

Distinguishing Upper Cretaceous flint types exploited during the Neolithic in the region between Maastricht, Tongeren, Liège and Aachen

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Zusammenfassung – In den südlichen Niederlanden, Belgien und dem Rheinland wurden im Neolithikum verschiedene Silices (Upper Cretaceous flints) lokaler und regionaler Herkunft verwendet. In diesem Beitrag werden makroskopische Merkmale dieser Silices von natürlichen Aufschlüssen und Abbaustellen vorgestellt. Multivariate Analysen zeigen, dass es damit möglich ist Silixvarietäten zu unterscheiden. Außerdem konnten vor allem innerhalb eines Inventars zuverlässige Kriterien gefunden werden, um Rohmaterialvarianten zu erkennen. Des Weiteren können verlässlichere Verknüpfungen zwischen Materialien aufgezeigt werden, die man an Aufschlüssen oder aus archäologischem Kontext finden kann. Geht man von den zumeist geringen Unterschieden aus, so scheint es ratsam sich nicht nur auf die Beschreibungen oder Fotos die hier vorgelegt werden zu verlassen sondern die gut dokumentierten Vergleichssammlungen heranzuziehen.

Schlüsselwörter – Westeuropäischer Kreidefeuerstein/Silex

Abstract – During the Neolithic, in the southern parts of the Netherlands and adjacent areas in Belgium and the Rhineland a wide range of Upper Cretaceous flints of local or regional origin was exploited. In this study, an attempt is made at the macroscopic characterization of these flints and of related flint types from exterior outcrops or extraction sites.

A multi-variate analysis demonstrated that it indeed is possible to distinguish most of the flint types under consideration. Moreover, reliable connections between raw material varieties found at extraction points and in other archaeological contexts often may be established, especially at the assemblage level. However, given the often ephemeral character of the differences, it seems highly advisable not to rely solely on the descriptions offered in this study, or even on photographs, but to consult the well-documented reference collections.

Keywords – Western-European Cretaceous Flint

1. Introduction

During the Neolithic, in the southern parts of the Netherlands and adjacent areas in Belgium and the Rhineland a wide range of flints of local or regional origin was exploited. The lithostratigraphical situation of the study area, located *grosso modo* between Aachen (D), Maastricht (NL), Tongeren (B) and Liège (B), has been described in depth by FELDER/BOSCH (2002; cf. FELDER ET AL. 1998 for an abridged version). FELDER/FELDER (1998) added additional information on the flint types from a geological perspective, and FELDER (1998) gave an overview of all known and suspected extraction sites. However, although most Stone Age lithic specialists habitually use designations such as Rijckholt, Rullen, Lousberg, and Valkenburg flint, no generally accepted type definitions exist, and opinions on the possibility to distinguish between them are strongly divided. Yet, establishing reliable connections between raw material varieties found at settlement sites and extraction points is a *conditio sine qua non* for all studies of procurement strategies, distribution and exchange mechanisms etc (cf. DE GROOTH 1991; 2007; ZIMMERMANN 1995; 2006). Therefore, in 1989 a Working Group on Western Flint – named after the designation

“Westeuropäischer Kreidefeuerstein” or Western-European Cretaceous Flint traditionally used by archaeologists to describe the flints under consideration; e.g. LÖHR ET AL. (1977), WILLMS (1982) – was established, in which geologists, archaeologists and petro-archaeological specialists cooperated. Under the expert guidance of W.M. Felder, from what was then the Dutch State Geological Service (now: TNO/NITG), material from some 25 extraction sites and geological outcrops, mainly located in the Dutch province of Limburg, but ranging from Spiennes in Hainault (B) to the Lousberg at Aachen (D) was sampled. The Working group had three main aims (DE GROOTH 1994):

1. To perform petrographical and geochemical analyses of the samples, as an independent method of characterizing raw materials and studying within- and between source variation.
2. To develop a set of variables with which the different flint types could be reliably described on a macroscopic level. This would be relevant to two goals. Firstly, to define the range of variation within the raw material from every source. Secondly, to determine whether it is possible to distinguish flint varieties from different sources that at first sight closely re-

semble each other, by means of methods available to 'common or garden' archaeologists, i.e. without relying on the connoisseurship of individual researchers.

3. To establish identical reference collections ('lithothèques', cf. TAKACS-BIRO/TOLNAY-DOBOSI 1990) at different research centres working in the study area. These collections would contain samples deriving from all known extraction points and major knapping sites, as well as from relevant geological outcrops.

The first petrographical and geochemical analyses had encouraging results (KARS ET AL. 1990; McDONNELL ET AL. 1997). The samples investigated originated from mining areas and knapping sites at Rijckholt (NL); Hoogbos (NL/B); Banholt (NL); Rullen (B); St. Pietersvoeren, Sparrenbos (Bois des Sapins) and Vrouwenbos (Bois Communal) (B); Rodebos (B). They could be classified into three distinct groups, comprising Rijckholt; Banholt & Hoogbos; and the samples from Rullen, St. Pietersvoeren, and Rodebos, respectively. These groups broadly corresponded to both the geological and geographical positions of the locations under consideration. Independent research by DE WARRIMONT/GROENENDIJK (1993) indicated that it would be possible to distinguish these samples by macroscopic means as well.

For the archaeological part of the project, initially a codebook with a restricted number of variables was designed. In practice this turned out to be too simplistic: Too many types ended up with more or less identical codes, and even the members of the working group themselves were unable to stay within its framework, using the field 'special remarks' to jot down more and more detailed information on types of inclusions and nuances of colour, in an increasingly desperate attempt at coming to grips with the problem of differentiating within the large group of 'nodules with a fine-to slightly coarse-grained texture, mostly matt artificial surfaces, dark-to-light-gray in colour, and showing large and small dots and specks'. The problems were increased through lack of time and funding. Consequently, the archaeological part of the project petered out – although reference collections were established and made available the Universities of Leiden (NL) and Leuven (B), the Maastricht archaeological Museum (NL) – now deposited at the Archaeological Centre of the city of Maastricht and with the present author –, and the Niederzier branch of the Rheinische Amt für Bodendenkmalpflege (D).

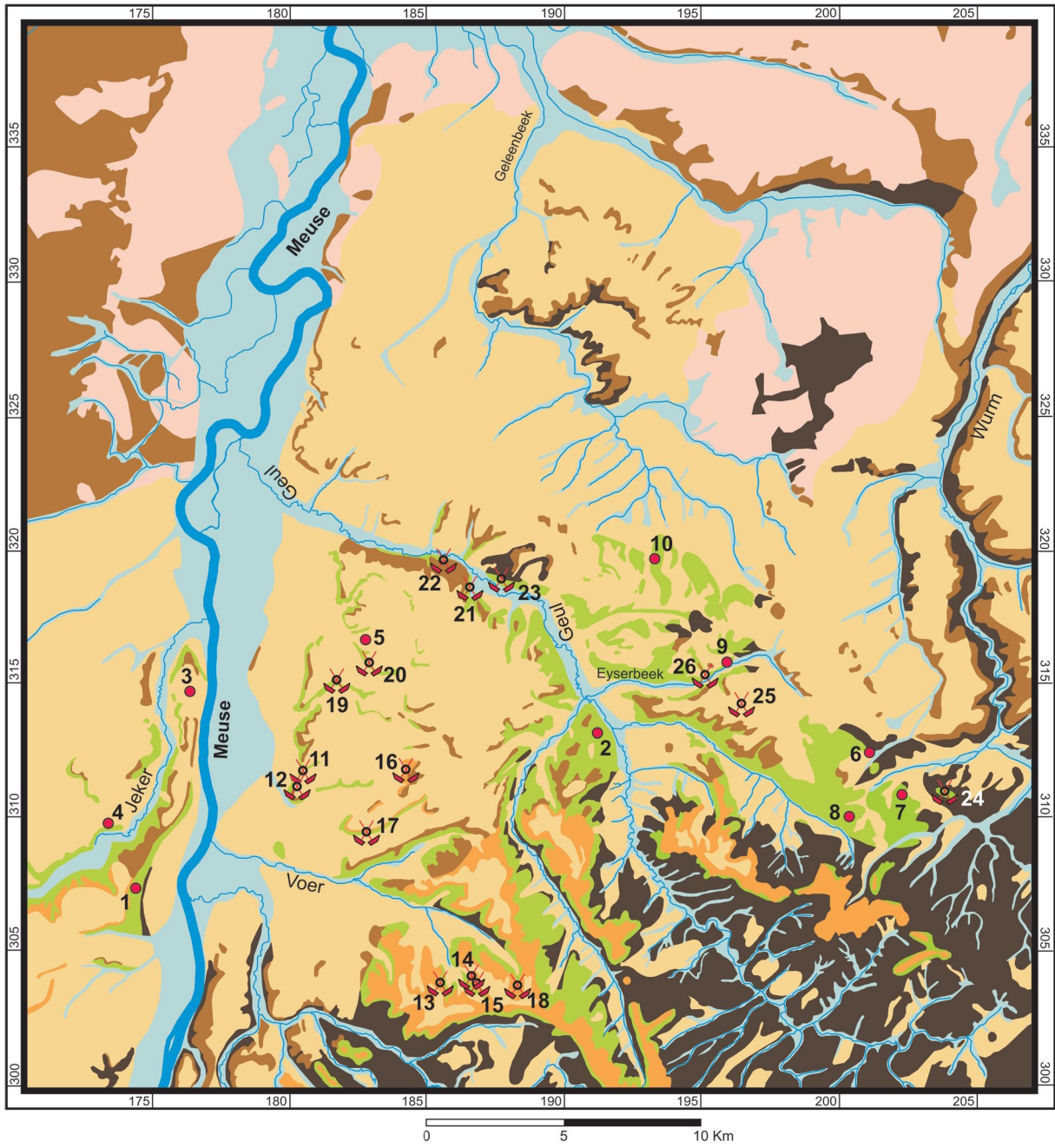
Later on, in the framework of ongoing re-

search into the temporal and spatial distribution of flints mined at Rijckholt-Sint Geertruid, I found the same basic situation to prevail, despite an increased general interest in raw material sources. Although the usually highly informative website <http://www.Flintsource.net> offers a general introduction, its descriptions of extraction points and flint types in our study area at the moment (October 2008) are not sufficiently detailed. The existing raw material characterizations (e.g. LÖHR ET AL. 1977; ZIMMERMANN 1988; FLOSS 1994; WEINER 1997; VERHART 2000) are predominantly based on material encountered at settlement sites located at a distance from raw material sources and extraction points. They tend to encompass only a limited part of the total raw material variation present at the sources and do not consider all the relevant regional extraction points. Moreover, this practice involves the danger that different researchers emphasize different attributes and thus arrive at disparate characterisations. Finally, uncharacterized and unreferenced raw material types were introduced, e.g. the flints of the Eben and of the Emal types listed separately in some recent Dutch archaeological reports (e.g. TICHELMAN 2006), whose relationship to the flints from the Emael Member (Appendix A 1.4.) or the uppermost seams of the Lanaye Member exploited at Eben Emael (Bassenge, Liège B; Appendix A 1.3.) remain enigmatic. In other cases flint types are incorrectly assigned to lithological units (e.g. the spurious linking of "Valkenburg" flints with the Valkenburg lithostratigraphical unit; cf. KEGLER-GRAIEWSKI 2004, 371).

2. Research aims

In the present study, a fresh attempt is made at the macroscopic characterization of the regional flint types thought to have been exploited during the Neolithic, based on samples collected either from geological outcrops or from Neolithic extraction points, and using an extended codebook. Hopefully, this facilitates the identification and sourcing of flints found in non-extraction contexts, and thus helps to form a more reliable basis for attempts at reconstructing raw material procurement strategies.

At present, material from 11 geological outcrops and 14 extraction and/or flint working sites within the study area has been analysed (Fig. 1). Additionally, material from eight exterior outcrops and extraction sites with related flint types were studied as well. For every source, at least



- | | | | |
|---|---|--|---|
| <p>Quaternary</p> <ul style="list-style-type: none"> ■ Holocene Pleistocene ■ Loess ■ Coversand / Loamy sand ■ River gravels | <p>Tertiary and older</p> <ul style="list-style-type: none"> ■ Cretaceous flint-bearing Chalks (Maastricht and Gulpen Formation) ■ Clay-with-flints (Heyenrath Formation) ■ Other | <p>● Flint outcrops</p> <ul style="list-style-type: none"> 1 Quarry CBR Lixhe (B) 2 Gulperberg (NL) 3 Quarry ENCI Maastricht (NL) 4 Eben (B) 5 Quarry 't Rooth Margraten (NL) 6 Vetschauerberg (D) 7 Wilkensberg (D) 8 Schneeberg (D) 9 Eyserbeek (NL) 10 Bergerweg (NL) | <p>⚒ Extraction and processing sites</p> <ul style="list-style-type: none"> 11 Rijkholt / St.-Geertruid (NL) 12 De Kaap (NL) 13 Rullen (B) 14 Vrouwenbos (B) 15 Sparrenbos (B) 16 Banholt (NL) 17 Hoogbos (B/NL) 18 Rode Bos (B) 19 Keerderbos (NL) 20 Schiepersberg (NL) 21 Biebos (NL) 22 Plenkertstraat (NL) 23 Schaelberg (NL) 24 Lousberg (D) 25 Bahneheide (NL) 26 Overeys (NL) |
|---|---|--|---|

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Fig. 1 Map showing the locations of sampled outcrops and extraction sites in the study area.

Geological Era		Formations	Members		
PALEOCENE	Danian	HOUTHEM FORMATION	Geleen Member		
			Bunde Member		
			Geulhem Member		
UPPER CRETACEOUS	Maastrichtian	MAASTRICHT FORMATION	Maastricht facies	Meerssen Member	Kunrade facies
				Nekum Member	
				Emael Member	
				Schiepersberg Member	
				Gronsveld Member	
				Valkenburg Member	
	Campanian	GULPEN FORMATION	Lanaye Member		
			Lixhe 3 Member		
			Lixhe 2 Member		
			Lixhe 1 Member		
			Vylen Member		
		Beutenaken Member			
		Zeven Wegen Member			
		VAALS FORMATION	Benzenrade Member		
			Terstraten Member		
Beusdaal Member					

Tab. 1 Lithostratigraphical division of the Upper-Cretaceous and the Danian in Southern Limburg and contiguous areas. Simplified after FELDER/BOSCH 2000, Fig. 3.4.

three specimens were described. Larger samples were studied when the source is known to have been important during the Neolithic, especially when the flints displayed a high variability.

The Appendix, containing a full description of outcrops, extraction points and their flint types, as well as characteristic photographs, may be found on the attached CD.

3. Nomenclature

The labels commonly used by archaeologists to identify flint types, may refer to major extraction sites (e.g. Lousberg, Rijckholt, Rullen), to the general region where outcrops and extrac-

tion sites are thought to be located (e.g. Valkenburg flint; Silex à grain fin de Hesbaye) or even simply to the knapping site where the type was first recognized (Simpelveld flint). This practice is understandable in those cases where the primary deposit involved is unknown, or when its lithostratigraphical position is still under discussion (e.g. Simpelveld, Lousberg, and fine-grained Hesbaye flints). As, ideally, the primary designation of a material should be the parent formation or deposit (CHURCH 1994), I shall use these in this study, whenever they are known, especially if that prevents confusion between archaeological and geological entities, or negates the connotation that the occurrence of a specific flint type is limited to a single extraction point. Consequently,

the descriptions of flints known as 'Rijckholt' and 'Rullen' will be presented under the heading 'Lanaye Member', as both originate in that deposit. 'Valkenburg' flints do not originate from the Valkenburg Member, but from the Emael (and to a lesser extent the Schiepersberg) Member (FELDER 1998), and thus will be described under that heading.

In a previous study (FELDER ET AL. 1998), it was recommended to replace the term 'Rijckholt flint' by 'Lixhe-Lanaye flint', as it seemed at that moment impossible to differentiate unambiguously the flints mined at the Rijckholt-St. Geertruid mines from other flints of the Lixhe and Lanaye Members. The more detailed macroscopic study of these flint types to be presented in this paper, however, has established criteria making it possible to differentiate Lanaye and Lixhe flints. Therefore, the present author tends to amend this earlier recommendation, and to advise the use of 'Lanaye flint' as primary designation instead. Additionally, if sufficient indications are present, an identification of the (suspected) depositional context may be added, differentiating e.g. between Lanaye flints from a primary source (such as the Rijckholt-St. Geertruid mines), from river gravels or from residual loams ('eluvial flints'). In some cases, the latter may be specified as well (cf. section 7.1.1). Given the fact that some flints from the eastern part of the study area may have their origin in an eastern facies of the Lanaye Member, one should ideally distinguish between 'Western' and 'Eastern' Lanaye flints. As the exact lithostratigraphical position of the eastern flints is still controversially discussed (cf. section 4 and the Appendix), I shall instead continue to use their traditional 'archaeological' names. Consequently the label 'Lanaye' will refer exclusively to material from the western facies of this member, thus avoiding the ponderous addition of 'Western' every time these widely used and therefore extensively discussed flints are mentioned.

4. Lithological situation

During the Late Cretaceous, the study area consisted of two different depositional environments. Its complex lithostratigraphical situation has been described thoroughly by FELDER/BOSCH (2000). Additional information is provided by a set of Geological maps 1:50,000 (RIJKS GEOLOGISCHE DIENST 1984; 1988; 1989).

In the western zone, roughly speaking between the rivers Jeker (or Geer) and Geul, chalks were

deposited in the fully marine environment of a relatively shallow Continental Shelf sea. During the Neolithic, flints from four lithostratigraphical units within the late Cretaceous Gulpen and Maastricht Formations are known to have been exploited in this region.

From the bottom to the top these units are (Table 1):

- the Zeven Wegen Member (Gulpen Formation, Campanian);
- the Lixhe 1-3 Members (Gulpen Formation, Maastrichtian);
- the Lanaye Member (Gulpen Formation, Maastrichtian);
- the Emael Member (Maastricht Formation, Maastrichtian).

In the eastern part of the study area chalks were deposited in a shallower littoral environment, close to the shore. Consequently, the lithological situation is more complicated, owing to unconformities in the sedimentation and heavy erosion. Only a few members of the Gulpen Formation are present in this area (according to HISS 2006a): the Zeven Wegen, Vijlen and Orsbach Members, with Orsbach representing an Eastern facies of the Lixhe and Lanaye Members, and the Maastricht Formation occurs as a separate facies: the Kunrade Member, corresponding in part to the German Vetschau Member (Hiss 2006b). Four main flint types are thought to have been exploited in the eastern part of the region (Lousberg, Vetschau, Orsbach and Simpelveld), but opinions differ on their lithostratigraphical positions.

Flints from all the above-mentioned chalk layers are not only found in primary position, i.e. embedded in their bedrock, but also occur in different secondary depositional positions. Close to the outcrops they occur in slope, talus or scree deposits, that came into being when valleys developed during the Pleistocene cut into the chalk beds, thus exposing and eroding them - this process still goes on. Then, they may be found in the residual loams of the Heijenrath Formation (also known as eluvial deposits, or 'clay-with-flints') that are the result of erosion of the chalks from the Pliocene onwards, i.e. after they had been lifted above the ground water table. Finally, they are present in gravels deposited during the Pleistocene and the Holocene. Although the flints were originally transported by the river Meuse, they may be found also in Rhine gravels, because during the Pleistocene Rhine and Meuse repeatedly changed their course and thus alternately cut into each other's deposits (BERENDSEN 2004).

	nodule	tablet	pipelike		small	large
ZEVEN WEGEN	X				X	
LIXHE	X				X	
LANAYE PRIMARY	X					X
LANAYE ELUVIAL	X					X
EMAEL	X	X	X			X
LOUSBERG		X			X	
VETSCHAU	X	X			X	
ORSBACH NODULES	X				X	
ORSBACH TABLETS	X				X	
SIMPELVELD		X				X
HESBAYE FIN	X				X	
OBOURG	X				X	
JJ/HESBAYE GRENU	X					X
SPIENNES	X					X

Tab. 2 Shape and size of the flints types under discussion.

The conditions prevailing in these secondary deposits sometimes led to visible alterations in the aspect of the flints. Whereas flints from slope deposits differ from the material in primary context only as regards a slight weathering of the cortex and other natural surfaces, the long stay in residual loams often caused considerable alterations, not only in the colour and texture of the cortex, but also in the colour and translucency of the flints. These phenomena are of great interest, as Lanaye flints from residual loams were exploited in some major Neolithic extraction sites in the study area. The best known are located at Sint Pietersvoeren (Vrouwenbos or Bois Communal; Sparrenbos or Bois des Sapins) and Rullen in the municipality of Voeren (B). Less known are Bantholt (Margraten NL), Hoogbos - located between Mheer (NL) and 's Gravenvoeren (B) - and Rodebos close to Remersdaal (B).

Material collected in river gravels may be identified as such only when parts of the cortex or other natural surfaces are still present. River transport leads to a decrease in size of the flints, to an increase in the frequency of non-cortical natural surfaces. These often are more or less intensely abraded.

5. Variables

LUEDTKE (1994) has described a wide range of parameters that have been used more or less suc-

cessfully to describe flints in macroscopic terms. Of these, the following were selected for use in this study:

- 5.1. General (shape and size).
- 5.2. Cortex (colour, surface, thickness and shape).
- 5.3. Interior (colour, texture, lustre, translucency, the shape and diversity of inclusions).
- 5.4. Post-genetic alterations

5.1. General (Table 2)

5.1.1 Shape

Within the material nodules, tablets and pipe like shapes occur. The latter were formed when the silica was deposited in vertical animal burrows.

5.1.2. Size

The material may roughly be divided into small (< 30cm) and large (>30 cm) blocks.

5.2. Cortex

This is the outer layer which constitutes a transition between the flint and its bedrock matrix, and which is visually and mineralogically distinct from either. In Anglo-Saxon literature cortex is often used in the sense of a thin outer layer with different colour or lustre, produced on the surface by chemical or mechanical weathering; this phenomenon is called patina or weathering rind in the present study, following continental European custom. The flints described in this study all have a well-defined cortex, with an abrupt, distinct transition to the flint. On most tabular flints cortex occurs only on the horizontal surfaces, the vertical planes are natural fractures. Nodular flints may be surrounded completely by cortex, but here too even on material in primary depositional position natural fracture surfaces may be present, the result of post-genetic tectonics. The natural fracture surfaces of flints from the Lanaye Member often are covered with iron incrustations, deposited by surface water infiltrating the chalk.

5.2.1. Cortex colour

Most flint types from a primary depositional position have a white or whitish cortex. The exceptions are Lousberg (brownish), and Emael flints (brown or grey). The cortex colour of Lanaye and Lixhe flints from an eluvial or river gravel context, however, also is brown or grey. Cortex colour may be affected by weathering processes in

	very thin	thin	thick	irregular
ZEVEN WEGEN	X			
LIXHE			X	X
LANAYE PRIMARY		X		
LANAYE ELUVIAL		X		
EMAEL	x	x	x	
LOUSBERG			X	x
VETSCHAU			X	X
ORSBACH NODULES	x	x	x	X
ORSBACH TABLETS	x	x	x	x
SIMPELVELD	X	X	X	X
HESBAYE FIN	X			
OBOURG	X			
JJ/HESBAYE GRENU		X		
SPIENNES		X		

Tab. 3 Thickness and structure of cortex of the flint types under discussion.

post-depositional, archaeological contexts too.

5.2.2. Cortex surface

Most of the flint types possess a rough cortex, the exceptions being Zeven Wegen, Obourg and Silex à grain fin de Hesbaye. Two caveats should be added, however: occasionally Zeven Wegen, Obourg and Hesbaye à grain fin have rough cortical patches; and the cortex of flints transported by water eventually become smooth.

5.2.3. Cortex thickness and structure

The cortex may be of varying thickness: Very thin (less than 1 mm); thin (1-2 mm); thick (over 2 mm); or variable. In some cases, the cortex is irregular, with cavities and protuberances (Table 3).

5.3. Interior

5.3.1. Colour

Colour is usually regarded to be an important parameter, but it is one of the most difficult to assess, partly because even an almost imperceptible weathering may affect it, partly because it often changes within singular specimens, thus biasing measurements made by means of Munsell Soil Color Charts. In this study, the homogeneity of the colour was assessed first, differentiating between homogeneous (without pattern); inhomogeneous with

	homogeneous	gradual transitions	concentric banding	parallel lamination diffuse	darker zone under cortex
ZEVEN WEGEN	X				
LIXHE	X				
LANAYE PRIMARY	X	x	x		x
LANAYE ELUVIAL	X	x	x		x
EMAEL	X	x	x		
LOUSBERG	x			X	
VETSCHAU				X	
ORSBACH NODULES	X				
ORSBACH TABLETS	X				
SIMPELVELD	x			X	
HESBAYE FIN	X	X			x
OBOURG	X				x
JJ/HESBAYE GRENU	X	x	x		x
SPIENNES	X	x	x		x

Table 4 Homogeneity of colour of the flint types under discussion.

unstructured gradual or abrupt transitions; and inhomogeneous with banding (lamination in Luedtkes terminology). The latter may be parallel to the cortex, or concentric, and also show gradual or abrupt transitions (Table 4).

The main colour was determined using a spectrophotometer on freshly struck artificial surfaces, following a method devised by DE WARRIMONT/GROENENDIJK (1993). I am very grateful to Mr. Jean Pierre de Warrimont for performing these colour measurements. For most flint varieties, although the readings for hue varied between 10 YR and 5Y (with some exceptional scores in the high GY range), the readings for both value and chroma were so low, that all would be described as 'black to (very) dark grey(ish brown)'. Given the uncertainties caused by weathering and inhomogeneity, in general colour was found not to be a distinctive characteristic for the flints in this study area. However, they proved helpful in characterising Lanaye (Rijckholt) flints from primary and secondary depositional contexts (cf. section 7.1.1), and in distinguishing Lanaye and Spiennes flints (cf. section 7.1.2).

	vitreous	fine-grained	granular
ZEVEN WEGEN	X		
LIXHE	X	(x)	
LANAYE PRIMARY		X	
LANAYE ELUVIAL		X	
EMAEL			X
LOUSBERG		X	
VETSCHAU			X
ORSBACH NODULES	X		
ORSBACH TABLETS		X	
SIMPELVELD		X	
HESBAYE FIN	X		
OBOURG	X		
JJ/HESBAYE GRENU		X	
SPIENNES		X	

Tab. 5 Texture of the flint types under discussion.

5.3.2. Texture

Despite its common use, considerable confusion exists on the definition of this variable (known as 'Struktur' in German language literature), and opinions differ on what exactly it describes and whether it is a macroscopic or microscopic variable. Many researchers, archaeologists and geologists alike, regard it as a parameter that may be assessed by macroscopic means. The labels used in their descriptions – glass-like, fine-grained or coarse-grained – incorrectly imply that these categories reflect the actual size of quartz grains, which, with a maximum size of only 50µ (0.05 mm) in diameter, of course are too small to be seen without a microscope. On the other hand, petro-archaeologists such as AFFOLTER (2002) and FÉBLOT-AUGUSTINS (2005) or HOLDERMANN (2004) see texture as a property that may only be assessed by means of microscopic observation. Thus, sometimes DUNHAM'S (1962) classification of carbonate rocks is used to distinguish texture in terms of mudstone, wackestone, packstone and grainstone. AFFOLTER (2002) suggests "grain" as an alternative for the macroscopic version of texture. This alternative term, in my opinion, does not offer a solution, because it still contains the inferred connection with actual size of the quartz grain. As this study has to do with macroscopic approach-

es, I decided to retain texture as a label, using it to describe variations in the perceived homogeneity and smoothness of the material as seen on fresh fracture surfaces.

The variable may be considered only in qualitative terms. It can be assessed by a combination of visual and tactile inspection. In the present study three relative categories are used: vitreous, or glass-like (very smooth to the touch); fine-grained (smooth to the touch); coarse-grained, or granular (slightly to markedly rough to the touch) (Table 5).

Texture too may be homogeneous or display gradual or abrupt transitions. Within the interior of the material under consideration, the transitions mostly are gradual, and remain within a single category. In many cases, however, the zone immediately under the cortex has a finer texture than the interior of the nodule. Thus, the sub-cortical parts of some Emael flints may be almost as fine-grained as the granular parts of Lanaye material, whilst the corresponding parts of Lanaye (and related) flints may be almost vitreous.

It should be noted that previous categorizations of texture are sometimes conflicting, because researchers have taken only a limited data-set into account. Lanaye flints, e.g., were described as "vitreous" or "glass-like" in comparison to granular, coarse-grained flints of the Maastricht Formation (FELDER 1960). However, similar flints found in the Belgian Hesbaye region are seen as granular (silex grenu), because they are only compared to the local "silex à grain fin fin de Hesbaye" (e.g. CASPAR/BURNEZ-LANOTTE 1994; 2006; ALLARD 2005).

5.3.3. Lustre

This variable describes the way some of the light that strikes a material is reflected from its surface. As was the case for texture, there is no reliable way of quantifying lustre (LUEDTKE 1994). Therefore, three qualitative categories were used: shiny, medium, matt. Lustre is easily influenced by patination, its assessment therefore is only feasible when fresh fracture surfaces are present (or can be created!) (Table 6).

5.3.4. Translucency

This variable has to do with the degree to which light passes through the material without being absorbed or reflected. The degree of translucency varies with the material's thickness, and thus may be quantified, using a method devised by AHLER (1983). Freshly knapped flakes were studied in a

	shiny	medium	dull
ZEVEN WEGEN	X		
LIXHE	x	x	
LANAYE PRIMARY			X
LANAYE ELUVIAL			X
EMAEL			X
LOUSBERG		X	
VETSCHAU			X
ORSBACH NODULES	X		
ORSBACH TABLETS		X	
SIMPELVELD		X	
HESBAYE FIN		X	
OBOURG	X		
JJ/HESBAYE GRENU			X
SPIENNES			X

Tab. 6 Lustre of the flint types under discussion.

darkened room with a light source (in this study provided by an 12 V/20W halogen desk lamp) diagonally behind them. The boundary between the opaque and translucent parts of the pieces was then marked in pencil, and the thickness measured with a pair of sliding callipers. Later on, the measurements were grouped into 5 classes, so as to create a scale that would be independent of the actual light source used. T1: translucency \leq 2.4 mm (opaque); T2: translucency between 2.5 and 4.9 mm (low); T3: translucency between 5.0 and 7.4 mm (medium); T4: translucency between 7.5 and 9.9 mm (high); T5: translucency greater than 10.0 mm (very high) (Table 7; c.f Fig. 4).

Translucency is not directly correlated to texture or lustre: some coarse-grained flints show high translucency (for instance the so-called Valkenburg flint from the Emael Member), whilst others, such as the flints from the Lixhe Member, combine a low translucency with a smooth, shiny surface. To complicate attempts at sourcing, Lanaye flints embedded in residual loams tend to have a higher translucency than material from the primary bedrock (cf. section 7.1.1).

The assessment of this variable in archaeological samples is not without its problems. It requires the presence (or creation) of fresh, unpatinated surfaces, and one has to take the thickness of the specimens into account. Opaque or slightly translucent flints may yield completely diaphanous flakes and blades, provided their overall thickness

	T1	T2	T3	T4	T5
ZEVEN WEGEN			X		
LIXHE	X	X			
LANAYE PRIMARY	x	X	x		
LANAYE SLOPES	x	X	x		
LANAYE ELUVIAL					
Hoogbos		X	x		
Banholt			X	X	
Rullen/St. Pietersvoeren			X	X	x
Rodebos			x	X	X
EMAEL		X	X	x	
LOUSBERG			X		
VETSCHAU			X	X	
ORSBACH NODULES		X	X		
ORSBACH TABLETS		X	X		
SIMPELVELD			X		
HESBAYE FIN		x	X	X	
OBOURG				X	
J J/HESBAYE GRENU	x	X	X		
SPIENNES		x	X	X	

Tab. 7 Translucency of the flint types under discussion.

is small enough. Despite these caveats, I found this a highly informative parameter, which e.g. helped in tracing the origin of the flints worked at the LBK settlement Geleen-Janskamperveld (DE GROOTH 2007).

5.3.5. Inclusions

Most inclusions are fossils, some are completely silicified, others remain chalky, others again exist only as casts, in which the original material has dissolved, leaving a cavity in the flint. A special category is formed by white, chalky spots, the remains of a deeply penetrating subcortical zone in irregular flints. I made no attempt at the identification of fossil types (cf. AFFOLTER 2002), but only described their colour, size, general shape and texture as visible under a low (10x) magnification.

Four size classes were distinguished: specks (smaller than 1 mm); small spots (c. 1-3 mm), medium-sized spots (c. 3-10 mm), and large spots (> 10 mm). Unless otherwise stated, inclusions found in the flints of the study area are round or oval in shape, with well-defined edges. In the assemblage, a total of 28 different kinds of inclusions were encountered (Table 8).

Table 8 INCLUSIONS	Banholt	Emael	Eys	Hoogbos	Hesbaye Fin	JJ/HG	Lanaye10P	Lanaye Other	Lixhe	Lousberg	Obourg	Orsbach Nodules	Orsbach tablets	Rodebos	Rullen	Simpelveld	Spiennes	Vetschau	Zeven Wegen
Light specks clustered	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X		X
Light specks isolated		X	X		X	X	X							X	X				
Light small spots clustered	X	X	X	X	X		X	X	X			X	X	X	X	X	X	X	X
light small spots isolated	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	
Light medium spots texture as matrix	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Light medium spots smoother than matrix				X		X	X								X				
Light medium spots coarser than matrix	X	X	X	X	X	X	X		X		X	X		X	X	X	X	X	
Light large spots texture as matrix	X	X	X	X	X		X	X	X		X	X		X	X		X		
Light large spots coarser than matrix	X	X	X	X	X	X	X	X	X			X		X	X	X	X		X
Light large oblong spots	X		X	X	X	X	X		X						X	X	X	X	
light diffuse spots	X				X		X	X	X		X				X		X	X	
Light spots dark centre, smooth	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X		X
Light spots dark centre coarse	X	X	X	X	X		X	X	X		X				X		X	X	
Light spots with dark rim	X	X			X		X				X						X		
Light sickle shaped spots							X	X							X		X		
White chalky spots									X			X						X	
Dark specks	X		X			X	X	X							X	X	X	X	
Dark spots small	X		X	X	X	X	X		X				X	X	X	X	X		
Dark spots medium	X			X	X	X	X	X						X	X	X	X		
Dark spots sickle shaped	X			X	X	X	X	X							X		X		
Dark wisps	X			X	X	X	X	X						X	X	X	X	X	
Reddish specks/ spots				(x)							X								X
Incompletely silicified fossils	X	X						X	X					X	X	X	X		
Interpenetrating inclusions								X									X		
Angular cavities	X		X	X		X								X	X			X	
Dusty surface	X													X	X				
Beads on a string					X														
Dark reticular patterns					X														

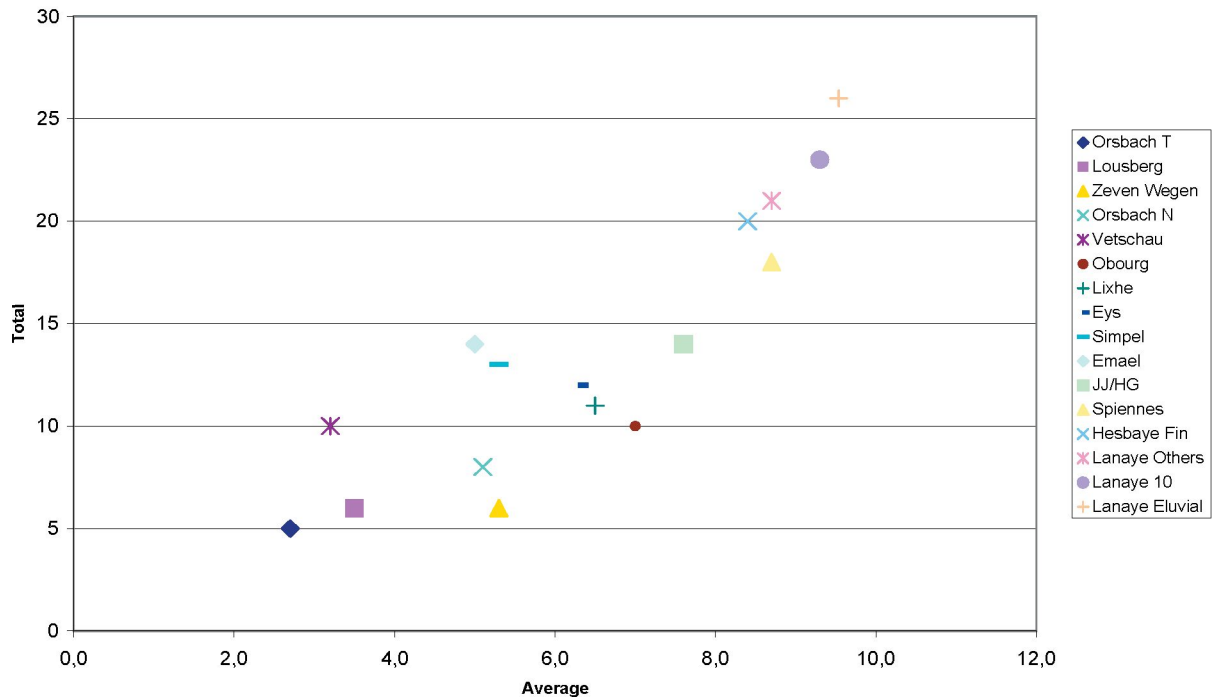


Fig. 2 Diversity of inclusions. X-axis: average number of different inclusions found in specimens, Y-axis: total number of different inclusions present in the sample.

Most inclusions were present in a great many of the flint types, although not necessarily in all specimens studied at a given outcrop or extraction site.

Only a few kinds of inclusions were found to be limited to one or two flint types.

Dark reticular patterns and small light spots arranged like beads on a string were encountered only in specimens of the Silex à grain fin de Hesbaye. White chalky spots occur only in Lixhe, nodular Orsbach and Vetschau flints.

The inclusions causing the flints to get a 'dusty' aspect were visible only in many of the eluvial flints (Rullen, Banholt, Rodebos). Red specks and spots are found almost exclusively in Zeven Wegen and Obourg flints, the exception being one specimen in the Rodebos sample. Angular cavities are present in Lanaye flint and its counterparts, but also in the Eyserbeek and Vetschau material.

For identification purposes, the dark inclusions in practice were found to be especially important, as they occur frequently, but only in a limited number of flint types. No dark inclusions were found in Zeven Wegen, Obourg, nodular Orsbach, Lixhe and Emael flints. Vetschau flints frequently contain dark wisps (*Schlieren*) and occasional dark specks. In tabular Orsbach and Lousberg flints small dark spots are sometimes found, and in Simpelveld flint dark specks. Medium-sized

and sickle shaped dark inclusions are only found in Lanaye flints and its counterparts (Hesbaye grenu, Spiennes and Jandrain Jandrenouille), and in the Silex à grain fin de Hesbaye. Moreover, in these flints various dark inclusions co-occur in almost all specimens.

Apart from the above-mentioned observations, the frequency and diversity of inclusions may be helpful in identification. Assessing the (relative) frequency of inclusions turned out to be unfeasible: as inclusions tend to be unevenly spread, the scores are dependent on the size of the studied flake, whereas flakes struck from different parts of a single block may present completely different scores. Instead, as a heuristic device to assess the diversity of inclusions, I plotted the average number of different kinds of inclusions on individual specimens and the total number of different inclusions in the total sample with a given origin. This way, three groups may be distinguished, showing a low, medium and high diversity (Fig. 2).

5.4. Post-genetic alterations

Under this heading the effects of chemical and mechanical weathering were recorded, in so far as these had come into being before the flints were extracted and worked. The main characteristics

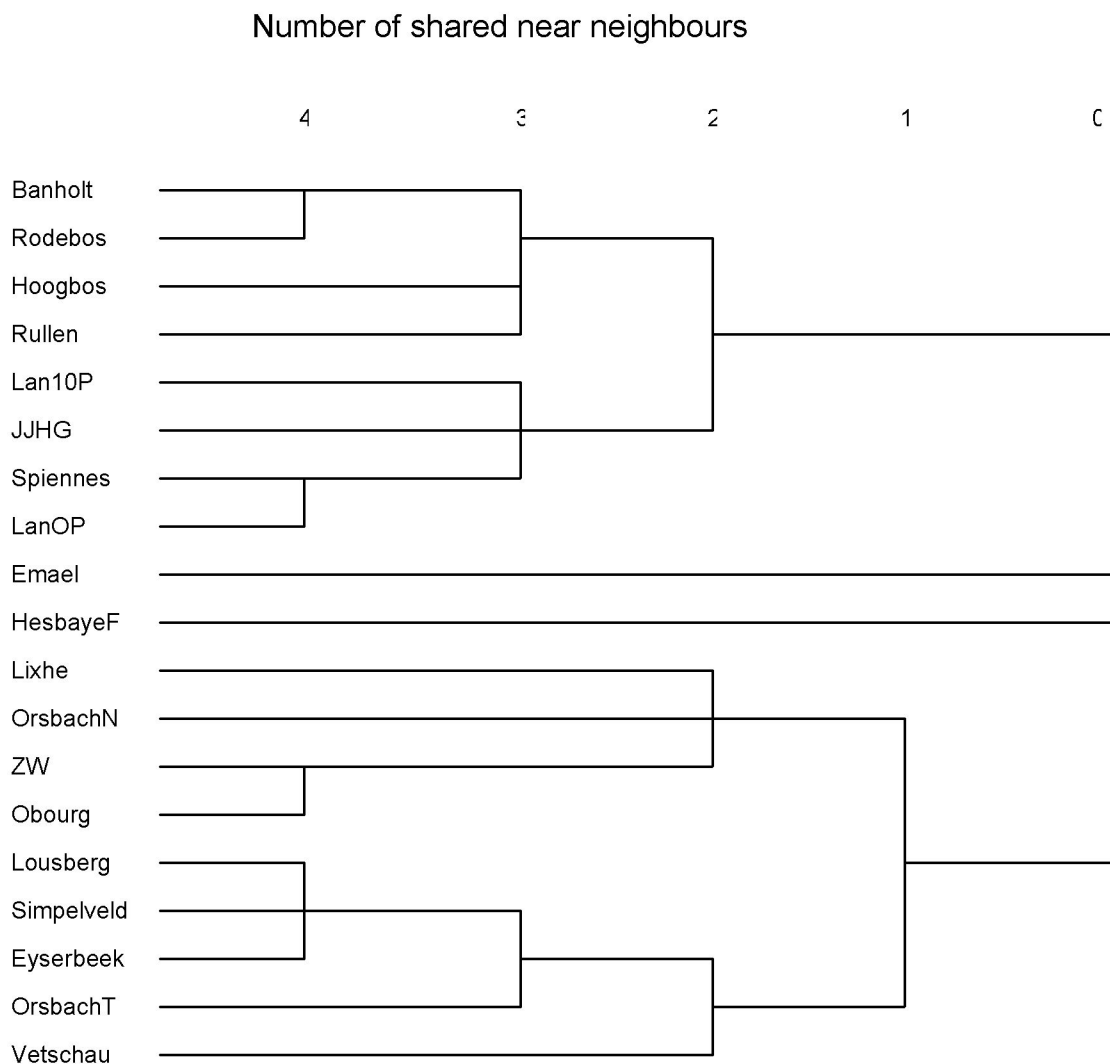


Fig. 3 Results of WINBASP Near Neighbour Clustering. Similarity Coefficient: Jackard; number of Neighbours considered: 4.

of posterior patination on flint artefacts are discussed by e.g. STAPERT (1976), ROTTLÄNDER (1989) and NIEKUS ET AL. (2001).

Chemical weathering sometimes has affected flints in a primary depositional position, when surface water infiltrated the chalks. Thus, the reddish-brown zones in Lousberg and tabular Orsbach flints are the result of the precipitation of iron oxides transported by infiltrating water. As has already been pointed out by DE WARRIMONT/GROENENDIJK (1993), the post-genetic alterations found in the interior of Lanaye (and to a lesser extent) Lixhe flints from residual loams (Heijenrath Formation) are of major importance. They result from the fact that these loams in part were mixed with considerable amounts of Oligocene sands, rich in iron oxides, displaying intense red and yellow colours. These phenomena will be discussed

more fully in Section 7.1.1.

Mechanical weathering causes breakdown of the rock, with little or no change in composition, e.g. as a result of the expansion and contraction caused by temperature changes, or of transportation. In our material it is mainly found on flints from river gravels. The cortex is abraded, and interior colours may be somewhat lighter than those on fresh material – but that phenomenon is found on flints embedded in residual loams as well. A special case is formed by flints that, after erosion in the Tertiary, had been part of an Oligocene (FELDER 1998) or Miocene (BERENDSEN 2004) pebble beach before being transported by the river Maas during the Pleistocene. These so-called ‘Meuse eggs’ or ‘Maaseier’ (LÖHR ET AL. 1977) possess heavily abraded, glossy dark grey or occasionally red or yellow natural surfaces.

6. Analysis and general categorization

The variables discussed in the previous section were initially recorded for individual specimens. In a second step, data for every outcrop and extraction point were summarized, and analysed by means of the Seriation and Cluster options of the WINBASP statistical package. The sample with primary flints from Lanaye seam 10 is labelled Lanaye10P; the other Lanaye seams were lumped together under the heading Lanaye Other; Jandrain Jandrenouille (Appendix 3.3.) and Hesbaye grenu (Appendix 3.4.) too were combined. On the other hand, I decided to regard the samples from the Eyserbeek extraction site and the Simpelveld-Baneheide knapping site as two separate entities, because at the latter flints from other extraction points in the vicinity may have been worked as well.

The analysis had to account for the high amount of within-group variation of the flints in the research area, as well as the high number of attributes common to (some of the) specimens from different groups. Although the majority of material from a given source may share important characteristics, and thus may be easily recognizable, many a specific specimens occur as well. Consequently, the flint types under consideration cannot be defined by means of a rigid, classical classification, i.e. in terms of singly necessary and jointly sufficient defining attributes (cf. DUNNELL 1971). Instead, they must be considered as polythetic sets, in which “each individual possesses a large but unspecified number of the attributes of the aggregate, each attribute is possessed by large numbers of these individuals, and no single attribute is both sufficient and necessary to the aggregate membership” (CLARKE 1968). Therefore, it was decided to use a graded categorization, in an approach resembling the prototype approach of cognitive psychology (HAMPTON 1995). Prototype representations categorize classes in terms of their central or most typical example – the prototype – rather than in terms of an explicit definition of the class boundary. A class is established through maximizing the number of attributes shared by its members, and minimizing the number of attributes shared with other classes. Moreover, some attributes are assigned a higher status, are considered to be more central than others. The well-known Lousberg flints may serve as an example to illustrate this point: the prototypical sample of Lousberg flint would be tabular; greyish in basic colour, posses chocolate brown to purplish infiltration zones under the cortex, and

be extracted at the mining site on the Lousberg in Aachen (D). Quite a few of the raw material specimens we collected at the Lousberg site, however, do not possess infiltration zones, whilst these are present in some of the material originating from a different lithostratigraphical unit, outcropping on the nearby Schneeberg and Wilkensberg, as well as on many nodular eluvial Lanaye flints. Other attributes (colour, translucency, lustre, texture) may be used to distinguish between them, but these in their turn are shared with several other types. The cortex of the so-called fine-grained Hesbaye flints (Silex à grain fin de Hesbaye) is another example. In my geological sample, all but one of the specimens had a smooth cortex; the single exception helped to identify artefacts found at the recently excavated LBK settlement of Beek – Remigiusstraat (NL).

Thus, although variables encountered only sporadically at a given location were included in the seriation, they are marked with smaller symbols in its graphic presentation, whereas the most common, prototypical attributes are emphasized (Table 9). Both axes in this seriation were sorted according to the seriation result, emphasizing similarities and differences between the units. The resulting matrix offers quite a nice characterization of the different flint types. In a cluster analysis performed with the same data-set, three clear groups of flint types emerge (Fig. 3).

The first consists of Lanaye flints from all seams and depositional contexts, together with Jandrain Jandrenouille/Hesbaye grenu and Spiennes. The second group contains Lixhe, nodular Orsbach, Zeven Wegen and Obourg, and the third Lousberg, Simpelveld and Eyserbeek, tabular Orsbach and Vetschau flints. Emael and the Silex à grain fin de Hesbaye both stand alone, without close connections to any of the other types. Within the main groups, subdivisions appear, indicating e.g. that it may be possible to discriminate primary and eluvial Lanaye flints – although Spiennes and Jandrain Jandrenouille/Hesbaye grenu still are annoyingly close to the primary Lanaye material. The groups and their subdivisions shall be discussed more fully in the next section.

7. Distinguishing related flint types

The seriation presented in Section 6 made clear that a number of flint types closely resemble each other, as was confirmed in the Cluster Analysis performed on the same data. Because this resemblance concerns important and widely used flint

TYPES	Zeven Wegen	Obourg	Orsbach N	Lixhe	Orsbach T	Lousberg	Eyserbeek	Vetschau	Emael	Hesbaje Fin	Simpelveld	Lanaye Other Prim	Rullen	Rodebos	JJ Hesbaje grenu	Lanaye 10 prim	Hoogbos	Spiennes	Banholt
Lustre shiny	X	X	X	x															
Colour hom	X	X	X	X	X														
Chalky spots			X	X				x											
Text vitreous	X	X	X	X						X									
Diversity low	X		X		X	X		X											
Red dots	x	x												(x)					
Div medium		X		X			X		X		X								
Cort cav			X	X	(x)	x	X	X			x	(x)							
Tablets					X	X	X	X	x		X								
Par lam						x	X	x			x								
Lus medium				x	X	X	X			x	X								
Cort thick			x	X	x	X	X	X	x		x	(x)							
Text granular								X	X										
Cort white	X	X	x	x	x		X	X		x	x	X	(x)	x	x	X		X	
Cort v thin	X	X							x	X		(x)							
Cor rough	x	x	X	X	X	X	X	X	X	(x)	X	X	x	x	X	X	X	X	X
White zone			x	x			X	X	(x)	x	x		x	x			(x)		x
Trans low			x	x	x				x			x			x	x	x		
Cort brown				x		x	X		x	x	x		x	x	x		X		x
Transl med	X		x		x	x	X	x	x	x	X	x	x	x	x	x	x	x	x
Nodules	X	X	X	X				x	x	X		X	X	X	X	X	X	X	X
Cort grey					x	(x)			x		(x)			x	X				x
Red brown infil					x	x		(x)			(x)		X	X			(x)		x
Transl (v) high		X						x	x	x			x	x				x	x
Text fine					X	X	X				X	X	X	X	X	X	X	X	X
Dark specks							X	(x)			x	X	X		X	X		X	X
Colour changes							X	X	X	X	x	X	X	X	X	X	X	X	X
Cort thin			x		x				x			x	x	X	X	X	X	x	X
Lustre matt						X		X	X			X	X	X	X	X	X	X	X
Small dark sp					x	(x)				X		X	X	X	X	X	X	X	X
Text inhom				(x)					x			x	x	x	x	x	x	x	x
Clear zone		X								x		x	x		x	x	x	x	x
Dark wisps								x		X		X	X	X	X	X	X	X	X
Yellow streaks										(x)			X	X			(x)		x
Conc lamin									x			x	x		x	x	(x)	x	x
Diversity high										X		X	X	X	X	X	X	X	X
Dark spots med										X		X	X	X	X	X	X	X	X
Dark sickle sp										X		X	X		X	X	X	X	X
Dusty surface													X	(x)					(x)

Tab. 9 Results of WINBASP seriation. Types and units are both ordered according to the seriation result. Upper case X : always present; lower case x: frequently present; (x): rarely present.

	Rijckholt/De Kaap	Hoogbos	Banholt	Rullen/ St. Pietersvoeren.	Rodebos	JJ/HG	Spiennes
White zone	No	Rare	Common	Common	Common	No	No
Red infiltration	No	Rare	Common	Frequent	Frequent	No	No
Yellowish wisps	No	Rare	Common	Frequent	Rare	No	No
Dusty surface	No	No	Rare	Frequent	Rare	No	No

Tab. 10 Comparison of post-genetic alterations in Lanaye flints from different extraction points and in related other flint types.

types, a fuller discussion of possible distinctive characteristics is called for.

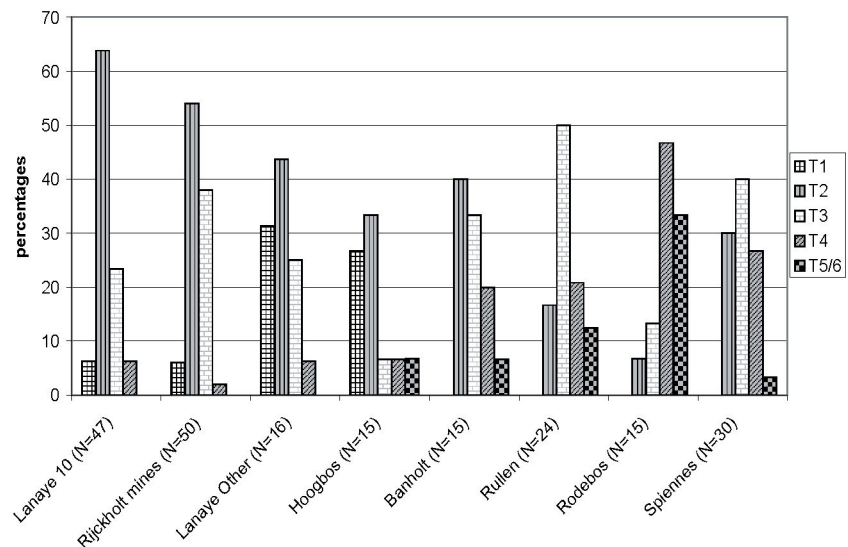
7.1. Lanaye flint and its counterparts

Flints from the western Lanaye facies may be distinguished from the other flint types in the study area through the combined presence of several kinds of dark inclusions. These occur as specks, small and medium-sized ovoid or sickle shaped spots and as tendrils. In texture they are similar to the matrix, or slightly more vitreous. Unfortunately, they share this trait with the material from Jandrain Jandrenouille/Hesbaye grenu and Spiennes, as well as with the Silex à grain fin de Hesbaye. In the latter case, however, other variables (notably texture, translucency and thickness of cortex) are so different that distinction is unproblematic.

7.1.1. Lanaye flints from different depositional contexts

Because the study area contains several important Neolithic extraction sites exploiting Lanaye flints from different depositional contexts, a number of researchers have sought to develop sets of variables with which flints from residual loams and those from a primary geological position can be reliably distinguished on a macroscopic level. Moreover several petrographical and geochemical analyses were undertaken, as an independent method of characterising raw material and studying within- and between-source variation (cf. FELDER ET AL. 1998, 13-16). Initial geochemical research was performed by a.o. BAKELS ET AL. (1975; BAKELS 1978) looking for differences in trace element content by means of neutron activation analysis, but it proved to be impossible to distinguish the material from the Rijckholt flint mines from that found at the exploitation sites of Banholt, Mheer and Rullen. Subsequent research by KARS ET AL. (1990) and McDONNELL ET AL. (1997) found differences between material from these differ-

Fig. 4 Lanaye flints from different depositional contexts and Spiennes flints: comparison of translucency.



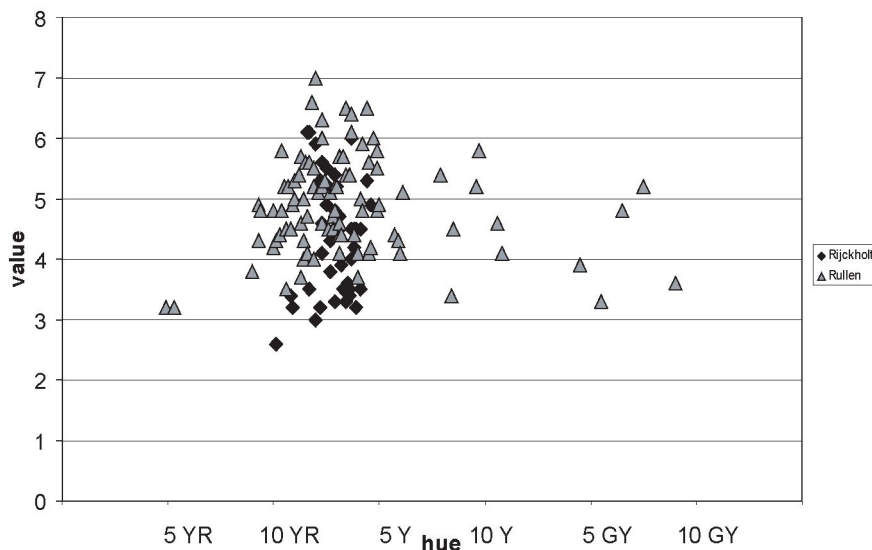


Fig. 5 Lanaye flint from different depositional contexts: comparison of Munsell hue and value scores. Rijckholt = primary Lanaye flints from the Rijckholt mining area; Rullen: Lanaye flints from residual loams at the Rullen and Sint Pietersvoeren extraction sites. Data after DE WARRIMONT/GROENENDIJK (1993, Table 2).

ent extraction points, using both macroscopic and petrographical and geochemical methods. KARS ET AL. (1990) recorded that a noteworthy character of the Western Lanaye Chalk flints is the sometimes high amount (varying between 5 to 50%) of carbonate. This carbonate is partly present as dispersed micrite (finely crystalline marine calcium carbonate), and as angular to rounded or elongated bioclasts (fossil debris). Later on, McDONNELL ET AL. (1997) reported that a combination of petrographical and geochemical analyses made it possible to distinguish between flints originating from Rijckholt and from the Rullen area, with Banholt and Mheer having an intermediate position. De WARRIMONT /GROENENDIJK (1993) offered an important contribution to the characterization and distinction of the flints under consideration, in a study that combined a macroscopic assessment with Munsell colour measurements using a

spectrophotometer. They outlined the importance of opaque white, and translucent reddish brown infiltration zones under the cortex, as well as differences in dominant colours.

To these parameters the present study adds:

- The occurrence of yellowish to brown wisps (tendrils) deeply penetrating into the nodules.
- Natural and artificial fracture planes with a 'dusty' aspect, probably because the presence of dense concentrations of minuscule vermiculate spots became visible through bleaching (loss of carbonate content).
- Differences in translucency. Whereas the material from the Rijckholt mine shafts and the slope deposits both displayed a low to medium translucency, those residual sites containing a mixture of loams and Oligocene sands produced highly translucent flints.

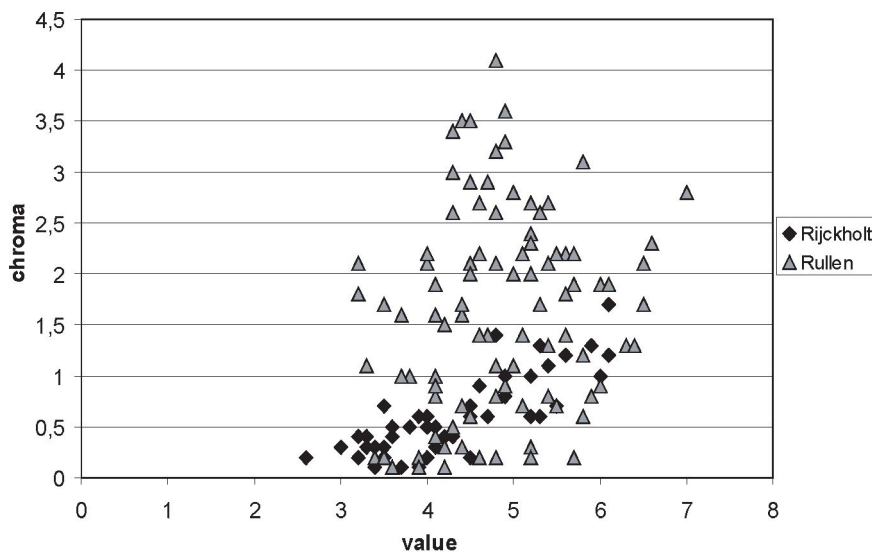


Fig. 6 Lanaye flint from different depositional contexts: comparison of Munsell value and chroma scores. Rijckholt = primary Lanaye flints from the Rijckholt mining area; Rullen: Lanaye flints from residual loams at the Rullen and Sint Pietersvoeren extraction sites. Data after DE WARRIMONT/GROENENDIJK (1993, Table 2).

Using these variables, in many cases it is indeed possible to distinguish between flints from different eluvial extraction points and those from primary sources (**Table 10 ; Fig. 4**). This holds true especially when dealing with large assemblages (cf. DE GROOTH 2007), although in some cases plausible sourcing has been achieved for single artefacts as well. It should be stressed, however, that those identifications were supported by direct comparison with specimens from the reference collection.

7.1.1.1. Rullen and Sint Pietersvoeren

Flints from the Rullen and Sint Pietersvoeren (Vrouwenbos/Bois Communal and Sparrenbos/Bois des Sapins) extraction sites are most easily identified.

As fits their origin in the Western Lanaye deposits, the basic colour of the flints found at these sites was grey. Specific post-genetic alterations make it possible to distinguish Rullen flints from the Lanaye material from primary chalk deposits. The cortex is brown, sometimes rough, sometimes smooth; mostly thin (1 mm), but sometimes thick (2-10 mm). A thick, white layer is often present, especially in material from the Sint Pietersvoeren (Bois Communal and Bois des Sapins) sites. The fracture planes mostly have bleached and 'dusty' aspect. Their translucency is high to very high. And, finally, the infiltration of the iron compounds present in the matrix led to a yellowish-brown discoloration. According to the spectrophotometric measurements performed by DE WARRIMONT/GROENENDIJK (1993), the Munsell hues of Rullen/Sint Pietersvoeren and Rijckholt flints are similar, the primary Lanaye flints from the Rijckholt area cluster between 2.5Y and 5Y, whilst the Rullen/Sint Pietersvoeren sample varies between 10YR and 5Y. The Rullen scores on value and chroma, however, in general are much higher. In the Rijckholt sample scores for value lay between 2.6/and 6/, those for chroma between/0 and/2. The Rullen/Sint Pietersvoeren specimens had readings for value laying between 4/and 7/ - resulting in lighter colours -, and scores on chroma between/1 and/4 - resulting in more saturated colours. Thus, besides the ubiquitous "very dark gray, dark gray, light gray" of the Rijckholt sample, in the Rullen/Sint Pietersvoeren material "light brownish gray", "olive brown", "dark and light yellowish brown", and even "(very) pale yellow" were present as well (**Fig. 5 and 6**) To this observation must be added that Rullen flints from an archaeological context may display even

stronger colours, resulting in the 'honey' or 'egg-yolk' coloured material often seen to represent the typical Rullen flint (esp. LÖHR ET AL. 1977).

7.1.1.2. Banholt

An assignment of material to this extraction site may be based on the following considerations: In basic colour, texture, and lustre, this material is very similar to the Rijckholt sample. The cortex, however, is rough, thin, brown or grey. Frequently a thin reddish brown, vitreous zone below the cortex is present, and a thick white layer may occur. Brown or yellowish wisps are common, as are concentrations of light specks (<1 mm). The average translucency of Banholt flints lays between that of the primary Lanaye/Rijckholt sample and the Rullen/Sint Pietersvoeren material. However, Banholt flints possess neither the gamut of colours nor the 'dusty fracture planes' found on the Rullen/Sint Pietersvoeren material. Using these criteria, Banholt is seen as the site where the majority of flints found at the Early Bandkeramik site of Geleen-Janskamperveld probably was extracted (DE GROOTH 2007).

7.1.1.3. Hoogbos

The majority of flints extracted at this site share most characteristics with primary Lanaye/Rijckholt material; the exception being a rough, thin and brownish cortex. The others are very similar to the Banholt sample (with infrequent yellowish wisps, opaque reddish brown zones and concentrations of small light spots). Therefore, it is impossible to identify flints from this extraction point in archaeological assemblages.

7.1.1.4. Rodebos

Lanaye flints with shiny fracture planes and high to very high translucency in combination with a reddish brown vitreous zone under the cortex may be tentatively assigned to this extraction point. This was the case for a Middle Neolithic pointed blade (*Spitzklinge*) from Beek-Spaubeek (BROUNEN/VROMEN 2005).

7.1.2. Lanaye - Spiennes

Spiennes and Lanaye flints do not only share the dark inclusions, but other characteristics too: they are similar in shape, size and cortex -rough, very thin or thin (under 1 to 1.5 mm), white/yellowish-, in texture (fine-grained, with some coarser

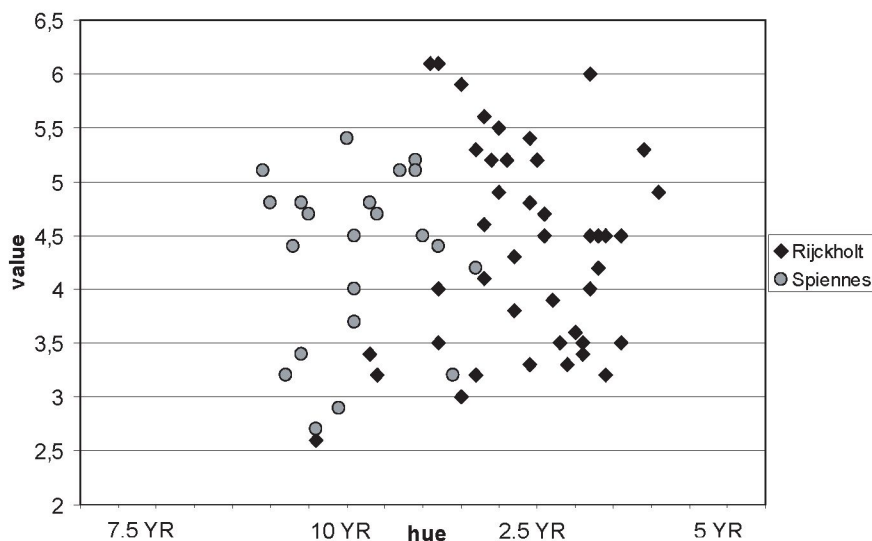


Fig. 7 Primary Lanaye and Spiennes flints: comparison of Munsell hue and value scores. Rijckholt: data after DE WARRIMONT/GROENENDIJK (1993, Table 2)

parts) and lustre (matt). They are both very dark grey to light grey in colour; the colour may be homogeneous, but often changes gradually from dark to light within individual nodules. In both, concentric laminations and a darker, more fine-grained zone under the cortex may occur; the contain the same kinds of light inclusions, in similar (high) frequencies. Moreover, the geochemical analyses that have been performed to assess the differences between the two types, had ambiguous results as well. ASPINALL/FEATHERS (1972) and STOCKMANS ET AL. (1981) found slight differences between samples from Spiennes and Rijckholt. KARS ET AL. (1990), however, using the ICPAES (inductively coupled plasma atomic emission spectrometry) technique, concluded that the flints from Spiennes and from the Lanaye Chalk are rather similar with respect to colour, grain size, mineral and fossil content, and could not be dis-

tinguished on macroscopical and microscopical grounds.

However, on fresh, unweathered material the following differences were found.

- Translucency is somewhat higher for Spiennes than for Lanaye: medium to high (60% of the sample is translucent to a thickness of over 5 mm; Fig.4).
- The Spiennes flints display Munsell hues around 10 YR, and the primary Lanaye samples (geological and from the Rijckholt mines) cluster between 2.5 and 5Y. The scores for value and chroma do not differ (Fig. 7 and 8).

Although the eluvial Lanaye flints described earlier, especially those from the Rullen sample, overlap with the Spiennes material both in colours and in translucency, the Spiennes material lacks their distinctive secondary characteristics (bleached aspect; dusty surface, brownish wisps,

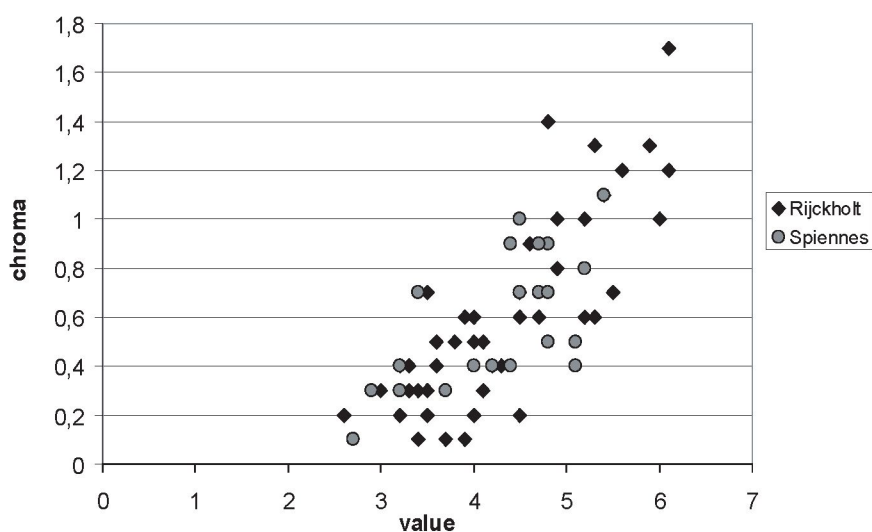


Fig. 8 Primary Lanaye and Spiennes flints: comparison of Munsell value and chroma scores. Rijckholt: data after DE WARRIMONT/GROENENDIJK (1993, Table 2)

reddish brown infiltration under the cortex).

As these differences are not of kind but of degree, and especially as they may only be assessed on fresh, unweathered surfaces, I think it pretty hazardous to distinguish between Spiennes and Lanaye/Rijckholt flints in archaeological samples, even with the help of a reference collection. Given the differences in geological age, however, a non-destructive microscopic study of micro-fossils, such as developed by AFFOLTER (2002), may in future lead to a reliable distinction.

7.1.3. Lanaye – Jandrain Jandrenouille/Silex grenu de Hesbaye

These two groups only differ as regards the diversity of inclusions (high for Lanaye vs medium for JJ/Hesbaye grenu). In practice, it seems impossible to distinguish these flint types macroscopically.

7.2. Zeven Wegen, Obourg, Lixhe, and nodular Orsbach

These four flint types share the following characteristics: they are small and nodular; with a white cortex; their colour is black or very dark grey and homogeneous; their texture is vitreous and their lustre shiny; the diversity of inclusions is low or medium. The group may be subdivided into two pairs, Zeven Wegen/Obourg and Lixhe/nodular Orsbach respectively. The following parameters are responsible: cortex (very thin and sometimes smooth for Zeven Wegen/Obourg vs. thick, with cavities and protuberances and a thick white zone underneath it for Lixhe/nodular Orsbach); translucency (medium to high for Zeven Wegen/Obourg vs. low to medium for Lixhe/nodular Orsbach); and the occasional occurrence of reddish specks and spots (Zeven Wegen/Obourg) vs. the regular presence of white chalky spots (Lixhe/nodular Orsbach).

Although they are closely connected, some differences between Zeven Wegen and Obourg flints were visible in the data-set: The Zeven Wegen nodules tend to be of smaller size (maximum dimension 10-20 cm), have a slightly lower translucency, do not possess a darker, slightly smoother zone underneath the cortex and have a lower diversity in inclusions. Moreover, our geological samples lack the yellowish brown infiltration zones under the cortex that occur occasionally on Obourg flints found in secondary depositional positions, e.g. at Obourg-La Haute Folie

(cf. <http://www.Flintsource.net>). Nevertheless, in archaeological practice distinguishing the two varieties is difficult, especially on small or medium-sized artefacts. Thus, the Zeven Wegen Member should be considered as an alternative source before suggesting very long-distance exchange contacts between south-western Belgium and e.g. the Rhineland (cf. WEINER 2005)

The differences between Lixhe and nodular Orsbach flints also are very slight, the former have a higher diversity of inclusions, sometimes a slightly lower translucency and may be a bit less shiny. Again, I think it would be very difficult to differentiate the two types in an archaeological context.

7.3. Lousberg, tabular Orsbach, Vetschau, Simpelveld/Eyserbeek

The types share the following characteristics: All occur as tablets (although Vetschau flints may be nodular too). Their cortex is thick, rough with cavities and protuberances, and their translucency is medium.

According to the Cluster Analysis, Lousberg and Simpelveld/Eyserbeek flints are very close. The latter, however, often display gradual changes in colour, may have a white zone under the cortex, a medium lustre and have a somewhat higher diversity of inclusions. Although two of the artefacts we collected at the Simpelveld-Baneheide knapping site carried reddish brown infiltrations, this characteristic was absent on the material from the Eyserbeek outcrop. Therefore, I think these pieces may originate from another extraction point.

The prototypical Lousberg and tabular Orsbach flints have extensive reddish or even purplish brown infiltration zones – although this trait is not present on all specimens–, a fine-grained texture, a low diversity of inclusions, with the occasional presence of small dark spots. They differ as regards colour (very dark grey of black for Orsbach tablets, lighter, brownish grey for Lousberg), lustre (matt for Lousberg, medium for tabular Orsbach), and parallel lamination (frequently present on Lousberg flints, absent in our tabular Orsbach sample).

Within this group, Vetschau has the weakest links. It occurs both as tablets and as nodules and its texture is coarse-grained. It has a matt lustre in common with Lousberg, and a low diversity, similar to Lousberg and tabular Orsbach; the tablets often are laminated, tablets and nodules show

gradual changes in colour (a trait shared with Simpelveld/Eyserbeek), white chalky spots and dark wisps (*Schlieren*) occur more often than in the Simpelveld/Eyserbeek sample. Red infiltration is very rare.

8. Identifying flint types in non-extraction contexts

As a final step, I tried to examine whether this scheme could also be used to identify flint artefacts found not at extraction sites but in other archaeological contexts (e.g. settlements, graves, hoards). This is not altogether unproblematic, because artefacts there are often small-sized or patinated. Firstly, one should always bear in mind the old adage: absence of evidence is not evidence of absence. This works two ways. On the one hand, not all variables characteristic for a given flint type, may be present on all the artefacts in an archaeological assemblage (e.g. the important information present on the cortex and in the subcortical zones, obviously, can only be recorded when present). On the other hand, as was outlined above, many nodules from a given extraction point do not display all characteristics regarded as 'typical'.

Even a slight patination may affect variables such as lustre, and translucency. For the evaluation of artefacts from the extraction sites presented in this study, fresh surfaces were produced regardless, but this is a procedure not generally recommendable for material from other contexts. As regards translucency, this is something of an one-sided problem: while seemingly opaque artefacts are difficult to evaluate, highly translucent material often may be identified (cf. DE GROOTH 2007). Lustre, however, can only be scored when fresh fracture planes are present. In my experience, texture may be assessed even on patinated flints. In most cases, fine-grained and vitreous material becomes even more so through weathering. Patinated coarse-grained Emael flints, on the other hand, may get a 'quartzitic' aspect, and become so de-silicified that they can easily be broken by hand (BROUNEN/PLOEGAERT 1992). Cortex colour may change as the result of posterior weathering, thus affecting the telling white cortex found on many flints from a primary depositional context. The types of inclusions and their diversity are least influenced by the effects of weathering, but this variable may be hard to assess on small-sized artefacts. However, the various dark inclusions characteristic for Lanaye flints and its

counterparts, may even be recognized on burned artefacts. I think, on small artefacts it would be difficult to distinguish between concentric zonations (Lanaye and related flint types, Emael) and parallel lamination (Lousberg, Vetschau, Simpelveld).

In practice, many artefacts in a given assemblage may not be sourced individually, but major trends will be recognizable. Moreover, using common sense may be helpful: when a number of artefacts in a settlement assemblage can positively linked to an outcrop or extraction point, other, less characteristic material may be assigned to the same source by default. Alternatively, when a settlement is located in the immediate vicinity of an extraction point, it would be logical to consider this as a probable raw material source, unless the characteristics of the artefacts refute this option. Likewise, at sites located on or near to river gravels, I would tend to regard these as probable origin of all artefacts not positively linked to other, non-local, extraction areas. In the end, one will always encounter flints that, although looking somehow quite familiar, do not fit the schemes. Originating from one of the flint seams not exploited systematically, they may have been collected from an eluvial or river gravel context.

9. Conclusion

This study showed that it is possible to distinguish the different Upper Cretaceous flint types exploited in the study area. Moreover, reliable connections between raw material varieties found at extraction points and in other archaeological contexts often may be established, especially at the assemblage level. Still, a cautionary note should be added. Given the often ephemeral character of the differences, it seems highly advisable not to rely solely on the descriptions offered in this study, or even on photographs, but to consult the well-documented reference collections established at the archaeological centres in Leiden, Maastricht, Leuven, Cologne, and at the present author's.

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The Appendix, containing a full description of outcrops, extraction points and their flint types, as well as characteristic photographs, may be found on the attached CD.

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The Appendix, containing a full description of outcrops, extraction points and their flint types, as well as characteristic photographs, may be found on the attached CD.