Beyond the caves : stone artifact analysis of late Middle Paleolithic open-air assemblages from the European Plain

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Chapter I: Introduction

1.1 Aims of the Thesis and general Introduction

What drives late Middle Paleolithic stone artifact variability? –
is the central question of this thesis. In its attempt to answer this question, this thesis is a contribution to understanding variability within and between late Middle Paleolithic assemblages of the European Plain. The selected research area is rich in late Middle Paleolithic open-air sites but up to now lacking detailed quantitative comparisons between them. Furthermore, to better understand changes within the stone artifact record during the Middle to Upper Paleolithic transition in central Europe or the development of transitional industries from a late Middle Paleolithic substrate, we first need to better understand how late Middle Paleolithic variability is structured. Additionally, late Neanderthal population dynamics in central Europe inferred from changes within stone artifact assemblages might be better understood in the future if we know more about the structure of late Middle Paleolithic variability. Therefore, the main aim of this study is to reveal factors that drive artifact variability on (1) an assemblage and inter-assemblage level, and (2) within a specific tool concept. Thereby, it provides a critical examination of established late Middle Paleolithic techno-functional units, which currently create a patchwork of differently named archaeological entities within the geographical range of the research area (e.g. Kozłowski, 2014, fig. 16).

For the scope of this thesis, I primarily focus on multilayered, directly dated late Middle open-air sites from the European Plain whose assemblages have been typo-technologically attributed to different archaeological entities (Fig 1): Königsaue (Mania and Toepfer, 1973; Mania, 2002) and Pouch (Weiss, 2015) from Saxony-Anhalt, central Germany, Wrocław-Hallera Av. (Wiśniewski et al., 2013) from southwestern Poland, and Khotylevo I-6-2 (Ocherednoi et al., 2014a, 2014b, 2015; Vishnyatsky et al., 2015) located in western Russia. For the regional analysis of tool concepts (Chapter IV) two late Middle Paleolithic artifact collections from around the site Pouch where incorporated in the study. From a techno-typological point of view, the lower assemblage of Wrocław-Hallera Av. and Königsaue B (e.g. Mania, 2002) are interpreted as Mousterian, and Königsaue A, C (e.g. Mania, 2002), Pouch and Khotylevo I-6-2 can typologically be classified as Micoquian. Additionally, both assemblages from Wrocław-Hallera Av. are interpreted as Taubachian due to their small artifact size (Valde-Nowak et al., 2016; Alex et al., 2017). The assemblages analyzed here date between Marine Isotope Stage (MIS) 5a (~ 82 ka (Lisiecki and Raymo, 2005)) and early MIS 3 (~60 ka to ~43 ka (Richter, 2016)).

Figure 1. *Map of the main sites of the European Plain analyzed here. Pouch-Terrassenpfeiler (Pouch) is described in Chapter II. Together with Königsaue, Wrocław-Hallera Av. and Khotylevo I-6-2, it is part of the study presented in Chapter III. The variability in tools from Pouch and from the two assemblages of collected artifacts around the site, Goitzsche and Löbnitz, are analyzed in Chapter IV.*

1.1.1 Variability of the late Middle Paleolithic and Outline of the Thesis

The late Middle Paleolithic is characterized by a high degree of stone tool variability together with an increased number of sites compared to former time periods. Recently, Richter (2016) has shown that for the German archaeological record the site density raised substantially towards the end of the Middle Paleolithic. He (Richter, 2016: 121) states that more than half of the German Middle Paleolithic record dates to the time period treated in the present thesis, more specifically the first half of MIS 3 between 57.000 (Lisiecki and Raymo, 2005) and 43.000 years ago. In the article's title Richter (Richter, 2016) states that Neanderthals "left at the height of the party". This certainly refers to the increased number of sites, but it also refers to the notion that almost all technological concepts of stone artifact manufacture that regionally occurred and vanished during the more than 250.000 years of Middle Paleolithic (for an overview of the early Middle Paleolithic record see Hérisson et al., 2016; for northwestern Europe see recently van Baelen, 2017; for central Germany see e.g. Lauer and Weiss, 2018) culminated in the late Middle Paleolithic record: "[…] *All earlier innovations which had been re-invented and re-lost several times, became now firmly established parts of OIS 3 [MIS 3] technological knowledge. Moreover, some entirely "new" innovations were added* […]." (Richter, 2000: 126). This variety of lithic technologies and tool forms led to increased variability in the late Middle Paleolithic record. It is due to this observed variability that researchers have divided the late Neanderthal material culture into regionally and/or technologically distinct groups based on typo-technological entities, technocomplexes or certain tool concepts ('type fossils'). This has resulted in a patchwork of techno-typologically different entities (see section 1.2 below). Often, the definition of some of the late Middle Paleolithic entities of central and eastern Europe is a relic of the research history (e.g. Mousterian and Micoquian, see section 1.2 below). Furthermore, the current assemblage classification is sometimes rather subjectively inferred from a modern point of view on lithic assemblage compositions and our current interpretations of past blank production strategies.

There are some important questions arising from the traditional typo-technological ways of assemblage classification. Following the classical techno-typological approach, human decisions embedded in cultural traditions seem to be the main agent driving stone artifact and assemblage variability. This relates e.g. to the manufacture of the type fossils (e.g. bifacial backed knives or Keilmesser), the blank production method and artifact size. Is this true or are there other factors besides human decisions – like e.g. raw material availability and constraints, environmental factors, taphonomy, or functional needs – that drive stone artifact variability? Is artifact size driven by humans (see Moncel and Neruda, 2000) or rather by factors like raw material conditions (see Schäfer, 1987; Weber, 2012)? Is the type fossil really the most important aspect of assemblage variability to differentiate archaeological entities (see e.g. Dibble et al., 2013)? Is a type fossil really a unique tool type or is there an underlying tool concept which was, for example, applied to different blanks? How many bifacial tools (see e.g. Monnier and Missal, 2014) and Levallois cores, for instance, distinguish a Micoquian from a Mousterian assemblage? Is a site without bifaces but with biface thinning flakes (see e.g. Faivre, 2006; Turq et al., 2013) Mousterian or Micoquian? Does or how does site function and length of occupation at a site or within an area alter the archaeological record (Richter, 1997, 2000, 2001, 2002, 2012, 2016)?

To solve some of these questions, we need a better understanding about how variability in the late Middle Paleolithic is structured beyond the limits of the current techno-typological classifications. If we try to reconstruct past human history and human behavior based on the established assemblage classifications only, other aspects that drive variability and connect or disconnect certain assemblages might be disregarded (Monnier and Missal, 2014; Shea, 2014). Therefore, this thesis aims to apply more quantitative ways of lithic analyses that treat all artifacts of a specific assemblage equally without making assumptions about end products, the importance of certain tool classes as type fossils, or potential sequences and processes of manufacture. The set of analytic tools applied here may help to reveal variability within and between assemblages on a continuous scale. Lithic variability is analyzed in this thesis in two ways, by looking at whole assemblage variability and by analyzing certain aspects of tool variability. Attribute analysis and subsequent multivariate analysis are applied to the flake assemblages to learn how the archaeological record is structured when the type fossils are taken aside. Subsequently, attributes of cores, flakes and tools are analyzed in relation to each other to reveal how raw material conditions, raw material management strategies, flaking behavior and tool production influence the patterns we see in the multivariate analysis of those flake assemblages. Further, a morphological analysis of the most prominent tool type of the Micoquian, the Keilmesser, is part of this thesis. Not focusing too much on the bifacial tool itself, 3D geometric morphometrics, Thickness Mapping of 3D models together with multivariate analysis based on attributes are applied to tackle the question of whether the morphological and functional concept of a Keilmesser is as well found in simple edge retouched and unifacially surface shaped tools. Additionally, whether there exists a relationship to the 'closest relative' of the bifacial backed knife, the Micoquian handaxe, is examined.

1.1.2 The Study of Open-Air assemblages from the European Plain

Open-Air Sites

In the European Plain, north of the low mountain ranges, late Middle Paleolithic sites are almost exclusively open-air, and up to now they are lacking detailed quantitative comparisons between them. Assemblages from open-air sites are interpreted as being less time-averaged compared to most assemblages from cave deposits and clusters of short-term occupations may be preserved (see e.g. Isaac, 1981; Roebroeks, 1988; Roebroeks et al., 1992; Roebroeks and Tuffreau, 1999; Enloe, 2006; Bailey and Galanidou, 2009 and references cited therein; Picin, 2016). Thus besides being the only data source in this geographical region, these short-term artifact accumulations allow us to analyze human behavior within a narrow time span.

From a methodological perspective, analyzing several short-term occupations makes it possible to adjust time scales during the analysis and to look at the assemblages from different angles in space and time. This is in line with the concept of 'time perspectivism' (Bailey, 1981, 2007, 2008; De Lange, 2008), which suggests adjusting the scale of observation to answer specific research questions: "*The idea here is that changes in the time scale at which we make observations change what we see and that varying time scales bring into focus different variables and processes that are not visible, or not so easily visible, at other time scales* [...]" (Bailey, 2008, p. 13). Applied to the aim of this thesis, narrow time scales for the accumulation of archaeological material reflected in short-term occupations are more suitable for isolating individual factors at a specific moment in space and time that may have driven stone artifact variability (e.g. raw material conditions, knapping behavior). In contrast, archaeological layers that are more time averaged (e.g. through repeated human occupations of the same place combined with a low sedimentation rate) have the advantage of reflecting long-term processes in human history (Bailey, 2007; De Lange, 2008; Bailey and Galanidou, 2009) or common factors that influence stone artifact variability. These long-term developments in human history are necessary to understand past human behavior on a broader scale. Therefore, within the analysis of open-air assemblages the time and space perspectives may then be adjusted in a second step and individual short-term stone artifact accumulations can be compared on a broader scale across assemblages. With this second step it is possible to compare lithic variability between the individual short-term artifact clusters and to verify broader archaeological entities or the variability of specific tool concepts.

However, it has to be kept in mind that the individual artifact clusters found in open-air sites leave also room for time averaging processes, as they may have formed on a substrate of isolated artifacts or low density scatters present in the landscape. This may have led to the formation of sites bearing artifacts or artifact clusters from different episodes of occupation, combined with a horizontal stratification of find scatters at those locations (e.g. Isaac, 1981; Roebroeks et al., 1992; Roebroeks and Tuffreau, 1999). To prevent or at least limit the analysis of mixed assemblages from repeated occupations, I primarily incorporated assemblages in the study that contain several refit sequences (see section 1.4 below). Of course that does not rule out that Neanderthals potentially knapped the same artifacts during several visits, but together with the rather fast sedimentation rate at the sites (see sections 1.4 and 1.5 below) it is at least evidence that the individual assemblages are the result of a single actions.

Selection of the Chronological Framework and a comparable Paleoenvironment

Assemblages from before and after the first glacial maximum during MIS 4 where selected to account for the whole chronological range of the late Middle Paleolithic and to reveal potential chronological changes of lithic technology and typo-technological archaeological entities (e.g. Richter, 1997, 2016; Jöris, 2004). The late Middle Paleolithic open-air assemblages within the framework of this study (for detailed description see section 1.4 below) range from around 80 ka during MIS 5a with the lower assemblage from Wrocław-Hallera Av. (Skrzypek et al., 2011) and potentially Königsaue (Mania and Toepfer, 1973; Mania, 2002; Jöris, 2004, but see Hedges et al., 1998; Picin, 2016), to around ~50 to ~44 ka during early MIS 3 with the site of Pouch-Terrassenpfeiler (Weiss, 2015).

The climate during MIS 5a is characterized by temperate mean summer temperatures around 15°C that allowed the growth of boreal pine and birch forests (Caspers and Freund, 2001; Litt et al., 2007). However, during the early Weichselian an increased continentality was recognized with a trend towards more open interstadial landscapes indicated by an increase in non-arboreal pollen (NAP) in MIS 5a compared to MIS 5c (Caspers and Freund, 2001). If we consider an MIS 5a age for the central German site Königsaue (see 1.4.3 for varying age interpretations), the pollen spectrum from the site suggests patchy pine and birch forests together with open grassland steppes in western central Europe. In contrast, during the early MIS 3 the European Plain was covered by tundra and/or steppe tundra environments (Huntley and Allen, 2003), also referred to as 'mammoth steppe' (Guthrie, 1990). Generally, the stone artifact assemblages from each time period (MIS 5a and MIS 3 respectively) were manufactured under more or less comparable environmental conditions and were potentially related to comparable subsistence strategies. As during the late MIS 5, continental climate and open landscapes in central Europe increased (Caspers and Freund, 2001), and environmental conditions and subsistence strategies in early MIS 3 and MIS 5a might also be comparable to some extent. Thus, the influence of environmental factors on stone artifact variability between the distinct assemblages is limited, and the analysis can primarily focus on variability caused by, for example, raw material size and knapping behavior (Chapter III) or tool shaping strategies (Chapter IV). Additional environmental conditions connecting these sites, like the location of the sites at lake shores or riverbanks with access to raw material, are described in Chapter III and Chapter IV.

Selection of the geographical Distribution of the Sites

Neanderthals inhabited a large territory ranging from the Altai in the east to the British Islands in the west. Together with the low estimated population size for Neanderthals (see Roebroeks et al., 2011 and citations therein; Prüfer et al., 2017), a low population density can be inferred. The lifeways of Neanderthal groups were likely characterized by high mobility with short-term stays and frequent movement of their camps (Roebroeks and Tuffreau, 1999; Verpoorte, 2006; MacDonald et al., 2009). Compared to modern humans, Neanderthals seem to have had a smaller residential foraging range, which is the result of higher energetic requirements and locomotion costs due to their larger body size and shorter limb length (e.g. Sorensen and Leonard, 2001; Steegmann et al., 2002; Aiello and Wheeler, 2003; Weaver and Steudel-Numbers, 2005; Verpoorte, 2006; MacDonald et al., 2009; Roebroeks et al., 2011). In the framework of a central place foraging model proposed by Kelly (1995), which assumes equal resource distribution around a central location or camp, the higher energetic requirements and locomotion costs led Neanderthals to reach the limits of the effective foraging radius at a shorter distance than modern humans (Verpoorte, 2006; MacDonald et al., 2009). Thereby, the effective foraging radius can be described as ‘the point of return’, as travelling further would result in higher energetic costs than the daily net return from foraging. As a result, Neanderthals would have depleted the resources of a given territory much faster compared to modern humans, and they therefore would have had to move their camp more frequently. In this model, although they moved generally slightly less over the year compared to modern humans (due to the larger foraging radius of the latter), their lifeway still led to highly mobile Neanderthal groups roaming within the vast tundra steppe or open grassland environments of the European Plain.

The highly mobile lifeway of Neanderthals and the occupation of large territories in central Europe is reinforced by studies of raw material transport. They have shown that Middle Paleolithic groups of central Europe ranged in a wider territory than in western Europe, as raw material transport distances of 100-300 km occur more often with increased continentality (Féblot-Augustins, 1993, 1999, 2009; Floss, 1994). This might be due to larger seasonal variation of annual temperature and precipitation and related larger scale animal (prey) movements in central Europe compared to western Europe (Féblot-Augustins, 1993, 1999, 2009).

To account for the low population density together with the high mobility and the expected wide (seasonal?) movement range of late Neanderthal groups in central Europe, I chose sites (Fig. 1) that cover a representative part of the vast geographical area of the European Plain: the assemblages come from its northwestern part (central Germany), the middle part (southwestern Poland) and the eastern part (western Russia).

Limits of the Conclusions drawn from the selected Assemblages

For various reasons, e.g. accessibility, assemblage integrity, excavations in-progress, or the lack of direct dates, not every assemblage of the European Plain could be incorporated in this study. There may be aspects of variability only visible in other late Middle Paleolithic assemblages that are therefore beyond the scope of this thesis. However, the number artifacts analyzed was sufficient to capture the quantitative characteristics of each assemblage (see Supplementary Information to Chapter III). Together with the distribution of the sites, i.e. the representation of different parts of the European Plain, and the chronological variation between MIS 5a and MIS 3, some inferences about the variability of the central European late Middle Paleolithic can be drawn. How valid they are for the entire late Middle Paleolithic will be the subject of subsequent work resulting from this thesis, as more and more assemblages will be added to the database in the near future. Some of these sites are already part of the assemblage comparison presented in Chapter II: Salzgitter-Lebenstedt in Lower Saxony/Germany (Tode, 1982; Pastoors, 2001), Lichtenberg in Lower Saxony/Germany (Veil et al., 1994; Veil, 1995), and Neumark-Nord 2/0 in Saxony-Anhalt/Germany (Laurat and Brühl, 2006). Currently, Pietraszyn 49a/Poland (pers. communication Andrzej Wiśniewski, excavator of the site) and Lichtenberg are being added to the results presented here. The set of methodologies for assemblage analysis and the analysis of tools developed within this thesis will be applied to these assemblages, and further promising insights into the structure of late Middle Paleolithic assemblages are expected.

1.1.3 Relevance and future Application of the Results

The two examples presented below illustrate the importance of better understanding late Middle Paleolithic stone artifact variability. For these broader archaeological questions, this thesis forms a baseline by building a detailed dataset of late Neanderthal stone artifact assemblages together with a subsequent analysis of the factors that drive stone tool variability. Some implications from these topics based on the results of this work will briefly be discussed in the Conclusion (Chapter V).

Beyond the limits of this thesis, the methodological approach, as well as the results for late Middle Paleolithic stone tool and assemblage variability presented here, may pave the way for future research about how and why the archaeological record changed during the Middle to Upper Paleolithic (MP/UP) transition. As an example, the validity of currently established archaeological techno-functional units found in the late Middle Paleolithic of the European Plain has a direct influence on our interpretation of the emergence of the transitional Lincombian-Ranisian-Jerzmanowician ("LRJ", Chmielewski, 1961; Kozłowski, 1983; Desbrosse and Kozłowski, 1988; Flas, 2006, 2011, 2013, 2014). Currently, it is interpreted as a single archaeological phenomenon spanning from Poland across the European Plain to Great Britain that may have developed from the local late Middle Paleolithic (Flas, 2006, 2011, 2013, 2014; see also Hublin, 2015). But if we want to understand the formation of the LRJ and its relation to the late Middle Paleolithic, we need to know if it developed out of a patchwork of late Middle Paleolithic units or from a single, variable stone tool industry overlapping largely within the same geographical region.

A related topic is the question of whether transitional industries like the LRJ developed out of the late Middle Paleolithic at all. The results from this thesis may contribute to these discussions as understanding aspects of late Middle Paleolithic variability better may also help to trace more efficiently technological similarities and differences between late Middle Paleolithic and transitional assemblages. Additionally, if we want to understand more about variability in LRJ leaf-points, i.e. bifacial leaf-points and leaf points on blades ("Jerzmanowice points"), or if we want to prove whether they developed from local late Middle Paleolithic tool manufacture concepts, we need to better understand the variability of late Neanderthal tool concepts.

A second future application of the present work is related to the chronological range of the assemblages. Here, I analyzed assemblage variability from MIS 5a to early MIS 3. None of the assemblages date to the cold MIS 4. The latter is interpreted as a bottleneck for northern Neanderthal populations, and local extinctions or southward movements to refuge areas are discussed (see e.g. Jöris, 2004; Hublin and Roebroeks, 2009; Roebroeks et al., 2011). In selecting assemblages from both of these late Middle Paleolithic time periods, potential similarities or differences within the stone tool record could be revealed, and the results of this thesis have then a potential to be included in future discussions about Neanderthal population dynamics in late Middle Paleolithic central Europe.

In the following paragraphs of the introduction, I will begin with a brief description of the most important late Middle Paleolithic archaeological entities defined for central and eastern Europe. Although it is discussed in Chapter III, it is presented here in more detail to give the reader an impression about the variety and research history of the established late Middle Paleolithic assemblage classifications. In the following, I will discuss the application of the two main methodological approaches: attribute and subsequent multivariate analysis of stone artifacts. I then present the sites included in this thesis as well as the analyzed assemblages in detail. The reason for this is the rather tight format of the papers (Chapter II to Chapter IV), where not all of the important background information and illustrations could be incorporated into the main text. Finally, an outline of the three studies of this thesis will be given.

1.2 Common late Middle Paleolithic Entities of central and eastern Europe

1.2.1 Mousterian

The definition of the central and eastern European Mousterian is based on the classification developed for the French Mousterian as formulated by Bordes (e.g. Bordes, 1961a, 1961b). It was adopted to central and Eastern European assemblages that (mostly) lack bifacial tools and that have a high share of Levallois blank production methods along with various flake tools (Bosinski, 1967; Kozłowski and Kozłowski, 1996; Kozłowski, 2014).

1.2.2 Taubachian

Some late Middle Paleolithic assemblages are distinctive for their small artifacts. Here, the term "*Taubachian*" (Collins, 1968; Valoch, 1971) names this group. Originally, it was attributed to the Eemian interglacial, but later it was attributed as well to last glacial assemblages (Valoch, 2003). It is regarded as a sub-type of central and eastern European Mousterian with increased discoid and rather rare Levallois blank production. The artifacts are usually smaller than 3 cm, the tools have a high proportion of notches and denticulates, and the assemblages lack bifaces (Valoch, 1984, 1988; see also Cohen and Stepanchuk, 1999; Cieśla and Valde-Nowak, 2016; Valde-Nowak et al., 2016; Alex et al., 2017). Some interpret these "microlithic" assemblages as an expression of a specific human flaking behavior (e.g. Moncel and Neruda, 2000; Cieśla and Valde-Nowak, 2016) or as a long lasting cultural tradition from the Lower to the Middle Paleolithic (Valoch, 1977). Obłazowa Cave, Poland, is one of the main sites that yielded a Taubachian small-tool assemblage in its layer XIX. This stands in contrast to large artifact assemblages with Levallois methods from the same cave (Cieśla and Valde-Nowak, 2016). Therefore, the Taubachian artifacts of the site are regarded as being small independent from raw material constraints. The authors (Cieśla and Valde-Nowak, 2016) interpret the Taubachian as being generally related to sites in a mountainous environment with close-by mineral water springs. In contrast, it was shown already 30 years ago (Schäfer, 1987) that the small artifact size at the eponymous site Taubach/Thuringia, Germany, is a result of the rather small raw material dimensions (see also Weber, 2012) on which knappers were eager to produce the largest flakes possible (Schäfer, 1987: 264).

1.2.3 Micoquian

The term Micoquian goes back to a definition for European Middle Paleolithic bifacial industries based on excavations at the site of La Micoque, southwestern France, by Otto Hauser (1916). Günther (1964) and especially Bosinski (Bosinski, 1967, 1968) used the term later, explicitly in reference to La Micoque layer N(6) (Peyrony, 1938), to describe central European late Middle Paleolithic assemblages with certain bifacial tools, like bifacial backed knives or Keilmesser, asymmetric handaxes ("Micoquekeile"), and bifacial scrapers, among others. Older (e.g. pre-Eemian) assemblages with bifacial tools were named *Jungacheuleen* ("younger Acheulean") (Bosinski, 1967) and were seen as separate from the last glacial Micoquian. Some argue that the development of the Micoquian in central Europe started as early as MIS 8 (Kozłowski, 2014), but in general the Micoquian is now defined for late Middle Paleolithic assemblages by the presence of certain typical bifacial tools, especially the Keilmesser, along with varying blank production strategies, like Quina, discoid or Levallois (e.g. Richter, 1997; Jöris, 2004; Kozłowski, 2014). With its reference to layer N(6) of La Micoque, the term is seen as problematic by some (e.g. Veil, 1995; Jöris, 2004), as it has a questionable geological context with an underrepresentation of bifacial backed knives. Especially the latter are typical for the eastern and central European assemblages. Therefore, La Micoque does not represent assemblages typically found in central and eastern Europe (Veil et al., 1994). On the other hand, Micoquian does not have its emphasis too much on the type fossil, like Keilmessergruppen (see below), and it is commonly used and widely accepted in the central and eastern European literature (e.g. Koulakoskaya et al., 1993; Boëda, 1995; Uthmeier, 2013; Demidenko, 2015; Stepanchuk et al., 2015; Golovanova et al., 2016; Valde-Nowak et al., 2016). Therefore, it will be used in this thesis as synonym to Keilmessergruppen (see below) to name late Middle Paleolithic assemblages of central and eastern Europe characterized by the presence of bifacial tools.

1.2.4 Keilmessergruppen

The term Keilmessergruppen was first introduced by Mania (1990). Because of the issues described above with the term Micoquian related to its provenience and research history, the new term Keilmessergruppen was introduced as a synonym for Micoquian assemblages again and further refined by Veil et al. (1994). The term defines those late Middle Paleolithic assemblages of central and eastern Europe that are based on their "lowest common denominator", the bifacial backed knife or Keilmesser (Veil et al., 1994: footnote 12). Characteristic for Keilmessergruppen assemblages are further diagnostic, standardized cutting tools, like leaf-shaped scrapers or leaf-shaped handaxes (*Faustkeilblätter*). Therefore, Veil et al. (1994) interpret the Keilmesser as the most important, but not exclusive, characteristic of this group. They state further (Veil et al., 1994: footnote 12) that the term Keilmessergruppen summarizes certain assemblages without making any assumptions or drawing inferences about ethnic, functional, activity-specific or chronological relationships within this group. The concept of Keilmessergruppen was later adopted and made prominent by Jöris (Jöris, 2001, 2004, 2006, 2012) with his work on bifacial backed knives. Besides Micoquian, it is now a widely accepted term (e.g. Ruebens, 2012, 2014; Kozłowski, 2014) for naming late Middle Paleolithic assemblages with bifacial tools of eastern and central Europe.

1.2.5 Prądnik cycle

The Prądnik cycle or Prądnik Culture was defined by Krukowski (Krukowski, 1939-1948). The term was initially created for Middle Paleolithic artifact assemblages from Poland containing handaxes and other bifacial tools. Thereby, the most important bifacial implements are the Prądniks: asymmetric or arch-shaped tools, today mostly called bifacial backed knives or Keilmesser. The Prądnik Cycle defined by Krukowski (1939-1948; Burdukiewicz, 2000) refers not only to bifacial tools. He views the Prądniks as a dynamic continuum from simple edge retouched and unifacially shaped knife-like tools ("Prądnikshaks"; Krukowski, 1939-1948) to bifacial tools and remnant pieces. A term that derived from this classification is the Prądnik technique, para-burin technique, or tranchet blow (Jöris, 2001; Frick et al., 2017). The Prądnik technique describes a method that was observed by Krukowski (1939-1948) on knives from Ciemna Cave, Poland. Thereby, the tools were re-sharpened by a strike on the tip or distal part parallel to the edge (Jöris, 2001; Frick et al., 2017) to create a thin and sharp cutting edge. This technique is not restricted only to bifacial tools and has been applied as well to scrapers (e.g. Jöris, 2001; Frick et al., 2017).

1.2.6 Mousterian with Micoquian Option (MMO)

Based on his analysis of the late Middle Paleolithic artifacts from Sesselfelsgrotte, Bavaria/Germany, Richter defined the concept of the MMO (Richter, 1997, 2000, 2001, 2002, 2012, 2016). The concept was then applied to the central European late Middle Paleolithic and represents four chronologically different land use cycles, between 60 and 43 ka, where Mousterian and Micoquian assemblages are treated as related and continuous components of a single archaeological entity. At Sesselfelsgrotte, 13 Mousterian assemblages with bifacial tools were present in the layer complex "G". Based on the observation that typologically different units defined by the presence or absence of bifacial tools consist of similar unifacial components that are not distinguishable, Richter (2016: 119) claims that "[…] Mousterian and Micoquian must, in this context, be products of one and the same people." In this sense, terms like Keilmessergruppen or Micoquian versus Mousterian may not necessarily have to be dropped, they might just represent two faces of the same coin. Within the G-Layer assemblages, Richter (e.g. 1997) observed four cyclic raw material procurement patterns that match the typological differences of the single units. Translated to a landscape scale, each cycle consists of assemblages that are classified as initial inventories ("Initialinventare") and subsequent inventories ("Konsekutivinventare"). Initial assemblages represent the arrival of humans in a specific area. They tend to have an increased variety of raw materials with a stronger Mousterian (e.g. simple scrapers) and denticulate component, as well as bifacial tools in a less reduced state. Subsequent assemblages refer mostly to base camps or special task camps. They occur after a certain amount of time when humans adapted to a region and started to exploit the local resources. Special task camps and base camps tend to have a stronger Micoquian component in terms of a higher quantity and more reduced bifacial tools. The four proposed MMO cycles belong to two larger technological-chronological units, MMO-A and MMO-B. MMO-A is characterized by a more Quina-type (A1) and other non-Levallois (A2) blank-production systems. In MMO-B, Levallois methods were applied exclusively, mainly centripetal-recurrent (B1) and parallel-recurrent (B2) methods. A major criticism of this concept concerns whether the MMO definition and its chronological sequence, derived from the sequence at one site, Sesselfelsgrotte (Germany), can be applied to the whole of the central European late Middle Paleolithic (Jöris, 2003). A second criticism concerns the chronological differentiation on the basis of blank production systems, which are seen by Jöris (2003) as highly variable in the late Middle Paleolithic, whereas the production of certain tool types seems to have more chronological importance and is interpreted as independent from the blank production system. Furthermore, Kozłowski (2014) states that the MMO concept finds no confirmation in the central European archaeological record. Without mentioning exactly where and from which chronological context he draws his inferences, he argues that "[…] long-term Mousterian camps are known which are centrally placed, with production relying on uniform raw material, while at the same time there are short-term Micoquian camps with more diversified raw material composition." (Kozłowski, 2014: 348).

1.2.7 The problematic NASTIES

Some studies see the typo-technological classification of stone artifact assemblages, as outlined above, as highly problematic (Monnier and Missal, 2014; Shea, 2014). Shea (2014) suggests dropping the "named stone tool industries" or "NASTIES" entirely, as entities like the Mousterian "[…] were formulated inductively and intuitively using selectively curated collections of artifacts" (Shea, 2014: 173). As an example, Mousterian industries seem to occur in a broad range of chronological contexts and paleoenvironments, from the late Middle Pleistocene to the late Pleistocene everywhere in Europe, potentially North Africa and western Asia (Shea, 2014). Therefore, it is impossible to link this artificial entity to Paleolithic human groups, implying that the term seems not to be meaningful to answer questions about human behavior or human evolution. The NASTIES are regarded as highly subjectively defined entities, based on a non-empirical and often an unspecified mix of variables (Monnier and Missal, 2014; Shea, 2014). Analyzing and interpreting the archaeological record with NASTIES might lead to a tendency to overlook the variability that traverses and unifies these assemblages (Monnier and Missal, 2014; Shea, 2014).

1.3 Methods – Attribute and Multivariate Analysis

Attribute analysis on flakes, cores and tools, with a subsequent multivariate analysis based on these attributes, are the main methods used in this dissertation (see Chapter II to Chapter IV). Therefore, only these methods will be discussed in this section. The aim here is to present and discuss some general remarks about the methodological approach. Exactly how these methods work and which algorithms were used are explained in detail within the respective chapters. Additional methodological approaches, like 3D geometric morphometrics and Thickness Mapping, are explained and discussed in Chapter IV.

Data collection was conducted using the open-source software "E4" (authored by Shannon P. McPherron, www.oldstoneage.com). Unless stated otherwise, the statistical analysis of this thesis, as well as data preparation and management, were performed with the open-source statistical software R (R Core Team, 2016). A detailed list of the individual attributes as well as the methods of recording these attributes on cores, flakes and tools, is provided in detail in the table of Appendix I.

1.3.1 Attribute Analysis

The currently defined late Middle Paleolithic entities of central and eastern Europe are mainly based on typo-technological approaches and potentially subjective or more qualitative interpretations and assumptions (Monnier and Missal, 2014; Shea, 2014). Interpreting and comparing stone artifact assemblages based on these categories might lead researchers to overlook important factors that drive stone tool variability, and this may hamper the analysis of more detailed questions about human behavior (Monnier and Missal, 2014; Shea, 2014). Therefore, this thesis is based on a more quantitative approach to analyzing stone artifact assemblages. Attribute analysis fulfills the requirements of a more quantitative method for stone tool analysis, as it consists mainly of measurements and pre-defined categories. Together with multivariate methods, the approach can distinguish between blank production strategies of different cores, as it has been shown in a recent study (Scerri et al., 2016). The method is, among others, able to identify reduction strategies (e.g. Dibble, 1995) or to analyze intra- and inter-site variability to draw inferences about past human behavior and cultural transmission (e.g. see Bolus, 2016; Nigst, 2012; Tostevin, 2012). The strength of the method is that it considers all artifacts in an assemblage and treats them equally without making assumptions about end products or potential sequences and processes of manufacture.

The attribute analysis applied in this dissertation is primarily based on an attribute analysis for Lower and Middle Paleolithic stone artifacts of central Germany developed and introduced by Weber and Schäfer (e.g. Weber, 1986, 1995; Schäfer, 1993). Despite differences concerning varying attributes that are proposed and collected by different researchers, there are a few general differences to other attribute systems that should be mentioned (see e.g. Dibble, 1995; Tostevin, 2003, 2012, Lin et al., 2010, 2015; Nigst, 2012; Rezek, 2015; Scerri et al., 2016). First, instead of cortex estimations, the dorsal scar coverage is estimated. However, this measurement is easily reversed to get a cortex measure. Second, instead of cortical surfaces versus surfaces altered by knapping or shaping, Weber and Schäfer (e.g. Weber, 1986, 1995; Schäfer, 1993) introduced the terms 'primary surface' and 'secondary surface'. On nodules or natural flint pieces, several types of natural surfaces can occur: original cortex, cortex polished by glacial transport or moraine cortex, cortex polished by water transport or fluvial cortex, natural fissures or breaks, or extensive frost fracture scars. All these surfaces are unaltered by humans and are, therefore, regarded as 'primary surface'. Contrarily, a 'secondary surface' describes an area on a stone artifact that was altered by humans, mainly in the form of flake scars or intentional breaks.

In contrast to measurements, like maximum dimensions, angles (edge angles, interior and exterior platform angles), or counts like dorsal directions or number of flaking surfaces on cores, some attributes are more qualitative. The first category are descriptive categorical variables. Examples are artifact color, preservation state, tool typology or the state of core exploitation. These subjective categorical variables were not included in the multivariate analysis. However, they were used in a descriptive way for the characterization of the assemblages and as typological baseline for the analysis of tools in Chapter IV. Furthermore, attributes like the dorsal scar coverage or platform scar coverage are based on estimations. Therefore, it is unavoidable that they possess some subjectivity. To account for this and to reduce the observer error, these attributes were estimated in pre-defined categories, e.g. 0%, 1-39%, 40-69%, 70-99% and 100% (Gnaden and Holdaway, 2000). On the one hand, this method is less precise than measuring the scar coverage in 10% steps as suggested by Weber (1986) and it slightly overestimates the amount of scar coverage. On the other hand, it was shown for the estimation of cortex on dorsal surfaces that this overestimation stabilizes with an increase in assemblage size. This stabilization occurs already with the number of flakes produced from five nodules (Lin et al., 2010), resulting in comparable results with a similar estimation error range between assemblages studied in this thesis. These estimation variables are as well a type of categorical variable, and they cannot be included in the multivariate analysis as they are. Some multivariate methods work with ratio scale variables only (see e.g. Scerri et al., 2016) and, therefore, these variables were transformed to a ratio scale ranging from 0 to 1. Although transformed, the categorical and the ratio scale expressions of the variables mean the same: e.g. 0 scar coverage, about ¼ scar coverage, about ½ scar coverage, about ¾ scar coverage and full scar coverage.

Not all of the recorded attributes (Appendix I) were used for the studies presented in this thesis. My aim was to create a large detailed dataset of late Middle Paleolithic stone artifact assemblages across the European Plain. This dataset will be enlarged and used for further studies in the future.

1.3.2 Multivariate Analysis – Principal Component Analysis and Nonmetric Multidimensional Scaling

Multivariate methods have been applied on Middle Paleolithic assemblages from southwestern France (e.g. Callow and Webb, 1981), the Levant (e.g. Culley et al., 2013; Hovers and Raveh, 2000), as well as on Middle Stone Age assemblages of South Africa (e.g. McCall, 2006). These studies use varying multivariate approaches, and they incorporate as variables mainly frequencies of tools and tool assemblage compositions, as well as technological and typological assemblage indices. This thesis, instead, includes the respective attributes of each individual specimen.

Here both linear and non-linear multivariate statistical methods are applied to artifact attributes. Thereby, the linear technique of Principal Component Analysis (hereafter: PCA) (Hotelling, 1933) is applied as well as the non-linear and nonmetric technique of multidimensional scaling (hereafter NMDS) (Kruskal, 1964a, 1964b; Kruskal and Wish, 1983). For a detailed description of both methods, the reader is referred to Chapter III. Metric (e.g. Ertmer, 2012; Weber, 2007, 1995) and nonmetric multidimensional scaling have already been successfully applied to stone artifact analysis (e.g. Iovita, 2009). PCA has been used recently in lithic analysis in the frame of 3D geometric morphometrics (Archer et al., 2015, 2016), but there are also recent applications to attribute data (Golovanova et al., 2016; Scerri et al., 2016). The multivariate analysis of the tools in Chapter IV is only carried out with PCA. This decision was made as both methods, metric and non-metric, lead to comparable results, and PCA is a better tool to explain the influence of the individual variables on the final result (see Chapter III). In other words, PCA is easier to interpret than NMDS because the influence of each variable on the position of each group can be demonstrated. All the multivariate methods were performed using the R package 'vegan' (Oksanen et al., 2016) in combination with some algorithms from the package 'depth' (Genest et al., 2016).

Multivariate analysis, like PCA and NMDS, analyze a combination of attributes of a set of artifacts in relation to each other. The results of the multivariate analyses are then illustrated by plots showing map-like configurations of the individual objects or groups. The basic assumption here is that artifacts that share more similarities in the combination of their attributes plot more closely together. In the study of Chapter III, flakes were chosen for this kind of assemblage analysis, whereas the study presented in Chapter IV works with attributes of tools. The analysis of the flake assemblages is based on the assumption that technological characteristics of an assemblage (e.g. method of blank production, bifacial tool shaping) are coded in the unique combination of attributes on a flake. Each assemblage consists then of flakes coming from different production sequences, like different cores, or bifacial or unifacial tools. As different assemblages might share certain methods and production sequences as well as raw material characteristics, assemblages may overlap when considering the flakes in the multivariate plots. Therefore, the spatial median (Gower, 1974; Bedall and Zimmermann, 1979) for each geometrical point cloud configuration (i.e. for each assemblage) was calculated. The spatial median represents a measure for flake assemblage composition and is used for the comparison of the assemblages.

Of course, this method analyses assemblages of flakes that come from different production sequences, such as tool production or core reduction. Different methods of raw material management or variation in raw material size may also cause variability in the flake record. The assumption here is that flake assemblages from different production sequences, even from different core types, differ concerning the combination of the flake attributes (see e.g. Scerri et al., 2016). The same might be true for underlying factors of raw material. So, if two sites are more similar concerning their technological and/or raw material, their assemblages should be more similar as well. However, the downside is that this methodology only works on the assemblage level. The multivariate analysis based on attributes cannot always distinguish individual flakes from each other, as flakes from different blank production or tool shaping methods can have overlapping attribute states.

That multivariate analysis is a suitable method for the analysis of flake assemblages has already been shown several times in the past (see e.g. Ertmer, 2012; Schäfer, 1993; Weber, 2007, 1995, 1986). Although these approaches calculated a mean for each attribute *before* performing the multivariate analysis, the method was able to differentiate chronologically distinct archaeological entities in central Germany, like Clactonian, or early Eemian and last glacial Middle Paleolithic. In the present study, every flake is included *first* with the respective attributes in the multivariate analysis and then the spatial median is calculated for each assemblage. As every flake is considered, this may result in a more accurate measure for each assemblage.

1.4 Materials Part I – Sites

1.4.1 Pouch-Terrassenpfeiler

Pouch-Terrassenpfeiler (hereafter Pouch; [note that in the first study in Chapter II the shortcut is Pouch/TPf to separate it more precisely from the collected assemblages around the site, see Weiss, 2015]) is described and presented in detail in Chapter II and it is part of the analysis and studies of Chapter III and Chapter IV. As the material was not entirely published before, the tools found in Pouch, as well as some flakes and cores, are displayed in the Appendix II catalog.

Pouch is situated in a former brown coal open-cast mine east of Bitterfeld in Saxony-Anhalt. The site was discovered during the refilling of the pit to create a lake and was subsequently partly excavated by the *Landesamt für Denkmalpflege und Archäologie Sachsen-Anhalt – Landesmuseum für Vorgeschichte* in 2002. Unfortunately, a flood of the Mulde river during the excavation raised the water level of the growing lake to the present state, and the site is now no longer accessible. The find layers are embedded in the basal part of the Weichselian river terrace succession consisting of sand, silt and gravel accumulations to a height of about 8 to 10 m (Wimmer, 1997). There is some evidence that this sequence started to accumulate in the beginning of MIS 3 after a major erosional event in MIS 4 (Mol, 1995, 1997; Mol et al., 2000; Van Huissteden et al., 2001; Weiss, 2015; see Chapter IV). The fluvial Quaternary sediments in this area are mostly situated directly on Miocene sands. The base consists of a sequence of coarse and fine gravels alternating with cross-bedded sand and silt with incised river channels filled with similar sediments containing the artifacts (Weiss, 2015). During the excavation, an eastern and a western artifact concentration, separated by roughly 5 m, were found and excavated in one square meter each (Fig. 2). Most of the artifacts were recovered from the eastern concentration, Layer 5, a probably cryoturbated silty clay with a sandy intrusion (Layer 6) on top of the eastern channel infill. As the profile was close to the growing lake, the sediments were affected by wave erosion. When the site was discovered, some artifacts were rescued from the profile and from the ground in front of the profile. Their documented vertical position (Seiler and Runck, 2003) indicates that they also originated from Layer 5. Although the whole sediment package seems to have been affected by small scale cryoturbation, the fresh and unrolled edges of the artifacts suggest that they are mostly in primary position. A small number of artifacts, 20 pieces only, were recovered from the western concentration, Layer 12. As the sediment was reported by the excavators to be similar to Layer 5 and affected by the same small scale cryoturbation, the artifacts were in this study treated as one analytical unit (Weiss, 2015). It should be noted that except for one flake and two shattered pieces, no artifacts below 20 mm were recovered. This indicates that, although the artifacts show very fresh edges and seven refit complexes were found, the artifacts may have been affected by water transport or perhaps small artifacts were lost during the recent destruction of the site by wave erosion.

The find layers were dated by radiocarbon (Table 1) and OSL (for detailed information and discussion see Weiss, 2015). OSL dating of the find Layer 5 produced ages of 46.2 ± 2.5 ka (R514-1) and 47.1 ± 2.7 ka (R515-2, Weiss, 2015). The radiocarbon dates confirm the ages obtained from OSL dating (Fig. 2; Table 1) and place the site in early MIS 3.

Erratic flint, directly available in the river gravel deposits around the site, served as raw material for the stone artifacts. The nodules originate from the outwash by the river of the Saalian and Elsterian moraines and can be characterized as large sized and high quality. A tested flint block found in the same area in the lower terrace sediments has a weight of 18.5 kg (Weiss, 2015: SI 1, Fig. 1). Prepared core methods including Levallois were the major forms of blank production (e.g. Appendix II, Plates 51-53). Except for the presence of prepared cores, these technical concepts are visible in the high share of faceted platforms on flakes and flake tools (Weiss, 2015). Most tools are simple scrapers followed by unifacially shaped tools. A few bifacial tools occur as well (e.g. Appendix II, Plate 38). Some of the simple edge retouched and unifacially shaped tools possess similar, knife-like features as the bifacial backed knives (e.g. Appendix II, Plate 34): a retouched and/or natural back opposing a sharp cutting edge as well as a retouched pointed tip (Weiss, 2015). Additionally, seven refits have been found in the assemblage so far

(Fig. 3). Raw material similarities suggest the presence of additional refits. The individual pieces were scanned using an Actis 225/300 CT-scanner with a resolution of 36 to 69 µm. Thereafter, the scans were refitted using the software AVIZO. The refits represent cores to flakes (Fig. 3: 1, 6, 7), flakes to flakes (Fig. 3: 4 & 5), a scraper to a transversal broken flake (Fig. 3: 2) and a partial bifacially shaped flake to a nodule (Fig. 3: 3).

The assemblage of Pouch can be interpreted as the result of a short-term occupation: the artifacts are preserved in a very fresh condition and they seem to have been covered relatively fast by silts and sands related to low energy channel and sediment accumulation in a braided river system. The seven refit sequences in the rather small assemblage of only 371 artifacts, and no traces of double patination in the assemblage, support the hypothesis of a short-term occupation.

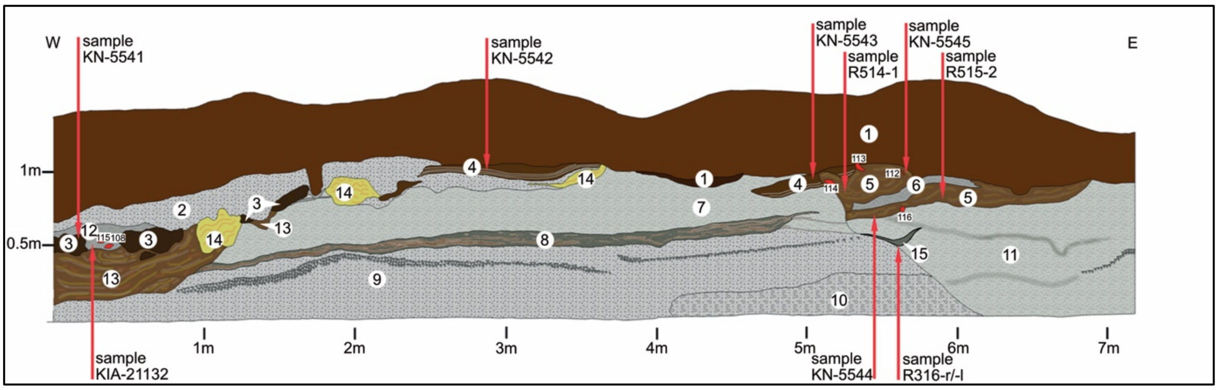

Figure 2. *East-West profile of the site Pouch ("Terrassenpfeiler"). Numbers in rectangles and related red spots represent main artifacts occurrences. (1) modern infill, (2) sandy gravel, (3) clay, silty, homogenous, ~46,000 to 43,000 calBP (1-σ), (4) clayey silt, fine sand, fine layered (+lignite), >40,000 BP and ~37,500 to 36,000 calBP (1-σ), (5) silty clay, artifacts, dated to 46.2 ± 2.5 ka and 47.1 ± 2.7 ka (OSL), ~43,000 to 41,000 calBP (1-σ) and ~37,500 to 36,000 calBP (1-σ), (6) middle sand, (7) sand with gravel, cross-bedded, (8) silt, (9) sand, gravel, (10) coarse gravel, gravel, sand, (11) fine to middle sand with gravel lenses, cross-bedded, (12) sandy intrusion in 3, artifacts, (13) silty clay, sand, (14) silty clay, (15) silt, OSL dated to 56.5 ± 4.4 ka and 56.2 ± 5.1 ka. Radicarbon calibration with OxCal 4.2, calibration curve IntCal 13. Redrawn from the profile drawing of H. Heilmann, LDA Sachsen-Anhalt. Graphic: Marcel Weiss/MPI-EVA; (Weiss, 2015).*

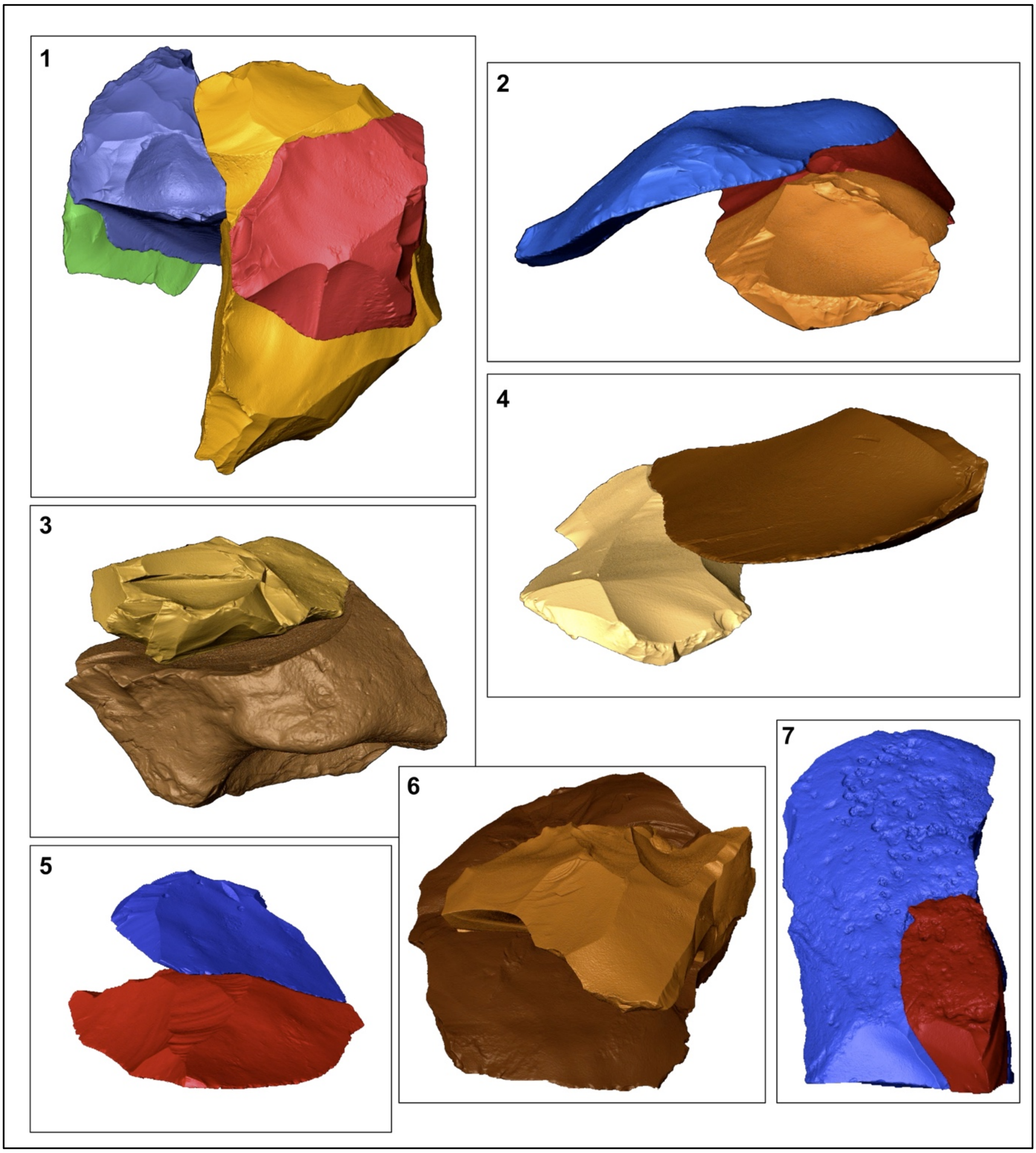

Figure 3. *1 – Refit of two core fragments (2004:8680,1 and 2004:8680,151) and two flakes (2004:8680,2 and 2004:8680,66); 2 – Refit of a scraper (2004:8679,12) to a transversal broken flake (2004:8680,5 and 2004:8680,6); 3 – Refit of a bifacially shaped flake to a nodule (2004:8679,150 and 2004:8680,142); 4 – Refit of two flakes (2004:8680,10 and 2004:8680,11); 5 – Refit of two flakes (2004:8680,13 and 2004:8680,62); 6 – Refit of a flake to the lower face of a core (6305:5:153 and 2004:8681,1); 7 – Refit of a flake to a flint slab (2004:8680,4 and 2004:8680,3). Without scale.*

1.4.2 Sites around Pouch

Between 1991 and 2002, artifacts were collected by volunteer archaeologists from various find locations within the former open-cast brown coal mine Tagebau Goitzsche (Fig. 4). Another site within the same area is the ongoing gravel quarry of Löbnitz. There, artifacts have been collected through to today. The artifacts of both sites come from the base of the Weichselian Lower Terrace of the Mulde river. Luminescence and radiocarbon dating suggest an age of the base of the fluvial gravel and sand accumulations of ~ 55 to ~ 40 ka (see Chapter IV). Thus, the artifacts from the two sites can roughly be dated to the early MIS 3 late Middle Paleolithic. The tools of both assemblages, the collections from Goitzsche and the gravel quarry of Löbnitz, are analyzed in Chapter IV.

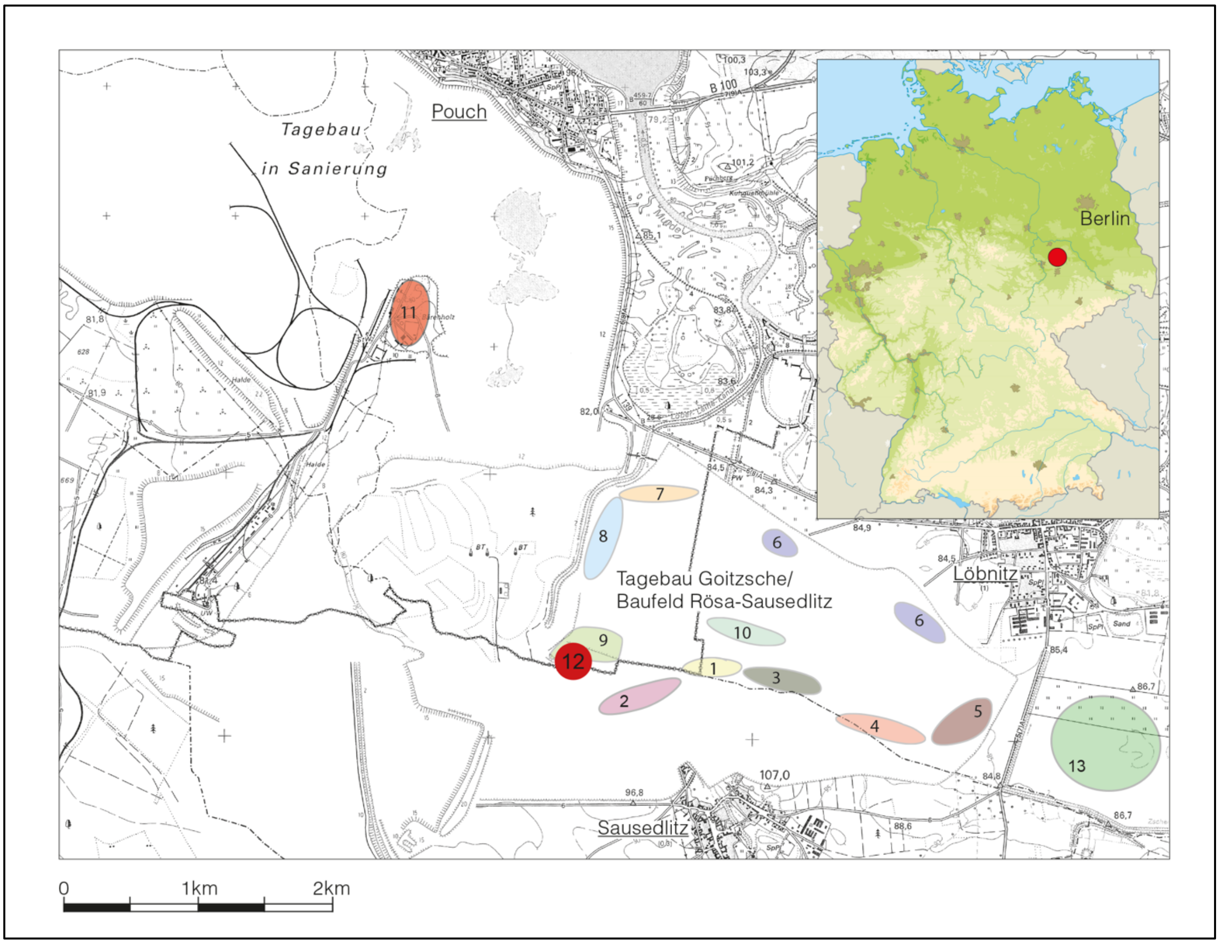

Fig. 4. *Map of the find spots in the former brown coal quarry "Tagebau Goitzsche" east of Bitterfeld and the gravel pit of Löbnitz.* *The tools analyzed in this study come from the excavated site of Pouch-Terrassenpfeiler (12), surface collections of the southern slope of the former brown coal quarry "Goitzsche" north of Sausedlitz (1-3), and the gravel pit of Löbnitz (13). The sites (1)-(6), (10) and (13) belong to the federal state Saxony, the assemblages (7)-(8) and (11)-(12) to Saxony-Anhalt. For detailed site names and analysis of the assemblages see* (Weiss, 2015). *Graphic: M. Weiss/MPI-EVA;* (Weiss, 2015).

1.4.2.1 Goitzsche Collection

Between 1991 and 2002, volunteer archaeologists and geologists collected artifacts from several locations (Saxony and Saxony-Anhalt) within the former brown coal quarry Tagebau Goitzsche – Baufeld Rösa-Sausedlitz. The artifact surveys took place during reconstruction works and refilling of the abandoned pit with water. Comparable to the geological background and the location of Pouch, the finds were recovered from several find horizons within the lowermost six meters of the base of the gravel and sand accumulations of the last glacial Lower Terrace sequence of the river Mulde (Wimmer, 1997; Weiss, 2015). The geological background as well as the characteristics of the assemblage are discussed in detail in Chapters II and IV. Based on tool typology, the main assemblage characteristics, with the presence of Keilmesser (Fig. 5), handaxes, bifacial and leaf-shaped scrapers (Ruebens, 2012, 2013, 2014; Weiss, 2015), place the artifact collection in the late Middle Paleolithic Mousterian with Micoquian elements of eastern and central Europe. The blank production methods, like the presence of Levallois (Fig. 5), prepared and non-prepared cores, reinforce this interpretation. That almost half of the artifacts show sharp edges (Weiss, 2015) indicates that they were found in primary position or that they were exposed only to small scale post-depositional displacement. The dating of the Lower Terrace sequence (see Chapter IV) confirmed a late Middle Paleolithic age for the artifacts.

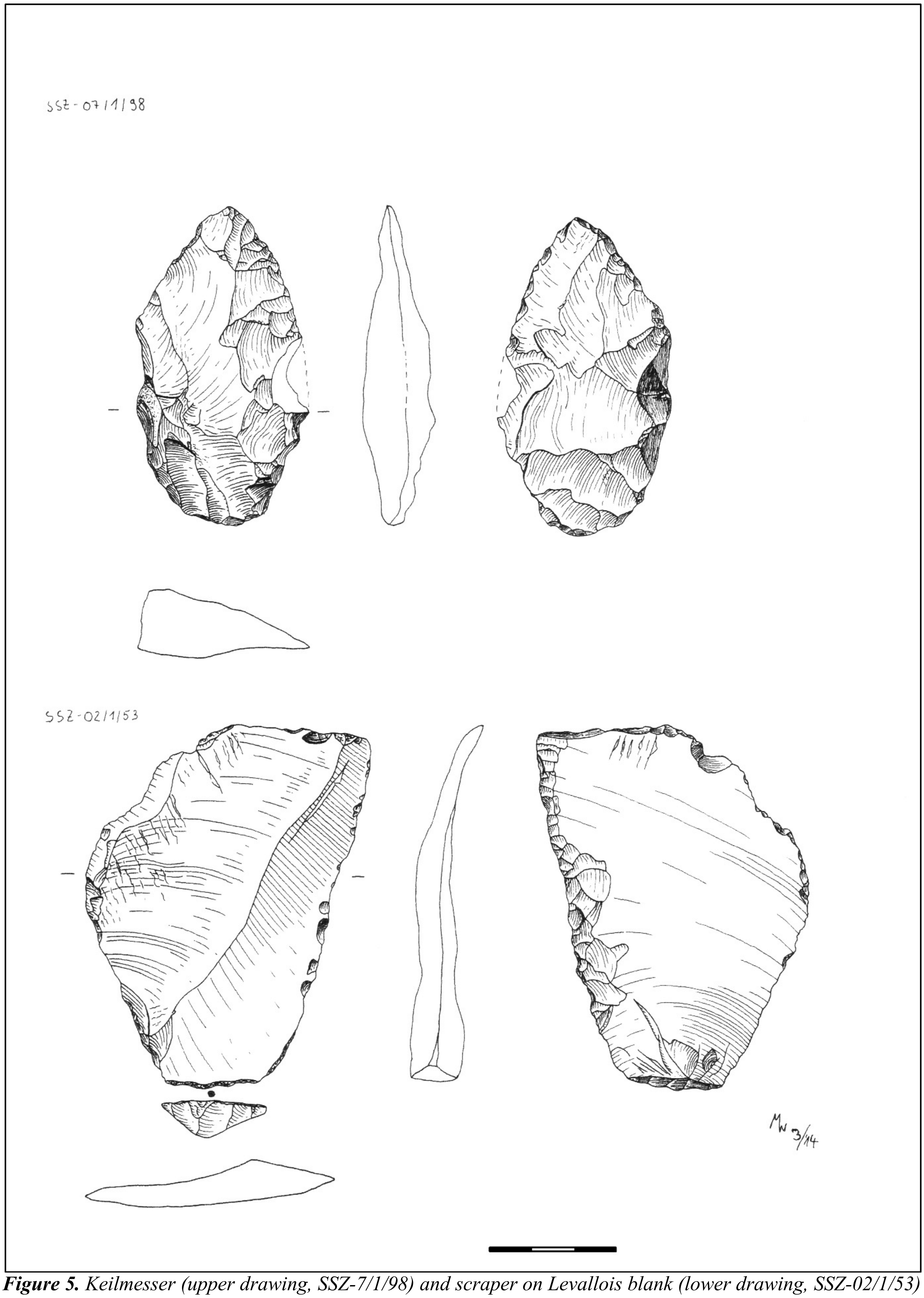

Figure 5. *Keilmesser (upper drawing, SSZ-7/1/98) and scraper on Levallois blank (lower drawing, SSZ-02/1/53) from the Goitzsche quarry. Drawings: M. Weiss.*

1.4.2.2 Löbnitz

The ongoing gravel pit of Löbnitz, Saxony, is less than 1 km east of the former brown coal quarry Goitzsche, quarry field Rösa-Sausedlitz (Fig. 4). There, the gravels of the Lower Terrace sequence are exploited by a floating dredger. Directly following the mining, the gravel is separated in different size fractions and the coarse gravel is dumped on a separate pile. From the latter, volunteer archaeologists and geologists have collected more than 3000 stone artifacts since the 1990s (Rudolph et al., 2003).

For the dissertation, a sample of 838 complete artifacts was analyzed (Table 2) with attribute analysis (see Chapter IV). Similar to the assemblages coming from the Goitzsche collection and from Pouch, blank production within the Löbnitz collection is primarily based on Levallois and prepared core methods. Diagnostic tool types, like Keilmesser (Fig. 6), leaf-shaped and bifacial scrapers as well as handaxes place the assemblage in the late Middle Paleolithic of central and eastern Europe. Therefore, and as there is no other gravel accumulation in this area other than the last glacial Lower Terrace sequence, it can be inferred that the artifacts collected in the gravel pit of Löbnitz originate roughly from the same chronological and geological context as the stone artifacts from the Goitzsche collection and from Pouch.

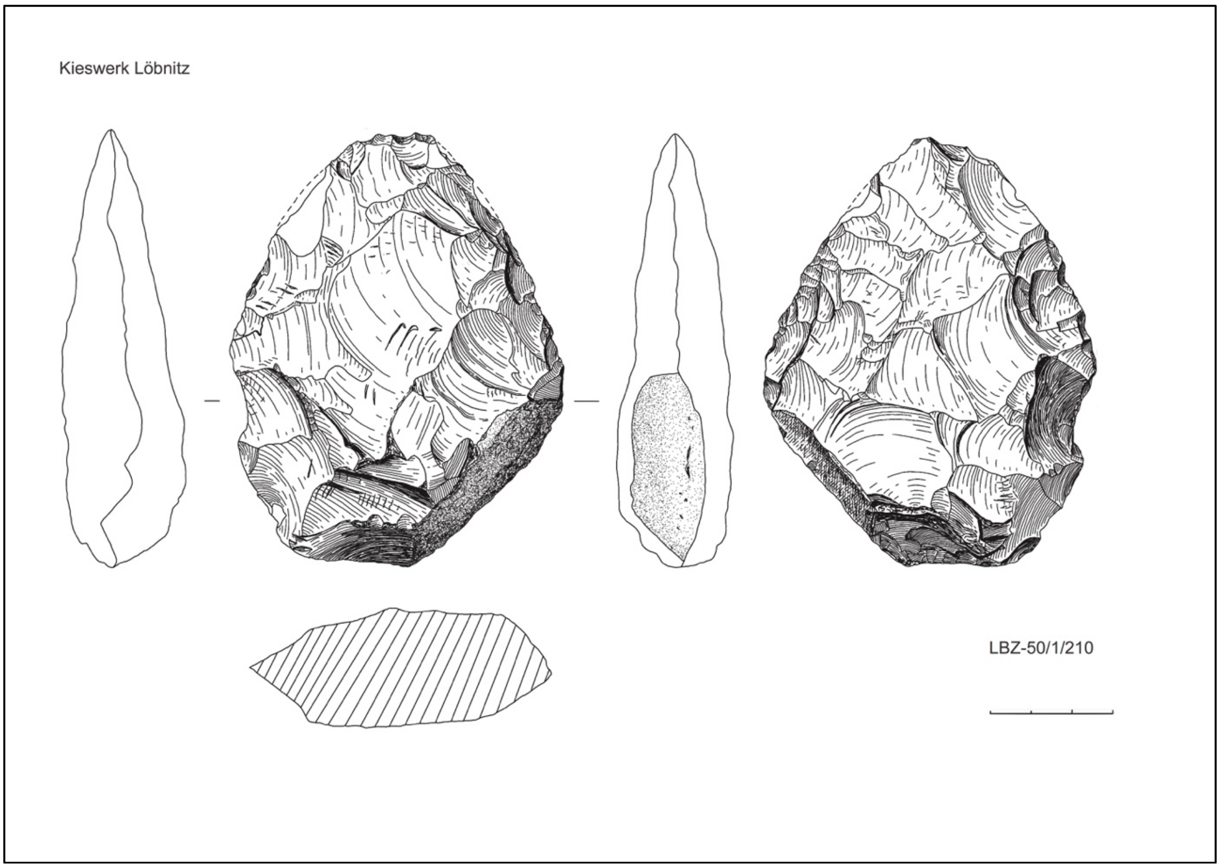

Figure 6. *Keilmesser from Löbnitz (LBZ-50/1/210). Drawing: M. Weiss.*

1.4.3 Königsaue

The assemblages of Königsaue (Mania and Toepfer, 1973; Mania, 2002) are included in the analysis of late Middle Paleolithic assemblage variability in Chapter III. Königsaue, situated in the northern Harz foreland, Saxony-Anhalt, is an open-air, lake shore site that was discovered by D. Mania in 1963 during geological prospections in the former open-cast coal mine. The late Middle Paleolithic artifacts were found in peaty sediments in the lower part of a geological profile. The whole section covers, according to the excavators (Mania and Toepfer, 1973; Mania, 2002), a time span from the Eemian interglacial up to the Holocene. The main arguments for this interpretation rely on the assumptions that the basal layers belong to the Eemian and that every transgression-regression cycle of the former lake, visible in sand/silt sediments in turn with peat accumulations, represents cold and warm periods respectively. Embedded in these peat sediments intermixed with sand accumulations of the geological unit "Ib" (Mania and Toepfer, 1973), a lower (Königsaue A), a middle (Königsaue B) and an upper (Königsaue C) archaeological horizon were excavated. Each archaeological layer consisted of several spatial clusters of artifacts along the former lake shore (Mania and Toepfer, 1973; Mania, 2002).

The radiocarbon dates for the archaeological layers of Königsaue were calibrated with OxCal 4.2, calibration curve IntCal 13. The first three were made on bulk sediment from the geological unit Ib that includes the find layers (Mania and Toepfer, 1973; Mania, 2002): >55,800 BP (GrN-5698), >45,000 BP (B 626) and 60,000 + 1400/-1200 BP (GrN-7001). They are difficult to interpret as two of them have infinite ages and another one, GrN-7001, is beyond the range of the calibration curve. Therefore, they are not included in Table 1 below. About 20 years ago (Hedges et al., 1998), two additional radiocarbon dates were made on two birch tar pieces of the levels A and B, the former bearing artifact and wood imprints (Table 1). The one from Königsaue A revealed an age of 49,000 calBP to ~46,000 calBP at 1σ (OxA-7124). The radiocarbon result for the second piece from Königsaue B, with an uncalibrated age of 48,400 ± 3700 BP (OxA-7125), is beyond the range of the calibration curve. D. Mania (2002) disagrees with these dates based on the geology which he argues places the artifacts clearly in the Odderade interstadial (MIS 5a). Whether this is the case has been highly debated (e.g. Richter, 2002; Jöris, 2004), and the problem is not yet resolved. On the one hand, the pollen spectrum of boreal pine and birch forests with some open landscape elements (Mania and Toepfer, 1973) typical for the Odderade interstadial (e.g. Caspers and Freund, 2001; Litt et al., 2007) support Manis's age estimation. On the other hand, recently published calibrated radiocarbon dates (Picin, 2016) of 45.570 – 44.850 cal BP (1-σ; MAMS-24487) on a reindeer bone from

Königsaue A support an MIS 3 interpretation, although further dating of the site is necessary. In conclusion, Königsaue could be placed either in MIS 5a or in early MIS 3

Except for a few pieces, the raw material is almost exclusively erratic flint (Mania, 2002) transported by the Elsterian and Saalian glaciers into this region. The flint nodules are not directly available at the lake shore, but there were sources in nearby moraine deposits (Mania, 2002) or riverine gravel accumulations about 5 km from the site (Mania and Toepfer, 1973: Fig 38). Regarding typological criteria, the three assemblages differ in their composition of stone tools and blank production. Königsaue A shows prepared core and Levallois blank production and, besides scrapers, bifacial backed knives characterize this assemblage (Fig. 7). Königsaue B is instead dominated by simple scrapers and Levallois blank production. Except for one or two pieces, bifacial tools are missing in this assemblage. In the upper level, again, bifacial tools are present and Levallois cores are rather rare. Due to these typological assemblage characteristics, Mania (2002) attributed assemblages A and C to the central and eastern European Micoquian or Keilmessergruppen and assemblage B to the Mousterian. In Chapter III, the relationship between the assemblages and their typological attribution will be analyzed in detail.

Figure 7. *Bifacial backed knife or Keilmesser from Königsaue A.*
Photo: A. Otcherednoy.

The assemblages from Königsaue suggest repeated short-term occupations of the former lake shore. The artifacts are preserved in a very fresh condition. They are embedded in and between fast growing peat deposits, indicating a fast sedimentation rate (Mania, 2002). No double patination, which would suggest re-use after the initial deposition, was observed. Horizontal refits within the layers and no vertical refits between the layers are also evidence of separate short term occupations. Additionally, a recent technological analysis of the three Königsaue assemblages (Picin, 2016) supports the interpretation of several short-term occupations.

1.4.4 Khotylevo I-6-2

The excavations in Khotylevo I-6-2 are still ongoing. Therefore, the site will be described in detail below, as not all of the new results are published yet. Khotylevo I (Ocherednoi et al., 2014b, 2014a, 2015; Vishnyatsky et al., 2015) is situated in the Bryansk region of Russia in the eponymous village 18 km north-west of Bryansk. Three assemblages from the recent excavations of this site are part of the assemblage analysis in Chapter III. The site is located on the high right bank of the asymmetric Desna valley. The bedrock of the right bank of the Desna is attributable to the upper division of the Cretaceous system. The right bank has a height of 22–25 m above the talweg and gently slopes down to the valley of the Gosoma, the right tributary of Desna River, located downstream of the site (Fig. 8).

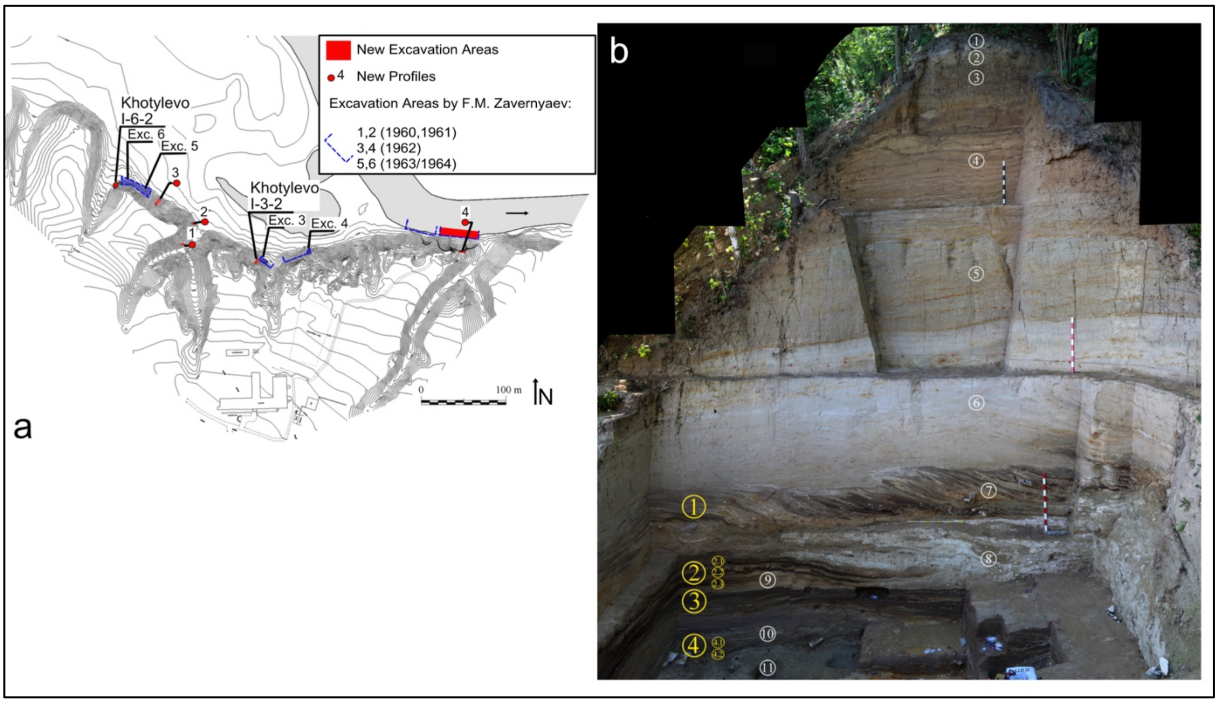

__Figure 8__. Khotylevo I: a) topographic plan showing the former and new trenches in Khotylevo. Khotylevo I-6-2 is the western new trench; b) the section of Khotylevo I-6-2, geological or lithological units are represented by white, Cultural Horizons by yellow numbers. Graphic: A. Otcherednoy.

The site was found in 1958 by an archaeologist of the Bryansk Regional Museum, F.M. Zavernyaev, who started excavations in 1960 in areas where surface finds were previously collected. During five years, his team excavated six large trenches and several test pits along the right bank of the Desna (Zavernyaev, 1978). The finds from Khotylevo I were associated with alluvial sediments and occurred in a redeposited context.

New work at the upstream sectors of the site began in 2010 and cultural remains were found in buried soils. In the present study, I focus mainly on the excavation area "Khotylevo I-6-2" (Fig. 8b). During the field seasons of 2010, 2012-2015 four horizons with cultural remains in different stages of preservation were found.

The sediments that include Cultural Horizon (CH) 4 (Lithological Layer 11) are characterized by light-gray, coarse-grained sands interlayered with bands of greenish clay and with numerous chalk and flint concretions. Cultural Horizon 4 lies on the Cenomanian bedrock sands (Lithological Layer 12), in the same position as is seen in the downstream sections. This cultural horizon was overlaid by a layer of floodplain alluvium up to 90 cm thick (Lithological Layer 10), represented by gray, laminated, small-grained sands and loams. The uppermost part of this layer yielded archaeological remains (Cultural Horizon 3). Humic acid from this layer was radiocarbon dated (Table 1) to ~ 42,500 – 41,000 calBP. The complex of Cultural Horizon 2, with its four sub-horizons, is associated with a laminated buried paleosol (Lithological Layer 9) consisting of four thin humus horizons separated by layers of fine-grained, rusty sands. For these sub-horizons, a series of radiocarbon dates was obtained (Table 1), suggesting an age for CH 2 of roughly 49,000 to 40,000 calBP (1σ). The second buried paleosol, which includes artifacts of Cultural Horizon 1, is characterized by brown sandy loam with lenses of black humus (Lithological Layer 7) overlying a horizon of greenish marl with pieces of chalk (Lithological Layer 8). The deformations of that paleosol are the result of down slope movement of the sediments in hydromorphic conditions associated with cryogenic deformation. The radiocarbon dates for this paleosol have large uncertainties, ranging between outside the range of the calibration curve (1σ) and ~27,000 calBP (Table 1). The deposits overlying the paleosols with cultural horizons are an about 8 m thick series of laminated loess-like, carbonate-free silt sediments (Lithological Layers 6-4) with some intrusions of gley and lenses of weathered pieces of chalk. The uppermost part of the section is a modern soil formation (Lithological Layers 3-1) (Ocherednoi et al., 2015; Vishnyatsky et al., 2015). The radiocarbon results (Table 1) confirm the geological conclusion (based mainly on palaeomagnetic, lithological and stratigraphic evidence) that the deposits enclosing the Middle Paleolithic assemblages date to the first half of MIS 3 (Ocherednoi et al., 2015; Vishnyatsky et al., 2015). However, as there is a large variation between the radiocarbon dates and as some have large standard errors and/ or are out of range after calibration (Table 1), an older age, e.g. MIS 5a for the deposits might also be possible. New radiocarbon as well as luminescence dating is currently ongoing. Regarding the stratigraphy, Cultural Horizon 1 was affected by down slope movement of the sediments and that there is a possibility that Cultural Horizon 4.1 has been disturbed by fluvial processes, at least in its sandy parts.

The Middle Paleolithic collections from Khotylevo I were described by F.M. Zavernyaev as "Acheulo-Mousterian", Mousterian of Quina type, and Mousterian "somewhat close to type La Ferrassie" (Zavernyaev, 1978). While F.M. Zavernyaev noted the presence of "leaf-shaped forms resembling *Blattspitzen*" and compared some of the Khotylevo I assemblages to those of Chokurcha, Staroselie, and Sukhaya Mechetka (Zavernyaev, 1978), he never designated them as Micoquian. This term was applied to Khotylevo I materials for the first time by V.N. Gladilin (Gladilin, 1985), and this definition is still quite acceptable for the old assemblages. The main problem for these assemblages is they were unfortunately mixed in storage, and today it is impossible to separate them according to the stratigraphy (Ocherednoi et al., 2015).

The alluvial sediments with archaeological finds were very rich in natural flint chunks, including numerous tabular pieces, which served as the main source of raw material for hominins. This is the main reason, together with plenty of flakes and partially broken cores, that Khotylevo I is interpreted as a workshop/habitation site. An important aspect of the old assemblages from Khotylevo I are the bifacially worked artifacts, semi-bifacial tools and unfinished or broken bifacial tools, suggesting a workshop character. These tool forms are supplemented with different types of intact bifacial backed knives and points. From the new excavations, CH 4 yielded a bifacial knife or Keilmesser (Fig. 9), and another one was found in the 2017 field season in the same layer (Fig. 10). A unifacially shaped knife or scraper with Keilmesser-morphology was found in CH 1 (Fig. 11), and some points or fragments of those could as well be recovered from this layer (Fig. 12). Only a potential preform of a bifacial tool has yet been obtained from CH 2, but this layer yielded the most numerous bifacial thinning flakes (see SOM IV of Chapter III), suggesting the production and removal of those tools. Besides other methods of blank production, flat prepared cores and Levallois cores (Fig. 13) form the main technological background in these assemblages.

Following from the descriptions above, the three different layers analyzed in this thesis suggest short-term occupations: they are embedded within and between fast growing humic beds and sands deposited by a braided river, they are preserved in a very fresh condition without double patination and several refits within the layers have been found.

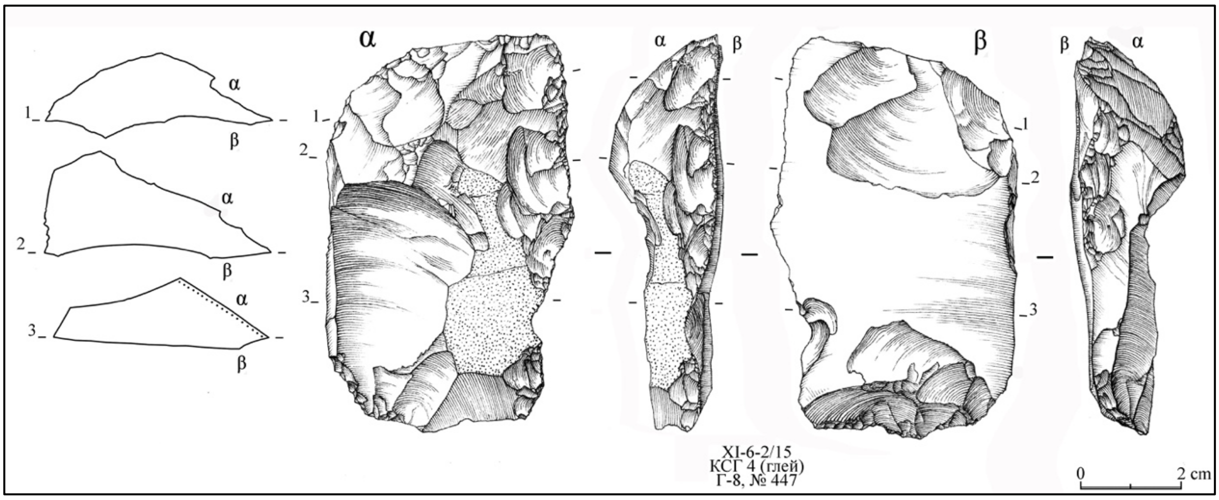

Figure 9. *Bifacial knife from Khotylevo I-6-2, Cultural Layer 4 (clay). Drawing: A. Otcherednoy.*

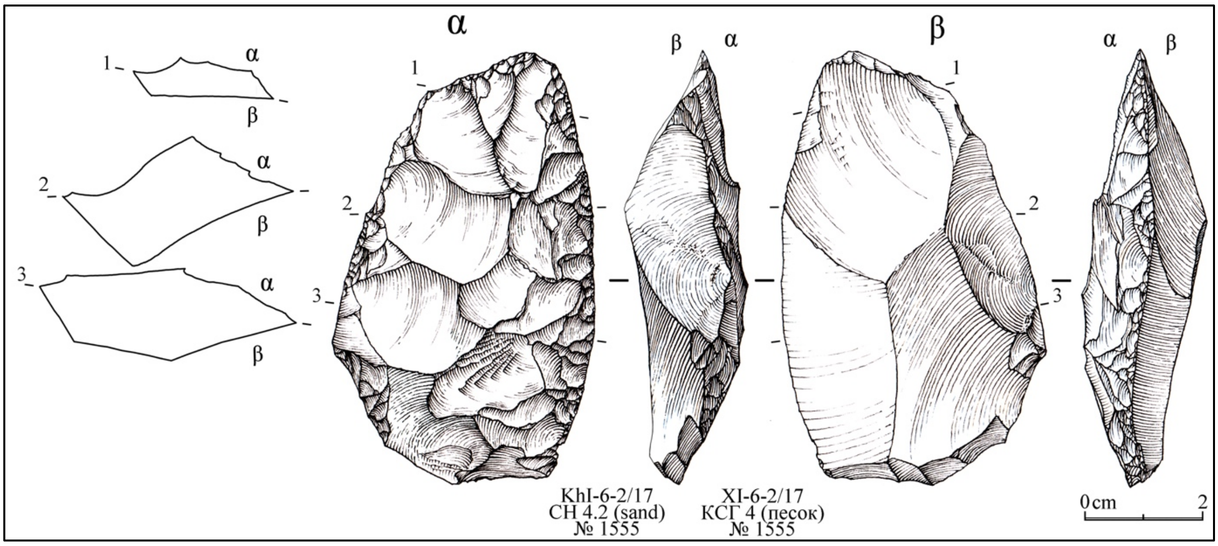

Figure 10. *Bifacial knife from Khotylevo I-6-2 found in 2017, Cultural Layer 4 (sand). Drawing: A. Otcherednoy.*

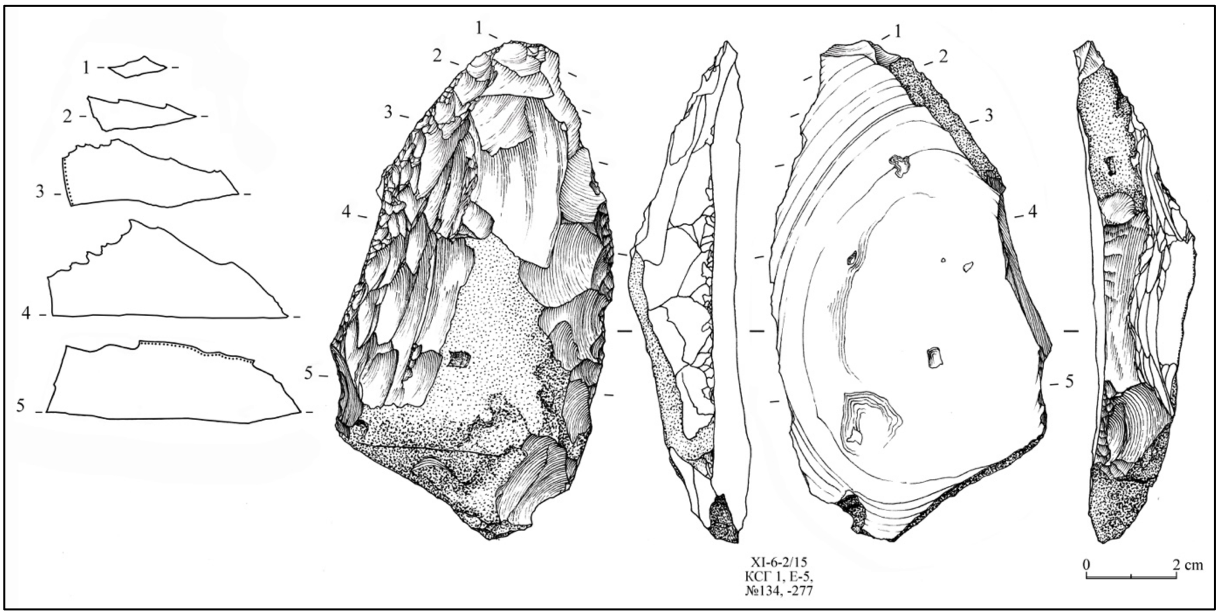

Figure 11. *Unifacially shaped knife with Keilmesser-concept from Khotylevo I-6-2 Cultural Layer 1. Drawing: A. Otcherednoy.*

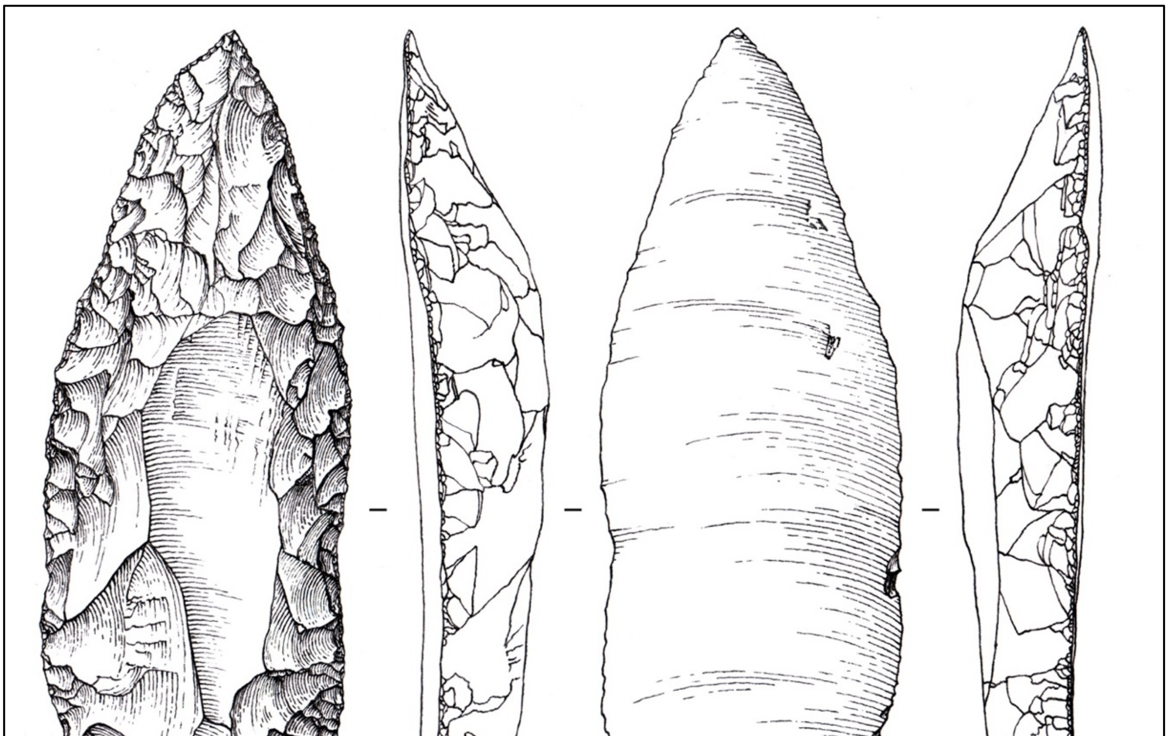

Figure 12. *Point or unifacially shaped knife from Khotylevo I-6-2 Cultural Layer 1. Drawing: A. Otcherednoy.*

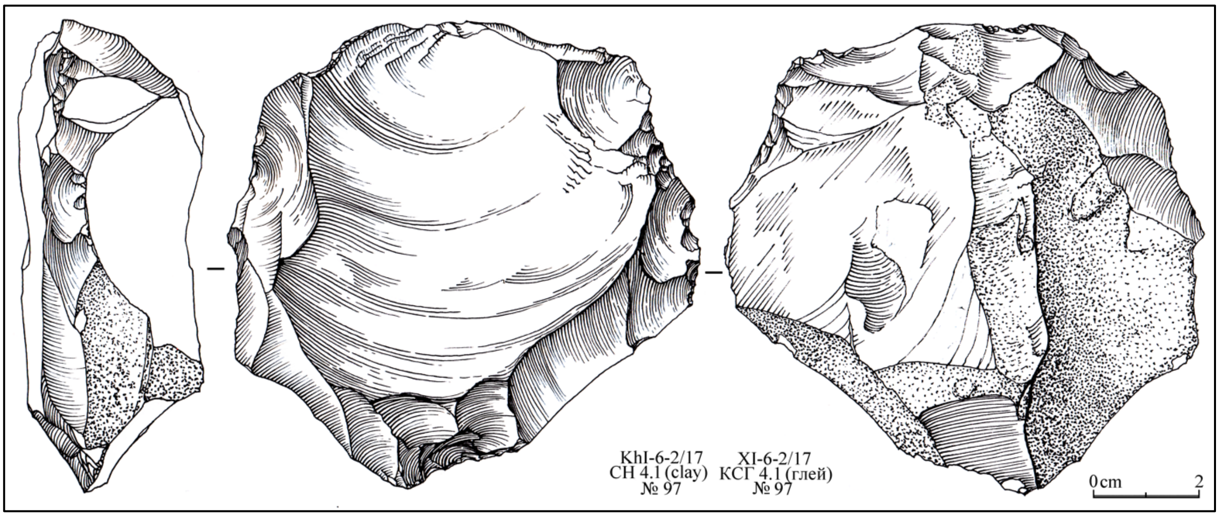

Figure 13. *Levallois core from Khotylevo I-6-2 Cultural Layer 4.1. Drawing: A. Otcherednoy.*

Table 1. *Radiocarbon dates of Pouch, Königsaue and Khotylevo I-6-2. Calibrated with OxCal 4.2, calibration curve IntCal 13. The following dates for Königsaue are not included in the calibration:>55,800 BP (GrN-5698), >45,000 BP (B 626) and 60,000 + 1400/-1200 BP (GrN-7001). They are difficult to interpret as two of them have infinite ages and another one, GrN-7001, is beyond the range of the calibration curve. For the calibration of the dates presented by Picin* (2016) *the reader is referred to the cited publication.*

Site	Layer	Lab code	Material	14C Age	1s Error	Cal BP 68.2%	Cal BP 95.4%	References
Pouch	3	KN-5541	sediment	41300	1600	46340 - 43330	48740 - 42610	Weiss, 2015
Pouch	4	KN-5542	sediment	>40000				Weiss, 2015
Pouch	4	KN-5543	sediment	32700	530	37580 - 36110	38360 - 35660	Weiss, 2015
Pouch	5	KN-5544	sediment	37400	1300	42880 - 40680	44400 - 39550	Weiss, 2015
Pouch	5	KN-5545	sediment	28530	940	33480 - 31570	34510 - 31020	Weiss, 2015
Pouch	12	KIA-21132	bone	14000 and >20700				Weiss, 2015
Pouch	0.3 m east of layer 5	KN-5546	pinewood	>43000				Weiss, 2015
Königsaue	A	OxA-7124	birch tar	43800	2100	49000 - 45640	out of range - 44620	Hedges et al., 1998
Königsaue	B	OxA-7125	birch tar	48400	3700	out of range - 44680	out of range - 43220	Hedges et al., 1998
Khotylevo I-6-2	3	GIN-15291	humic acid	40000	970	42566 - 40968	43588 - 40424	Ocherednoi et al., 2014a; Vishnyatsky et al. 2015; Weiss et al. 2017

Site	Layer	Lab code	Material	14C Age	1s Error	Cal BP 68.2%	Cal BP 95.4%	References
Khotylevo I-6-2	2.2	UCIAMS-17369	charcoal	47160	2680	49091 - 42606	out of range - 40781	Ocherednoi et al., 2014a; Vishnyatsky et al. 2015; Weiss et al. 2017
Khotylevo I-6-2	2.3	GIN-15195	humic acid	35900	600	39236 - 37986	39774 - 37342	Ocherednoi et al., 2014a; Vishnyatsky et al. 2015; Weiss et al. 2017
Khotylevo I-6-2	2.4	GIN -15197	humic acid	41900	600	43850 - 42802	44498 - 42308	Ocherednoi et al., 2014a; Vishnyatsky et al. 2015; Weiss et al. 2017
Khotylevo I-6-2	1	GIN - 15287	humic acid	25150	350	27644 - 26842	28282 - 26570	Ocherednoi et al., 2014a; Vishnyatsky et al. 2015; Weiss et al. 2017
Khotylevo I-6-2	1	UCIAMS-17368	charcoal	49780	3710	out of range - 44110	out of range - 42650	Ocherednoi et al., 2014a; Vishnyatsky et al. 2015; Weiss et al. 2017
Khotylevo I-6-2	1	UCIAMS-18727	charcoal	37910	1030	41030 - 39472	42186 - 38596	Ocherednoi et al., 2014a; Vishnyatsky et al. 2015; Weiss et al. 2017

Table 1. *Continuation.*

1.4.5 Wrocław-Hallera Av.

Wrocław-Hallera Av., today close to the center of the Lower Silesian city Wrocław, is part of the study presented in Chapter III. The site is in the area of the Wrocław ice-marginal valley, adjacent to the Wrocław Plain. The Wrocław ice-marginal valley is within the Odra river valley. This unit, however, belongs to a larger system called Wroclaw-Magdeburg-Bremen ice-marginal valley which originated in the Middle Pleistocene (Saale complex) (see Litt et al., 2007; Marks, 2004). The archaeological site is on a rise about 12 – 15 m above the talweg of the Odra Valley (124–125 m a.s.l). This geological form is interpreted as the accumulativeerosion terrace of Weichselian glaciation (Wiśniewski et al., 2013). The substratum of this fluvial complex is composed of the glaciotectonically deformed sediments, which consist of Elsterian and/or Saalian deposits, Neogene clays of Poznań Formation and sands with gravels of the Plio-Pleistocene Gozdnica Formation. The excavations carried out between 1991 and 2016 covered a significant area within the northern (~114 m^2), middle (~829 m^2) and southern (25.5 m^2) sectors of the site.

The middle sector is characterised by the presence of considerable amounts of finds and clear stratigraphy supported by a series of geophysical dates. The deposits recorded within the middle sector have been divided into seven geological complexes (Fig. 13a). Complexes A, B, C and E contain sequences of fluvial sediments. Complexes D and F were interpreted as lacustrine infill of local depressions, but with new data it cannot be ruled out that both layers are of fluvial origin corresponding to low energetic flows. Loessic sediments in the top part of the analysed profile were classified separately as complex G. The sediments were covered by modern soil.

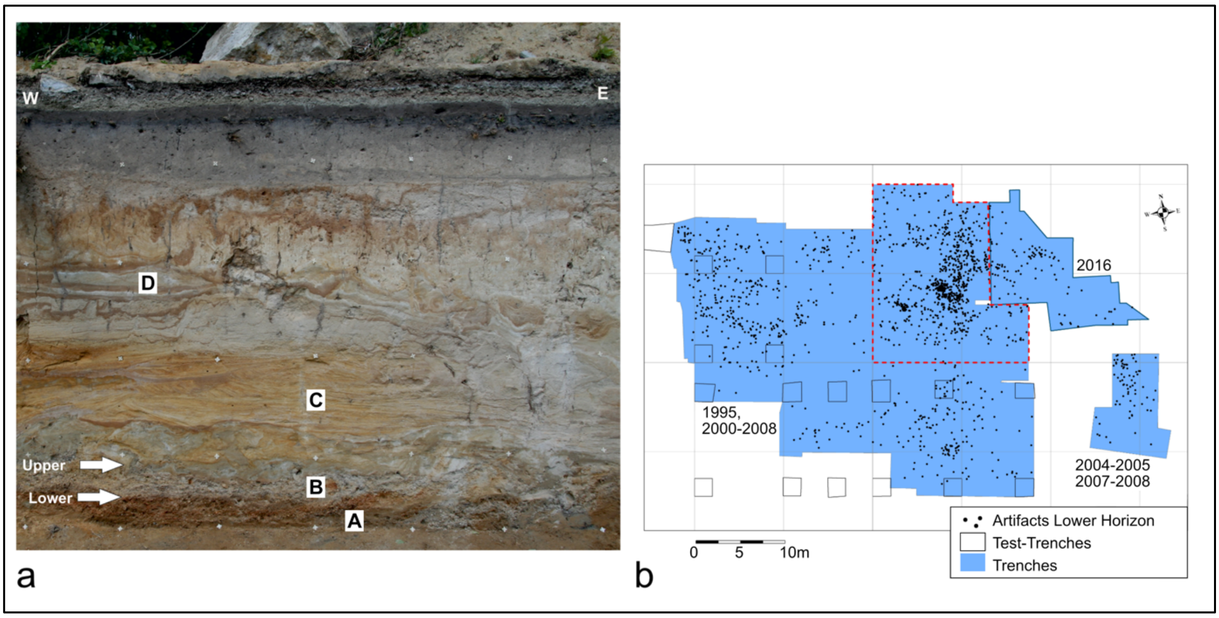

__Figure 14__. Wrocław-Hallera Av.: a) W-E profile of the site, letters in black mark geological units; b) plan with artifact distribution of the Wrocław-Hallera Av. lower find horizon. Marked in red is the area of the peninsula with the artifacts analyzed in this study. The remaining parts are channel deposits. The part excavated in 2016 was not available during data collection. Graphic: A. Wiśniewski.

The lower level of artifacts was found in deposits of complexes A and B, whereas the upper artifact level comes from the bottom of Complex C (Fig. 14a). Complex A/B represents sediments coming from an energetic environment. Complex A consists of pebbles and boulders while Complex B consists of gravels, sands and silts. Deposits from Complex B were deposited in a braided gravel-bed river with a relatively large amount of sinuosity. During excavation, two channels and a small peninsula located between them were recorded. Bones as well as stone artifacts are known from both parts but also within the channels, and they did not cluster due to water flow. The relative abundance of refitted artifacts (153 conjoined pieces) together with the very good state of preservation suggests that the occupation remains were minimally disturbed by alluvial processes during the final stage of deposit formation.

The Complex C consists of sands and gravelly sands belong to the second fluvial episode within the middle sector. The sediments of this complex are interpreted as typical for braided sandy-bed rivers of lower sinuosity. The flow was ephemeral and much less energetic than in the case of complex B. The artifacts of the Upper Horizon and bones occurred in the lower part of complex C. In contrast to complex B, the artifacts and bones have been found only in the middle and eastern part of the sector. It is worth mentioning that it was possible to distinguish 7 concentrations consisting of refitted blocks. It seems that the original spatial distribution of finds in this case was only influenced by periglacial, small-scale deformation structures.

The age of the deposits comes from OSL. Complex B yielded five ages between 80.4 ±3.3 ka and 51.9 ± 2.0 ka, and complex C yielded three OSL ages from 57.5 ± 3.4 ka to 53.8 ± 3.9 ka (Skrzypek et al., 2011; Wiśniewski et al., 2013). These dates place the Lower Horizon in the early Weichselian glaciation (most probably Odderade interstadial, MIS 5a) and the Upper Horizon is dated to the middle Weichselian (Glinde–Oerel interstadials, MIS 3) (Skrzypek et al., 2011; Wiśniewski et al., 2013; see also Bobak et al., 2013). Additional dates obtained in 2016 confirmed this age model (P. Moska, personal communication).

The exploration of sediments described as complex A/B and C resulted in a relatively abundant collection of faunal remains, comprising bones, antlers and teeth of herbivores, carnivores and fish. The assemblages from complexes A/B and C are typical for a steppe-tundra environment. The predominance of bovid fossils within the Complex A/B suggests that their accumulation was related to human activity. The lithic artifacts of both find horizons were made of local rocks of glacial origin. Mainly erratic flints and sporadically other rocks were used. A main source were potentially gravels found within Complex A.

The Lower Horizon artifacts (Fig. 14b) are dominated by debris related to core reduction. It seems that flake production was of some importance, and these blanks were used for simple retouched tools. Discoidal and proto-prismatic cores are dominant in the assemblage, but cores and flakes related to Levallois technology are also present (Fig. 15). The retouched tools are dominated by unifacial flake forms like side-scrapers (Fig. 16), but bifacial shaped tools (Fig. 17) and debris connected with their production were also recorded. From a typological perspective, the Lower Horizon is Mousterian.

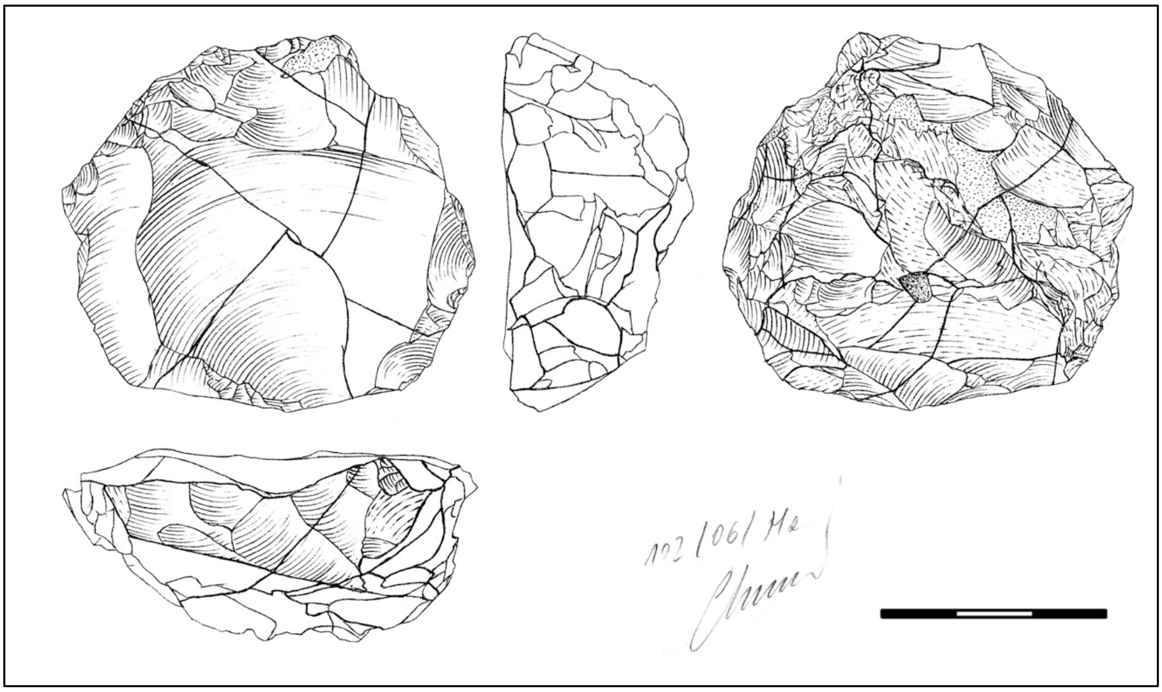

Figure 15. *Levallois core from Wrocław-Hallera Av. Lower Horizon (102/06/Ha). Drawing: T. Chmielewski.*

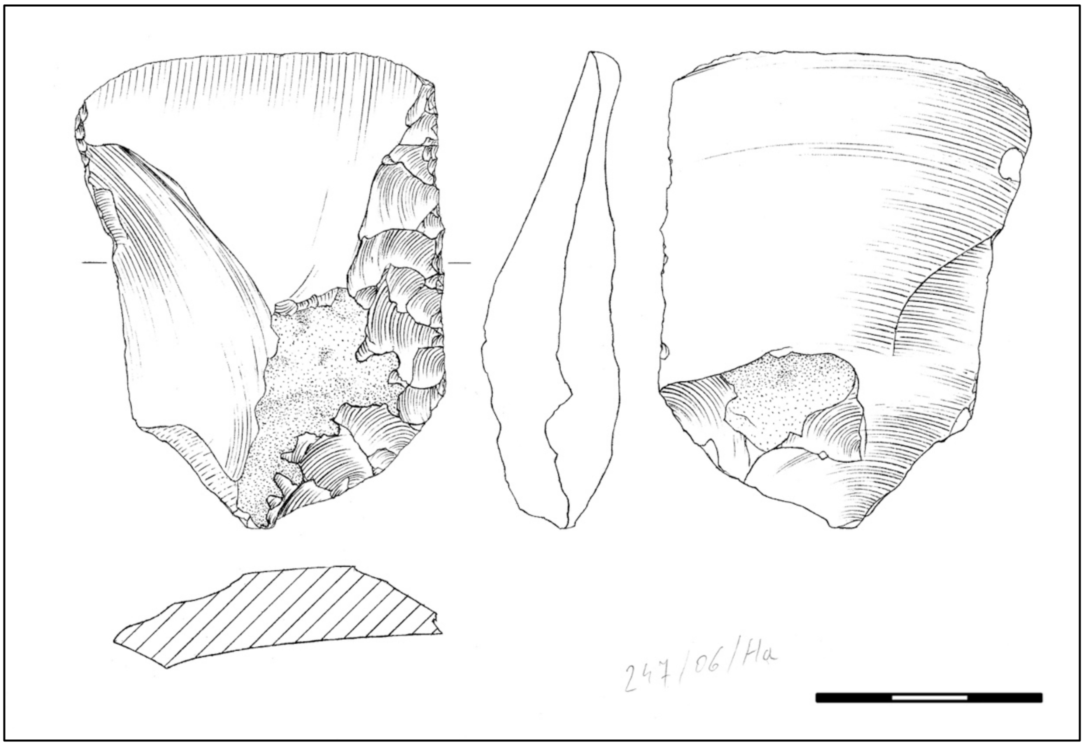

Figure 16. *Scraper from Wrocław-Hallera Av. Lower Horizon (247/06/Ha). Drawing: T. Chmielewski.*

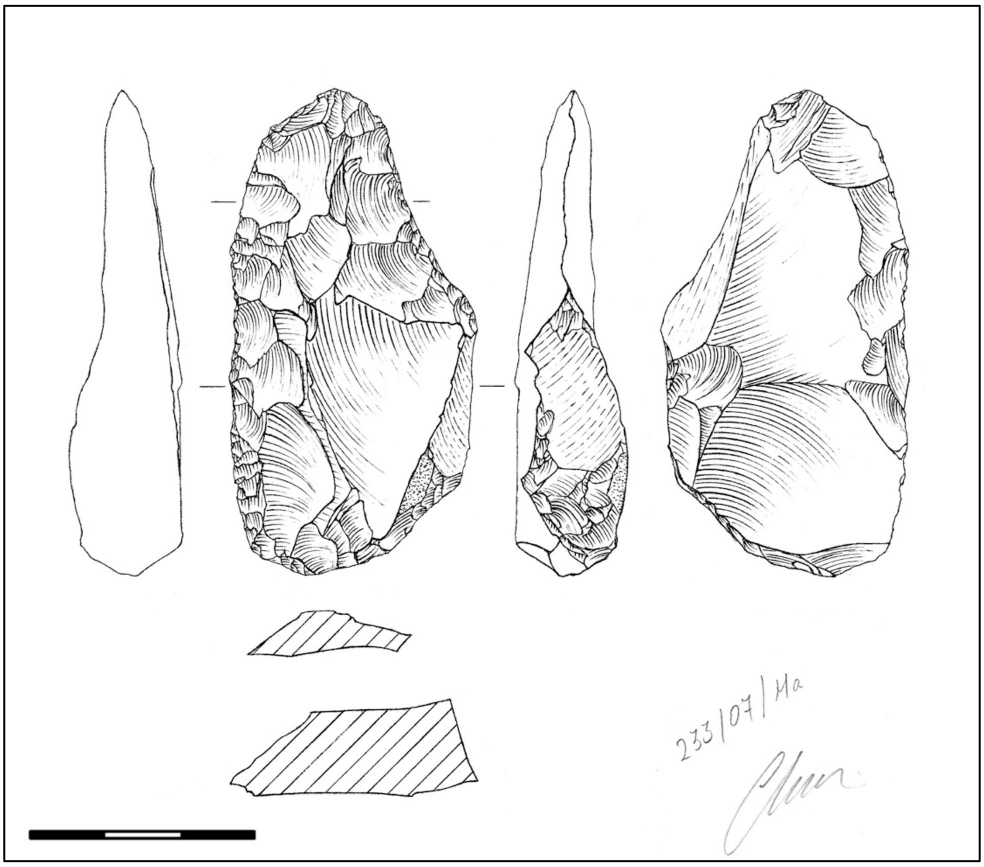

Figure 17. *Keilmesser from Wrocław-Hallera Av. Lower Horizon (233/07/Ha).*
Drawing: T. Chmielewski.

The stone artifacts from the Upper Horizon are divided into two groups. The first group is represented by cores and flake production debris. The second comprises forms from manufacturing tools by shaping (Fig. 18). It seems that production of flake blanks was based on unidirectional cores with a small proportion of centripetal methods including Levallois. The second direction of tool production by bifacial shaping included remains of unfinished or broken forms of tools, perhaps discarded due to their small dimensions. In general, tools are represented by rather small forms, including side-scrapers, irregular retouched flakes and uni- or bifacially retouched small knives (Fig. 19). Taking a typological and technological perspective into consideration, the Upper Horizon is Micoquian.

Figure 18. Refit of flakes from Wrocław-Hallera Av. Upper Horizon. The sequence belongs to the shaping of a bifacial tool, which is missing in the center. The arrow points to a broken scraper. Photo: A. Wiśniewski.

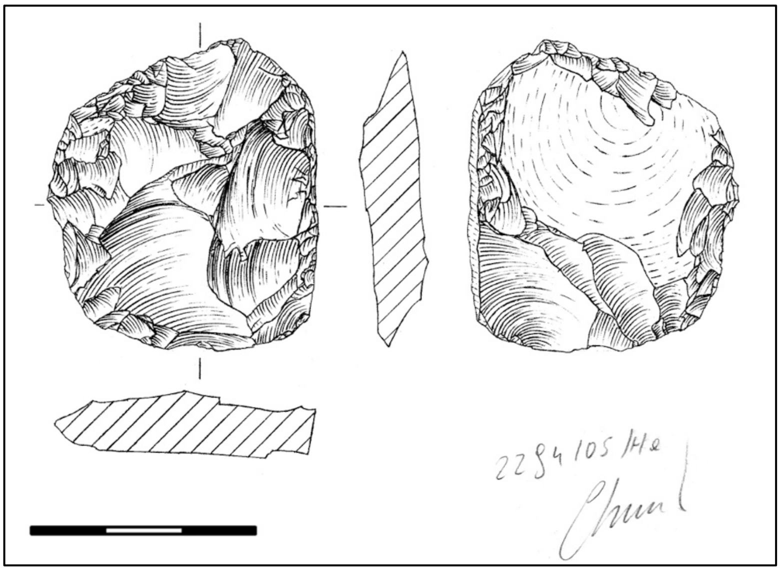

Figure 19. Small bifacial backed knife or bifacial scraper from Wrocław-Hallera Av. Upper Horizon (2284/05/Ha). Drawing: T. Chmielewski.

Concluding from what was described above, the artifacts from the two layers may represent short-term artifact clusters. A rather fast sedimentation rate is indicated, as they were covered with medium and low energetic alluvial sediments in a river channel environment. Fresh preservation, no double patination, and a large amount of refits in the individual layers suggests two short-term occupations.

1.5 Materials Part II – Analyzed Samples from the Assemblages

From the sites mentioned above, data was collected on 750 cores, 4549 flakes and 343 tools (Table 2). Only complete artifacts ≥ 20 mm were considered. The methods of the data collection were described above (section 1.3) and in Appendix I.

Table 2. *Number of complete artifacts included in this study.*

Assemblage	Cores	Flakes	Flake tools	Core tools	Total
Pouch	9	209	55	3	276
Goitzsche	207	744	35	22	1008
Löbnitz	290	459	51	38	838
Königsaue-A	24	513	25	9	571
Königsaue-B	118	1256	34	4	1412
Königsaue-C	8	104	9	3	124
Hallera-Lower	37	363	26	5	431
Hallera-Upper	24	219	2	4	249
Khotylevo I-6-2 CH1	17	231	8	2	258
Khotylevo I-6-2 CH2	11	296	4	1	312
Khotylevo I-6-2 CH4.1	5	155	3	0	163
Total	750	4549	252	91	5642

In some respect, just over 5600 artifacts is perhaps a small sample on which to base general conclusions about the late Middle Paleolithic of such as vast territory as the European Plain. For the aims of this thesis, however, the sampling strategy placed first importance on having many short-term assemblages from mostly multilayered sites representing different parts of the research area, attributed to different archaeological entities and covering different occupation times between MIS 5a and early MIS 3. Additionally, for the study presented in Chapter III, the number of artifacts needed to represent the general characteristic of each assemblage is statistically tested (see Supplementary Information to Chapter III). I could show that 100 randomly drawn artifacts from each assemblage are representative for the individual artifact inventories. Therefore, the samples selected here from each assemblage are larger than needed, and sufficient artifacts were analyzed to draw general conclusions about the relationship and characteristics of the assemblages in this study.

To have directly comparable flake assemblages in terms of their physical fracture mechanics, especially for the analysis presented in Chapter III, almost exclusively flint artifacts were analyzed. A bifacial backed knife from Königsaue C, which was made of Kieselschiefer (siliceous shale), is the only exception. As it is only one artifact and as its presence among flint artifacts indicates tool transport, it has not been removed from the dataset.

The flake assemblage analysis presented in Chapter III relies on more or less complete assemblages. An important factor, whether an assemblage was included in the assemblage analysis of Chapter III, is the (at least partial) integrity of the assemblage. One argument for the integrity is the method of recovery, i.e. if an assemblage was properly excavated or only collected from various locations on the surface. Therefore, the assemblages from Goitzsche and Löbnitz were not part of the study in Chapter III. As there are some geological implications that some of the excavated assemblages were disturbed by post-depositional processes (e.g. Pouch, Wrocław-Hallera Av. lower assemblage, Khotylevo I-6-2 CH1 and CH4.1), refit sequences are a suitable indication that at least parts of the assemblage are still in primary context or, at least, part of the same original unit. Therefore, to record, where possible, refit sequences within each assemblage was a very important part of the approach.

For the assemblage of Pouch, every complete artifact ≥ 20 mm was analyzed (Table 2). Seven refit sequences (Fig.3, Weiss, 2015) could be observed, which is evidence for the (at least partial) integrity of the assemblage. For the Goitzsche Collection, collected from the vicinity of Pouch, every complete artifact ≥ 20 mm was included as well (Table 2). From Löbnitz, data on a random sample of 838 cores, flakes and tools was collected (Table 2). As the artifacts were collected from the coarse gravel dump of the quarry, they were completely out of context (in contrast to the artifacts from Goitzsche where several find locations could be recorded). Comparing attributes from single flakes or cores that are out of context does not make much sense. Therefore, the analysis of tools in this collection had the main importance for this thesis, as their features could be compared more easily to tools from other sites within the same chronological context. Nevertheless, a sample of flakes and cores from Löbnitz were recorded as well to have an idea about the general technological characteristics of the artifacts from the site.

From the Königsaue assemblages, every available complete artifact ≥ 20 mm was recorded (Table 2). Excluded from the analysis of Königsaue A are the artifacts on display in the Landesmuseum für Vorgeschichte Halle (Saale). For some of the bifacial tools though, original-sized casts where available in the museum's collection and used for this study. This made it possible to include data for the major part of the Königsaue tools. Only the mass could not by recorded for these specimens. Unfortunately, the refit sequences presented in the monograph (Mania and Toepfer, 1973), consisting of about ten flakes, could not be measured, as the artifacts were glued together. Königsaue B is the biggest assemblage in this dataset (Table 2). In contrast to assemblage A, data on flakes from 5 refit sequences could be recorded as well, as they were not glued together. With the exception of artifacts on display in the museum, the major part of the cores, flakes and tools could be included into the thesis. With only 124 recorded complete artifacts ≥ 20 mm (Table 2), Königsaue C represents the smallest assemblage of the dataset.

From the Lower Horizon of Wrocław-Hallera Av., a representative sample of 431 complete artifacts ≥ 20 mm was analyzed (Table 2). The sample includes all the finds of the main find concentration found on the peninsula between the two channels (Fig. 13b). This area was chosen because it represents the less disturbed part of the site. Additionally, the presence of artifacts from 26 refit sequences in the dataset attests to the integrity of the selected part of the assemblage. The same is true for the Wrocław-Hallera Av. Upper assemblage where, as part of the dataset, artifacts from 21 refit sequences were recorded. Here, 249 complete artifacts ≥ 20 mm were available for study (Table 2).

From Khotylevo I-6-2, the assemblages ≥ 20 mm of the Cultural Horizons 1, 2 and 4.1 were analyzed for this study (Table 2). Layer 3 was not included as it yielded only a few artifacts. CH 4.2. was excluded as well, as only a part of the assemblage was excavated at the end of 2016, when the data were recorded. From CH 2, artifacts from four refit sequences belonging to the sublayer 2.4 were analyzed, illustrating the integrity of the assemblage. From the assemblage of CH 4.1, artifacts from one refit sequence could be included in the dataset.

1.6 Outline of the Thesis Chapters

Chapter II – Stone tool analysis and context of a new late Middle Paleolithic site in western central Europe – Pouch-Terrassenpfeiler, Ldkr. Anhalt-Bitterfeld, Germany

The first paper of this thesis (Chapter II) was designed as the baseline for the subsequent studies. It describes the site of Pouch-Terrassenpfeiler and the collected artifacts found in the vicinity and discusses the assemblages in their central German context. Pouch-Terrassenpfeiler yielded radiocarbon and luminescence ages of around 46 ka. With these ages and together with 58 complete tools out of 371 stone artifacts, the site marks an important data point for the late Middle Paleolithic of central Europe. The flake assemblage of Pouch-Terrassenpfeiler is the result of Levallois and prepared core blank production, as well as bifacial and unifacial tool production. How the variability within the flake assemblage is structured compared to other sites of the European Plain is explored in Chapter III. The first paper discusses as well certain special features of the tools that are part of this assemblage. The first main observation is that different types or concepts of backs opposite a working edge are a common feature of bifacial, unifacially shaped and simple edge retouched tools. Backs are either cortical, retouched ("backed"), formed by a former core edge or by the former flake platform. The second observation is that some bifacial, unifacially shaped and simple edge retouched tools seem to be connected by a single morphological concept. This concept is typologically restricted to a certain late Middle Paleolithic tool type, the bifacial backed knife or "Keilmesser". The Keilmesser (Bosinski, 1967; Jöris, 2001, 2004, 2006, 2012) consists of a bifacially shaped cutting edge opposite a natural and/or retouched back, a proximal base and a shaped distal tip region. Thereby, it has an asymmetric cross section with the thickest part at the back. Except for bifacial surface shaping, this concept was found as well on unifacially shaped and simple edge retouched flake tools. Krukowski (Krukowski, 1939-1948) already suggested at the beginning of the 20th century that these kinds of tools form a continuum (e.g. a result of re-sharpening and/or reduction) and might be connected in the concept of his "Pradnik-cycle". This relationship is explored further in Chapter IV using multivariate analysis, 3D geometric morphometrics and Thickness Mapping.

Chapter III – Using multivariate techniques to assess the effects of raw material, flaking behavior and tool manufacture on assemblage variability: An example from the late Middle Paleolithic of the European Plain

In the second paper (Chapter III), variability at the assemblage level is analyzed across the European Plain using mainly multivariate analyses of flakes. The study explores assemblage variability without regard for the type fossils (e.g. bifacial tools like Keilmesser). Furthermore, it tries to see whether a distinction between different archaeological entities (Micoquian, Mousterian or Taubachian) on the basis of only the flakes is possible. The analysis is based on the hypothesis that flakes are the most numerous artifact category and all technological aspects should be coded in their morphology. Certain flake attributes can capture these technological features of an assemblage, which are then analyzed and compared using multivariate methods. Based on the spatial distribution of the individual flakes in the multivariate plot, the spatial median (Gower, 1974; Bedall and Zimmermann, 1979) is calculated for each flake population, which is interpreted as a measure for the general flake assemblage composition. These spatial medians are than used for comparisons between assemblages. The analysis of the flake assemblages from the European plain shows that the assumption that flakes from similar production sequences and that share raw material conditions and management strategies have similar attribute configurations might indeed be the case. In a second step, the individual attributes used within the multivariate analyses are analyzed and compared including the remaining parts of an assemblage, namely the cores and the tools. More specific, factors that drive flake variability within an assemblage are analyzed in light of raw material, flaking behavior, like blank production, and tool manufacture. Sites with Levallois and prepared core techniques and varying degrees of bifacial shaping as well as other forms of tool production form one large cluster in all the multivariate plots. Further, sites that are similar in raw material size cluster together as well. And assemblages with special raw material treatments form also a tight group within the larger cluster of technologically comparable sites. An example from our study is the case of Königsaue where the transport of pre-shaped nodules to the site can be inferred based on our analysis. This pattern was consistent in all multivariate methods. In contrast, one assemblage, Wrocław-Hallera Av. Upper layer, behaves as an outlier to all the other assemblages. In comparison to the other sites, the raw material is rather small, Levallois and prepared core techniques are almost absent and bifacial tool production might play a bigger role. The latter is evidenced by refits showing that rather "ordinary" looking flakes originate from bifacial shaping (see Fig. 17).

One of the major results of the analysis is that on the basis of the multivariate analysis of flake attributes, no distinction between assemblages classified as Mousterian, Micoquian and Taubachian could be made.

Chapter IV – The variability of the Keilmesser-concept: a case study from central Germany

In contrast to the second study, the third study of this thesis (Chapter IV) focusses on variability in the type fossil "Keilmesser" and its underlying morphological concepts that may in fact be part of the late Middle Paleolithic tool manufacture across multiple tool types. The study is an attempt to explore Micoquian tool variability from a different perspective using a varied set of analytical methods. It turns back to the site of Pouch and the collected assemblages from the vicinity of the site. As a small-scale study, stone tools from one micro-region with the same paleoenviroment and the same chronological time frame are analyzed. The aim of the study is to explore the relationship and variability between bifacial backed knifes or Keilmesser, simple edge retouched and unifacially shaped scrapers with a knife-morphology as well as handaxes. The basic assumption of this study is that if the tools in question show a similar morphological concept with comparable edge treatment, then this may indicate similarities concerning their function. Therefore, the tools were broken down into their techno-functional parts, i.e. prehensile versus active zones (e.g. Boëda, 1997, 2001; Soressi, 2002; Soressi and Hays, 2003; Claud, 2012). For the purposes of the study, the components defined for the bifacial Keilmesser (Veil et al., 1994; Veil, 1995; e.g. Jöris, 2001, 2006, 2012) were used to define the techno-functional or mophological components of the tools: the prehensile base and back, opposite the active zones of cutting edge and tip. Another, partially sharp edge is adjacent to the distal end of the back and converges with the main cutting edge at the distal tip. Based on these components, 3D geometric morphometrics, 3D Thickness Mapping, and edge angle analysis based on the thickness maps as well as multivariate methods were then used to analyze different aspects of variability related to function/prehension connected to retouch intensity but also to blank type, and classification or typology. As result, it can be inferred that the tool concept underlying the bifacially shaped Keilmesser is not exclusively restricted to bifacial shaping and was as well applied to simple edge retouched and unifacially shaped flake tools. The unifacially shaped tools show the most similarities to the bifacial Keilmesser. Therefore, it is suggested that they can be classified as a unifacial variant of latter. Despite being within the range of the variability of the *Keilmessser-concept*, Micoquian handaxes are somewhat different in having a more symmetric shape. Therefore, they might form a separate but functionally related tool.

With some caution related to low sample size, they appear to be a special, symmetric form of Keilmesser. The simple scrapers with Keilmesser-like morphology can be interpreted as a special simple variant of Keilmesser, where the blank already fulfills most of the functional requirements. In conclusion, Neanderthals had a certain but very flexible concept of the production of a distinct tool type, causing variability within the archaeological record.

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