Between Petrographic Diversity and Techno-Economic Behaviors During the Middle Paleolithic: Some Observations on Lithic Raw Material Management at the Sites of Achenheim “Sol 74” and Mutzig “Rain” (Alsace, France)

Simon Diemer[1]

1 Doctorant UMR 7044 ArcHiMèdE (Strasbourg), Maison Interuniversitaire des Sciences de l’Homme -Alsace

ABSTRACT

The identification of lithic raw material sources used to produce tools and the characterization of their management are essential when studying a prehistoric population. For the Middle Paleolithic, it may be one of the crucial keys to understanding the technological and typological variability observed within the lithic assemblages, particularly in the Rhine Valley where the scarcity of flint and geological complexity go hand in hand with the exploitation of a wide diversity of the raw materials by Neanderthal groups.

In this paper we propose an analysis of raw material management on the only two Middle Paleolithic sites in the French part of the Rhine Valley to have been actually excavated and well-documented and which have yielded sufficient quantities of lithic material: Achenheim “Sol 74,” an open-air find horizon dating to the Saalian glaciation, and Mutzig “Rain,” a multi-layer rockshelter settlement from the beginning of the Weichselian glaciation. These two sites occupy quite different environments and belong to different chronological periods but they probably had access to the same raw material sources. The analyses carried out combine petrography, observation of the natural surfaces on the lithic artifacts and the reconstruction of reduction sequences and *chaînes opératoires*. For both sites, this approach has allowed us to highlight the exploitation of raw materials which were primarily sourced locally. It has also revealed other techno-economic behaviors such as the circulation of certain kinds of products, especially retouched tools made from good quality flint. Our observations allow us to propose interpretations regarding the functioning of Neanderthal groups and the functions of sites within the territory that they exploited.

RÉSUMÉ

L’identification des sources de matières premières utilisée pour la production de l’outillage et la caractérisation de leur gestion sont essentielles pour étudier une population préhistorique. Pour le Paléolithique moyen, cela peut être un des éléments clés pour tenter de comprendre la variabilité technologique et typologique au sein des assemblages lithiques, en particulier dans la vallée rhénane où la

 / https://doi.org/10.51315/9783935751353.007

Cite this article: Diemer, S. 2024. Between Petrographic Diversity and Techno-Economic Behaviors During the Middle Paleolithic: Some Observations on Lithic Raw Material Management at the Sites of Achenheim “Sol 74” and Mutzig “Rain” (Alsace, France). In *The Rhine During the Middle Paleolithic: Boundary or Corridor?*, ed. by H. Koehler, N. J. Conard, H. Floss, A. Lamotte, pp. 143–161. Tübingen: Kerns Verlag. ISBN: 978-3-935751-35-3.

rareté du silex et la complexité géologique vont de pair avec l'exploitation d'une large diversité de matières premières par les groupes néandertaliens.
Nous proposons dans cet article une analyse de la gestion des matières premières au sein des deux principaux sites du Paléolithique moyen de la partie française de la Plaine du Rhin actuellement bien documentés et avec suffisamment de restes lithiques. Achenheim « Sol 74 », un niveau d'occupation de plein air daté de la glaciation du Saalien, et Mutzig « Rain », un abri sous-roche ayant livré plusieurs niveaux d'occupations du début de la glaciation Weichselienne. Ces deux sites sont situés dans des environnements et des contextes chronologiques différents, mais avaient probablement accès aux mêmes sources de matières premières. Les analyses ont combiné la pétrographie et l'observation des surfaces naturelles, ainsi que la reconstruction des schémas de débitage et des chaînes opératoires. Elles ont permis d'attester pour les deux sites de l'exploitation des matières premières de l'environnement très majoritairement local, ainsi que d'autres comportements techno-économiques comme la circulation de certains types de produits, en particulier les outils retouchés en silex de bonne qualité. Elles permettent de proposer des interprétations concernant le fonctionnement des groupes néandertaliens et sur la fonction des sites au sein du territoire exploité.

ZUSAMMENFASSUNG

Die Identifizierung der Rohmaterialquellen, die für die Herstellung von Werkzeugen verwendet werden, und die Charakterisierung ihrer Bewirtschaftung sind für die Erforschung einer prähistorischen Bevölkerung von wesentlicher Bedeutung. Für das Mittelpaläolithikum könnte dies eines der Schlüsselelemente beim Versuch sein, die technologische und typologische Variabilität innerhalb lithischen Inventar zu verstehen, insbesondere im Rheintal, wo Knappheit von Feuerstein, geologische Komplexität und Verwendung einer großen Rohstoffvielfalt von den Neandertaler-Gruppen, zusammenhängen. Wir schlagen in diesem Artikel eine Analyse der Rohstoffbewirtschaftung vor, der beiden Hauptstandorten des Mittelpaläolithikums im französischen Teil der Rheinebene, die derzeit gut dokumentiert sind und über ausreichende lithische Überreste verfügen. Achenheim „sol 74", eine aus der Saale-Eiszeit datierte Freiland-Besatzungsstufe, und Mutzig „Rain", ein Felsüberhang, der mehrere Besetzungsstufen aus dem Beginn der Weichsel-Eiszeit hervorbrachte. Diese beiden Stätten befinden sich in unterschiedlichen Umgebungen und unterschiedlichen zeitlichen Kontexten, hatten aber wahrscheinlich Zugang zu denselben Rohmaterialquellen. Die Analysen kombinierten Petrographie und Beobachtung natürlicher Oberflächen sowie die Rekonstruktion von technischen Konzepten der Abschlagproduktion und von die chaînes opératoires. Sie haben es ermöglicht zu beweisen, für die beiden Standorte, die Ausbeutung von Rohmaterial aus der sehr überwiegend lokalen Umgebung, sowie andere technoökonomische Verhaltensweisen wie die Zirkulation bestimmter Arten von Produkten, insbesondere retuschierten Feuersteinwerkzeugen, aus sehr guter Qualität. Sie ermöglichen Interpretationen über die Funktionsweise der Neandertalergruppen und über die Funktion der Standorte innerhalb des ausgebeuteten Gebiets.

INTRODUCTION

Despite the fact that Alsace occupies a central location in the Rhine Valley, and that research began here relatively early (Faudel and Bleicher 1888; Schumacher 1907), there is very little data available for studying Middle Paleolithic behaviors in the region. In 2018, only two excavations had revealed evidence of stratified occupations for this period. The first, located in Achenheim, is known as “Sol 74” and was excavated in 1974 and 1975. This excavation yielded a prehistoric find horizon of about 200 m^2 dating from the Saalian glaciation (Sainty and Thévenin 1978). The second site, known as Mutzig “Rain,” was discovered in 1992 (Sainty 1992) and is still being excavated each summer since 2009 (Koehler et al. 2016). These excavations provide us with new data on at least eight successive find horizons dated from the beginning of the last glaciation.

These two key sites are about 12 km apart and present a number of important differences and similarities. They provide evidence of Neanderthal occupation from two different glaciations in two different types of settings. The first site, Achenheim “Sol 74,” is an open-air find horizon located in the loess hills bordering the Rhine Valley, the second, Mutzig “Rain,” is a rockshelter in the sub-Vosges Hills with multiple find horizons. But they are also both located along the Bruche River (Fig. 1), and they had access to relatively similar lithic resources. Both lithic assemblages are characterized by a great diversity of rock types, mainly sedimentary, metamorphic and volcanic rocks from the Vosges.

These two sites allow us to study the behaviors of at least two different Neanderthal groups in two different kinds of settings but with some convergence in terms of raw material constraints. This study is part of a PhD Dissertation that the author is currently preparing at the University of Strasbourg on the Middle Paleolithic lithic industries of the Middle and Upper Rhine area, with a focus on these assemblages from Alsace. This article presents some of the initial results of this study; they concern raw material management for the production and maintenance of the lithic tool kit from the two main Alsatian sites.

ACHENHEIM “SOL 74”

Achenheim is located 15 km west of Strasbourg, in the first Loess hills overlooking the Bruche River (Fig. 1). This area is well known for the important stratigraphic sequence identified in its loess quarries. The correlations between several loess profiles in the four main quarries in Achenheim and in the neighboring town of Hangenbieten have allowed the reconstruction of a nearly continuous stratigraphic sequence spanning about 600,000 years, providing a reference stratigraphy for the Upper Middle Pleistocene and the Upper Pleistocene (Heim et al. 1982; Lautridou et al. 1985; Schumacher 1907; Sommé et al. 1986). The stratigraphy includes the sedimentary records of the last three glacial cycles, and part of the fourth. A large collection of Quaternary faunal remains and Paleolithic lithic artifacts were discovered during the exploitation of these quarries and were collected by Paul Wernert, who carefully positioned them within the general stratigraphy (Wernert 1957; Junkmanns 1995).

In 1974, the archaeological layer known as “sol 74” was excavated over an area of 200 m^2 at the “Hurst” Loess quarry in Achenheim (Sainty and Thévenin 1978). This excavation uncovered faunal remains, such as those

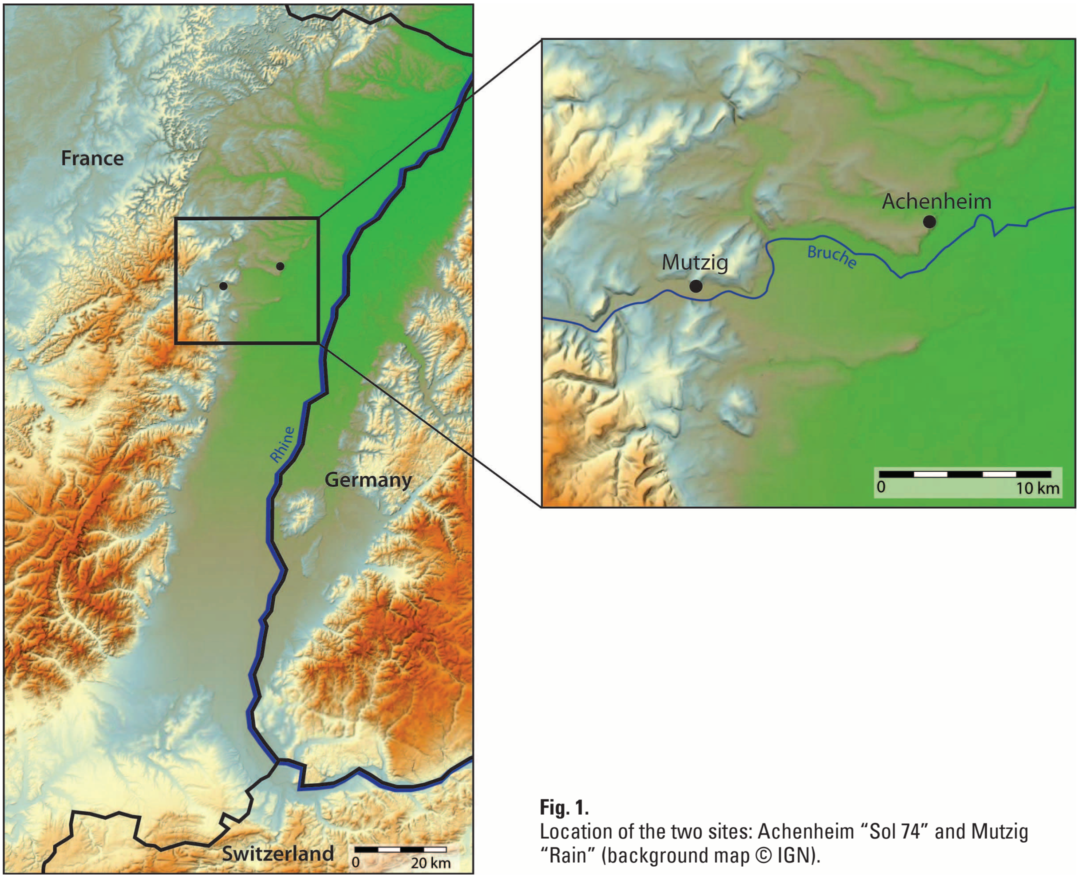


Fig. 1.
Location of the two sites: Achenheim "Sol 74" and Mutzig "Rain" (background map © IGN).

of woolly rhinoceros and horse, as well as a hundred lithic artifacts mainly made on "split pebbles that were cracked by percussion" (Thévenin 1976). Some spatial organization can be seen: faunal remains, sometimes still articulated, are concentrated in the central part of the site along with some rare lithic artifacts. In contrast, in the southern part of the site, lithic artifacts are more numerous, accompanied by more fragmented faunal remains. Finds are rarer and more scattered in the northern part of the site.

This unique find horizon seems to have largely escaped disturbance by taphonomic processes, and even though it is difficult to prove that all of the finds are strictly contemporary, we can suppose that it corresponds to a single prehistoric occupation. On the other hand, the spatial distribution of the archaeological material suggests that the limits of the occupation have probably not been revealed by the excavation and that these 200 m^2 are part of a more extensive site.

During the excavation, the stratigraphic position of this find horizon could not be dated due to erosion in the area of the quarry. However, it was quickly attributed to the beginning of the last glaciation on the basis of the rhinoceros (*Caelodonta antiquitatis*) and horse remains (Byrne and Prat 1978; Guerin 1978). However, a new study in the 1980s allowed the position of the find horizon to be placed within the general stratigraphy, at the base of the Pleniglacial Loess of Series II, corresponding to an older date during the Saalian glaciation (Buraczynski and Butrym 1984; Lautridou et al. 1985).

The lithic corpus from Achenheim "Sol 74" consists of 105 artifacts, including 73 flakes, six cores or fragmented cores, seven retouched tools, and 17 indeterminate fragments. The published post-excavation studies are quite brief (Rebmann 2007; Sainty and Thévenin 1978) and the corpus was never really examined in depth. The new study presented here provides a better characterization of this assemblage and allows some interesting observations to be made, although the small number of artifacts means that we must remain cautious regarding any interpretations.

Raw material procurement

The lithic assemblage is characterized by a high degree of petrographic diversity (Rebmann 2007). It includes some very fine-grained stones such as flint, chalcedony, rhyolite and phtanite, but also coarser stones such as spilite and graywacke. The only type of noticeable natural surface on artifacts is alluvial neo-cortex, which is present on 43.8% of artifacts (n = 46). This means that the supply of raw material came from alluvium or from an alluvial deposit.

The majority of rocks used were from the Vosges Mountains, and more particularly, from the Bruche Valley. The geology of the Bruche Valley is complex, and several geological formations provide suitable materials for knapping activities. The primary sources of these volcanic, sedimentary and metamorphic rocks are located in different parts of the middle Bruche Valley, about 30 km from Achenheim:

- The most common petrographic varieties are brown fluid rhyolites and rhyolithic ignimbrites from the Permian volcanism of Nideck (n = 24).
- Various volcanic rocks from the Devonian massif of Schirmeck. These mainly consist of spilites (n = 17) and also some other varieties such as diabase (n = 2) and keratophyre (n = 1).
- Quartz (n = 16), often full of cracks, and quartzite (n = 8). They come from the Buntsandstein conglomerate.
- Sedimentary and metamorphic rocks from the Devonian of the middle Bruche Valley. These include fine-grained stones, such as phtanite (n = 7), or slightly more coarse-grained types, such as graywacke (n= 5).

- Flints and Chalcedonies (n=12). These correspond to pelloidal flint and chalcedonies from the middle Triassic (*Muschelkalk*) that are found in outcrops in the sub-Vosges Hills. Some of them may be found along the Bruche Valley, but similar flints can also be found in the hills further to the north and south.

We can argue that most of these raw materials were collected in the Bruche alluvium. For the flint and chalcedonies, this is a probable scenario, but they may also have been collected in the alluvial deposits from other Vosges rivers. Nowadays, the Bruche flows two kilometers away from the site, but Saalian paleo-alluvial deposits are located within a kilometer.

A small handful of artifacts are not made from raw materials of Vosgian origin but rather from raw materials that were collected from Rhine alluvium. This is the case for a retouched tool and a small flake of flint (Rebmann 2007, and identification J. Affolter) and for one core and a flake of quartzite. Saalian Rhine alluvial deposits occur around 3 km to the east of the site. We have good evidence, therefore, that the bulk of raw materials were sourced in the immediate locality, although similar material can be found at moderate distances from the site, all along the fluviatile formations.

Due to the diversity in the appearance of the raw materials, even within the different geological families, this assemblage was particularly suitable for refitting and for sorting into Raw Material Units (RMU). Raw material units are defined according to macroscopic characteristics including color, grain size, inclusions and cortex structure, and each RMU groups together all of the artifacts presumed to have been produced by the reduction of one single nodule (Roebroeks 1988; Conard and Adler 1997; Turq et al. 2013). For our assemblage, only the rhyolites allowed significant RMU grouping. All 24 rhyolite artifacts were sorted into three distinct RMUs, and for two of these units they include a core with refittings (Fig. 2: 1). We can then argue that although this is the most frequently used raw material, only three individual rhyolite pebbles were actually reduced on the site.

Lithic production

Most of the cores are fragmented or show evidence for very expedient flake production. Only two refitted cores display a more organized production (Fig. 2: 1). They correspond to a discoidal debitage concept, with unifacial modality (Boëda 1993; Mourre 2003; Terradas 2003). Striking platforms are partially prepared by very secant removals. A large proportion of flakes can be attributed to this debitage concept. They are often quite thick and squat, produced by centripetal management, especially pseudo-Levallois points (Fig. 2: 2). There is no clear Levallois debitage. Comparison of the length to the thickness ratio of the pseudo-Levallois points from Achenheim and Mutzig "Rain" clearly shows a difference in the size of the desired

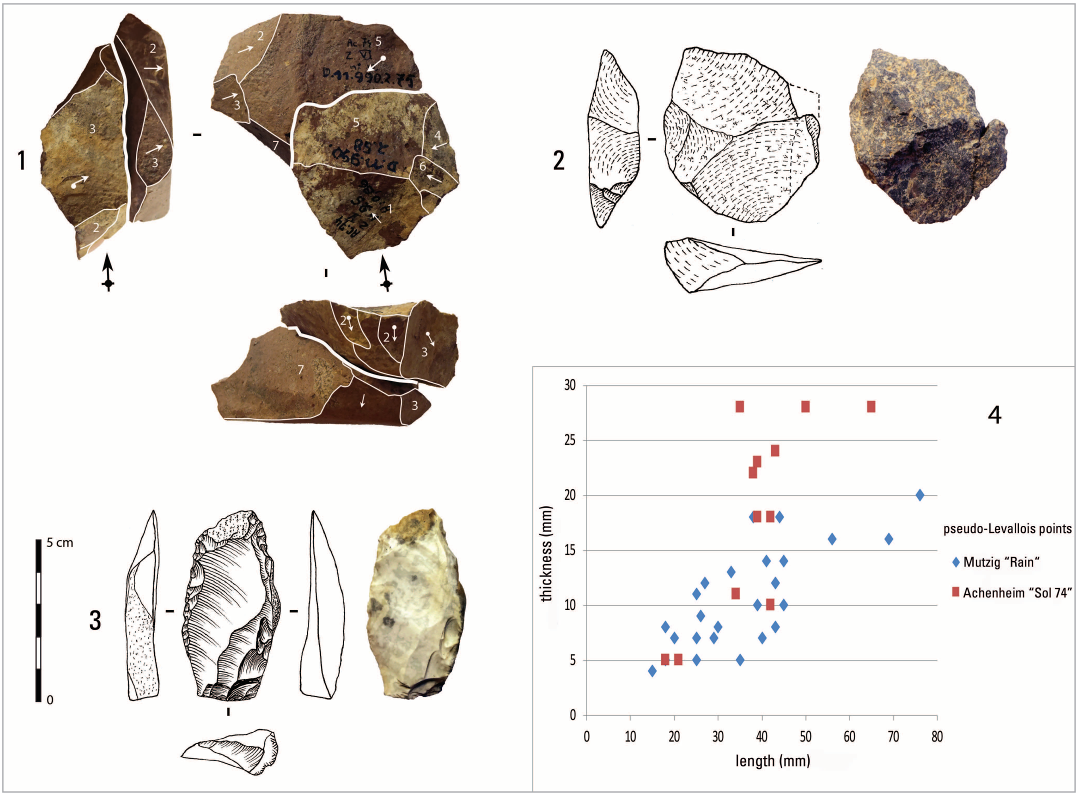


Fig. 2.
Achenheim "Sol 74."
1: Rhyolite pseudo-Levallois point refitted on a unifacial discoidal core. 2: spilite pseudo-Levallois point.
3: Flint side-scraper. 4: Comparison of the thickness/length ratio of the pseudo-Levallois points from Mutzig "Rain" and Achenheim "Sol 74."

products: relatively thick at Achenheim and finer at Mutzig (Fig. 2, 4), where, as we will see below, Levallois debitage is more dominant.

In addition to this important emphasis on discoid-type debitage, some products were produced by more rapid and less productive debitage by unipolar exploitation of a volume selected for its natural convexities. This corresponds to "C"-type debitage according to the classification developed by É. Boëda (Boëda 2013).

Only 7 retouched tools have been found. These are mainly scrapers (n = 4) (Fig. 2: 3). They are all made of flint or chalcedonies from Muschelkalk layers. In addition, there are two denticulates made of flint, and one denticulate tool with convergent edges made of quartzite, a "pointe de Tayac" according to Bordes's typology (Bordes 1961). There is no evidence for bifacial technology.

The blanks used for these tools vary quite a lot in size, morphology and technological type. While some of these tools seem to indicate the selection of quite regular elongated blanks, sometimes with the presence of prehensile parts, such as backs, we cannot determine a strict choice of these blanks.

The only clear choice for the selection of these blanks concerns the raw materials. We can underline the importance of the choice of good quality materials, especially flint and chalcedonies. These materials were used for all of the tools except for the denticulate with convergent edges, made of quartzite.

Raw material management

The retouched tools, mainly made of flint or chalcedony, clearly show that the different raw materials were not managed in the same way. The distribution of the various categories of artifacts for each raw material allows us to determine the form in which the raw materials were brought to the site and also allows us to study the segmentation of lithic production strategies (Geneste 1991; Turq et al. 2013).

Concerning flint and chalcedonies, slightly more than half are unretouched (n = 7). These are small debitage pieces whose place in the *chaîne opératoire* is somewhat uncertain (waste debris?). There is also considerable diversity of micro-facies since all flint artifacts appear to come from different blocks. No retouch flakes were identified, but in the absence of sieving it is impossible to know if tools were retouched or re-sharpened on site. Nevertheless, everything suggests that flint and chalcedonies were mainly introduced onto the site as retouched end-products. The circulation of the most technically elaborate objects, generally those made of the finest materials, is a behavior that is often observed for the Middle Paleolithic (Bourguignon et al. 2006; Conard and Adler 1996; Geneste 1991), especially on short-term occupation sites where they are interpreted as components of the "toolkits" carried by Neanderthals in anticipation of needs that might arise during their travels (Porraz 2009).

For the other materials, in order to see if the corpus could be the result of a selection of certain types of artifacts by the Neanderthals, and to determine if the knapping activities could have been performed in the excavated area, we sorted the artifacts with or without at least one functional edge (Fig. 3). We preferred this distinction rather than a distinction between waste and first-intention products because we consider that a

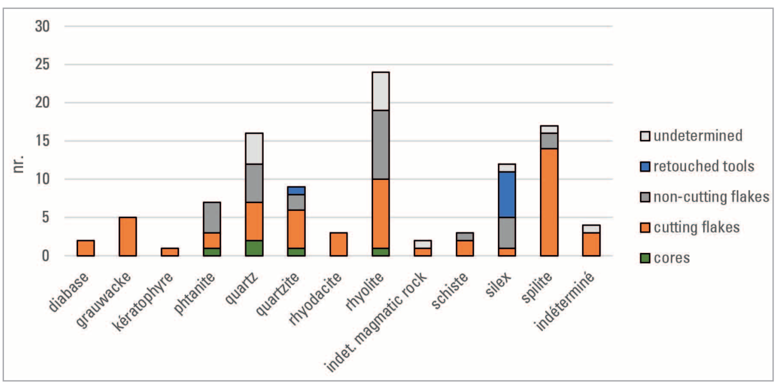


Fig. 3.
Achenheim "Sol 74." Frequency of raw materials by functional category.

waste product with a functional cutting edge may have been selected and transported for use in the same way as a first-intention product.

In the case of rhyolites and quartz, both of which are very common in the corpus, we can observe the presence of all stages of the *chaîne opératoire*: nucleus, wastes and flakes with functional edges. This demonstrates that the entire core-reduction process was performed at the site. For phtanites and quartzites, the phenomenon seems to be similar, but with a smaller number of objects.

In the case of rhyolite, sorting by petrographic microfacies even allows us to evaluate the number of different pebbles that were knapped in the excavated area. Of the 24 artifacts, 21 could be grouped into three different Raw Material Units, meaning that three pebbles of rhyolite were knapped within the excavated zone. Such sorting by micro-facies did not produce convincing results in the case of quartz, but it seems that the number of quartz pebbles exploited was also quite low.

Most of the other rocks—diabase, greywacke, keratophyre, rhyodacite, and schist—are only represented by a few flakes, which generally feature a functional edge, whereas no nucleus has been identified. Therefore, we cannot demonstrate that debitage took place on site, or at least in the excavated area. The flakes might correspond to very minor debitage activities carried out on the site, but the great diversity of the micro-facies instead suggests an input of flakes that had been knapped outside the excavated area, selected for their functional cutting edges and then brought on site to be used.

The case of spilite is quite similar, but it is a much more common raw material (16.2% of the corpus). There are no nuclei present, and almost all artifacts are probable end-products, or at least have one functional edge, such as pseudo-Levallois points (Fig. 2: 2) or other backed flakes. We do not believe that this is due to the better quality of this material, because spilite is, in fact, quite heterogeneous. Importation of flakes can, therefore, also be proposed in this case. Unfortunately, sorting by petrographic microfacies could not be carried out because this rock type tends to be poorly preserved thus preventing precise observation of the petrographic variety.

It can therefore be proposed that the corpus consists of three categories of artifacts corresponding to three different modes of management of raw materials and tools:

- Pebbles from the Bruche, and probably the Rhine, which were gathered locally to be reduced on the site. Their relatively variable quality suggests that they were gathered for an immediate need, probably for butchering activities;
- raw blanks brought onto the site - or at least to the excavated area – and produced some distance from the site, perhaps at the location where the raw material was gathered. They correspond either to a certain anticipation of needs or to an immediate need, but also reveal

a desire to minimize the weight of the materials to be transported between the knapping location and the place of use;
- tools with high technical investment and made of good quality flint, probably produced outside the settlement and carried over a greater distance. They thus respond to a higher level of anticipation of needs, corresponding to mobile toolkits carried by Neanderthals during their travels (Porraz 2009).

MUTZIG "RAIN"

Mutzig is located at the foot of the Bruche Valley, just before it opens onto the Rhine Valley. The Middle Paleolithic site was discovered in 1992 at the foot of the Felsbourg Cliff, which features several sandstone rockshelters. Excavations carried out since 2009 have focused on one of these rockshelters and have revealed at least eight *in situ* archaeological layers, all dated to the Early Weichselian Glaciation (MIS 5, ca. 90,000 BC; Koehler et al. 2016). Faunal remains are abundant, consisting mainly of reindeer and mammoth, and provide an insight into hunting strategies (Sévêque 2017). Below we will present the first results of the lithic study, with a particular focus on raw material management. For more information about the context, stratigraphy, environmental and spatial data, we refer the reader to a more general paper outlining the Middle Paleolithic occupation of Mutzig "Rain" in this volume (Koehler, this volume).

Raw material procurement

All of the archaeological layers at Mutzig "Rain" yielded lithic artifacts with a large diversity of raw materials. There are approximately 15 different types of rocks represented in the assemblage, mainly volcanic, sedimentary and metamorphic rocks from the Bruche Valley. It is roughly the same range of raw materials that we find in the assemblage from Achenheim

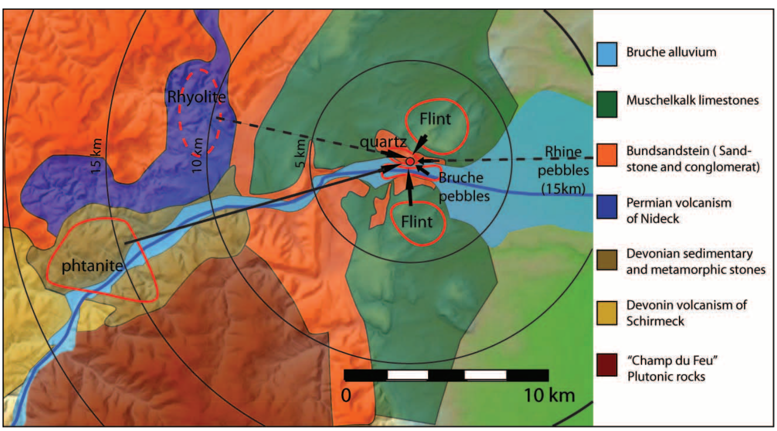
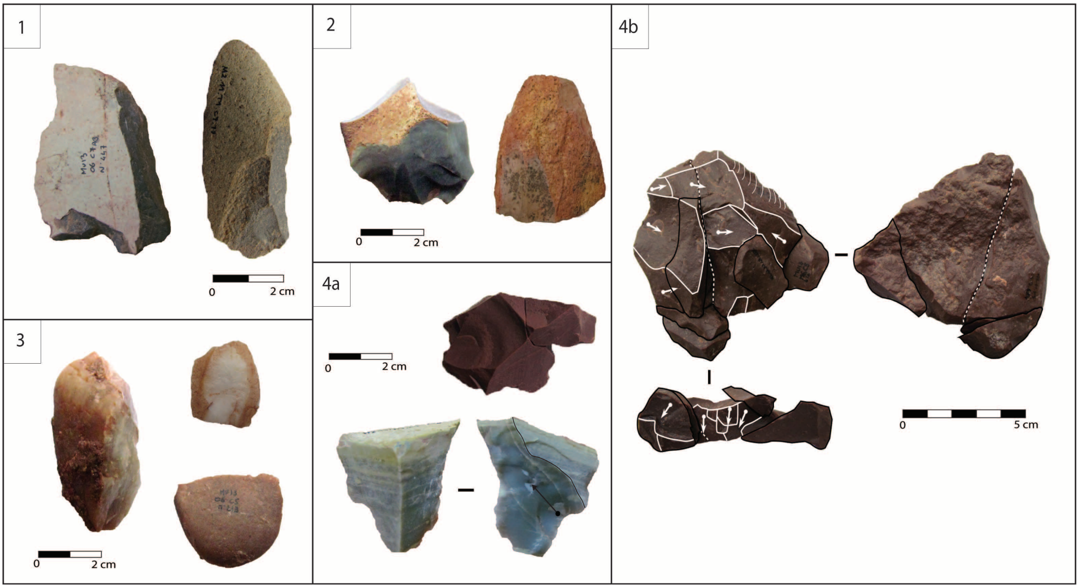


Fig. 4.
Mutzig "Rain." Location of the supply areas.



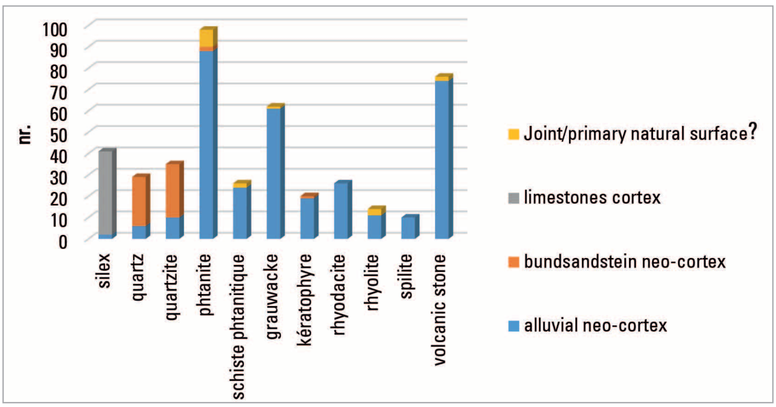


Fig. 5. above
Mutzig "Rain." Types of natural surfaces. 1: Fluviatile pebbles. 2: Limestone cortex. 3: Conglomerate pebbles. 4a: Primary natural surface (phtanite). 4b: Primary natural surface (rhyolite).

Fig. 6. left
Mutzig "Rain." Frequency of the identified natural surfaces.

"Sol 74." The study of the natural surfaces of the artifacts has allowed us to identify different supply areas (Figs. 4, 5 and 6):

- Approximately 35% of the artifacts display alluvial neo-cortex (Fig. 5: 1). It is, therefore, the most frequently occurring type of natural surface, and concerns sedimentary and metamorphic rocks such as phtanite, graywacke and schist, and volcanic rocks such as rhyolite, rhyodacite, spilite or keratophyre. The primary sources of these Devonian and Permian rocks are all located in the middle valley of the Bruche River, between 10 and 20 km away from Mutzig. They were thus collected in the Bruche alluvium. Even though we cannot identify the precise collection area, it is probably very nearby as alluvium occurs just 100 m below the site.

- The Muschelkalk flint artifacts display almost exclusively limestone cortex on their natural surfaces (Fig. 5: 2), indicating that they were collected directly from the outcrops in the sub-Vosgian Hills. Surveys have revealed similar flint nodules about 1 or 2 km from Mutzig; it is probable, therefore, that they were collected in the local area.
- Most of the quartz and quartzite pebbles are from the Bundsandstein conglomerate (Fig. 5: 3). They were collected directly on the site or nearby. However, since they are quite small and full of cracks they were rarely used, mostly for expedient flaking.
- Some artifacts made of stone from the middle valley of the Bruche display joints and natural surfaces that were not eroded by the river. However, it is often difficult to be sure that such joints were not present inside the pebbles themselves. There are just a few artifacts of phtanite (Fig. 5: 4), and probably rhyolite (Fig. 5: 5), for which we can be certain that they were collected directly from outcrops in the middle valley, about 15 km from Mutzig.

Most of the raw materials were, therefore, collected in the local area, less than 5 km away from the site. These materials were augmented by small quantities of raw material from moderate distances away, about 15-20 km (Fig. 4).

The frequencies of occurrence of the raw materials used in the different layers of the site are quite similar: there is always a lot of phtanite, graywacke, and various volcanic stones. But some differences can be observed, particularly in the case of flint, which is more frequent in Layer 7A and totally absent in Layer 7C1 (Fig. 7). Moreover, it was possible to carry out 40 refittings, which include 114 artifacts, and to identify 76 different Raw Material Units grouping between 2 and 17 artifacts (a total of 286 artifacts including the refittings).

Lithic production

A variety of flake reduction methods are observed within the assemblage, but there is most evidence for exploitation of single flat surfaces to produce thin and covering flakes. We also observe quite simple reduction with the removal of few unipolar flakes on the natural flat surfaces of the pebbles, corresponding to "type C" debitage according to Boëda's classification (Boëda 2013), or reduction methods with a higher level of predetermination corresponding to the recurrent Levallois system (Boëda 1994). This recurrent Levallois reduction was mostly executed using the centripetal method and was more often used in conjunction with good quality raw materials such as phtanite or fine-grained volcanic stones (Fig. 8: 1 and 2). This reduction system allows for better management of the morphology and thickness of the blanks, but more importantly, it results in better productivity.

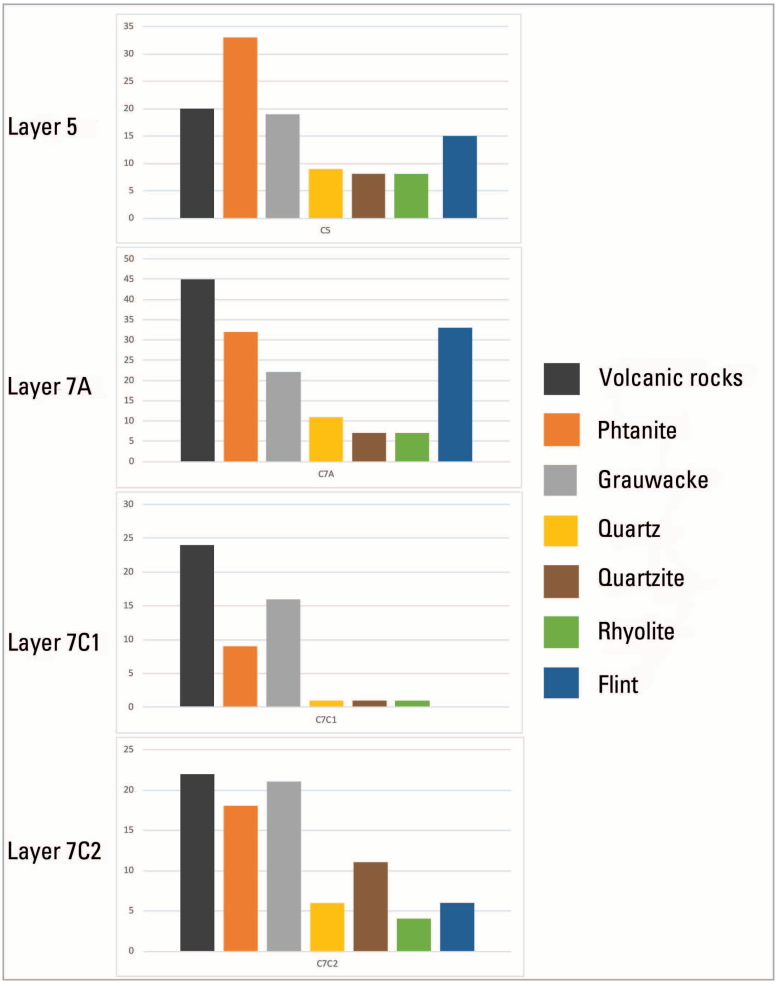
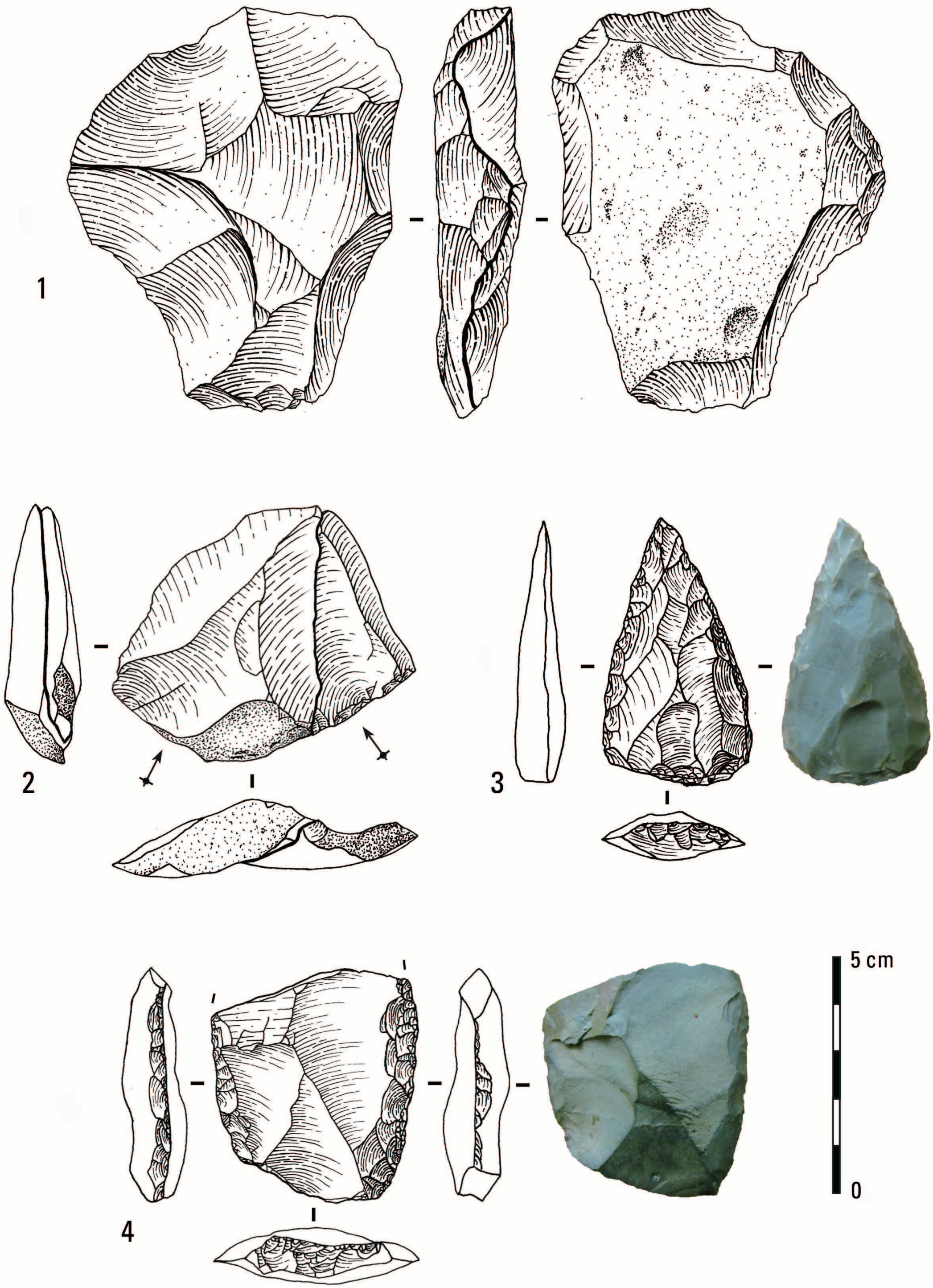


Fig. 7.
Mutzig "Rain." Frequency of the raw materials for the major archaeological layers.

More secant flaking, similar to the discoid method (Boëda 1993; Mourre 2003; Terradas 2003), also occurs in Mutzig but is quite marginal. It only occurs frequently in Layer 5, the most recent in-situ layer, thus indicating a potential cultural change. It is also more frequent for the coarser raw materials, such as graywacke.

Most of the flakes were left unmodified. Only around 5% (n=85) of the artifacts are retouched tools; these mostly take the form of sidescrapers, often slightly retouched. The most retouched tools, such as the single Mousterian point (Fig. 8: 3) or the few double scrapers (Fig. 8: 4), are generally made from highly predetermined blanks such as Levallois flakes. There are also a few notches and denticulates, often made on thicker blanks. There is no evidence for bifacial tool production.



1
2
3
4
5 cm
0

Fig. 8. left
Mutzig "Rain." 1: Levallois core (magmatic rock). 2: Refitting of a Levallois point and a pseudo-Levallois point (phtanite). 3: Mousterian point (phtanite). 4: Double scraper (phtanite).

Raw material management

We find artifacts corresponding to all of the various stages of the reduction process, apart from first flakes which are under-represented for most of the raw materials. Most of the pebbles and nodules were therefore tested, and perhaps partially prepared, at the collection zone, then they were brought to the site to be knapped to produce usable blanks. First flakes are only frequent for quartz and quartzite from the Bundsandstein Hills. These small pebbles, which were probably collected in the immediate vicinity, were therefore integrally knapped on site.

To date, 286 artifacts have been grouped into refittings or RMUs and these allow us to identify some *in situ* reduction, often represented by waste debris and by-products. But there are also isolated artifacts, especially end-product flakes and retouched tools. This is evidence for the circulation of certain kinds of artifacts; however, since the excavated areas for each layer are quite limited, we cannot determine if these artifacts reflect short-distant movements within the settlement or larger-scale circulation.

For all of the layers, the majority of retouched tools tend to be made of good quality raw material, mostly fine-grained phtanite. Notches, denticulates and sparsely retouched scrapers, however, are made from more varied raw materials.

Among the small lithic fragments collected by sieving, retouch flakes of various raw materials have been identified in each of the *in situ* layers (Fig. 9). They bear witness to the production of retouched tools directly within the excavated area. Phtanite retouch flakes are generally dominant, in accordance with the retouched tools, except in Layer 7A where flint retouch flakes largely predominate. While flint is dominant in Layer 7A, flint retouched tools are not especially frequent. Thus, we can suggest that flint blanks were retouched or re-sharpened here before being carried away from the site, or at least from the excavated area.

CONCLUSION

Analyses of the assemblages from Achenheim "Sol 74" and Mutzig "Rain" highlight differences and similarities in lithic technology and raw material management on the two sites. We have been able to characterize a certain range of variation of behavior within the Middle Paleolithic.

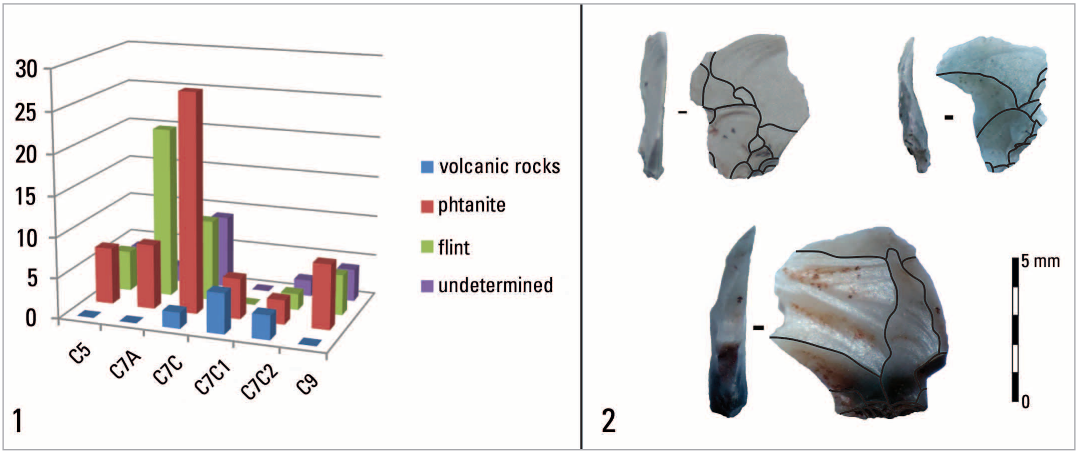


Fig. 9.
Mutzig "Rain." 1: Frequency of retouch flakes by layers and raw materials. 2: Flint retouch flakes from layer 7A.

These differences and similarities are linked to variation or stability of both anthropogenic and environmental parameters.

Most of the lithic raw materials exploited on the two sites were collected from the immediate local areas, i.e., within about 5 km of both sites. Material procurement from moderate distances of up to 20 km can be proposed in the case of Mutzig "Rain," even if we cannot precisely determine its significance. The availability of the entire range of raw materials in the local alluviums makes it difficult to ascertain whether some artifacts were imported from further afield, especially in the case of Achenheim "Sol 74"; all we can say with certainty is that the material was procured in alluviums.

But the overabundance or the lack of certain kinds of products indicates the circulation of artifacts, especially retouched tools made of flint. In Achenheim, these retouched flint tools were brought to the site as end-products. In contrast, in Mutzig Layer 7a, flint blanks appear to have been produced and retouched *in situ* and were then probably taken off site. This highlights the higher mobility of those products that were most transformed; this pattern has often been observed in Mousterian assemblages and is interpreted as reflecting the existence of mobile toolkits that were produced in anticipation of future needs and carried by Neanderthals as they moved outside the settlement (Porraz 2009).

These techno-economic behaviors allow us to propose interpretations regarding the mobility and the economic strategies of Neanderthal groups, and help us to determine the function of the sites within this system.

In the case of Achenheim, the input of end-products combined with the *in situ* debitage of a few pebbles accords quite well with the initial interpretation of the site as a short-term occupation, probably for butchering activities (Sainty and Thévenin 1978). In contrast, at Mutzig "Layer 7a" we seem to be looking at the anticipated production of retouched tools probably intended to be taken off the site, the acquisition of better quality raw materials which were probably more difficult to collect, such as small flint nodules from the surrounding hills, and greater diversity of petrographic microfacies (RMU). Taken together, this evidence could reflect a longer-term occupation with more varied activities. The existence of a base camp at Mutzig "Rain" is a possibility, given the presence of a rock-shelter, the site's dominant position overlooking the Bruche Valley, and the presence of abundant and varied raw materials. The attractiveness of the location also explains the recurrence of occupation; occupations were sometimes of shorter duration, such as, for example, Layer 7c1, as evidenced by the lithic and faunal data (Sévêque 2017).

Furthermore, it is interesting to note that while a certain differential management of the raw material can be observed, the technological differences between the assemblages do not reflect raw material differences. The same raw materials were knapped at both sites, but we can clearly see technological differences for the reduction strategies between the discoid assemblage from Achenheim "Sol 74" and the more Levallois-like assemblage from Mutzig "Rain" (apart from Layer 5). Environmental constraints and especially the differences in the quantity and quality of raw material available in the immediate vicinities of the settlements have sometimes been put forward as an explanation for such technological variability within Mousterian assemblages (Rolland and Dibble 1990; Jaubert and Farizy 1995). For our assemblages, these differences may have a chronological or cultural explanation, but this will be the focus of future research.

While our work has allowed us to characterize certain behaviors connected to raw material management, our hypotheses must be tempered by the weakness of the available data. The small number of lithic assemblages currently available in Alsace prevents us from building strong interpretations regarding chronological and functional variability within the Mousterian assemblages. This is currently a work in progress and further study is necessary, especially on intrasite spatial organization and its role in variability in the lithic remains, and on a better characterization of the differences between the layers at Mutzig "Rain."

ACKNOWLEDGMENTS

We would like to thank the Archaeological Museum of Strasbourg and in particular Bernadette Schnitzler for her welcome to us during study of the collection from Achenheim "Sol 74." The excavation and post-excavation studies of the site of Mutzig "Rain" were made possible by the participation and the collaboration of many actors and institutions such as Archéologie Alsace, the Universities of Strasbourg, Basel, Lille and Cologne, the Muséum National d'Histoire Naturelle in Paris. This study is part of a PhD thesis being undertaken at the University of Strasbourg under the direction of C. Jeunesse and the co-direction of É. Boëda (University of Paris-Nanterre) and is supported by a ministerial grant.

LITERATURE

Boëda, E. 2013. *Technologique & Technologie: Une paléohistoire des objets lithiques tranchants*. Prigonrieux: @rchéo-éditions.

Boëda, É. 1994. *Le concept Levallois: variabilité des méthodes, Monographie du CRA*. Paris: CNRS Éd.

Boëda, E. 1993. Le débitage discoïde et le débitage Levallois récurrent centripète. *Bulletin de la Société préhistorique française* 90: 392–404.

Bordes, F. 1961. *Typologie du Paléolithique ancien et moyen*. Bordeaux: Impr. Delmas.

Bourguignon, L., A. Delagnes, and L. Meignen. 2006. Systèmes de production lithique, gestion des outillages et territoires au Paléolithique moyen: Où se trouve la complexité. In *Normes techniques et pratiques sociales. De la simplicité des outillages pré-et protohistoriques, actes des Rencontres, 20-22 octobre 2005 / XXVIe Rencontres internationales d'archéologie et d'histoire d'Antibes*. ed. by L. Astruc, F. Bon, V. Léa, P.-Y. Milcent, and S. Philibert, pp. 75–86. Antibes: ed. APDCA.

Buraczynski, J., and J. Butrym. 1984. La datation des loess du profil d'Achenheim (Alsace) à l'aide de la méthode de thermoluminescence. *Bulletin de l'Association Française Pour L'étude du Quaternaire* 21: 201–9.

Byrne, N., and F. Prat. 1978. Grands mammifères des loess d'Achenheim, loess gris verdâtre (couche F), sol 74 (couche B), cervidae, bovidae, elephantidae, equidae. *Recherches Géographiques À Strasbourg* 7: 97–114.

Conard, N. J., and D. S. Adler. 1997. Lithic Reduction and Hominid Behavior in the Middle Paleolithic of the Rhineland. *Journal of Anthropological Research* 53: 147–75.

1996. Wallertheim Horizon D: An Example of High Resolution Archaeology in the Middle Paleolithic. *Quaternaria Nova* 6: 109–125.

Faudel, F., and G. Bleicher. 1888. *Matériaux pour une étude préhistorique de l'Alsace*. Colmar: Imprimerie et lithographie de veuve Camille Decker.

Geneste, J.-M. 1991. Systèmes techniques de production lithique. Variations techno-économiques dans les processus de réalisation des outillages paléolithiques. *Techniques & Cultures* 17-18: 1–35.

Guerin, C. 1978. Les nouveaux restes de rhinoceros (Mammalia, Perissodactyla) recueillis dans la formation pleistocene d'Achenheim (Bas-Rhin). *Recherches géographiques à Strasbourg* 7: 115–23.

Heim, J., J.-P. Lautridou, J. Maucorps, J.-J. Puisségur, J. Sommé, and A. Thévenin. 1982. Achenheim: Une séquence-type des loess du Pléistocène moyen et supérieur. *Bulletin de l'Association française pour l'étude du quaternaire* 19: 147–159.

Jaubert, J., and C. Farizy. 1995. Levallois Debitage: Exclusivity, Absence or Coexistence with Other Operative Schemes (Garonnes Basin, SW France). In *The Definition and Interpretation of Levallois Technology*, ed. by H. L. Dibble and O. Bar-Yosef, pp. 227–248. Monographs in World Archaeology. Prehistory Press.

Junkmanns, J. 1995. Les ensembles lithiques d'Achenheim d'après la collection de Paul Wernert. *Bulletin de la Société préhistorique française* 92: 26–36.

Koehler, H., F. Wegmüller, J. Detrey, S. Diemer, T. Hauck, C. Pümpin, P. Rentzel, N. Sévêque, E. Stoetzel, P. Wuscher, P. Auguste, H. Bocherens, M. Lutz, and F. Preusser. 2016. Fouilles de plusieurs occupations du Paléolithique moyen à mutzig-Rain (Alsace). Premiers résultats. *Bulletin de la Société préhistorique française* 113: 429–474.

Koehler, H., F. Wegmüller, B. Audiard, P. Auguste, J.-J. Bahain, H. Bochens, S. Diemer, F. Preusser, C. Pümpin, N. Sévêque, E. Stoetzel, O. Tombret, and P. Wuscher. 2021 The Middle Palaeolithic Occupations of Mutzig-Rain (Alsace, France). This volume. Tübingen: Kerns Verlag.

Lautridou, J.-P., J. Sommé, J. Heim, J.-J. Puisségur, and D.-D. Rousseau. 1985. La stratigraphie des loess et formations fluviatiles d'Achenheim (Alsace): nouvelles données bioclimatiques et corrélations avec les séquences pléistocènes de la France du Nord-Ouest. *Bulletin de l'Association française pour l'étude du quaternaire* 22: 125–132.

Mourre, V. 2003. Discoïde ou pas discoïde? Réflexions sur la pertinence des critères techniques définissant le débitage discoïde. *BAR International Series* 1120: 1–18.

Porraz, G. 2009. Middle Palaeolithic Mobile Toolkits in Short-Term Human Occupations. Pié Lombard Rockshelter (Provence, France) and Broion Cave (Venetia, Italy): Two Case Studies. *Eurasian Prehistory* 6: 33–55.

Rebmann, T. 2007. Caractérisations pétroarchéologiques, provenances et aires de circulations des industries moustériennes différentes du silex en Région du Rhin Supérieur, entre la Moselle et le Jura: stations de Mutzig et Nideck (Alsace, France), de Lellig (Luxembourg). Ph. D. diss., University of Strasbourg.

Roebroeks, W. 1988. *From Find Scatters to Early Hominid Behaviour. A Study of Middle Palaeolithic Riverside Settlements at Maastricht-Belvédère (The Netherlands)*. Analecta Praehistorica Leidensia 21. Leiden: Leiden University Press.

Rolland, N., and H. L. Dibble. 1990. New Aspects of Middle Palaeolithic Variability in Western Europe. *Nature* 266: 251–252.

Sainty, J. 1992. *Mutzig (Bas-Rhin). Sauvetage urgent 1992 (Rapport de fouille).* Service régional de l'archéologie d'Alsace.

Sainty, J., and A. Thévenin. 1978. Le sol 74. *Recherches géographiques à Strasbourg* 7: 99–112.

Schumacher, E. 1907. Achenheim als paläolithische Station. *Vogesen* 14: 181–83.

Sévêque, N. 2017. Variabilité des comportements alimentaires au Paléolithique moyen en France septentrionale - Apports des études archéozoologiques. Ph. D. diss., University of Lille 3.

Sommé, J., J.-P. Lautridou, J. Heim, J. Maucorps, J.-J. Puisségur, D.-D. Rousseau, A. Thévenin, and B. V. Vliet-Lanoë. 1986. Le cycle climatique du Pléistocene supérieur dans les loess d'Alsace à Achenheim. *Bulletin de l'Association française pour l'étude du quaternaire* 23: 97–104.

Terradas, X. 2003. Discoid Flaking Method: Conception and Technological Variability. *BAR International Series* 1120: 19–32.

Thévenin, A. 1976. Alsace. *Gallia Préhistoire* 19: 479–502.

Turq, A., W. Roebroeks, L. Bourguignon, and J.-P. Faivre. 2013. The Fragmented Character of Middle Palaeolithic Stone Tool Technology. *Journal of Human Evolution* 65: 641–655.

Wernert, P. 1957. *Stratigraphie Paléontologique et préhistorique des sédiments quaternaires d'Alsace: Achenheim*. Mémoires du Service de la carte géologique d'Alsace et de Lorraine 14.