## 1. Introduction

The Neolithization process, i.e. the transition from a Mesolithic hunting-gathering-fishing subsistence to a Neolithic farming-herding economy, within the Lower- Scheldt basin of NW Belgium has been extensively studied in the framework of several excavation projects (Crombé, 2005; Meylemans et al., 2016) and doctoral researches carried out in recent years (Halbrucker, 2021; Messiaen, 2020; Teetaert, 2020). These studies indicate that this important transition was triggered by increased contact and interaction between the last indi- genous hunter-gatherers and the first farmer-herders occupying the loamy area of the Upper-Scheldt basin from ca. 5300 cal BC onwards. The first proof of exchange consists of cereal grains found in the Lower- Scheldt basin dating to 4850/4610 cal BC, long before local agriculture started in the region (Meylemans et al., 2018). Almost simultaneously, some domesticated animals, including sheep/goat and probably also cattle and pig, entered the area (Crombé et al., 2020). The nature of these earliest domesticated animals is still debated, but there is indirect evidence that points to small-scale local husbandry from at least 4600/4500 cal BC. Around the same time, and probably even earlier, indigenous hunter-gatherers started to produce pottery displaying clear technological and typological parallels with Neolithic pottery from the adjacent loess area (Teetaert, 2020; Teetaert & Crombé, 2021). In the present study, it will be demonstrated that similar cultural links are to be found within the indigenous lithic industries, further supporting the theory of acculturation of local hunter-gatherers following intense contact with and transmission from the adjacent farmer-herders.

## 2. Archaeological sites

This paper focusses on the lithic industries of four sites in the Lower-Scheldt valley (Figure 1). All four are well-pre- served thanks to later covering with peat and (peri-

)marine clay and are securely radiocarbon dated. The site of Verrebroek-Aven Ackers (Robinson et al., 2011) goes back to the Late Mesolithic (LM) and is radiocarbon dated to ca. 5730–5630 cal BC. Excavations yielded a small artifact cluster of 32 m² containing 4501 lithic artifacts. Aside from a very restricted admixture with Middle Mesolithic artifacts, the assemblage is very homogeneous. The site is important as it represents one of the few well-dated LM sites in Belgium.

The three other sites were discovered during the construction of a large dock in the harbor of Antwerp, called the Deurganckdok. Site B and M in the Deurganckdok yielded archaeological remains (burned bones, lithics, pottery, … ) belonging the Swifterbant Culture (SWB), with minor admixture with respectively Final Palaeolithic (Federmesser Culture) and Early Mesolithic artifacts (Crombé et al., 2002). The SWB is a transitional culture between Mesolithic and Neolithic that extends from the Lower-Scheldt valley in Belgium to the Lower-Rhine and Lower-Elbe in the Netherlands and Germany. Site B consists of six individual artifact loci/ sectors (B-1 to B-6; n = 14,154 artifacts), most of which could only be partially excavated due to the harbor works. The radiocarbon dates cover the entire second half of the 5th millennium cal BC, from ca. 4500 till 3990 cal BC. Site M yielded two artifact clusters (n = 2,040 artifacts), also partially destroyed by the construction works, dated between ca. 4575 and 4040 cal BC. Although the occupation duration is similar for both sites, the main occupation in site B dates to the third quarter of the 5th millennium, while site M is situated in the fourth quarter. Finally, site C yielded a small lithic assemblage (n = 323) dated to 4193/3952 cal BC and 3973/3721 cal BC and culturally linked to the Michelsberg Culture (MK)/Spiere group (SG) (Crombé et al., 2002). Although farmer/herders settled in the loam area of the Upper-Scheldt from 5300 cal BC onwards, the MK/SG is the first fully Neolithic group to occur in the Lower-Scheldt. The analysis of these four sites consequently allows to reconstruct the manner in which flintknapping evolved throughout the neolithization process in the Lower-Scheldt valley, from the LM of Verrebroek – Aven Ackers to the SWB and MK/SG clusters from Doel.

## 3. Methodology

### 3.1 Raw material analysis

Raw material analysis was primarily conducted on a macroscopical level: flint types were distinguished by visual properties including color, patina, translucency, texture, inclusions and variability of the cortex.

Reference samples from the Mons Basin, Dutch Limburg and Northern France, as well as the lithic artifacts and geological samples comprised in the Flepostore reference collection at Ghent University (https:// flepostore.ugent.be/) were subsequently consulted to gain a general idea of the provenance of the flint types on our sites. Keeping the many pitfalls of macroscopic flint sourcing in mind, for some flint types the mineralogical and chemical composition was determined on both archaeological and geological samples in view of tracking their provenance (Fiers et al., 2019; Laforce et al., 2021). Characterization of quartzite – in particular Wommersom quartzite (WSQ) – is less problematic since it has just one outcrop area, the Steenberg at Wommersom in Middle Belgium (Figure 1) (Cnudde et al., 2013). In this paper, the terminology local (<30 km), regional (30–60/70 km) and supra-regionally (>70 km) will be used.

### 3.2 Tool typology

The typology used is primarily based on the work of Crombé (1998), which was developed specifically for Mesolithic assemblages within the Lower-Scheldt basin. Since this typology was mainly focused on Early to Middle Mesolithic assemblages, some additions had to be made (cf. below). Retouched artifacts were specifically studied in light of the raw material used, blank selection and the technological attributes of the blanks. For most of the tool-types − including common tools such as scrapers, drills and retouched flakes − no detailed sub-categorizations were made. For the Neolithic toolkits (Doel C), the categorization was limited to general types as well, based on the works of Vermeersch et al. (1990) and Cornelissen (1988). Armatures, mainly comprising trapezes, were classified following the typology of Robinson et al. (2011, 2013). Additional attributes were recorded to allow for a comparison with their dataset: lateralization, presence/absence of a microburin negative or piquant trièdre, presence of flat ventral retouch, and morphology and raw material of the blank.

Retouched flakes and bladelets are a recurrent tool category as well, for which the types of retouches and their location was noted. Special attention was given to the retouched bladelets issued from the plein débitage, as well as to the notched (Montbani)bladelets, a tool typical for the LM bladelet and trapeze techno-complex (Gassin et al., 2013; Marchand & Perrin, 2017). Unmodified flakes and bladelets with potential use- wear − micro-retouches, rounding and polishes − were frequently encountered but were not included in the total count of the toolkit since their use has not yet been confirmed by microwear analysis.

Faceted tools are artifacts shaped by multiple short detachments giving them a multi-faceted appearance. Terminology and further typological divisions of these tools were based on French studies of similar Neolithic artifacts, named outils facettés (Allard, 1999; Denis, 2019). Lastly, splintered pieces (pièces esquillées) are tools characterized by bifacial use-retouches, either bipolar (on opposed sides) or unipolar (Binder, 1987; Gibaja et al., 2007; Le Brun-Ricalens, 2006).

### 3.3 Technological analysis

All artifacts > 1 cm were further included in a basic typo- technological attribute analysis, in which metric and morphologic attributes were noted, as well as the directionality of the dorsal negatives. Only for WSQ artifacts, plein débitage blades and bladelets, as well as part of the flake and faceted tool productions, more specific supplementary attributes were recorded that could yield information on the applied knapping techniques,

i.e. platform morphology, core-edge preparation, exterior platform angle (angle de chasse), the presence or absence of a bulb, lip, hackles, ripples, and impact points. For the cores, overall core morphology, the number of striking platforms, the exterior angles between striking platforms and exploitation table, the position of the principal exploitation table (e.g. frontal, semi-peripheral, peripheral), as well as the presence of core-edge preparation were recorded. In addition, diacritical sketches of the few unmistakable cores were made. Assessment of the trends emerging from this approach were then combined to make inferences about the chaine(s) opératoire(s)/reduction sequences implemented at the sites (cf. Pelegrin et al., 1988; Shott, 2003) and in other words to gain insight into the objectives of the reduction sequence, the used methods (the organization of detachments according to a conceptual scheme) and techniques (the physical gestures made and knapping instruments used to apply this scheme, cf. Inizan et al., 1999). Inter- and intrasite comparisons were finally made to see how knapping traditions evolved from the LM to the SWB and MK/SG group assemblages.

## 4. Results

### 4.1 Raw material spectrum

The studied assemblages show considerable differences on an interand intrasite level in the ratios of exploited local and (supra)regional stone varieties (Figure 2). The LM assemblage of Verrebroek is almost exclusively made on different types of exogenous flint of good quality, which are likely derived from cretaceous out- crops from Middle Belgium (Figure 1). Almost half (ca. 45%) belongs to the Upper Turonian flint type originating from distances of at least 90 km, either from the Tournaisis area (Fiers et al., 2019; Vandendriessche et al., 2021), the Deûle and Upper-Scheldt river basin in northern France (Allard et al., 2010) or the Mons basin (Saint-Vaast Formation) (Collin, 2019, p. 104). Almost 10% of the flint at Verrebroek has been identified as fine-grained Ghlin flint from the Baudour-Douvrain area of the Mons basin (Collin, 2019, p. 140; Denis, 2019). Other exogenous flint types from the Mons basin, including flint from the Ciply-Malogne Formation and from the Obourg-Nouvelles Formation occur in limited numbers. The same holds true for WSQ, rep- resented by just 3 blade(let)s.

The younger SWB Culture assemblages from Doel B and M considerably differ from the LM assemblage of Verrebroek. Local flint dominates the spectrum with resp. ca. 51% and 81% of all determined raw materials (Figures 3 and 4). These local flints are frequently frost- fractured and are characterized by a rough rolled cortex, confirming their collection from secondary deposits. The variety in color, translucency, texture and inclusions is large. One possible source are residual gravel layers that occur on the contact between Neogene (old terminology: Tertiary) and Quaternary layers and which can be found on the top and flanks of the Wase Cuesta, a tertiary hill and in Pleistocene terrace deposits along the Scheldt basin in layers of varying thicknesses (Gullentops & Wouters, 1996, p. 79). A second potential source are the North Sea beaches, the cortex of pebbles present at Doel can appear pounded, a feature which might be linked to the supratidal and intertidal zone. Very similar pebbles can be collected along the present-day beaches of the Western Scheldt estuary (Fiers et al., 2019). On the bottom of the North Sea gravel layers comprising of mainly flint are present on locations where the base of the Quaternary crops out (Gullentops & Wouters, 1996, pp. 78–79). The gravel originates from deposits reworked by marine transgressions, deposited by the Pleistocene Scheldt and Thames rivers (Deleu et al., 2007, p. 102).

The exogenous flint at Doel B and C comprises the same varieties as at Verrebroek. However, there are also indications for the limited presence of other types, among which Spiennes/Orp/Rijckholt flint and fine- grained light-grey flint from the Hesbaye region (Figure 1). In addition, at Doel B almost 16% of the industry is made of WSQ; the frequency in locus B-6 (Figure 4) even reaching ca. 62%.

Finally, the youngest site, Doel-C, is characterized by a weak increase of exogenous flint (ca. 58%). Yet, its origin is different compared to the older sites, as most flint comes from the Upper Campanian Spiennes Formation in the Mons basin (Collin, 2019, pp. 113–119). The absence of clearly delineated black micritic pockets in the matrix seems to make an origin in the area of Hesbaye (Orp-type flint) or Dutch Limburg (Lanaye or Rijckholt flint) less likely (Collin, 2019, p. 148). Furthermore, the use of WSQ seems to have stopped completely.

## 4.2 Technological results

### 4.2.1 Verrebroek-Aven Ackers

Debitage in Verrebroek – Aven Ackers focused on the production of bladelets to be used as blanks for trapezes. This is evident from the exclusive presence of bladelet cores, the proportions of bladelets (i.e. 30%, see comparisons in Figure 5) and from the microburins that are well-represented within the assemblage (5%).

Most of the bladelets are fragmented, the length of all complete specimens (n = 166; Figure 6) is 23.2 mm on average (between 10 and 75 mm), the average length of all fragments is 56.5 mm. According to the definition of Rozoy (1968, p. 366), the largest among these (i.e. > 5 cm) can actually be defined as "blades". However, we opted to not make this distinction in what follows, as the blades simply appear to correspond to the initial and hence, slightly longer removals from the bladelet sequences. The width of all bladelets (n = 439; Figure 7) averages 8.9 mm (between 1 and 29 mm), the thickness 2.5 mm (between 1 and 10 mm). A sample of 117 plein débitage bladelets shows a slight preference for triangular cross-sections (45.3% versus 31.6% trapezoidal cross-sections). The remaining have irregular, rectangular or plano-convex cross-sections. 29.9% of these bladelets further display regular edges and ribs, while most are classified as ranging from semi-parallel to irregular (64.1%, e.g. Figure 8). The dorsal negatives are predominantly unidirectional, with only three exceptions, indicating a preferred use of a single platform during bladelet production.

Furthermore, the proximal attributes of a sample of 103 of these plein débitage bladelets and of the proximal microburins were recorded (Figures 9 and 10). Most have plain platforms (73%), of which 20% are concave (Figure 10(g and h)), followed by faceted (15%) and dihedral (7%) platforms. The latter two are, on the one hand, related to a preparation and/or rejuvenation of the striking platforms through the detachment of small flakes. On the other hand, the category of faceted platforms also consists of bladelets with "micro-faceting" (Figure 10(e and f)), which is a highly localized preparation also known in French LM contexts (Allard, 2017; Marchand, 2014). The average platform measurements are 6.8 × 2.5 mm. A lip is present in most cases (93%), as well as a bulb (87%) which is predominantly weakly pro nounced (70%). The flaking angle is mostly orthogonal (71%), while sharp angles were observed on 12% of the bladelets. The preparation of the overhang shows some variety but was mainly done by abrasion (38%), small retouches (27%) or both (9%), while 16% do not show any preparation. Taken together, the cooccurrence of these proximal attributes makes it likely that these plein débitage bladelets were produced by means of the indirect percussion technique (Pelegrin, 1991, 2006).

Unfortunately, only two complete cores were documented at Aven Ackers (Figures 8). Nonetheless and despite being completely exhausted, their characteristics are in line with what was described above. Bladelet production on these cores took place making use of a single dominant striking platform and was carried out in a frontal to semi-peripheral manner. The back of the cores does not participate in the production phase. Platform angles range from relatively sharp on the first core to orthogonal on the second. Especially this second core (Figure 8: 7), with its quadrangular volume is reminiscent of cores worked according to the "Essart A" method (Marchand & Michel, 2009), which seems to have been a widespread method in Northern France during the LM (Allard, 2017; Marchand, 2014). Although cores are scarce at Aven Ackers, a review of cores found at other LM sites in the Scheldt basin, i.e. Oeudeghien (Allard, 2017) and Aalter-Stratem (Messiaen, 2020, Figure 1), confirms the similarly widespread presence of this knapping method.

Although all debitage sequences aimed at the production of bladelets, different mechanisms seem to have been at work in regard to how the raw materials entered the site. The Upper-Turonian flint from the Mons basin was probably brought in as small secondary collected nodules that were knapped on site. The first stages of the reduction sequences are present (with cortical flakes and elements from core preparation), but cores from this raw material are lacking and only a few fragmented bladelets are present. Conversely, other flint types must have been brought along as preshaped cores and were further processed on site. Some of these cores were discarded completely exhausted, as attested by the Ghlin-type and possible Northern French flint cores. Lastly, isolated blade and bladelet blanks seem to have been brought in as well, which was the case, for instance, for a few WSQ and Upper Turonian flint artifacts from the Lille-Tournai area. Overall, the picture is that of a very dynamic raw material procurement system, in which raw material nodules, pre-shaped cores, blade and bladelet blanks circulated between sites.

#### 4.2.2 Doel B and M

The raw material procurement system at Doel B and M is by contrast with Verrebroek Aven Ackers clearly associated with a dichotomy in the technological organization. Local pebbles were brought to the sites as small (< 60 mm) frost-fractured, irregular nodules of low quality, with a roughly rolled cortex. This raw material is predominantly associated with flake productions, essentially to create blanks for tools such as scrapers and retouched flakes. Bladelet productions occur on this raw material but are clearly minoritary (Figure 11). The attributes recorded on pebble flint flakes from site Doel B-1 and M-2 indicate the application of direct hard hammer percussion as the main technique. The proximal attributes show a dominance of cortical (B-1) and plain platforms (M-2) with average dimensions of resp. 9 × 4.7 mm and 10.7 × 10.7 mm. Concave and facetted platforms are almost completely missing (Figure 12). Impact points are present (18.2%) as well as percussion cones (24.7%). Sharp exterior angles dominate (ca. 80%), even if orthogonal angles also occur on a regular basis (ca. 20%). Platform-edge preparation is mostly lacking on these pebble flint productions. Only 10.4% to 12.4% show preparation at the Doel sites.

The dorsal sides of these flakes often present cortical surfaces or unipolar negatives that might indicate the use of primarily unipolar reduction methods. However, the Doel B and M sites yielded no clear-cut pebble flint cores to support this assumption, as it seems that once discarded, these cores were all either transported away from the site or recycled as faceted tools (cf. infra). The shaping and use of the latter, unfortunately, make it impossible to discern between negatives related to the knapping of the cores and negatives resulting from their subsequent recycling as tools.

The first stages of reduction are present on this pebble flint, most apparent through the presence of high numbers of cortical flakes (ca. 30–46%). However, preparation and rejuvenation artifacts are scarce (Figure 11), which might point to a lack of a fixed operational scheme and to the lack or limited character of core shaping prior to flake production. Concluding, this raw material seems to have been used in rudimentary reduction sequences, focusing on the production of flakes on potentially thick and blocky volumes, that were in a following stage recycled as tools. On the other hand, exogenous flints are associated more often with regular bladelet productions (cf. proportion of bladelets:flakes in Figure 13) having a length of up to 67 mm, with widths of 5–12 mm on average and a thickness between 3 and 5 mm (Figures

6 and 7). An attribute analysis of 97 blade(let)s in exotic flint from Doel B-1 reveals that most have straight edges, triangular (48.8%) or trapezoidal (40.5%) cross-sections and straight profiles with slight distal curvatures (Figure 14). The proximal attributes of these blade(let)s (Figure 9) reveal a dominance of plain (56%, Figure 15 (a–c)), plain concave (11%, Figure 15(e,f)), or faceted (28%) platforms (among which a few micro-faceted plat- forms, Figure 15(d)), which measure 7.5 × 3 mm on average. Lips are clearly present (70.7%) and the plat- form edge is mostly unprepared (63%); in 34% of the cases, the edge is prepared, either through abrasion, retouching or a combination of both. Finally, the flaking angle is in most cases orthogonal (56.1%). Again, as it was the case for the LM of Verrebroek Aven Ackers, these attributes, although expressed slightly less clearly (i.e. somewhat lesser percentages of concave platforms and orthogonal exterior angles) point towards the use of indirect percussion for most of these bladelets. They moreover contrast strongly with the attributes noted above on the pebble flint productions.

Concerning the knapping methods applied, the dorsal negatives on 85.7% of these bladelets are exclusively unidirectional, indicating the predominant use of cores with a single platform for their production. Some bladelets, in addition showed bidirectional (10.7%) or orthogonally crossing negatives (3.6%). Data from cores to support this, is, however, lacking again, as bladelet cores are also largely absent, with the exception of a few that were re-used as faceted tools. Their interpretation, with regards to the amount of platforms used, the core circumference that was worked, etc., is also not straightforward.

The bladelet reduction sequences are incomplete and show variation. Some of these artifacts were clearly brought in as blanks, for instance, at sites B-6 only few (fragmented) regular blades are present. However, on some sites, for instance, B-1 and B-2, the presence of more complete assemblages, also comprised of flakes and preparation/rejuvenation artifacts points to the possible on site debitage of these exogenous flints. In general, though, it seems that cores were likely introduced in a pre-shaped form, as indicated by the lack of the first stages of reduction. Cortical flakes, for example, account for only 10–12% of the assemblage compared with the pebble flint (ca. 30–46%).

A third raw material category that needs to be assessed is WSQ. WSQ is mostly encountered as blade- lets or bladelet fragments (Figure 16). The length of the complete blade(let)s can reach up to 66 mm, however, most are <40 mm, with average widths between 7 and 12 mm (up to 15 mm), and average thick- ness of 2–3 mm (up to 5 mm). An attribute analysis con- ducted on the two largest samples, Doel B-1 (N = 25) and B-6 (N = 18), indicates the morphology of the blade(let)s shows no preference for triangular (n = 23) or trapezoidal cross-sections (n = 20). All have semi-regular to very regular edges, and display only unidirectional dorsal negatives. When examining the few complete and proximal bladelets (n = 25), the attributes equally point to the use of indirect percussion for these WSQ blade- lets: all platforms are plain and have a demi-lune or lenticular shape. The platform edge preparation is either absent (n = 7) or executed through abrasion (n = 10) and/or small retouches (n = 8). The striking angle is mainly orthogonal, lips are present and bulbs are diffuse. While knapping was also mainly conducted from a single striking platform, the two cores (one pre-core?) found at the site, further indicate that core-preparation took place by making use of both unilateral and bilateral cresting. These crests were as it seems installed by making use of the natural narrow plaquette-shape of this raw material. Finally, similar to the exogenous flint types, the WSQ reduction sequences are always fragmentary. At B-1, B-2 and B-6 there are indications that WSQ was restrictedly knapped, as attested by a core, a few pieces of preparation or rejuvenation, flakes and chips. The first stages of the reduction sequence generally seem to lack from which we could derive that WSQ likely also circulated as pre-shaped cores. At other sites likely only a few artifacts entered the site as a blank or tool.

### 4.2.3 Doel C

At the younger MK /SG site of Doel C, the use of local/ regionally collected pebbles, still associated with simple reduction sequences made with a hard stone hammer continues, however, with the possible addition of direct percussion with a soft stone hammer as well. The attributes of the flakes are diverse, with either plain (but relatively small) (50%), linear/punctiform (25%) or crushed (18.8%) platforms. Impact points and cone-formation on four of the flakes point to the use

of a direct percussion with a hard hammer. The linear and punctiform platforms − one of which is associated with a lip, one with a platform scar and a well-prepared platform edge − might point to the use of a direct percussion with a soft hammer.

The flakes in exogenous Spiennes-type flint (n = 19) have small mean dimensions of 15.4 × 11 × 2.6 mm. Their attributes show a predominance of punctiform platforms (70%), associated with lipping (30%) and well-prepared platform edges (60%). Three platforms are crushed, while three are plain (both 15%), two of the latter associated with an impact-point, cone-formation and bulbar scars. As with the pebble flint flakes discussed above a mix of direct soft and direct hard hammer might have been used. Of the few larger Spiennes artifacts (Figure 17(b–d)), a proximal blade fragment with use-retouches (Figure 17(c)) has a large dihedral platform, no preparation of the overhang, a straight flaking angle, a diffuse bulb with a bulbar scar and a lip. A splintered piece in the same raw material made on a flake has similar attributes. Both might have been detached by indirect percussion.

The largest and most regular blade (Figure 17(d)) – a proximal fragment broken in two pieces – has a trapezoidal cross-section and measures 87 (fragmented) × 20 × 6 mm. Its plain platform has dimensions of 4 × 4 mm, the flaking angle is straight, the platform edge is pre- pared through abrasion, and under the bulb a marked ripple runs from the left to the right edge of the artifact. The latter, according to Pelegrin (2006) and, Gallet (1998:, pp. 161–163), commonly occur during pressure flaking and might point to the fact that a device was used to immobilize the core. Such ripples, although in much lesser frequencies, can also occur when applying other techniques (Gallet, 1998, p. 163). Apart from that, the blade also has a clear “medial belly” – a bulge at the medial ventral part of the blade – that seems to indicate that it was produced by indirect percussion (Pelegrin, 1991; 2006). Anyway, the regularity of the blade in question combined with its other features indicates that either indirect percussion or a type of lever pressure was used to produce it (cf. Denis et al., 2020).

Although this assemblage is quite small and incomplete, hampering a thorough analysis, it seems to be characterized by the use of diverse knapping techniques: direct percussion with either a soft or hard hammer on both pebble and exogenous flint artifacts, as well as indirect percussion. The artifacts knapped with the latter technique were not produced on site, but were again brought in as blanks or finished tools, while the smaller artifacts such as the pebble flint flakes and the other Spiennes-flint flakes, associated with direct hard and soft stone hammers, were possibly processed on site.

## 4.3 Toolkit

The amount of tools clearly is lowest at the LM site of Verrebroek (ca. 3%; Figure 5) and is dominated by armatures and retouched blade(let)s (Figure 18). The former (Figures 19–21) consist mainly of rhombic trapezes (n= 5), followed by rectangular (n = 2) and asymmetrical ones (n = 1), made preferably on bladelets with a thick- ness of 2–3 mm and width of 9–14 mm. Among the retouched blade(let)s only few can be classified as typical Montbani retouched bladelets. Other common tools, such as scrapers, are missing or scarce. Based on these features, the site of Verrebroek has been interpreted as a short-term, special activity site focused on hunting (Robinson et al., 2011).

The amount of tools is much higher at the SWB sites of Doel (Figure 5), varying between ca. 13% and 17%. Although this might be biased to a certain degree by the partially different excavation technique – some clusters (e.g. Doel B-2) or sites (Doel M and C) have been shoveled instead of water sieved – the difference in tool frequency with Verrebroek is, however, too big to be fully explained by this. Instead, the tool frequency might reflect a difference in site function or occupation duration in comparison with Verrebroek, but this needs to be further explored by means of microwear analyses. In addition, the ratio armature/common tools is different with respect to Verrebroek: all Doel-sites yielded a much higher amount of common tools up to 80/95% of all tools (Figure 20). These consist mainly of scrapers and retouched blade(let)s and flakes, together representing between ca. 40% to 62% of all common tools (Figure 18). For the production of tools on blade(let)s clearly the longest and widest blade(let)s were selected (Figures 6 and 7).

One of the main differences with the toolkit from Verrebroek is the explicit presence of splintered pieces and faceted tools (Figure 22), both preferentially made on local pebble flint. These two tool types, which are completely lacking at Verrebroek and other LM sites (cf. discussion), represent 10% to 34% of the common tools (Figure 18). Preliminary micro- wear analysis points to the use as wedges for most of the splintered pieces. Faceted tools are large flakes, pieces of debris, discarded cores and unidentifiable blocky pieces (all with dimensions around 20– 40 mm) which are partially (faceted flakes, debris and denticulates) or completely (polyhedrons) shaped through small detachments (<20 mm). Commonly these artifacts display macroscopically visible traces of use, such as multiple impact points and extensive crushing of the ridges and in a few cases even macroscopically visible white residues. According to a preliminary assessment the latter might be remains of crushed bone, meat and/or marrow (Halbrucker et al., 2021).

Among the few armatures (Figures 19 and 21), trapezes still dominate the SWB Culture assemblages of Doel B and M. Yet, their length is clearly smaller and they belong to different types compared to the ones found at Verrebroek. Most are asymmetrical (n = 7) and symmetrical (n = 6) trapezes, while just two are rectangular. Their mean length is 15 mm (between 11 and 24 mm), mean width 12 mm (between 9 and 17 mm) and mean thickness 3 mm (between 1 and 4 mm) (Figure 23). In addition, they seem no longer produced by means of the microburin technique, since on none of the trapezes a piquant trièdre was attested. This is further corroborated by a lack of microburins, the few small microburins found at B-1 likely being intrusive. Simultaneously a new armature type appears, the trans- verse arrowhead, which in fact is nothing more than trapezes with a length/width ratio of <1. These transverse arrowheads will become increasingly important towards the end of the SWB Culture and in the MK/SG Culture. At the same time leaf-shaped arrowheads, characterized by a bifacial flat retouching, make their first appearance (Figure 21).

## 5. Discussion

The lithic industry of Verrebroek, dated to the second quarter of the 6th millennium cal BC, fits perfectly within the LM lithic technological tradition of the Scheldt basin (Allard, 2017; Blancquaert, 1989; Vandendriessche et al., 2019) and adjacent regions (Huyge & Vermeersch, 1982), characterized by a pro- duction focused on regular blade(let)s carried out by means of indirect percussion and a lack of indications for separate flake productions. Good quality flint is preferred over local secondary flint, and seems predominantly procured towards the south, over distances of 70 km and up, in the Mons basin, the Hainaut province and likely Northern France. In (south)eastern direction smaller quantities of WSQ and flint from the Hesbaye region are procured. In this sense the LM differs substantially from the Early Mesolithic, which is characterized by a predominant use of local flint of mediocre quality in view of producing irregular short blade(let)s (Perdaen et al., 2008). This marked change in raw material circulation, which most likely started already during the Middle Mesolithic, probably reflects fundamental changes in mobility and exchange networks in response to changing environment and raw material quality demands (Crombé et al., 2011; Van Maldegem et al., 2021). Indeed, the production of the regular blade(let)s to be modified into trapezes seems to have required the use of larger and better quality volumes of raw material, extracted from (near-)primary context rather than the locally available frost-fractured pebble flint. This is also observed in the adjacent areas, such as the Campine region. According to an extensive analysis (Robinson et al., 2013) LM armatures in the Campine were prefer- ably made on exotic, fine-grained WSQ, with frequencies reaching up to 70% of all armatures. Thanks to its homogeneity and natural occurrence as tabular nodules or plaquettes, this raw material would have been perfectly suited for the production of regular blade(let)s with only a minimum of preparation using frost edges as natural crests, in contrast to the local highly weathered pebbles (Gendel, 1984).

Connected to the use of a large variety of exogenous raw materials during the LM in the Lower-Scheldt basin, the dynamic way in which these circulated, as raw material nodules, pre-shaped cores and finished blades is interesting. Atelier sites where pre-shaped cores and blades were prepared, such as Œudeghien along the Upper-Scheldt (Allard, 2017; Crombé et al., 1992) and maybe the Steenberg in Wommersom (Gendel, 1984), might have been an integral part of this system. From a technological point of view the blades from Verrebroek and other LM sites in the Scheldt basin are produced with a method resembling that of the LM of Northern France, more precisely the “Essart A method” (Allard, 2017; Marchand, 2014). The latter is characterized by unidirectionally exploited cores with a narrow and flat flaking surface and a striking platform often maintained by small flakes. These cores were used to produce thin blades with (semi-)parallel edges and a straight profile with little curvature. They are either selected for trapeze production, for instance, at Verrebroek, where high numbers of fragmented blades and microburins are present; or as tools that are mostly used unmodified, as attested at Kerkhove (Vandendriessche et al., 2019). Except for some sites, e.g. Oudenaarde-Donk (Blancquaert, 1989) Montbani-retouched blades are only present in low numbers on LM sites of the Scheldt basin and have some of the thickest and largest blades as a blank. These inter-site differences might point to functional differences between the LM sites of the Scheldt basin, but lacking microwear data, this seems currently difficult to assess further. The trapezes of Verrebroek typologically fit perfectly with the LM spectrum of the Scheldt basin, dominated by right lateralized asymmetric and rhombic types, supplemented with few rectangular and symmetric trapezes (Robinson et al., 2013).

Unfortunately, the lack of well-preserved and securely dated sites from the second half of the 6th and first half of the 5th millennium cal BC does not allow us to deter- mine how the LM lithic traditions evolved once the first farmers colonized the adjacent loess region. The site of Bazel situated at a close distance from Verrebroek might fill in this chronological gap, but it is impossible to discriminate artifacts according to the different occupation phases due to admixture as a result of intense bioturbation (Crombé et al., 2019; Meylemans et al., 2016). However, based on the SWB Culture sites of Doel, presented in this paper and dated to the second half of the 5th millennium cal BC, it is clear that major changes occurred in different aspects of the lithic traditions in the course of this time span. The SWB lithic industries are characterized by a dual mode of pro- duction, comprised of blade productions similar to those of the LM traditions on the one hand and flake productions that are completely new in the Scheldt basin on the other hand (Figure 24).

The regular blade productions are still associated with a large variety of exogenous flints and WSQ, mainly pro- cured towards the south (flint) and (south)east (WSQ), with again evidence for fragmented reduction sequences pointing to the circulation of blanks and pre-shaped cores, even more pronounced compared to the LM. Blade cores are largely absent, or re-used as tools/ hammerstones, but the used knapping methods seem at first sight to be a continuation of LM methods. The obtained blade(let)s too are fully in line with the LM. Even if they are overall slightly wider, they display the same general morphological and technical features (among which are a preference for mostly plain and concave platform, orthogonal exterior angles, an abundance of lipping and indications of potential micro- faceting of the platforms) that point to a continued use of the indirect percussion technique.

Although a completely new element, the flake pro- ductions dominate the assemblages of the Doel SWB sites, where their share seems to increase over time. Instead of being made on good-quality imported flints, these flake productions are predominantly carried out on small frost-fractured and weathered pebbles of local origin, that were hardly exploited during the LM. Hence, the SWB assemblages can to some extent be characterized as “raw material economies” according to the concept defined by C. Perlès (1987, 1991), in which the different knapping objectives strived after not only originate from different chaines opératoires but were also produced on different raw materials. In sharp contrast with the exogenous flints, the entire reduction sequence of these local nodules moreover took place at the sites, they involved limited preparation and were carried out by applying direct percussion with a hard stone hammer. A LM heritage is also clearly visible in the SWB toolkits (Figure 24), through the presence of trapezes, retouched bladelets and low numbers of Montbani-retouched bladelets. Armatures are still dominated by trapezes but compared to the LM ones, they have changed in form (predominant symmetric and asymmetric types), technique (no microburin technique) and size (shorter), with some rather being closer to transverse arrowheads (Figures 21 and 23). On the other hand, the presence of two tool types – splintered pieces and faceted tools (Figure 22) – which constitute entirely new elements in the lithic traditions of the Scheldt basin, is particularly interesting as these are respectively very scarce and even lack completely in Mesolithic assemblages (LM and older) in Belgium. Both seem to be produced prefer- ably, but not exclusively on local pebble flint. Apparently, the closest parallels for both splintered and faceted tools are to be found in the Early Neolithic assemblages of the adjacent loess areas of Middle Belgium and, Northern France. Initially appearing in highly variable frequencies in LBK (5300-5000/4900 cal BC) assemblages of Hainaut and Hesbaye (on average 3.3%, Allard, 2005), splintered tools constitute around 2% of the toolkit within the subsequent Blicquy/Villeneuve-Saint-Germain (BQY/VSG; ca. 5000/4950-4750/ 4650 cal BC) tradition in the same area (Denis, 2017).

Later during the Rössen Culture (ca. 4700–4450 cal BC) of the Rhineland their frequency increased to between 0% and 4% and 16% of the toolkits (Gehlen, 2009). The frequency of faceted tools follows the same trend in the loess area. They first appeared on final LBK-sites (Allard, 2005) but become increasingly important from the BQY/VSG onwards, where they reach frequencies up to 6–12% (Denis, 2017). Preliminary microwear and residue analyses even point to some level of functional correspondence in the use of these tools within both the SWB and the BQY/VSG communities (Halbrucker et al., 2021). Moreover, during the BQY/VSG, faceted tools are also the result of simple domestic productions made on local raw materials of lesser quality, that are opposed to more elaborate blade productions (Denis, 2019). Despite the limited chronological overlap between the BQY/VSG and SWB Cultures, all this suggests a technological transfer from farmer-herders of the loess area toward the final indigenous hunter- gatherers of the Lower-Scheldt valley. This is in agreement with recent observations based on SWB pottery analysis (Teetaert, 2020; Teetaert & Crombé, 2021), which also revealed technological resemblances with the BQY/VSG Culture.

The passage towards the MK/SG Culture around ca. 4300/4000 cal BC is finally also characterized by both continuity and change in the lithic traditions of the Scheldt basin, which seems in line with the results of pottery analysis (Teetaert, 2020). Continuity is illustrated by the use of locally collected pebbles, still associated with simple flake reduction sequences and hard hammer percussion, as well as the use of faceted tools, splintered pieces and transverse arrowheads (Figure 24). Disruption is demonstrated by the end of bladelet production and WSQ circulation and the import of other exotic flint types, this time consisting of Spiennes/Orp/Rijckholt flint from the Mons basin and/ or Hesbaye area (Figure 24). These new imports reached the Lower-Scheldt sites as blanks and (semi-)finished tools, including new tool types such as polished axes, retouched long blades and leaf-shaped arrowheads. All this is probably linked to the development of flint mining centers in the cretaceous regions of Belgium from the MK Culture onwards and the creation of new exchange networks (Collin, 2016).

## 6. Conclusion

In the context of the Neolithization debate, the observed long-term continuity in lithic technologies, e.g. in blade (let) production, armatures and raw materials, from the middle of the 6th till the 5th- to 4th-millennium transition are strong arguments in favor of population continuity in the Lower-Scheldt basin rather than colonization by external groups. Moreover, the observed technological changes, such as the introduction of a dual system including simple flake knapping and the production and use of new tool types, including faceted and splintered tools, testify of gradual acculturation of these indigenous hunter-gatherers as a result of trans- mission of technological knowledge from the first agro-pastoral communities in the loess area at least from 4600 cal BC and possibly even earlier (ca. 4800/ 4700 cal BC). Together with other evidence, such as the early import of cereal grains and domesticated animals or parts of these as well as local pottery pro- duction, it suggests intense, long-term contact between both communities, possibly in the context of exchange networks of commodities and maybe even people, e.g. through intermarriages. The latter is supported by recent DNA research on human bones from northern France (Brunel et al., 2020; Rivollat et al., 2020), demonstrating much more hunter-gatherer ancestry in early farmer's genes in western Europe com- pared to central and SE Europe. It thus seems that indigenous hunter-gatherers from the Scheldt basin played a significant role in the introduction and spread of the agro-pastoral economy and lifeway over the NW European Plain.

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