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Raw material economy and mobility in the Rhenish Allerød

Rohmaterialökonomie und Mobilität im rheinischen Allerød

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Abstract - Hunter-gatherer mobility in the Allerød has long been suspected to be fundamentally different from preceding and following periods due to the development of forested vegetation following the Allerød warming. Now, new primary data from a recently excavated, well-preserved Federmesser site in Wesseling can contribute to this question. An in depth analysis of the raw material use and spatial organisation of Wesseling including operational chain reconstruction, refittings, least cost analysis and statistical evaluation in comparison with other Federmesser assemblages can shed light on the mobility patterns of the Rhenish Allerød hunters. The results indicate a residential mobility pattern focused on an embedded procurement of the closest sources of raw material in a radius of roughly 100 km around the sites. In the case of Wesseling the potential route of raw material acquisition could be reconstructed to have led from the end-moraines at Krefeld, over Aachen and Bonn-Muffendorf to Wesseling. The comparison of contemporary Rhenish inventories furthermore hints at the presence of different regional systems oriented along the major drainages and topographic features as of yet insufficiently understood.

Zusammenfassung - *Die Mobilität allerød-zeitlicher Jäger und Sammler wird seit längerem in der Literatur als grundsätzlich unterschiedlich von den vorherigen und folgenden Perioden eingeschätzt. Die allerød-zeitliche Wiederbewaldung wird als hauptverantwortlicher Faktor für eine opportunistische Ressourcenausbeutung und eine geringere Gruppengröße der federmesserzeitlichen Jäger und Sammler genannt. Nun können neue Primärdaten aus dem kürzlich untersuchten, gut erhaltenen Federmesserfundplatz Wesseling dieses Bild unterstützen und präzisieren. Eine detaillierte Untersuchung der Mengen und Gewichtsprozentanteile, der erhaltenen Operationskettenstadien der verschiedenen Rohmaterialien, sowie der Gerätenutzung in Wesseling erbringen klare Anzeichen für eine Rekonstruktion der Wanderroute von den Endmoränen in Krefeld, über Aachen und Bonn-Muffendorf nach Wesseling. Weiterhin zeigt die Auswertung der Flächenorganisation des Fundplatzes klare, funktional getrennte Aktivitätszonen mit unterschiedlicher Rohmaterialkomposition auf, welche das Bild der Besiedlungsereignisse an diesem Fundplatz präzisieren. Im fundstellenübergreifenden Vergleich ist eine klare Nord-Süd Dependenz der genutzten Rohmaterialien statistisch nachweisbar, welche das vermutete Bild der eingebetteten Rohmaterialbeschaffung unterstützt und das Einzugsgebiet der Fundplätze auf einen etwa 100 km Radius beschränkt. Weiterhin zeigt der Datensatz Hinweise auf bisher unzureichend verstandene, regionale Untersysteme, welche sich an den primären Entwässerungssystemen sowie an den wichtigsten topografischen Einheiten im Untersuchungsgebiet orientieren.*

Keywords - **Late Palaeolithic, Final Palaeolithic, spatial organisation, constrained correspondence analysis, operational chain sequences, least cost analysis**
Spätpaläolithikum, Endpaläolithikum, Flächenorganisation, Kanonische Korrespondenzanalyse, Operationsketten

Introduction

Repeated rapid and strong climatic changes at the end of the Pleistocene change the living conditions of hunter-gatherer communities radically. Especially the Allerød period, dated between 11'900 and 10'800 calBC caused a climatic amelioration leading to vegetal expansion and reforestation, forming the greatest environmental shift before the onset of the Holocene. This sudden change in environmental productivity and land cover forces rapid human adaptation of resource exploitation and mobility. Such adaptational reactions are best understood through provenance studies and on site-spatial plotting of the used lithic raw materials. However, well-dated and well-preserved late Pleistocene sites are rare in the Rhineland due to low sedimentation rates and strong modern overprint. One exception is the Federmesser site of Wesseling for which the primary results of the raw material analysis shall be presented here. Subsequently, it will be compared to additional well-preserved assemblages with the aim to understand the development of mobility in connection to climatic fluctuations.

*corresponding author

The site of Wesseling

The site lies on the left side of the Rhine between Cologne and Bonn in the Western part of Germany at the outskirts of a small industrial town called Wesseling (Fig. 1). It yielded very well-preserved remains of a Federmesser or Azilian occupation with different activity zones including gravel pavements, brown coal art objects and several grinding slabs as well as haematite pigments (Heinen 2014, 2016). ^{14}C dates place it in the middle of the late glacial GI-1c1 (Heinen 2016: fig. 21). The site lies at the slip-off slope of an abandoned meander left by the braided river course of the Pleistocene Rhine. It is currently unclear if and to what extend the meander was connected to the Rhine system during the time of occupation in Wesseling, although it has certainly been water bearing as the site was repeatedly flooded and is embedded in alluvial loams (Fig. 2). The horizontal and vertical find distribution suggests little geo- or bioturbatic influence on the material. The preservation of the site is affected by constructions from the time of the Second World War leading to spatially well-definable areas without preserved Pleistocene remains (Fig. 3). In total 1'100 m^2 were excavated of which 700 m^2 preserved undisturbed material.

Activity zones

The site preserves twelve distinct activity zones (Fig. 3) of which eight contain the processing of lithic raw materials partially in spatial correlation to a hearth feature. Two include a gravel pavement in combination with a hearth feature and three additional artefact concentrations contain one singular hearth, one gravel pavement without associated finds and another under which fragmented faunal remains could be uncovered. Structurally, the southernmost concentration (activity zone III) is the largest and most diverse recovered on site and thus likely represents the major focus of settlement activities. Most of the other artefact concentrations represent short-term and specialised activities, often connected to hafting and retooling. Multiple refits and the representation of debitage from a single nodule in different activity zones suggest total contemporaneity of the recovered artefact concentrations. Apart from the, so far, singular gravel pavements, Wesseling yields an additional unique feature, which is the processing and geometric shaping of brown coal. These small shaped pieces of brown coal and their associated production debris were found in spatially distinct areas (Fig. 7) in the western part of the occupation and may be connected to personal adornment and art.

Fig. 1. Location of Wesseling.
Abb. 1. *Lage von Wesseling.*

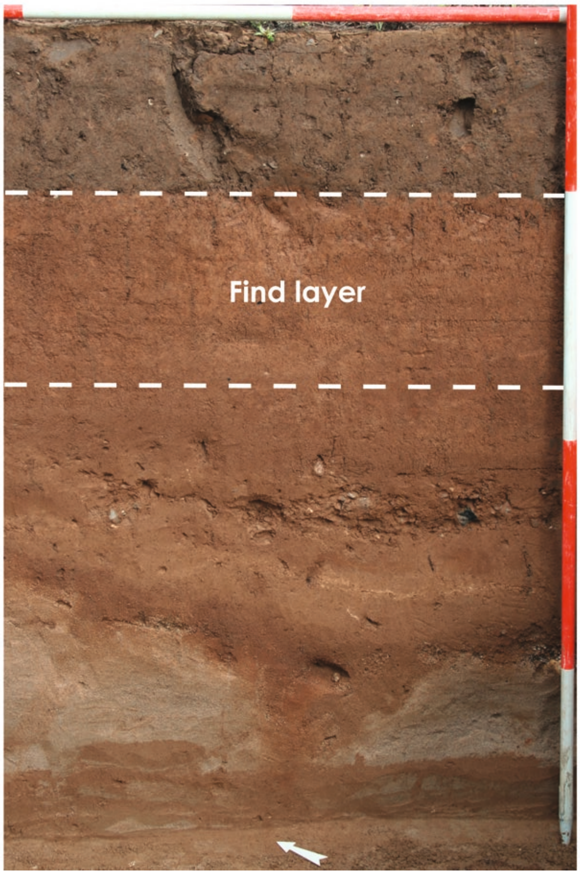

Fig. 2. Stratigraphy.
Abb. 2. *Stratigrafie.*

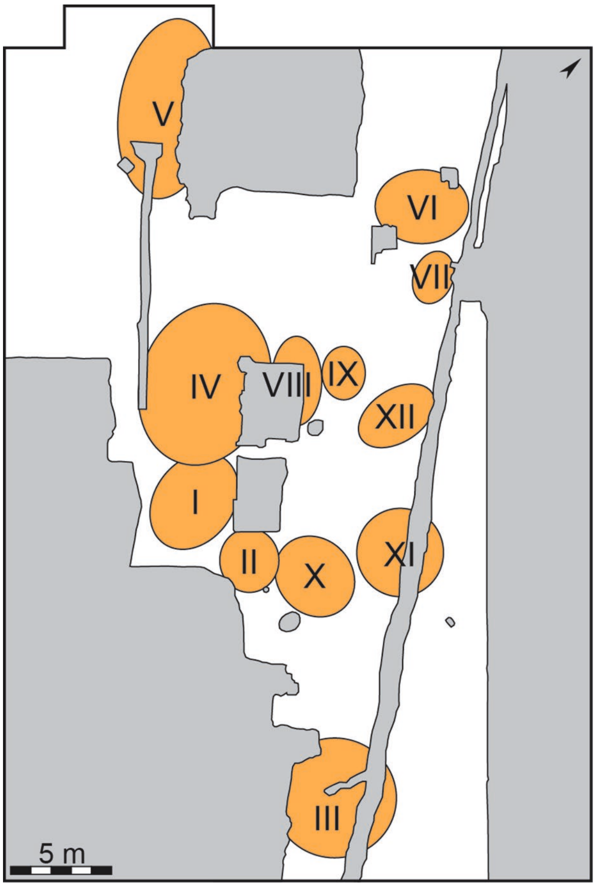

Fig. 3. Site map with disturbances and find concentrations.
Abb. 3. *Fundstellenplan mit Störungen und Aktivitätszonen.*

Raw material use in Wesseling

Lithic material

Four different types of lithic raw material were processed in Wesseling (Figs. 4 & 5). Flints from at least six different sources around Wesseling yield the majority of processed raw material (Fig. 6) and make up 56 % of the total number of artefacts. Tertiary quartzite yielded 31 % of the total find numbers, chalcedony 11 % and lydite less than 1 %. For nearly the complete inventory (97 %) the raw material could be identified on differing levels of accuracy, while only 2 % of the material remain indeterminable and another 1 % consist of clearly singular pieces which might have been brought to the site as part of a personal toolkit.

Flint

A total of 1'594 lithics are made out of different types of flint (56 %), most of them can be assigned to different sources (n=1'530, 96 %) and even to single nodules or raw material entities (RME) (n=1'237, 78 %). 24 flint nodules could be identified in Wesseling, which have been brought to the site from different sources.

- Vetschau/Orsbach flint
  At least four different nodules of Vetschau or Orsbach flint were processed on site. This blackish, shiny, but cavernous material was used intensively in Wesseling, 520 lithics could be determined to belong to it (18 %). It has certainly been acquired from a primary source as the cortex is well-preserved, thick and chalky and, furthermore, this material does not occur in secondary context. A high number of large cortical caverns developed in the flint nodules, in addition to a great general homogeneity, makes it difficult to sort this raw material into single nodules. Therefore, only four clearly differentiable nodules could be determined, which is very likely a minimal number. Vetschau or Orsbach flint can be found around the modern city of Aachen in Western Germany. Currently two outcrops of the flint-carrying Orsbach limestones are known, the Vetschauer Berg close to Laurensberg, directly on the border between Germany and the Netherlands, and the Schneeberg in Vaals on the other side of the border. Possibly further sources were known or accessible in the late Palaeolithic.

Fig. 4. Wesseling raw materials.
Abb. 4. *Rohmaterialien Wesseling.*

- Lousberg flint
  Another primary source from Aachen could be identified for the first time in Federmesser lithic material, the greyish or brownish, sometimes even greenish, flints from the Lousberg. This source is well-known for Neolithic flint mining (Schyle 2010), and was so far thought to have been unknown in the Federmesser timeframe. Only a small share of material from the Lousberg has been processed in Wesseling, two nodules yielding only 81 individual lithics (3 %) could be found.

- Secondary Meuse flint
  A large share of flint belongs to Meuse flints acquired from river gravels. This material is very heterogeneous and generally of inferior quality. Colours can range from yellowish, over brownish and greenish to greyish sometimes including reddish iron stains. Characteristic are white roundish inclusions and an abraded fluvial cortex. Due to its deposition in the river gravels most of the nodules show fissures or abrasions which frequently lead to knapping accidents. None withstanding its problematic knapping properties 18 % of the flint material is made from this raw material (n=512). Due to its heterogeneous appearance the identification of single nodules is very easy, leading to the confirmation that 8 different nodules were processed in Wesseling. Only 4 individual lithics could not be assigned to one of the known nodules. The easy

Raw material		n	%	weight in g	%
I total	Flint total	1'594	*55.8*	1'886	*47.1*
I	Flint indet	64	*2.2*	7	*0.2*
Ia total	Vetschau/ Orsbach	520	*18.2*	525	*13.1*
Ia	Ia indet	127	*4.4*	118	*2.9*
Ia1		378	*13.2*	290	*7.2*
Ia2		6	*0.2*	15	*0.4*
Ia3		7	*0.2*	62	*1.5*
Ia4		2	*0.1*	40	*1.0*
Ib total	Lousberg	81	*2.8*	157	*3.9*
Ib1		80	*2.8*	137	*3.4*
Ib2		1	*0.0*	20	*0.5*
Ic total	Secondary Meuse flint	512	*17.9*	704	*17.6*
Ic indet		4	*0.1*	3	*0.1*
Ic1		114	*4.0*	93	*2.3*
Ic2		117	*4.1*	108	*2.7*
Ic3		33	*1.2*	76	*1.9*
Ic4		100	*3.5*	225	*5.6*
Ic5		117	*4.1*	116	*2.9*
Ic6		5	*0.2*	46	*1.1*
Ic7		19	*0.7*	21	*0.5*
Ic8		3	*0.1*	16	*0.4*
Id total	Tertiary Meuse flint	242	*8.5*	324	*8.1*
Id indet		134	*4.7*	92	*2.3*
Id1		22	*0.8*	5	*0.1*
Id2		23	*0.8*	23	*0.6*
Id3		17	*0.6*	6	*0.1*
Id4		27	*0.9*	77	*1.9*
Id5		5	*0.2*	40	*1.0*
Id6		6	*0.2*	4	*0.1*
Id7		2	*0.1*	15	*0.4*
Id8		6	*0.2*	62	*1.5*
Ie total	Residual flint	146	*5.1*	97	*2.4*
Ie1		141	*4.9*	62	*1.5*
Ie2		5	*0.2*	35	*0.9*
If	Baltic flint	1	*0.0*	14	*0.3*
S	Singular	28	*1.0*	58	*1.4*
II	Tertiary Quartzite	885	*31.0*	926.5	*23.1*
III total	Chalcedony	313	*11.0*	1'147.21	*28.7*
III		311	*10.9*	1'141.21	*28.5*
IIIa		2	*0.1*	6	*0.1*
IV	Lydite	1	*0.0*	1	*0.0*
X indet	indetermi-nable	63	*2.2*	43	*1.1*
Total		**2'856**	***100***	**4'003.71**	***100***

Fig. 5. Raw material numbers and weights.

Abb. 5. *Rohmaterialanzahlen und Gewichte.*

differentiation and good preservation of this raw material makes it the ideal subject for further studies regarding raw material use.

- Tertiary Meuse flint
  A smaller share, only 9 % (n=242), of lithics was made out of a material known in Germany under the term of *Maasei*. Those lithic nodules originate from the Meuse limestones and share characteristic inclusions and colour variations with the secondary and primary Meuse flints. Their depositional context is however clearly different, as they have been eroded and abraded in the tertiary seashore and are distributed widely in north-western Germany, the Netherlands and Belgium. Those small, usually less than fist-sized, roundish flint nodules are characterised by a very heavily abraded and scarred exterior surface, which bears no trace of former cortex but is exclusively made of abraded flint material. Due to this strong geological influence, the flint body of the nodules is heavily fissured and many of those fissures are iron stained. In terms of knapping quality, it is certainly the most difficult material used in Wesseling. Again its heterogeneity makes the differentiation of single nodules very easy and a further 8 nodules could be identified.

- Residual flints
  At least two nodules of residual Meuse flints have been used. Their origin is not clearly inferable, one nodule resembles Simpelveld flint, the other one is blackish and of unknown origin. Characteristic is their weathered, thin residual cortex clearly indicating their depositional context. 146 individual pieces could be identified to belong to this material (5 %).

- Baltic flint
  Only one lithic, a core, of Baltic flint was found at Wesseling. It is of blue-greyish colour and shows characteristic inclusions. No associated production debris could be found, therefore it is concluded that the prepared core was brought to Wesseling and discarded here without further use.

Tertiary Quartzite

Tertiary Quartzite has the highest numerical share of finds in Wesseling. 885 artefacts are made from it, a share of 31 % of all finds. This characteristic fine-grained, greyish quartzite with yellow dots and easily visible glittering quartz grains is very homogeneous, sturdy and of excellent knapping quality. No clear cortical elements are preserved, a few individual pieces show an iron stained, weathered but unabraded outer surface. Certain colour variations are present in the material, but they are not sufficiently developed to help identifying single nodules or facilitate refitting.

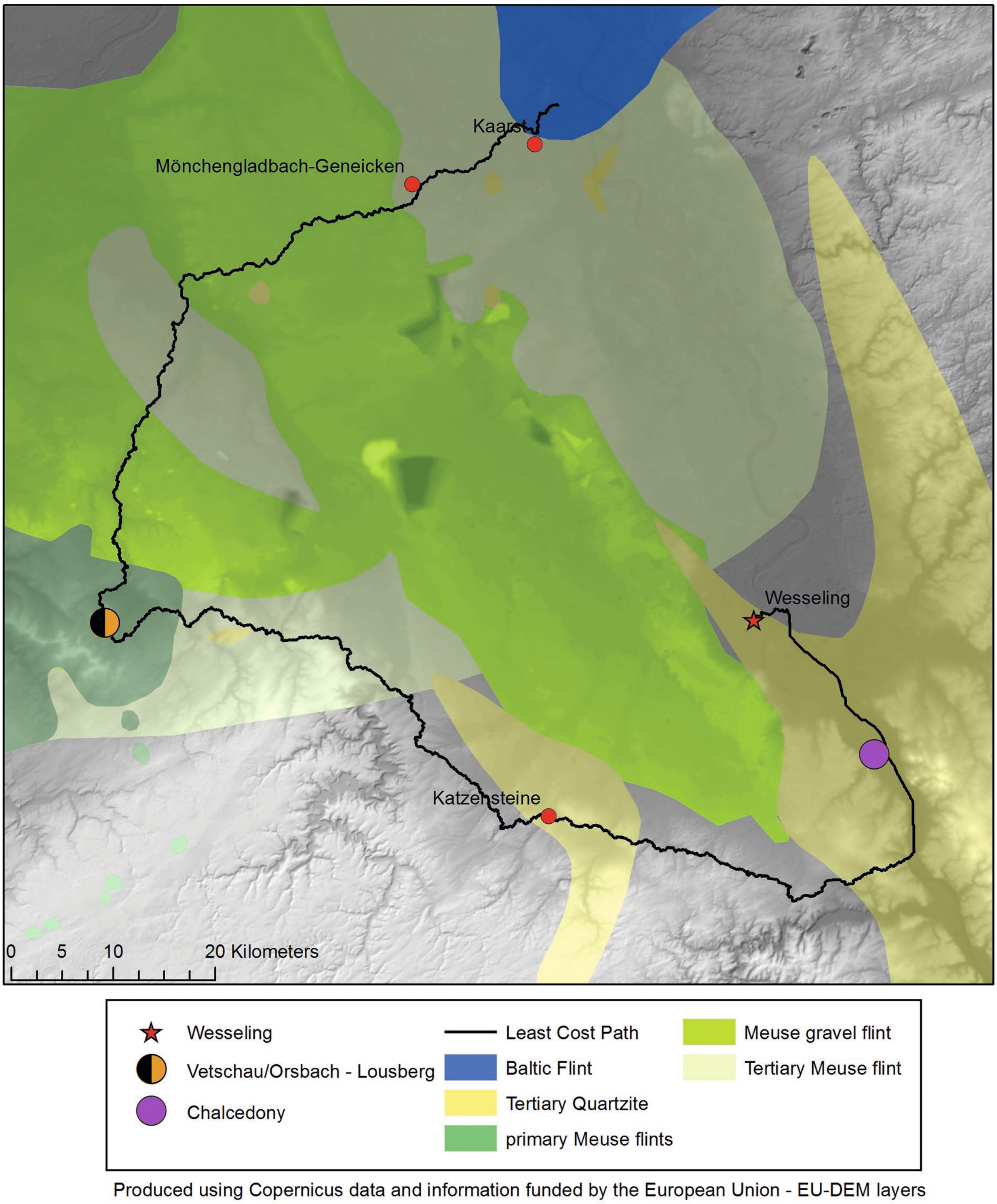

Fig. 6. Raw material sources around Wesseling including the least cost expensive route.

Abb. 6. *Rohmaterialquellen in der Umgebung von Wesseling inklusive der kostenoptimalen Route.*

Therefore, it is currently impossible to estimate the number of nodules brought to and processed at the site. Eight cores are preserved in the material, but likely several more have been exported from the site.

Chalcedony

A numerically relatively small share of only 11 % (n=313) is made out of Chalcedony. The source of this highly variable material with characteristic gastropod inclusions can be located in Bonn-Muffendorf. It is of varying flaking quality and ranges in appearance from translucent, homogeneous and fine-grained to opaque and coarse. Many of the chalcedony artefacts were patinated complicating the designation of single nodules. Refits were partially able to solve this issue, although the number of nodules brought to the site remains similarly unreconstructable as for the tertiary quartzite. At least five cores were processed in

Wesseling in addition to an unused manuport of very poor flaking quality.

Lydite

Only one artefact, a backed point, is made of a shiny black opaque lydite. This raw material is fine-grained, hard and of good quality. It can be found in the Rhine gravels on site as well as up- and downstream from the site including the tributaries. Therefore, the lydite backed point and the Baltic flint core are the only two artefacts of singular raw material which could be identified securely.

Origins

The raw materials used in Wesseling (Fig. 6) come from distances of up to 65 km in a straight line. The closest sources to the site are the Rhine gravels at the site itself and in the direct vicinity, which yield lydite and potentially tertiary quartzite. The tertiary quartzite can be found upstream from Wesseling in a large area and is the primary used material in the well-known contemporary sites in the Neuwied basin. For neither raw material, a definite source can be given and their spatial distribution includes the area of Wesseling. The closest external source is the chalcedony source of Bonn-Muffendorf. It is a spatially restricted area in the highlands outside the, here relatively narrow, Rhine valley, currently in mixed silvicultural and agricultural use. In straight line Bonn-Muffendorf lies about 20 km south of Wesseling. Tertiary Quartzite and Muffendorf Chalcedony are the only two raw materials that have reached Wesseling from the south. To the west and north-west, primary, secondary and tertiary Meuse flints can be found as well as Baltic flint to the north. The sources of the primary Meuse flints, Vetschau/Orsbach and Lousberg, are easily identified at the direct vicinity of Aachen, a distance of 63 km in straight line from Wesseling. Those sources are well-known, intensively surveyed and can be identified with great certainty. The secondary Meuse flints reworked in the river gravels have naturally a wider distribution, correlate with the distribution of the Meuse gravel terraces and were accessible at their Late Pleistocene outcrops. Currently the closest occurrence is in the Jülich Börde, about 45 km north-west of Wesseling. Tertiary Meuse flints, or Meuse eggs, can be found in a wide area north and west of Wesseling. Until today, they are easily found on fields, waysides or river terraces of the whole region. The last raw material with a clearly identifiable origin is the Baltic flint. While having a large area of distribution in Northern Germany its southernmost occurrence is around the end moraine at Krefeld, a distance of about 65 km.

Nodules and refits

As already mentioned, all activity zones could be connected through refits or material from the same nodule represented in different activity zones (Fig. 7). Especially tertiary Meuse and Meuse gravel flints were well-suited for refitting due to their diverse nodules in contrast to tertiary quartzite and Vetschau flint, where no complete sequences could be reconstructed. One Meuse gravel nodule (Ic4) could nearly completely be reconstructed and forms its own activity zone. One further interesting refit is one Chalcedony core, which's debitage is spread over three different activity zones before the core has been discarded outside of the concentrations. Overall, however, the ratio of refits is with only 7 % relatively low (Fig. 8). The well-differentiable raw materials from the Lousberg, the Meuse gravels and the tertiary Meuse eggs reach refitting ratios of about 6 - 17 %, the Chalcedony 15 %, while Vetschau and tertiary quartzite remain below 5 %.

Operational chains and the sequencing of events

The reconstruction of the operational chain stages (Fig. 9) of the different raw materials can yield information about transport distance, reduction intensity and the sequencing of events. Vetschau flint and tertiary quartzite are, however, inappropriate for an evaluation as the cortical caverns in the former and the lack of a cortex development in the latter skews comparisons with the other raw materials. Comparing the other raw materials, certain conclusions are immediately apparent: The chalcedony shows a high percentage of stage I debitage, the only material, where stage I outnumbers stage II. This picture would indicate a relatively recent acquisition of the chalcedony nodules, not surprising for material from the closest source. Singular and indeterminable pieces have the highest shares of tools. For both the initial stages of the operational chain are weakly represented suggesting an acquisition event relatively far back in time, as is certainly even more the case for the one singular Baltic flint core. Residual flint, Meuse gravel and tertiary Meuse flints show a relatively balanced distribution, where tertiary Meuse shows higher amounts of stage I than Meuse gravel flint, as the nodules are smaller. For all three no indication points to a specifically recent or early acquisition of the material. The low share of stage V in the Lousberg material, only composed of one backed point, is noticeable, especially in combination with the high shares of reduction and the low shares of decortification. Maybe its reduction was a very inferior side aspect at the site or major shares of the material are lost skewing the picture. Therefore, the representation of the stages of the operational chain would suggest an early acquisition of Baltic flint and the singular pieces, while later on tertiary Meuse and Meuse gravel material was collected. Most likely, this is followed by the primary Meuse material and the residual flint from Aachen and terminated by tertiary quartzite and Chalcedony.

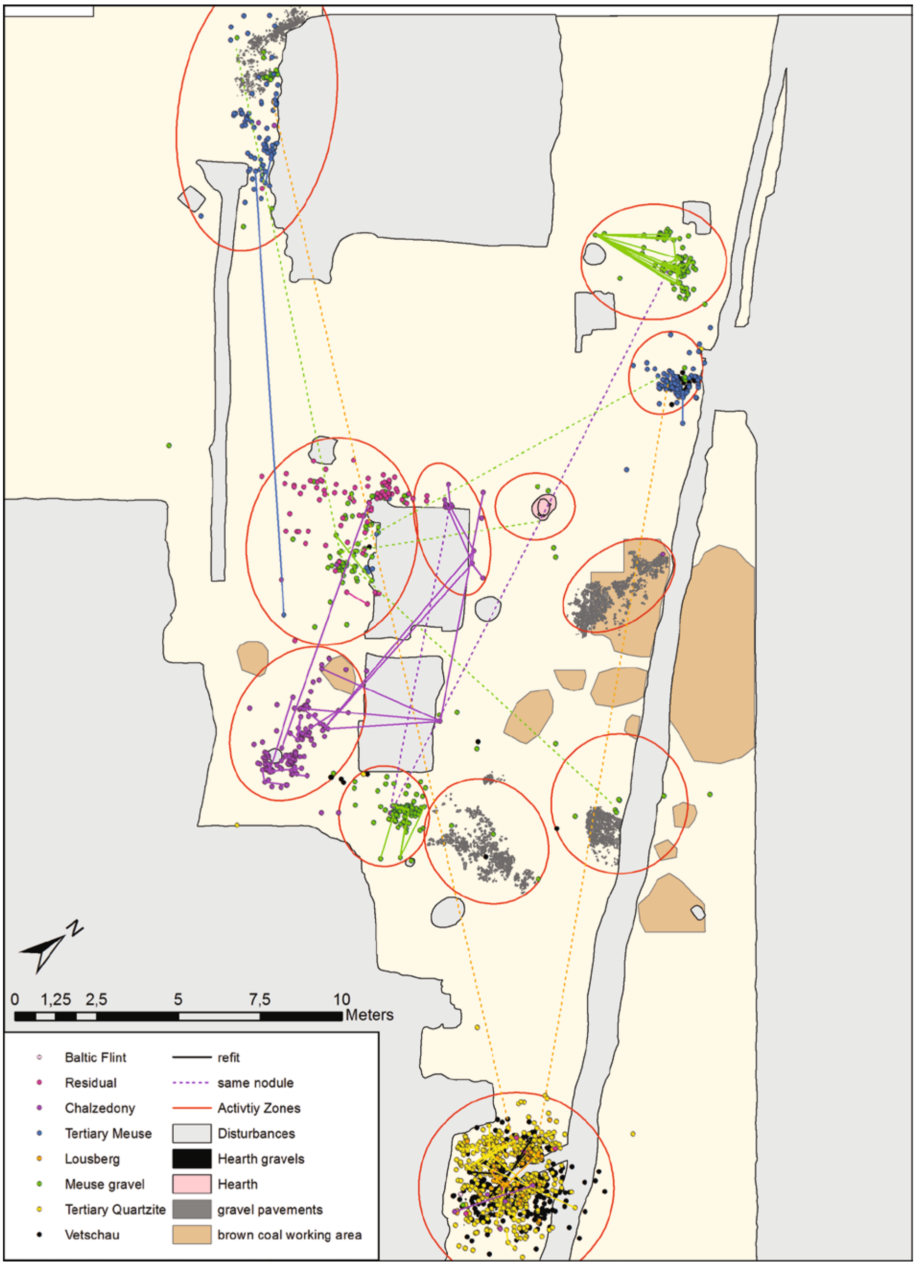

Fig. 7. Wesseling. Spatial raw material distribution and refittings.

Abb. 7. *Wesseling. Flächenverteilung der Rohmaterialien und Zusammenpassungen.*

	refits	n (total)	%
Vetschau/Orsbach	12	520	*2.3*
Lousberg	14	81	*17.3*
Meuse gravel	70	512	*13.7*
Tertiary Meuse	15	242	*6.2*
Residual	3	146	*2.1*
Tertiary Quartzite	39	885	*4.4*
Chalcedony	46	313	*14.7*
Total	**199**	**2'856**	***7.0***

Fig. 8. Wesseling. Refitting ratios.

Abb. 8. *Wesseling. Rate der Zusammenpassungen.*

Tool use

In total the Wesseling inventory contains 6 % tools (Fig. 10), overall 173 specimens including 23 backed points (13.3 %), 20 backed elements (11.6 %), 30 end scrapers (17.3 %), 23 burins (13.3 %), 4 borers (2.3 %), 18 lateral retouches (10.4 %), 6 truncations (3.5 %) 3 notched pieces (1.7 %) and 46 pieces with macroscopically visible use wear (26.6 %). In addition, tool production waste is represented by 4 microburin Krukowski and 49 burin spalls.

Differentiating this tool inventory according to raw material yields clear sings for a differential treatment of the different raw materials. Baltic flint is the only raw materials without tools. The majority of tools are made out of Tertiary Quartzite (24 %), Vetschau flint (24 %),

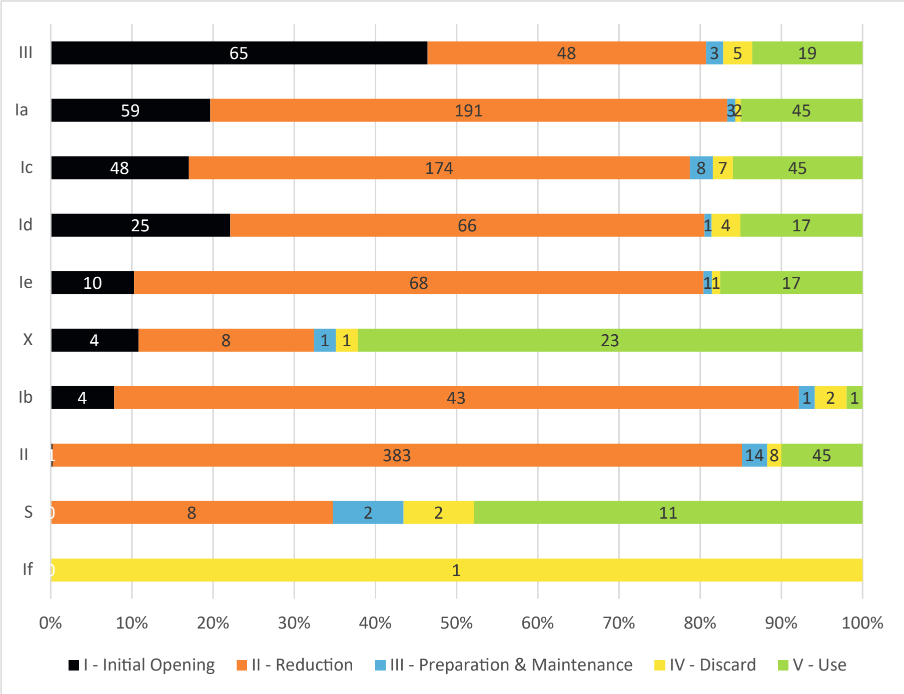

Fig. 9. Wesseling. Operational Chain Stages (CO) per raw materail (RM) in %.
Abb. 9. *Wesseling. Operationskettenstadien nach Rohmaterial (RM) in %.*

Meuse gravel flints (18 %) and less importantly Tertiary Meuse flints (5 %). The highest share of tools in one raw material, however, are found in Lydite (100 %), singular lithics (32 %) and indeterminable pieces (19 %). The residual flint contains the highest tool percentage of the raw materials reduced on site (9 %). Therefore, Tertiary Quartzite, Vetschau, Meuse gravel and Tertiary Meuse were the mainly reduced and used raw materials on site. Lydite and Residual flint were mainly processed off-site as well as the raw materials of the singular and indeterminable pieces which arrived at the site mainly as finished tools. This observation well mirrors the one already depicted by the operational chain stages discussed above.

In terms of content and functional raw material selection also clear differences occur. Backed points are fashioned from a wider variety of raw materials, most prominently Vetschau and Meuse gravel flints. They also have the highest shares of indeterminable raw materials. Only one tertiary quartzite backed point could be found in contrast to the high reduction intensity of this raw material. The majority of backed blades are made from either Vetschau flint or residual flint. A similar, though more diverse picture is formed by the burins: nearly all raw materials are represented, while singular and indeterminable raw materials play important parts. For nearly all raw materials, except for the singular burins, the number of burins spalls exceed that of the burins itself indicating intensive use. The spatial distribution of backed points (Fig. 11) clearly shows four activity zones (III, IV, V, VII) to be concerned with hafting and retooling activities, where, in addition, each contains a hearth feature for the processing of birch tar or a similar adhesive.

The burins (Fig. 11) also mirror this picture where chalcedony burins were produced and only used relatively little, while singular ones were mainly discarded. Burins from Meuse gravel flint were used and resharpened intensively as were a few ones each from Vetschau, Tertiary Meuse, Residual and Tertiary Quartzite. In terms of spatial distribution burins are found wherever backed points were produced. Further burins are, however, found without the connection to backed points, so spatially and possibly also functionally distinct areas of burin use are additionally present. The low number of backed points from Tertiary Quartzite suggests the last retooling event before the stop at Wesseling to have lacked this raw material and thus likely to have happened between Aachen and Bonn. Use wear analysis to differentiate between used and unused backed points has not yet been performed, so no definite statements about the succession of backed point use can be made yet.

Moving to domestic tools like end scrapers, borers and notched elements a clear dominance of tertiary quartzite is noticeable for end scrapers and notched pieces. Borers are made out of Vetschau, Meuse gravel and residual flint. The dominance of Vetschau flint and Tertiary Quartzite in the end scraper assemblage mirrors the reduction intensity of both raw materials. The dominance of tertiary quartzite likely origins from the sturdier and slightly coarser texture of this raw material, which makes it very well suited for end scrapers. The ad-hoc fashioned tools again show a more diverse picture: lateral retouches, used blanks and, to a lesser degree, truncations are made from a

	I	Ia	Ib	Ic	Id	Ie	If	S	II	III	IV	X	total n	%
	Flint indet	Vet-schau	Lous-berg	Meuse gravel	Tertiary Meuse	Resi-dual	Baltic flint	singu-lar	Tertiary Quart-zite	Chalze-dony	Lydite	Indet		
backed point		7	1	4	2	3			1			5	23	*13.3*
backed element		7		2	2	7			1		1		20	*11.6*
Endscraper		10		3				1	16				30	*17.3*
Burin		2		3	2	1		3	3	5		4	23	*13.3*
Borer		1		2		1							4	*2.3*
Lateral retouch		2		2	1	1		1	6	2		3	18	*10.4*
Truncation				3				1	2				6	*3.5*
Notched									2	1			3	*1.7*
use wear	1	11		12	2	1		3	9	5		2	46	*26.6*
Total tools	**1**	**40**	**1**	**31**	**9**	**14**	**0**	**9**	**40**	**13**	**1**	**14**	**173**	***100.0***
Burin spall	1	5		12	7	3		2	5	5		9	49	
Microburin Krukowski				2	1					1			4	*2.3*
V - Use	**2**	**45**	**1**	**45**	**17**	**17**	**0**	**11**	**45**	**19**	**1**	**23**	**226**	
Total number of lithics	64	520	81	512	242	146	1	28	885	313	1	63	2'856	
Tool % of RM	1.6	7.7	1.2	6.1	3.7	9.6	0.0	32.1	4.5	4.2	100.0	22.2	6.1	
% of all tools	0.6	23.1	0.6	17.9	5.2	8.1	0.0	5.2	23.1	7.5	0.6	8.1	100.0	
RM %	2.2	18.2	2.8	17.9	8.5	5.1	0.0	1.0	31.0	11.0	0.0	2.2	100.0	

Fig. 10. Wesseling. Tools per raw material.
Abb. 10. *Wesseling. Geräte pro Rohmaterial.*

variety of raw materials. The differences of singular raw materials in burins, end scrapers and truncations suggest that burins and truncations were more often transported than end scrapers.

Therefore, in summary, four clear retooling events are preserved in Wesseling where mainly the western raw materials were discarded in the process. In close connection, burins show signs of curation or transportation through their diversity in raw materials. End scrapers and other domestic tools as well as ad-hoc tools were fashioned mainly on-site from the locally intensively processed raw materials.

Spatial organisation

The spatial organisation of settlement activities in Wesseling yields further information on the structural organisation and the sequencing of events at the site. Overall, eight activity zones form an easily visible circular structure in the centre of the settlement (Fig. 7), with gravel pavements located at the eastern part of the circle, while lithic production areas are located in the west of the circle. Four activity zones lie outside this circular structure, zone III in the far south-east closest to the abandoned meander, zones VI and VII to the north in close spatial connection and zone V in the west. Brown coal was mainly processed in the north-east close to the gravel pavements. Six hearth features (Fig. 11) could be reconstructed either through evident preservation of charcoal and/or burned quartz cooking stones (AZ IX, III) or through burned lithic material (AZ V, IV, VII and XI).

Most activity zones are dominated by one or two processed raw material varieties and show a clear pattern (Fig. 12). The large activity zone III in the south is dominated by Vetschau/Orsbach and tertiary quartzite. Activity zone IV includes mainly residual flint and Meuse gravel material. The latter was also processed to large shares in activity zones II, X, XI, IX, and VI. Its use is therefore most widespread on site. Zones I and VIII are exclusively concerned with the production of chalcedony, while zone V focuses on tertiary Meuse flints. The reasons for such a clear-cut separation of raw material processing are still a matter of debate. Either, a connection with different individuals or small subgroups carrying this particular variety can be assumed, a functional or intentional selection imagined or simply chance in terms of the stacking of the raw materials in a carrying container and subsequent working through these stacks speculated. The refits and the clear and undisturbed spatial distribution of finds horizontally and vertically would argue against a chronological distance of those separate reduction events and would argue in favour of a one-phased occupation.

In terms of find numbers, diversity of the toolkits and size activity zone III, as the southernmost activity

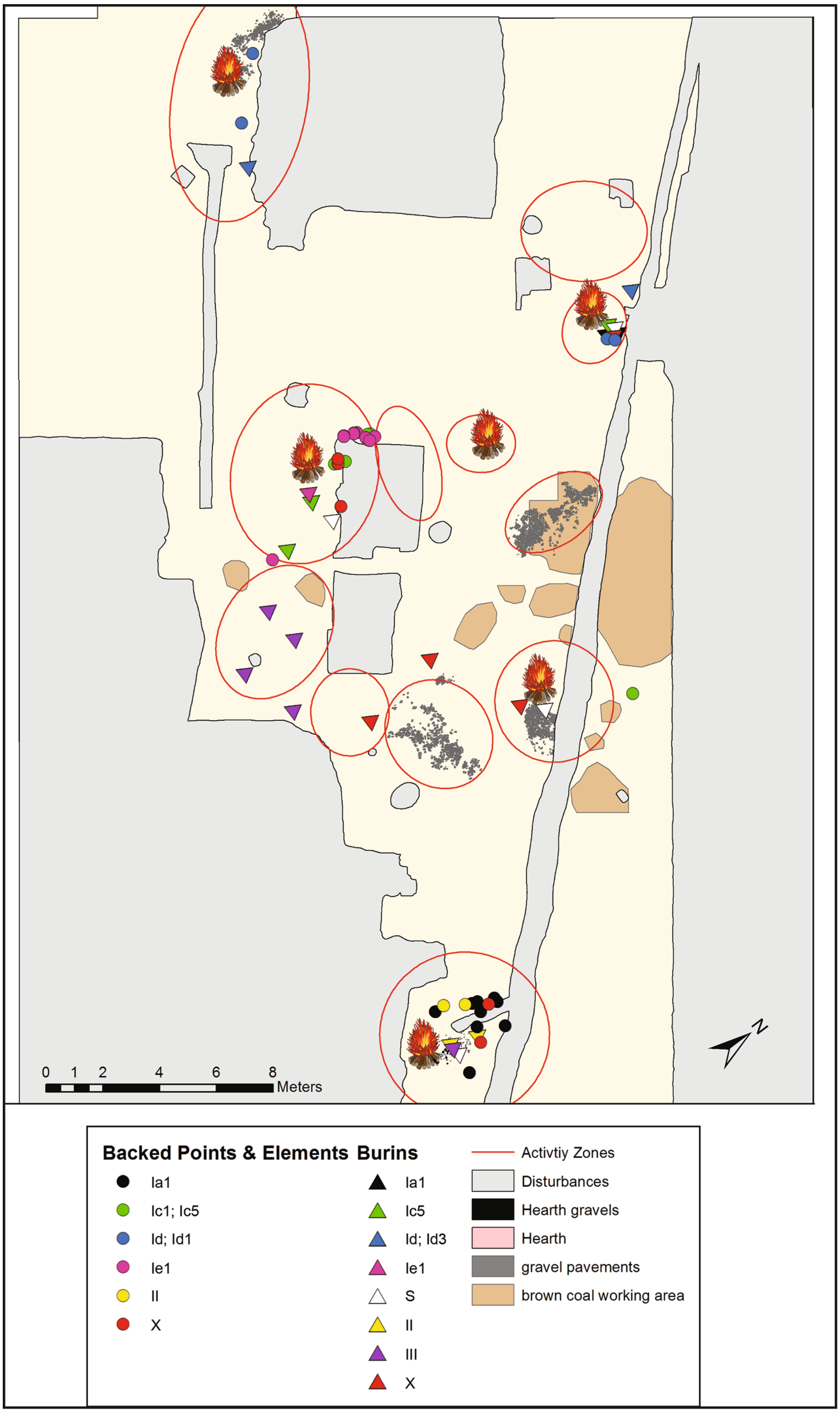

Fig. 11. Wesseling. Distribution of backed bladelets and burins per raw material.

Abb. 11. *Wesseling. Verbreitung von rückengestumpften Elementen und Sticheln.*

zone in Wesseling, is clearly the focus of activity preserved on site. Mainly tertiary quartzite and Vetschau/Orsbach flints were reduced here, the Lousberg material processed and the singular Baltic flint core discarded. Reduction activities dominate, retooling of backed pieces took place and an intensive us of end scrapers can be established (Fig. 14). Furthermore, is this activity zone spatially large and shows a very dense find concentration including charcoal and burned quartzes. Nearly half the finds from Wesseling were found here. Similarly diverse, but much less intensively occupied is activity zone IV, where residual flints and Meuse gravel was processed. Again, this activity zone shows evidence of a retooling

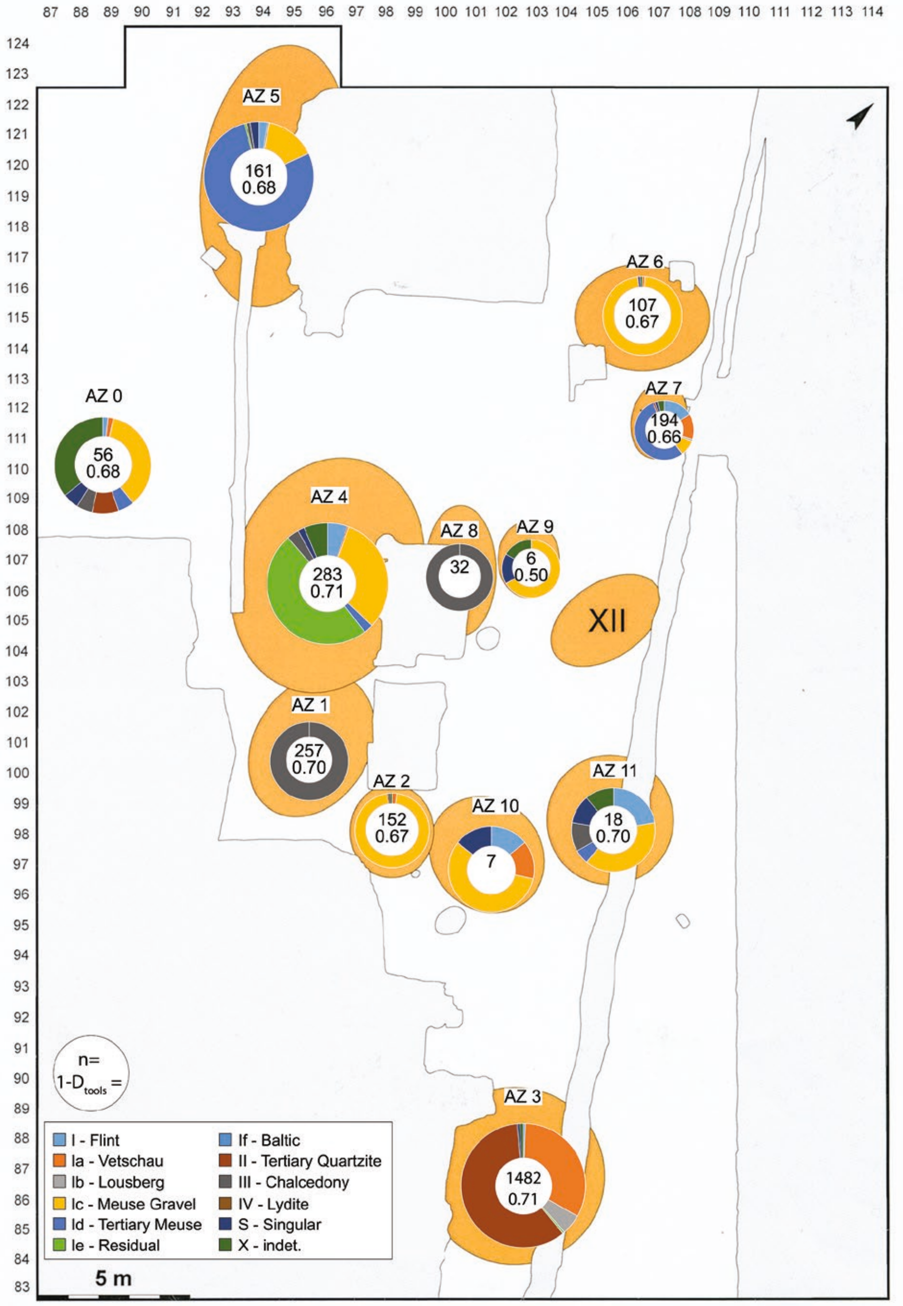

Fig. 12. Wesseling. Raw material (RM) and tool diversity by activity zone.

Abb. 12. *Wesseling. Rohmaterial (RM) und Gerätediversität pro Aktivitätszone.*

event, although here this seems the major focus of activity as evidenced by the share of backed material and burins. Reduction and use are the mainly represented stages of the operational chain. A focused production of blanks for retooling can therefore be reconstructed for this activity zone. Those two activity zones, III and IV have yielded the majority of tools on site.

A focus on initial chalcedony processing can be reconstructed for activity zone I in combination with a limited burin production from the same raw material. A close connection through refittings can be established between zones I and VIII, where the initial production from zone I was continued on a small scale in VIII before the core was discarded between both. A focus on the initial preparation and reduction of Meuse gravel flint is visible for activity zone II, tool production and use plays a minor part here. Here a clear successive processing of three different Meuse gravel nodules can be easily seen (Fig. 13). Nodule Ic1 was processed first as its production debris is most widespread. Then, successively nodules Ic2 and Ic3 were processed showing denser concentrations. This picture can also be found in the representation of the operational chain stages (Fig. 15). Nodule Ic1 was completely processed on site, including intensive

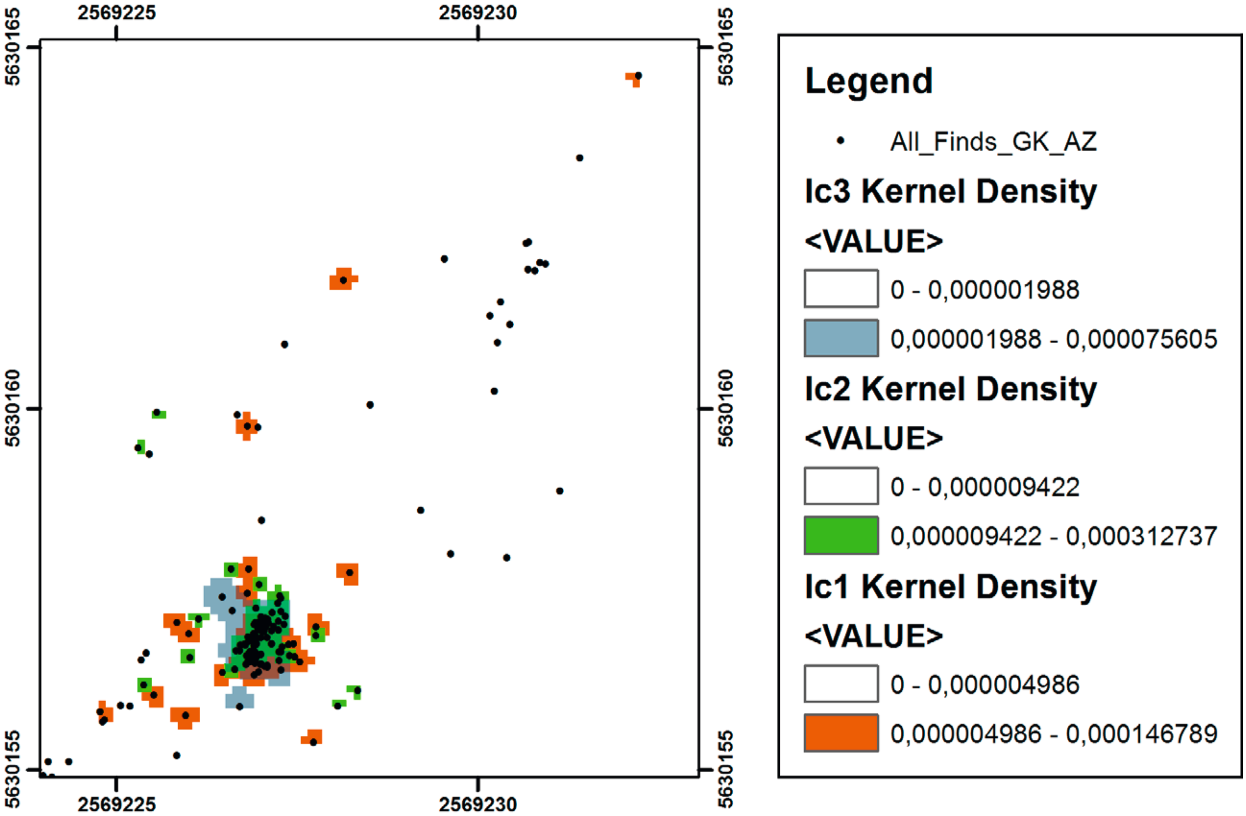

Fig. 13. Wesseling. Kernel Density Plots of 3 Meuse Gravel nodules successively reduced one after the other.
Abb. 13. *Wesseling. Kerndichtekartierung von 3 Maasschotterknollen, die nacheinander am gleichen Ort zerlegt wurden.*

reduction, tool use and an export (or loss due to preservation) of the core. Nodule Ic2 was initiated, reduced and discarded on site and possibly blanks for further use were exported. Nodule Ic3 was initiated and only shortly reduced with no other parts of the reduction sequence being preserved.

Activity zones VI and VII are both specialised. While zone VI was mainly concerned with the processing of one nearly completely refitted Meuse gravel nodule (Ic4) and lacks larger shares of tools, zone VII shows a higher variability in raw materials although it is dominated by tertiary Meuse flints. Here seemingly a burin production and use area can be defined, where out of 29 elements from the use stage 6 are burins and 16 burin spalls. Zone VI represents clearly the reduction of a nodule deemed inappropriate for intensive further use, most of the debitage was left on site, only relatively few blanks, especially blades, are missing. Only two formal tools, one backed element and one truncation were left on site, together with three pieces with use wear. Activity zone V is concerned with the processing of tertiary Meuse nodules and not particularly specialised. Tool production and use is low, of most formal tool classes one piece is represented. A hafting and retooling event and probably the production of arrow shafts can be proven through one fragmentary backed point and a shaft-smoother, which were found on the south-eastern border of the zone. One relatively small-grained gravel pavement is preserved here.

The remaining activity zones IX, X, XI and XII are not focused on lithic production. Zone IX represents an evident hearth feature with a few assorted Meuse gravel blanks, several of them with macroscopically visible use wear. As use wear studies have not been performed it can only be speculated what type of activities took place here, maybe they were concerned with food processing. Activity zones X, XI and XII include a large gravel pavement each, in XI connected to a hearth feature. All only show a few stray lithics, which in zone XI were seemingly connected to domestic activities as they include mainly tools, two burins, two end scrapers, one truncation and one piece with use wear. Zone XII lies in a zone of intensive brown coal processing, indicating a connection of the pavement with the fabrication.

Overall, the site of Wesseling shows a distinct spatial organisation in terms of areas for tool production and use, the processing of different nodules of raw material and areas connected with the use of gravel pavements and brown coal.

Mobility

Finally adding the weights of the used materials to the discussion (Fig. 5) already hinted at during the analysis of the operational chain stages and the tool use, a

CO-Stage	AZ 0	AZ 1	AZ 2	AZ 3	AZ 4	AZ 5	AZ 6	AZ 7	AZ 8	AZ 9	AZ 10	AZ 11	AZ 12	Total
I - Initial Opening	1	59	34	62	18	18	13	7	2			2		**216**
II - Reduction	9	29	58	614	101	43	69	51	14	3	3	2	1	**997**
III - Preparation & Maintenance		3	2	19	3	2	4	1						**34**
IV - Discard	2	2	1	16	2	5	2	1		1	1			**33**
V - Use	8	13	3	95	53	10	6	30		2		6		**226**
0 - Chips & Chunks	37	151	154	675	106	83	13	104	16		3	8		**1'350**
Total	**57**	**257**	**252**	**1'481**	**283**	**161**	**107**	**194**	**32**	**6**	**7**	**18**	**1**	**2'856**
							Tools of Stage V - Use							
Backed point	1			11	9	1		1						**23**
Backed element				7	9	1	1	2						**20**
Burin	2	3	1	5	4	1		6				1		**23**
Endscraper				27		1						2		**30**
Borer				2	2									**4**
Truncation				3	1		1					1		**6**
Lateral retouch	3	2		7	3			2				1		**18**
Notched		1		2										**3**
use wear	2	2	1	20	9	5	3	1		2		1		**46**
Total tools	**8**	**8**	**2**	**84**	**37**	**9**	**5**	**12**		**2**		**6**		**173**
Burin Spall		4	1	11	15	1	1	16						**49**
Mikroburin Krukowski		1			1			2						**4**
Total Stage V	**8**	**13**	**3**	**95**	**53**	**10**	**6**	**30**		**2**		**6**		**226**

Fig. 14. Wesseling. Operational Chain Stages (CO) and tools per Activity Zone.
Abb. 14. *Wesseling. Operationskettenstadien (CO) und Geräte pro Aktivitätszone.*

conclusive picture forms. Chalcedony was processed in few individual lithics while its weight is highest of all raw materials. More than a quarter of the processed raw material weight is taken up by the Chalcedony further confirming the assumption that the source of Bonn-Muffendorf was the last one visited before the settlement at Wesseling. Next comes the tertiary quartzite with nearly another quarter, further confirming the southern route on the way to Wesseling. Vetschau and Meuse gravel flints are both represented by about 500 - 700 g, so together forming a third of the total weight and indicating previous acquisition events close to Aachen and its surroundings. The few, but for the low numbers relatively heavy Lousberg finds are closely connected to the acquisition of the Vetschau material, as are the tertiary Meuse flints to the Meuse gravel. The acquisition of the residual flints can be put further back in time as here the situation of the Lousberg material is reversed. The acquisition of the Baltic flint core lies furthest back in time.

The here sketched succession of acquisition events could be used to argue for a single group of hunter-gatherers following the assumed route from the region of Krefeld, over Aachen and Bonn-Muffendorf to Wesseling. Alternatively, a meeting of two groups, one from the south and one from the west could be hypothesised, but then the Western group would have brought less material to the site than the Southern group. The second hypothesis shall therefore be dismissed as unlikely here. The combination of the weight distribution with the clear indication of the operational chain stages would strongly point to the first scenario as being the most likely cause of events.

As this fortunate locality of Wesseling, right in the middle of those easily differentiable raw material sources, opens up the rare possibility of tracing the route followed by the Federmesser hunter-gatherers, an additional analysis of the way they might have used shall be given. It consists of a least cost path analysis after a set of methods compiled by Daniel Becker (Becker, et al. 2017) using Toblers Hiking function (Tobler 1993) as a base of analysis. The least cost expensive route (Fig. 6) leads from Krefeld in south-western direction and crosses the Niers River passing by the Mönchengladbach sites before arriving in Aachen and at the primary outcrops there. Further onwards, it follows the margins of the Central German Uplands south passing by the site of Abri Katzensteine before descending into the Rhine valley and leading downriver over Muffendorf to Wesseling, overall a route of 287 km length.

Raw material use in the Allerød

The picture gained at Wesseling now needs to be compared to other contemporaneous sites to find out, if the results from Wesseling are in accordance with the raw material use and mobility of the Federmesser timeframe. A number of 21 sites have been available for this study, including many well-known and well-published sites, especially from the Neuwied Basin, but also a number of new, currently less intensively published sites which have been collected and analysed by one of the authors (M. Heinen). Those sites shall be published in full detail in the future, but are to be described here shortly to give a first impression and enable contextualisation.

Raw material	I - Initial Opening	II - Reduction	III - Preparation & Maintenance	IV - Discard	V - Use	0 - Chips & Chunks	Total
I		9			2	53	**64**
Ia	4	48	1		12	62	**127**
Ia1	53	134	2	1	30	158	**378**
Ia2	2	2			2		**6**
Ia3		6		1			**7**
Ia4		1			1		**2**
Ib1	4	43	1	1	1	30	**80**
Ib2				1			**1**
Ic	1	2				1	**4**
Ic1	7	31	2		4	70	**114**
Ic2	13	20		1		83	**117**
Ic3	13	7				13	**33**
Ic4	13	66	4	1	2	14	**100**
Ic5	1	36	2	2	36	40	**117**
Ic6		3		1	1		**5**
Ic7		7		1	1	10	**19**
Ic8				1	2		**3**
Id	11	36	1		6	80	**134**
Id1		9			7	6	**22**
Id2	7	8			2	6	**23**
Id3	3	7			1	6	**17**
Id4				1		26	**27**
Id5		3		1		1	**5**
Id6	3	1				2	**6**
Id7				1		1	**2**
Id8	1	3		1		1	**6**
Ie1	10	65	1		16	49	**141**
Ie2		3		1	1		**5**
If				1			**1**
S		8	2	2	11	5	**28**
II	1	383	14	8	45	434	**885**
IV					1		**1**
III	65	48	3	5	17	173	**311**
IIIa					2		**2**
X	4	9	1	1	23	26	**64**
							2'856

Fig. 15. Wesseling. Operational Chain Stages (CO) per raw nodule.
Abb. 15. *Wesseling. Operationskettenstadien (CO) pro Rohknolle.*

Sites

Kaarst

The site is located on an expansive sand dune in Kaarst-Hinterfeld and was discovered during an excavation of a Roman *villa rustica* in 2010. The site is heavily eroded and yielded about 60 lithics including a backed element, a combination tool of a burin and an end scraper, an end scraper and one piece resembling a borer. Further notable finds include a retoucher and a grinding slab (Englert & Heinen 2011).

Mönchengladbach-Geneicken, Excavation

The extensive Federmesser site of Mönchengladbach-Geneicken was discovered during rescue excavations necessitated by the construction of a flood retention basin on the banks of the Niers River and contains, on an area of about 4'000 m², 10 distinct activity and discard zones. Due to the wet environment along the banks of the Niers, the bone preservation is exceptional for Rhenish standards and allows the identification of horse, red deer, beaver and fox as hunting prey. The lithic inventory contains 1'115 individuals including all characteristic target and debitage products in addition to a tool inventory consisting of backed points, backed elements, burins, end scrapers, truncations, lateral retouches and utilised pieces. Burned artefacts indicate the presence of hearths in at least four activity zones. Notable is the high share of Baltic flint (26.9 %) which can only be found north of the Ruhr River in the good quality used at this site. ^{14}C dates place the occupation in the first half of the Allerød period around 11'500 calBC (Heinen 2015).

Mönchengladbach-Geneicken, Surface

North of the excavated site of Mönchengladbach-Geneicken lies the late Palaeolithic-Mesolithic surface site with the same name where more than 2'500 lithics have been collected since 1982. From the total extend of the site a small area can be separated on the north-eastern margin yielding a Federmesser inventory of 406 artefacts. This inventory contains, in addition to debitage and debris, backed points, backed elements, burins and end scrapers (Gerlach et al. 1999; Heinen & Kopecky 2001; Heinen 2006a).

Mönchengladbach-Bungt

The late Palaeolithic surface site of Mönchengladbach-Bungt is located on a small ridge in the Niers meadow about 1 km north of the surface site of Mönchengladbach-Geneicken. A small inventory of 371 lithics could be collected on a spatially restricted area including backed points, backed elements, burins and end scrapers (unpublished).

Wegberg-Berg

The surface site of Wegberg-Berg is located atop the "Feltenberg", a spur formed by a confluence of the streams Schwalm and Mühlenbach, and was discovered at the beginning of the 1990ies. Apart from the dominating late Palaeolithic occupation, additional artefacts of Upper Palaeolithic, Mesolithic and Neolithic age were recovered and separated from the Federmesser material through differences in raw material and technology. The late Palaeolithic inventory consists of more than 1'050 artefacts including the usual target and debitage products in addition to a numerous tool inventory of backed points and elements, end scrapers, burins, borers, lateral retouches and truncations (Heinen 2006b).

Viersen, Hoher Busch

The surface site of Viersen, Hoher Busch was found in 1975 inside the urban boundaries of Viersen at the southern foothills of the Süchteln heights. The 2'500 m^2 surface site lies on a spur surrounded by small springs and yielded nearly 650 late Palaeolithic artefacts until a reforestation of the former agrarian land rendered the site inaccessible. The tool inventory is composed of backed points and elements, short end scrapers and small, unstandardized burins and thus typical for the North-West European Federmesser groups (Heinen 1993).

Grefrath, Bronkhorst 1 and 3

The two surface sites of Bronkhorst 1 and 3 lie 200 m apart from each other in the urban area of Grefrath on a slightly elevated terrace remnant at the margin of the Niers meadow. Longstanding collections of the agrarian surface in the 1980ies yielded 592 lithics in Bronkhorst 1 and 507 lithics in Bronkhorst 3. In both cases backed points and elements, short end scrapers and small burins attest for an occupation during the Allerød period (Clemens 1990).

Used material

Only one new raw material shall be included in this study here, which is the so-called "Obourg Flint". Many sites include further raw materials, here subsumed under "other", especially those from the Neuwied Basin, which partially have shares of material from even further south or further local sources. As this study is focused on the Rhenish raw materials, these additional sources shall be omitted.

"Obourg" flint is represented on many sites in the Rhineland and neighbouring regions of the Southern Netherlands (Deeben & Rensink 2005). The primary source is not yet exactly localized. Until a few years ago, it seemed to be clear that the source of this raw material is located in the area of Mons in Southern Belgium, but after recent investigations another source in the Maastricht area cannot be ruled out. The very homogeneous raw material is of black colour, a silky lustre, and shows occasionally small whitish inclusions or tiny red dots. The cortex of varying thickness is smooth or slightly grained and of light brownish to yellow-whitish colour. The material plays an important role in several of the discussed sites. In Goch-Kessel and, e.g. Geldrop 3-4 (Deeben 1999) in the Netherlands, this raw material has a ratio of 90 % or more.

The raw material percentages of the different sites are displayed in Fig. 16 (Appendix Tab. 1). Easily visible are four different groups of sites, where four sites (Rietberg 1&2, Salzkotten-Thüle and Westerkappeln A) nearly exclusively use Baltic flint, a further five sites around Mönchengladbach and possibly (Floss 1994: 305) also Abri Katzensteine, are dominated by Meuse gravel flint, and most sites from the Neuwied Basin by Tertiary Quartzite. A small number of sites share a more balanced distribution of raw materials, among them Wesseling, Kaarst, Andernach-Martinsberg and Kettig. Two sites fall out of this picture, areas I to VII of Niederbieber are dominated by Muffendorf-Chalcedony and Goch-Kessel by Obourg flint.

Statistical Evaluation

Overall, the general picture seems clear: The majority of sites uses mainly raw material found in the immediate vicinity of the camp location, and other raw materials are used more sparingly. This raw material use follows the north-south gradient in the distribution of the raw material sources and is apparently closely reflected in the inventory compositions. This might be interpreted to indicate a generally embedded raw material procurement by the Federmesser hunter-gatherers.

This observation can easily be tested through a constrained correspondence analysis (CCA, Legendre & Legendre 2012). This handy method sets a dataset, in this case the raw material use on site (Appendix Tab. 1), in relation to an independent covariable, in this case the UTM Northing values of the site coordinates. The result (Fig. 17) shows a highly significant contribution of the north-south gradient to the representation of different raw materials on the different sites (p=1E-04).

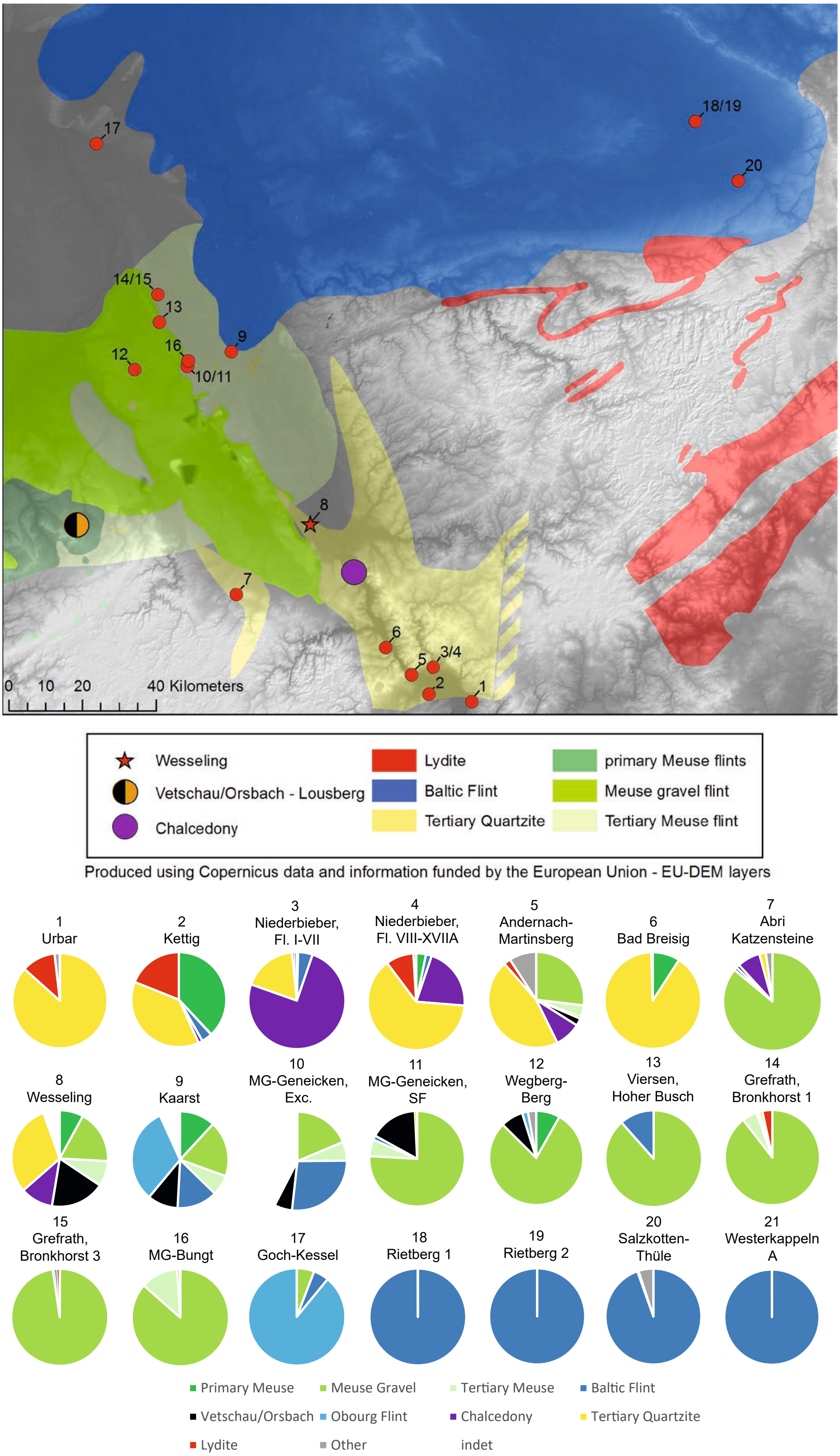

Fig. 16. Raw material use of comparative sites.

Abb. 16. *Rohmaterialnutzung der Vergleichsfundplätze.*

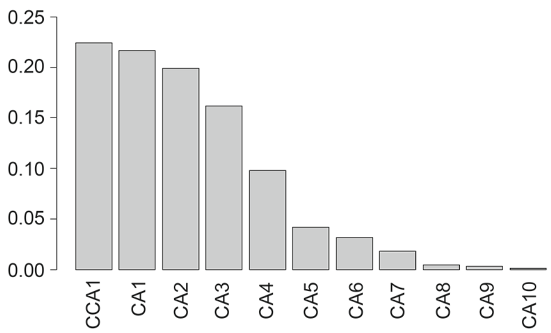

Fig. 17. Screeplot of the constrained correspondence analysis (CCA).

Abb. 17. *Screeplot der Kanonischen Korrespondenzanalyse (CCA).*

It indicates that 22.4 % of the total inertia, or variation, in the raw material shares of the different sites can be explained by their Northing value. As visible in the triplot of the sites and the covariable (Fig. 18) the formerly suspected grouping of sites is valid, while the contributions plot (Fig. 19) clearly identifies Baltic flint as mainly responsible raw material for this result.

Therefore, the CCA has clearly shown that the representation of raw material types on the sites is strongly and significantly connected to the regionally available sources, indicating an embedded raw material procurement. Comparing the radius of the raw material catchment (Appendix Tab. 1) this picture is further clarified as to show a mean radius of seldom more than 100 km in which often all exploitable sources were used.

Discussion

The analysis of the raw material use on Federmesser sites has shown a strong dependence on the regionally available raw material sources, following a north-south gradient, and a limited impact of raw materials from a distance of usually not more than 100 km. This result is consistent with the previously suggested residential mobility system (Hahn 1991). The here intensively analysed and well-preserved site of Wesseling fits seamlessly into this system, although does offer the unusual advantage of being located outside of major raw material sources and therefore does not include

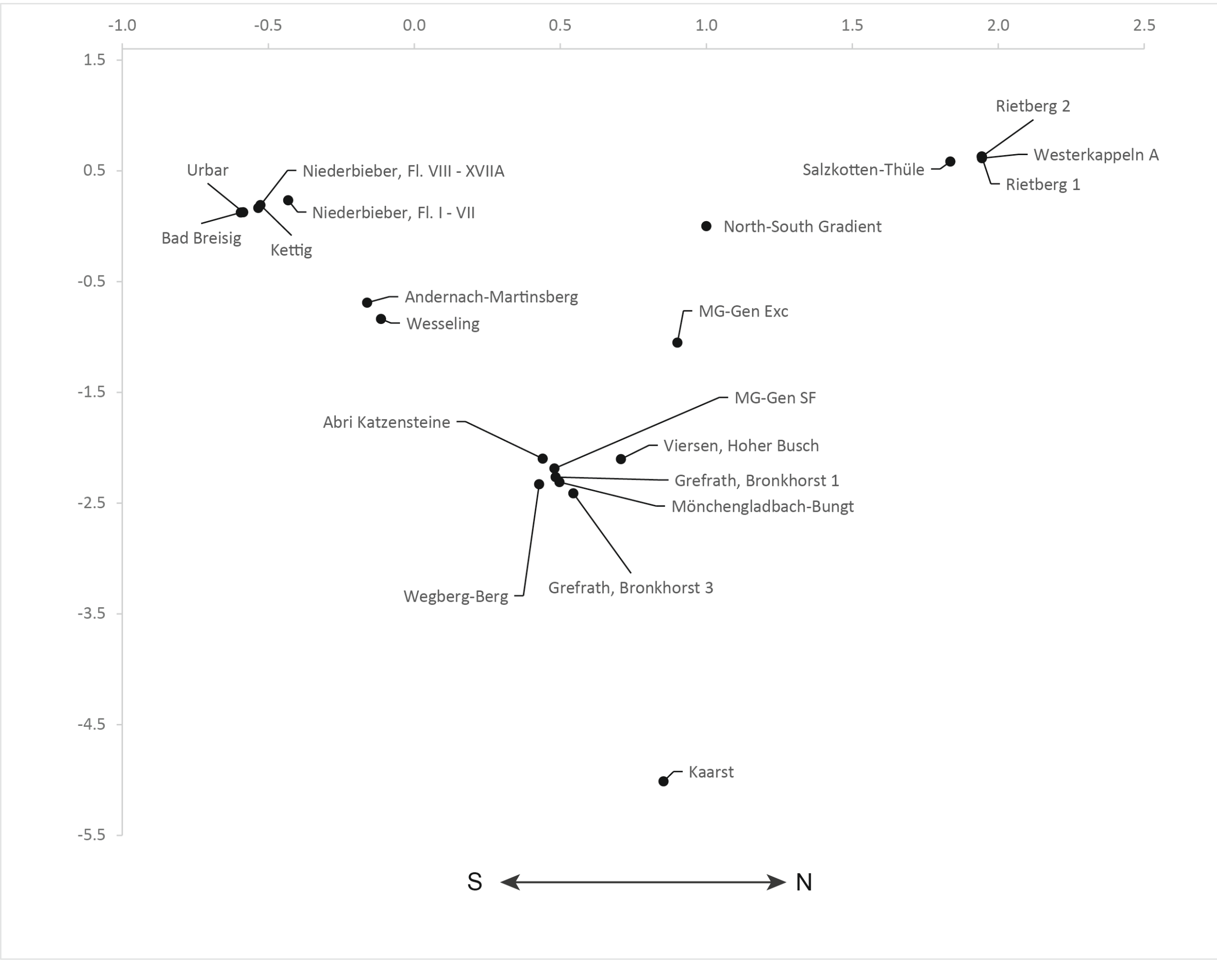

Fig. 18. Triplot of the constrained correspondence analysis (CCA) (Note: Goch-Kessel is not displayed as it is far out of range with values of x=1.5 and y=-12.1).

Abb. 18. *Triplot der Kanonischen Korrespondenzanalyse (CCA) (Anm. Goch-Kessel ist aufgrund stark abweichender Werte (x=1,5 und y=-12,1) nicht abgebildet.)*

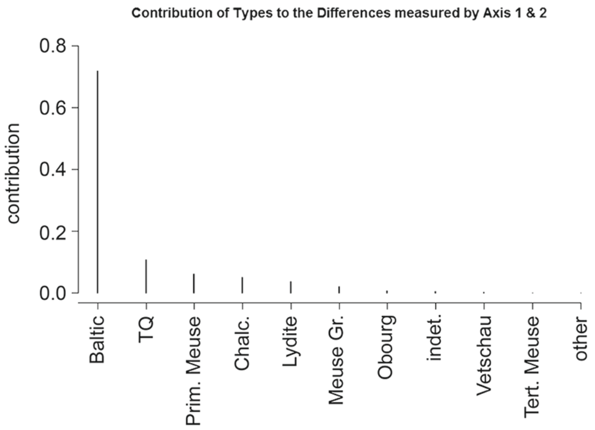

Fig. 19. Contributions of the different raw material types to the result of the constrained correspondence analysis (CCA).

Abb. 19. *Beitrag der verschiedenen Rohmaterialtypen zu dem Ergebnis der Kanonischen Korrespondenzanalyse (CCA).*

large scale on-site or local raw material acquisition. The unusual locational benefit of Wesseling allows the reconstruction of the most likely migratory route from the endmoraines around Krefeld over the secondary and tertiary sources of Meuse flint to their primary sources in Aachen, turning south towards the Neuwied Basin and the areas of well-accessible Tertiary Quartzite over Bonn-Muffendorf to Wesseling, suggesting a near circular route.

The overall raw material distribution of the analysed Federmesser sites furthermore may suggest the presence of two different regional systems in the dataset. The majority of sites uses the Rhenish raw materials including Lydite, Tertiary Quartzite and Chalcedony. A minority of sites, however, mainly Goch-Kessel, Kaarst and less importantly Wegberg-Berg, show, with the presence of Obourg Flint, a clearly exogenous raw material in addition to Meuse and Baltic flint. Possibly, therefore two different regional mobility systems, oriented along the major drainages, the Rhine and the Meuse, existed, converging in the source regions of Meuse gravel, tertiary Meuse and Baltic flint in the Lower Rhine Basin. A potential third system may be the reason for the dominance of Baltic flint in the northernmost sites of Rietberg, Salzkotten-Thüle and Westerkappeln A, which might then be the southernmost occurrences of a system following the wide-open plains of the Westphalian lowlands.

Overall, this general picture of groups exploiting raw material sources in an embedded manner following landscape units formed by the major drainage lines and/or the major topography units presents a stark contrast to the preceding and following timeframes. The preceding Magdalenianians cross large distances in the hunt of reindeer, resulting in raw material distances of up to 200 - 300 km (Weniger 1982: 198; Floss 1994: 222ff, 386) and also form clearly differentiable logistically organised settlement systems (Bosinski 1987). The following Ahrensburgian shows a strongly similar settlement organisation and land use (Baales 1996). Therefore, on environmental terms, the contrast of logistical systems in cold climatic settings and a residential system in warmer, forested settings is clearly visible in the Rhenish late Palaeolithic. This observation has been made many times before (Hahn 1991; Floss 1994: 386) but can now be further supported by newly excavated sites and comparative statistical analysis. The potential of regional subgroups visible in the raw material acquisition is as of yet not fully exploited and should be refined in the future.

Fundplatz	Primary Meuse	Meuse Gravel	Tertiary Meuse	Baltic Flint	Vetschau/ Orsbach	Obourg Flint	Chalce-dony	Tertiary Quartzite	Lydite	Other	indet	Total	Max. Distance to RM in km	RM Literature source	further literature
Bad Breisig	145							1'436	5	3		**1'589**	80	Waldmann, Jöris & Baales 2001; Baales & Jöris 2002	
Kaarst	7	11	4	8	6	19					4	**59**	min 80		Englert & Heinen 2011
MG-Geneicken SF		308	23	6	66			3				**406**	55		Gerlach et al. 1999; Heinen & Kopecky 2001
MG-Geneicken Exc.		208	69	300	65						473	**1'115**	55		Heinen 2015
Wegberg-Berg	86	834			81	21				30		**1'052**	min 50		Heinen 2006b
Viersen, Hoher Busch		575		75								**650**	60		Heinen 1993
Kettig	9'134		36	870			337	9'112	4'558			**24'047**	100	Baales 2001	Baales 2002
Niederbieber, Fl. I - VII	46			564			8'729	2'085	109	81		**11'614**	110	Gehlhausen 2007a/b	
Niederbieber, Fl. VIII - XVIIA	260			154			1'679	5'059	743	75		**7'970**	110	Gehlhausen 2007a/b	
MG-Bungt		321	46	1						2	1	**371**	0		unpublished
Goch-Kessel		8		7		122						**137**	min 100	Heinen et al. 1996	
Grefrath, Bronk-horst 1		530	30	5				7	20			**592**	20		Clemens 1990
Grefrath, Bronk-horst 3		495	4	4					4			**507**	20		Clemens 1990
Urbar								1'090	145	22	1	**1'258**	120	Floss 1994	Baales et al 1996
Andernach-Mar-tinsberg		751	111	17	69		245	1'279	64	257		**2'793**	100	Floss 1994	
Westerkappeln A				5'260								**5'260**	0		Günther 1973
Wesseling	227	512	242	1	520		313	885	1		155	**2'856**	65	Parow-Souchon 2010	Heinen 2008, 2014, 2016
Abri Katzensteine		80		1	1		7	2		2		**93**	70	Floss 1994	
Rietberg 1				2'616					1			**2'617**	0	Richter 2012	
Salzkotten-Thüle				2'796					13	148		**2'957**	0	Heidenreich 2008	
Rietberg 2				274								**274**	0	Richter 2012	

Appendix, Tab. 1. Raw material representation of comparative sites.

Appendix, Tab. 1. *Rohmaterialverteilung der Vergleichsfundplätze.*

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