43,2
block	3	2,8	1	0,5	2	1,7	5	0,9	1	0,5	26	2,6
debris	6	5,6	10	4,7	9	7,7	11	2,0	16	7,2	54	5,4
tool spall	-	-	3	1,4	6	5,1	2	0,4	18	8,1	80	8,0
indet.	3	2,8	2	0,9	9	7,7	2	0,4	7	3,2	42	4,2
small flake	33	30,6	19	8,9	12	10,3	113	20,3	26	11,8	136	13,5
total	**108**	100	**213**	100	**117**	100	**556**	100	**221**	100	**1005**	100

Fig. 5 Table presenting the classification of lithic artefacts according to the nature of the blank (in numbers and %).

each site is sufficiently large. First, the easternmost site of Müddersheim appears to be particularly unusual. It has yielded a very high number of flakes and very few blades. It is also characterized by a large quantity of small flakes, defined as being smaller than 20×20 mm. These are even more numerous at the Langweiler 10 site which also displays, as does Müddersheim, a lower number of blades compared to the other sites. For its part, Hambach 260 has yielded the highest number of blades.

These differences can be better explained by analysing the productions themselves. We can identify two main groups of productions: blade productions and simple productions.

The attribution of the different pieces to their respective productions allows an insight into the evolution of the organization of the production (**Fig. 6**). This shift is related to the transition between Planig-Friedberg and Rössen. On the sites of Langweiler 10 and Hambach 260, the tool blanks are mainly produced from blades and waste from blade production. Simple productions seem to have more importance on the sites of Langweiler 12, Inden 3 and Inden 1. Müddersheim appears to be an exception to this because blade production is highly dominant. Almost all the flakes identified in Müddersheim were produced within the blade *chaîne opératoire* (see Section 2 for the description of the characteristics). A straightforward quantification of the different stages of the *chaîne opératoire* enables the visualization of the site's status through techno-economic diagrams, providing insights into the production strategies and economic organization within the sites (**Fig. 7**). In **Figure 7**, the sites that are contained within the white rectangle area can be considered as consistent with local blade production and consumption as seems to be the case for Hambach 260. Müddersheim exhibits a higher proportion of shaping and maintenance waste alongside a deficit of blades and cores, suggesting a spatial segmentation of the *chaîne opératoire* whereby blades and preforms may have been transported away from the site, or at least from this particular area. This pattern could be interpreted as being indicative of a redistribution site. Langweiler 10 displays a slightly different profile, but the deficit of blades similarly suggests that they were likely transported away from the site, or at least from this specific area. This spatial segmentation of the *chaîne opératoire* appears less marked at the more recent Inden sites.

Simple productions are different and highlight different technical behaviours:

- the use of debris or gravel, raw or retouched. Use-wear analysis is required to determine the related activity;
- the knapping of flakes;
- the use of blocks or cores mostly as hammers;
- the presence of waste from the work of less-skilled knappers.

site	LW10		Ha260		LW12		MH		IN3		IN1	
	nb	%	nb	%	nb	%	nb	%	nb	%	nb	%
laminar	60	55,6	164	77,0	57	48,7	411	73,9	118	53,4	457	45,5
simple	3	2,8	15	7,0	21	17,9	5	0,9	26	11,8	197	19,6
indet	45	41,7	34	16,0	39	33,3	140	25,2	77	34,8	351	34,9
total	**108**	100	**213**	100	**117**	100	**556**	100	**221**	100	**1005**	100

Fig. 6 Table presenting the attribution of the different artefacts to their production (in numbers and %).

These technical behaviours are often linked to poorer quality raw materials or inadequate morpho-dimensional characteristics to obtain blades. Gravels are often used for simple productions. For example, some of the gravels were used as splintered pieces (**Fig. 8**). They were initially fractured, perhaps by percussion on an anvil. The use and probably the preparation of these tools create waste characterized by split fracture.

The second technical behaviour evident among these simple productions is the production of flakes. Most of the cores identified are blade cores that have been reused to produce flake blanks by direct percussion with a hard hammer stone (**Fig. 9**, n° 1 et 2). The recycling of blade cores to produce flakes occurs almost exclusively in Langweiler 12. Flakes produced can reach up to 40 mm in length and 25 mm width (**Fig. 9**, n°1) for the largest and they seem to have been produced mostly by a succession of unipolar

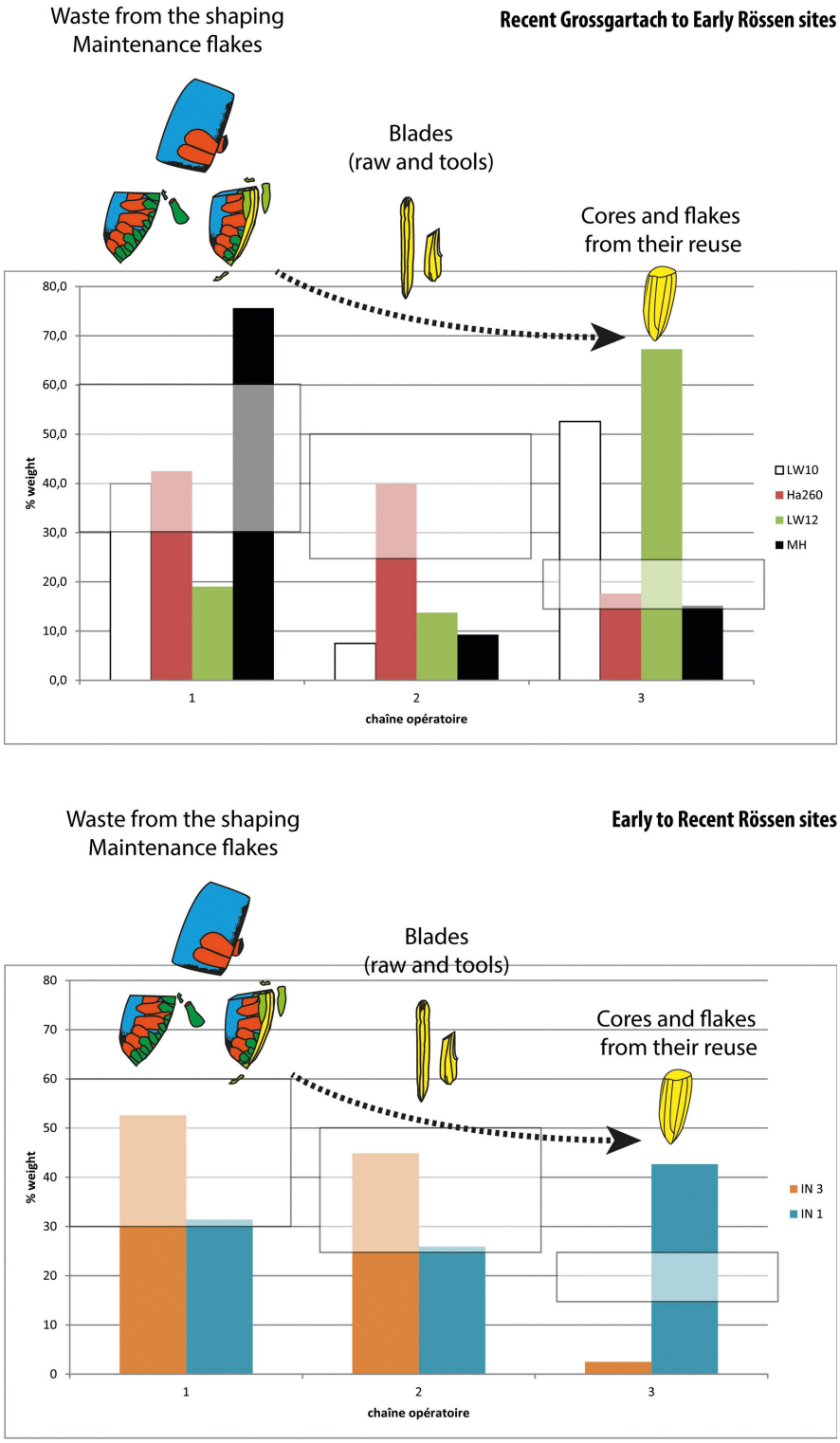

Fig. 7 Simplified techno-economic diagrams of the blade production on Rullen flint. First graph groups together sites from the beginning of the chronological sequence under study (from recent Grossgartach to early Rössen); second graph is related to the second part of the chronological sequence (between early Rössen to recent Rössen). N° 1 corresponds to the waste arising from the shaping out and maintenance of the cores. N° 2 are the blades. N° 3 corresponds to the cores and flakes from their reuse. In white: expected volume (% weight) of pieces related to this kind of debitage, based on the experiment of Jacques Pelegrin (CNRS UMR 8068), oral communication.

débitage sequences. However, Inden 1 has yielded flake cores that are not related to blade production waste. This shows that these two productions are independent. Several cores were exploited using centripetal *débitage* to produce discoid cores that were knapped by direct percussion with a hard hammer stone. Sometimes, the negatives of the removals on the cores are very small and are

Fig. 8 Splintered piece made on a small piece of flint gravel. Inden 1. Picture: S. Denis.

not the right size required for flake tools (e.g. end of exploitation of **Fig. 9**, n° 2). This inconsistency raises the question of whether these faceted pieces are tools or cores (Allard, 1999; Denis, 2019). A use-wear analysis would be the best method to resolve this issue. Inden 1 is also the only site where flakes were produced from former polished axes.

The third technical behaviour is the use of raw blocks/debris of silicite or cores as hammers. The term *"hammer"* will be used here in a broad sense, without presuming the exact function of the pieces. It will be used to describe artefacts bearing use zones characterised by crushed and pecked surfaces (see **Fig. 10** for an example), which may appear either fresh and sharply defined or rounded and abraded as a result of use. Blade cores were often reused as hammers. This can lead to some adjustment of the morphology of the core and to some waste linked to the use of the tool. The related flakes or tool spalls can thus be isolated. Furthermore, it happens that some blocks were specifically shaped to produce these tools (**Fig. 10**).

Finally, we identify a number of artefacts that could be related to the work of inexperienced knappers. The example presented here is small debris measuring 40 x 30 x 12 mm (**Fig. 11**). Four little elongated flakes have been knapped from a flat platform. One is hinged. The longest one measures 16 x 7 mm. This kind of blank is absent from the tool blanks record. This demonstrates a certain inconsistency with the production objectives and a deviation from the expected *chaîne opératoire*. Including the hinged removal negatives, these are criteria that point to a low level of know-how (Bamforth & Finlay, 2008; Klaric, 2018), so probably represent the work of an inexperienced knapper. This technical behaviour relies on the existence of inexperienced knappers within the settlement and thus highlights the organization of apprenticeship. It is not to be confused with the production objectives pursued by effective knappers but it is equally not to be equated with the behaviours previously described above.

Figure 12 presents a synthesis of the various technical behaviours identified at the different sites. We observe that there is a larger range of variability in the simple productions within the sites of Inden and a broader range of tools related to these simple productions at the more recent site of Inden 1.

Discussion

These simple productions are defined in a very general way by the exploitation of small blocks/gravel/debris, employing hard percussion or an anvil (especially for gravel), using gestures that have little or no relation to pre-determined *chaînes opératoires*; the aim was (i) to shape massive tools (e.g. hammers, splintered pieces) or (ii) to produce irregular flake blanks for the manufacture of retouched flakes, denticulated and splintered pieces, and sometimes scrapers.

These kinds of tools are not an innovation in themselves because they also occur in LBK assemblages (e.g. Allard, 2005; Zimmermann, 1995). In fact, it is the selection of blanks that differs. For instance, splintered pieces used to be mostly produced on blades within LBK settlements, except for the sites located far from the raw material sources where small alluvial blocks or gravel were often used (Allard, 2005). Thus, the difference between the LBK and post-LBK lies in the selection of blanks and the frequency of some of these specific tools. Denticulated pieces or hammers may have been more frequently produced by post-LBK groups. Further use-wear analysis is essential to have a better picture of the increase in simple productions in post-LBK contexts. Recent use-wear analysis has been conducted on faceted tools attributed to simple productions from the BQY/VSG and Swifterbant cultures (Halbrucker et al., 2022). This study shows that the tools were primarily used for crushing, pecking, and battering hard animal materials, like bone, and fish. In Early Neolithic contexts, however, they appear to have been used for more diverse activities, including for stone-working. The use-wear results underline that both cultural areas, are involved in bone crushing using these tools. Hypothetically, this could be linked to marrow or fat extraction, glue production, or pottery tempering. Do these simple productions represent a

transfer or adaptation of LBK-related activities into a new toolkit? Alternatively, could these simple productions reflect the emergence of new activities within these cultural contexts? Whatever the case

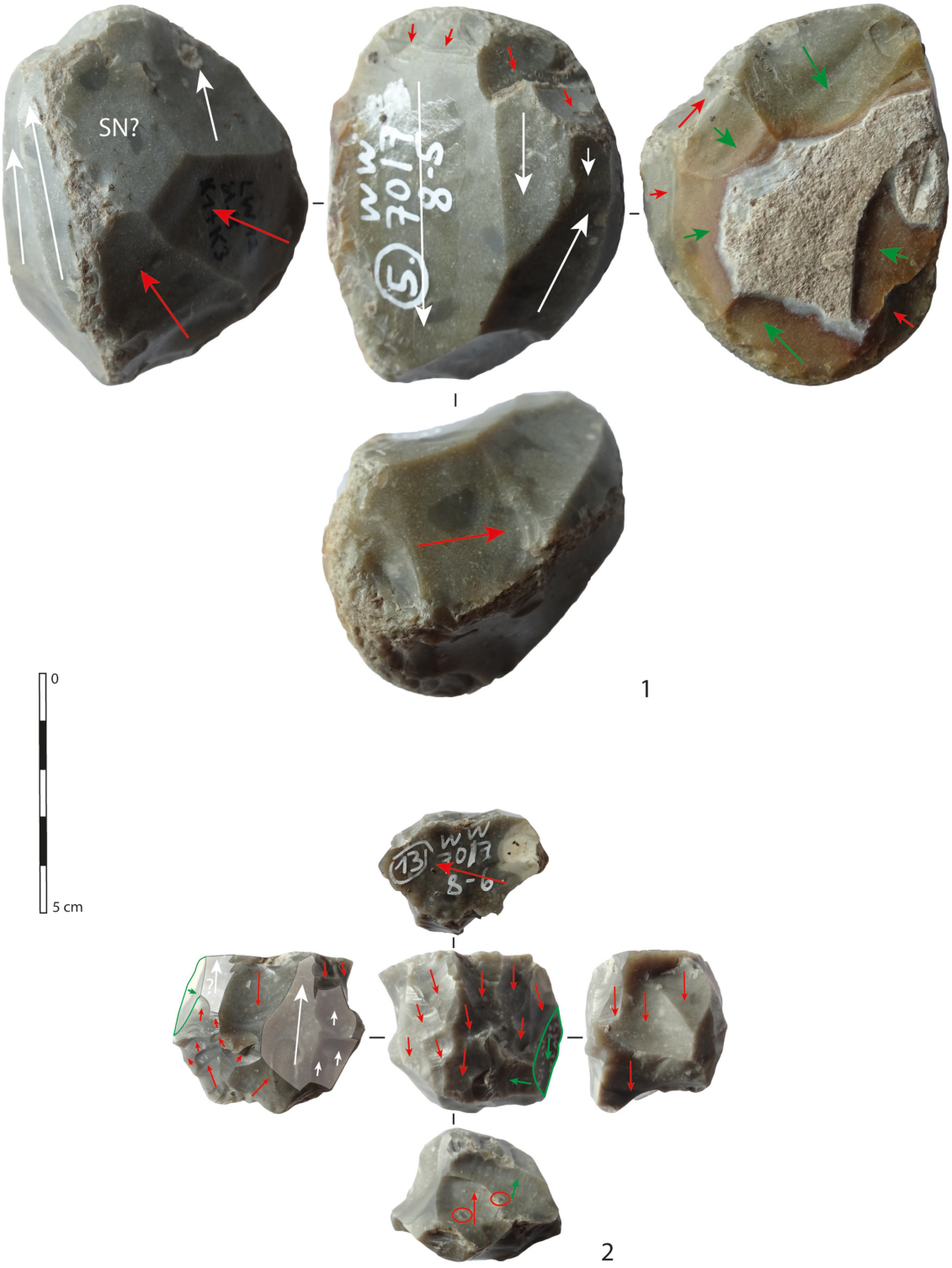

Fig. 9 Two flake cores that were made from a previous blade core. In white: negatives related to blade production; in red: negatives related to flake production; in green: unknown. 1: Rullen flint; 2: Campanian flint from Hesbaye. Langweiler 12 (LVR LandesMuseum, Bonn). Pictures: S. Denis.

Fig. 10 Hammer shaped from a low-quality block of Rullen flint. Inden 3. Removal negatives of the shaping correspond to flakes that must be attributed to simple productions. Picture: S. Denis.

may be, the low occurrence of simple productions is of importance for highlighting the social and economic organization of this population. Indeed, the know-how involved in the production of blades is quite different from that of flakes. The production of blades requires a higher level of know-how. The shaping out of the blocks involves a volumetric construction carried out via the installation of crests, regularized by indirect percussion. Each removal is dependent on the success of the previous one (e.g. Pelegrin, 1995) and thus each stage in blade production. This is not the case for flake production as the examined blanks are less standardized. The adaptations are smoother and errors do not ruin a complex process. This distinction based on the level of know-how involved in each production is at the roots of the interpretation of a specific production organization based on two groups of knappers (Augereau, 2004; Denis, 2017; 2019).

We can now discuss the production organization observed at the post-LBK sites of Cologne Bay:

(i) No change is observed at either Langweiler 10 or Müddersheim. Knappers here were only producing blades, as during the LBK. Their originality lies in the fact that Langweiler 10 is the older site studied and Müddersheim is the easternmost in terms of location and they seem to share a high productive nature even if they are not strictly comparable.

(ii) Hambach 260 should be added as it has the same kind of continuity as within the LBK production organization. The production is almost exclusively centred on blades and the simple technical behaviours identified involve the use of raw or slightly modified gravel and the reuse of blade cores as hammers. These opportunistic behaviours also existed in LBK contexts (see Allard, 2005 for example).

(iii) The first shift within the production organization occurs at Langweiler 12 where the first attempts to produce flakes are related to the reuse of blade cores. But the fact that flake and blade productions are integrated encourages us to suggest a connection between producers.

(iv) The real disconnection between blade and flake production is underlined for the two sites at Inden, attributed to the Rössen culture. Here the coexistence of two groups of knappers can be supposed.

The development of this kind of organization can also be considered in light of the exchanges with the BQY/VSG of Hesbaye mentioned previously. Figure 13 lists the main arguments highlighting the links between BQY/VSG and post-LBK populations of the Rhineland. Both Langweiler 10 and Müddersheim present only slight evidence of a connection with Hesbaye. The more active connections seem to be related to the site of Langweiler 12 where a high percentage of Campanian flint from Hesbaye has been discovered (Denis, 2020; Gehlen & Schön, 2007) along with BQY pottery (Spatz, 1991) and a transverse arrowhead identified by Gehlen and Schön (2009b) as being potentially typical of BQY. We cannot then exclude that the appearance of the flake production in the Rhineland context relies on these inter-cultural contacts. Indeed, the duality of blade and flake productions is typical for BQY/VSG contexts (Allard, 1999; Augereau, 2004; Bostyn, 1994; Denis, 2017). In Hesbaye and more specifically at Vaux-et-Borset, simple productions are overwhelmingly present. They may represent up

Fig. 11 Debitage attempt by an inexperienced knapper. Rullen debris. Langweiler 10 (LVR LandesMuseum, Bonn). Picture: S. Denis.

to 90% of the assemblages (Denis, 2017). Another argument could also support this hypothesis. No flake production has yet been recorded in the Worms area (Denis, in prep.), which is one of the emergent zones of the Hinkelstein/Grossgartach cultures. It must be stated that, in our opinion, the potential transmission of the idea for simple productions may have simply involved oral transmission and not necessarily the movement of knappers. As they are simple productions, they did not require a long or sustained apprenticeship. Just the knowledge of the existence of this simple way of producing interesting blanks could have been enough to initiate this way of doing things. In other words, if this hypothesis of BQY influence on the development of simple

	LW10	Ha260	LW12	IN3	IN1
waste of young knappers	X			X	X
use of debris or gravels		X	X	X	X
flake debitage on blades cores			X	X	X
autonomous flake debitage				X	X
blocks or cores as hammer		X	X	X	X
specific tool produced		splintered pieces, retouched flakes, hammers/ *bouchardes*	splintered pieces, retouched flakes, hammers/ *bouchardes*, denticulated pieces	retouched flakes, hammers/ *bouchardes*	splintered pieces, retouched flakes, hammers/*bouchardes*, denticulated pieces, scrapers, faceted pieces

Fig. 12 Synthesis of the different behaviours related to simple productions and their presence/absence within the sites studied.

sites	% Campanian Hesbaye	BQY ceramic	Schist bracelet	Specific BQY typology	% Simple productions
LW10	-	X			2,8
HA260	2,3			X	7
LW12	11,1	X		X	17,9
MH433	0,2				0,9
IN3	1,8		X		11,8
IN1	2,5				19,6

Fig. 13 Different characteristics linked to the exchanges between BQY populations and Rhineland cultures compared to the quantitative representation of simple productions on the studied sites.

productions within PF / Rössen contexts can be confirmed, it does not require the movement of knappers, it could also mean other members of the community transmitted the idea. A more refined comparison of the operating schemes deployed could help to resolve this question.

Conclusion

This short paper aims to highlight how technological analysis helps us to better understand the *chaîne opératoire* of blank production, which is a prerequisite for classifying the archaeological material within the different stages of their respective productions. This identifies two main families of productions on the post-LBK sites of the Cologne Bay: blade production and simple productions. The qualitative data allows us to distinguish different technical behaviours within the simple productions: the use of small blocks / gravel / debris as tools; the reuse of blade cores and flake production. Traces of apprenticeship have also been noted on some sites.

Within these technical behaviours, the production of flakes remains the true innovation compared to LBK production. Indeed, it could signify two distinct groups of knappers within the production organization: one with a high level of know-how and one without. This dichotomy is at the root of the organization of the production of the second half of the fifth millennium BCE where specialized production was disconnected from the settlements where more simple productions were crafted. In this context, the true shift in the production organization characterizes the Rössen culture assemblages. We cannot exclude the possibility that intensive contacts with BQY populations are at the roots of the new organization in Rhineland cultures.

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