Raw material procurement economy and mobility in Late Palaeolithic Northern Bavaria

Rohmaterialbezug und Mobilitätsmuster im Spätpaläolithikum Nordbayerns

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Abstract - The PhD project "Late Palaeolithic Landuse Patterns in Northern Bavaria", which was part of the DFG-project "GIS-based reconstructions of Late Palaeolithic landuse patterns in the low mountain range of northeastern Bavaria" analysed the use of lithic resources and also investigated settlement patterns and bioeconomic opportunities in the territories of the penknife-sites in northern Bavaria. Numerous different raw materials were identified in the various assemblages found in the study area. Locally procured toolstones of limited quality as well as high quality tabular cherts and erratic flints originating at a great distance were used. It was possible to show that the different raw material variants were reduced in similar ways, unrelated to their transportation distance. Nevertheless, the Late Glacial hunter-gatherers distinguished between the varying raw material qualities, which is shown by the different maximum transportation distances. The materials reflect a transportation network that spans from the Danube to northern Bohemia as well as the northern part of the Ore Mountains, testifying to intensive contact between the region of the Upper Palatinate in northerastern Bavaria and Bohemia.

Zusammenfassung - *In der Doktorarbeit "Spätpaläolithische Landnutzungsmuster in Nordbayern" im Rahmen des DFG-Projektes "GIS-basierte Rekonstruktionen spätpaläolithischer Landnutzungsmuster der nordostbayerischen Mittelgebirgszone" wurde neben dem Siedlungsmuster und der Verfügbarkeit organischer Ressourcen auch die Nutzung lithischer Ressourcen analysiert. In den untersuchten Fundplätzen der Federmessergruppen wurde eine Vielzahl unterschiedlicher Rohmaterialien genutzt. Dabei wurden sowohl lokal anstehende Rohstoffe niedriger Qualität, als auch Plattenhornsteinvarianten und Kreidefeuersteine aus größerer Entfernung verwendet. Es konnte gezeigt werden, dass die verschiedenen Silexvarietäten eine vergleichbare Ausbeutung erfahren haben, unabhängig von der Entfernung zu ihrer Quelle. Dennoch wurde von den Jägern und Sammlern des Spätglazials zwischen unterschiedlichen Qualitäten unterschieden, was sich in den unterschiedlichen maximalen Transportdistanzen niederschlägt. Die Rohstoffe zeigen ein Transportnetzwerk, das sich vom Donauraum bis nach Nordböhmen und den nördlichen Teil des Erzgebirges erstreckt. Sie weisen einen intensiven Kontakt zwischen dem oberpfälzer Raum und Böhmen nach.*

Keywords - Penknife-Groups; Late Glacial; GIS-analysis; raw-material economy
Federmesser-Gruppen; Spätglazial; GIS-Analyse; Rohmaterial Bezugsmuster

Introduction

Raw material procurement patterns are regularly employed to analyze land-use and mobility strategies of hunter-gatherer groups. For the Late Palaeolithic, studies from the Rhineland (e.g. Floss 1994; Baales 2001, 2004) and the Paris Basin (e.g. Valentin 1995; 2008) are well-known examples. At present, such studies are lacking for Northern Bavaria, despite the fact that a great number of penknife-sites are known from this region.

Since the 1970's amateur collectors have discovered numerous sites and collected large assemblages with more than 10,000 pieces each. The presence of backed points, burins and short scrapers assigns these collections to the Late Glacial Penknife-groups (ca. 12,000 – 10,800 BP). Especially the use of lithic resources transported over long distances has been a topic of discussion in the active scene of amateur archaeological collectors in Northern Bavaria. A supposed focus on exogenous raw materials also led to the definition of a putative regional group called the Atzenhofen Group, which is defined, in part, by a regular use of these specific flint varieties (Schönweiß 1974, 1992). The Atzenhofen Group is rejected by a number of authors on various grounds (Beck et al. 2009; Ikinger 1998) and is not in use today. However, the effort that was undertaken, and continues to be, by Schönweiß and other amateur collectors (Süß & Thomann 2009) makes it possible to easily obtain information about these sites in the study area.

Although the use of exogenous raw materials has long been a major topic in relation to the Bavarian Late Glacial sites, hardly any attempts have been undertaken to examine the situation closely. This article presents pertinent results obtained as part of the PhD project "Late Palaeolithic Land Use Patterns in Northern Bavaria". One of the goals of the project was

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to address the lack of critical research in precisely the topic of raw material procurement, economy, and mobility in Late Palaeolithic Northern Bavaria.

Materials and methods

The area of interest is made up by five individual natural landscape units (Fig. 1, Meynen et al. 1962a, 1962b). These regions are delimited by the hydrological, ecological and topographical characteristics of the various units. The lowlands of the Keuper-Lias Land and the Upper Palatinate Valley as well as the highlands of the Franconian Alb, the Upper Palatinate Forest and the Franconian-Thuringian Range provide the setting for the work.

The climatic context of the Penknife-Groups in Bavaria is characterized by the relatively warm temperatures of the Allerød-interstadial and the succeeding Younger Dryas stadial. While the Younger Dryas results in the return of open landscapes in northern Germany, vegetation change in Bavaria is limited to the high-altitude regions of the Alps and some select regions of the Bavarian Forest (Frenzel 1983; Knipping 1989; Stalling 1987). Palynological analyses show that the study area exhibits hardly any thinning of forestation or fundamental changes in floral composition. Therefore, the climatic and ecological background of the Penknife-groups does not change significantly.

A total of 94 sites are subject to investigation in the PhD project, although information on the lithic composition could only be obtained for 26 sites. Three of the assemblages are not located within the study area, but instead are located in the vicinity of Würzburg. Their locational information was obtained from the Bayerische Landesamt für Denkmalpflege (Bavarian Heritage Administration). Data on the lithic raw materials present in the various assemblages (e.g. the site of Oberweiherhaus, Schwandorf Distr., Appendix, Plate 1 or Lindenhof, Kemnath Distr. Appendix, Plate 2) was gained in three different ways resulting in a record with varying levels of quality. The dataset with the highest resolution was generated by an attribute analysis for 11 sites, that were entered into a Microsoft Access© database. Roughly 18,000 entries were recorded. A smaller dataset was obtained from the literature, especially for the sites outside the study area in the Czech Republic. A coarse grained dataset for a larger number of sites was extracted from the archives of the Bavarian Heritage Administration.

All 26 sites are surface collections and most likely represent the result of multiple occupations. In the beginning of the project assemblages were evaluated in terms of the probable admixture of Mesolithic artefacts. Collections with significant percentages of pieces from other time phases were not incorporated into the dataset. Since the collections did not provide any information that could lead to a chronological subdivision of the dataset, changes to the procurement

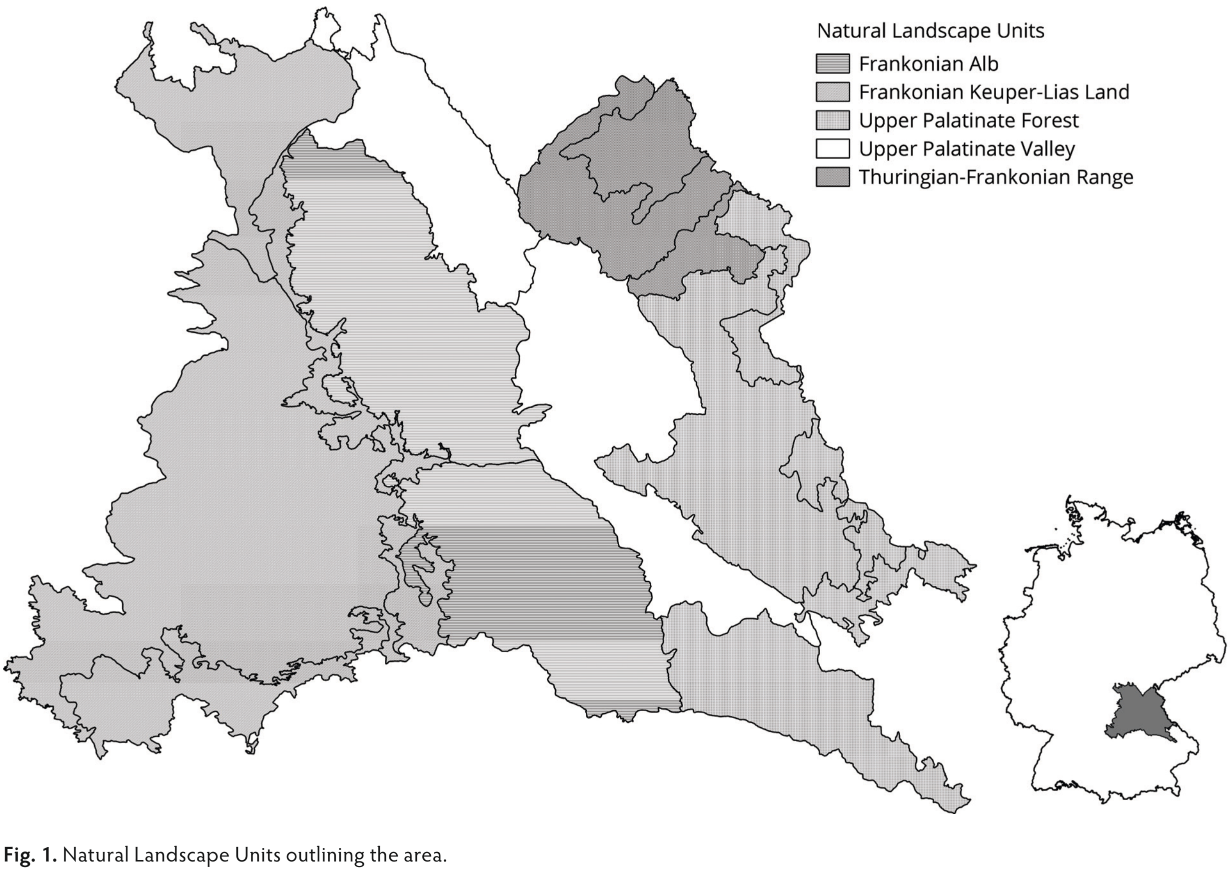


Fig. 1. Natural Landscape Units outlining the area.

Abb. 1. *Naturräumliche Landschaftseinheiten die das Untersuchungsgebiet umschreiben.*

and exploitation patterns over the period of the Penknife-groups could not be investigated. Given the little changes in climatic and ecological conditions, the land use pattern is assumed to be relatively steady as well. This assumption is corroborated by the investigation into the settlement and land use patterns which was also part of the PhD project. Both the ecological context of the sites and their topographic characteristics showed limited variance.

Besides the traditional attribute analysis of the 26 different assemblages, an important part of the work was the investigation of the relationship between transportation distance and the proportion of the various raw materials at the different sites. To generate a more accurate representation of the rate of discard, instead of the commonly used Euclidean distance a cost distance approach was selected to better reflect the distance between the specific outcrop and the site. This was conducted using the algorithm presented by van Wagtendonk and Benedict (1980). It estimates the movement speed by the impediment of the local slope. A speed on level ground of 3.2 km/h was chosen (Watts et al. 2003). In this paper, the cost distance (CD) was favored over the least cost path (LCP) that is often used in this context (Aubry & Luís 2015; Risetto 2012). The LCP's selectiveness in terms of choosing only a single pathway while rejecting any alternative routes with insignificantly longer distances seemed unsuitable for the task at hand.

The cost grid (raster dataset containing the calculated cost to traverse a given cell; the unit of cost in this work is time) for the CD was calculated based on a hiking function that estimates the walking speed for any raster cell by the impediment determined by the local slope (van Wagtendonk & Benedict 1980). The speed for travelling on a level surface used in the calculation was 3.2 km/h. By using the 25 m digital elevation model (DEM) for Bavaria, as it was provided by the Bayerische Vermessungsverwaltung (Bavarian administration for land survey), a continuous raster set was generated, which formed the basis for further analysis. The cost-distance was calculated with the corresponding ArcGIS tool for each outcrop. Due to the fact that in most cases a point-like location for the origin of the lithic resources was impossible to obtain (e.g. the Jurassic cherts generally originating from the Malm Delta to Zeta layers are present throughout all of the Franconian Alb), the geological layer was employed to be the origin for the calculation. The geological layers were extracted from the geological map-set of Bavaria and the corresponding set for Germany. The latter also contained a shapefile representing the ice-borders of the last glaciations (flint-line), which were used to model the erratic flint's potential CD.

Every site bearing the various raw materials in question in the study area was evaluated in terms of their modelled cost distance to the various outcrops. In this way it was possible to relate the variability in raw material frequencies to a close-to-realistic distance, acknowledging the landscape's topography in between. Changes in topography over the last millennia most likely has only limited influence on the results of the calculation. At this scale topography is relatively stable (MacMillan & Shary 2008).

Results

Raw materials identified in the study area

A variety of lithic raw materials were identified in different frequencies throughout the different sites. Jurassic chert originating from the Layers of the Malm Delta to Zeta (Weißmüller 1995), which make up the body of the Franconian Alb (Zimmermann 1995: 40), is the dominant lithic material and is found at all of the sites in question. These cherts are high quality toolstone, which is reflected by their recurring use over all of the Palaeolithic, Mesolithic and Neolithic in the Region. The Triassic layers that compose most of the lowland areas surrounding the Franconian Alb and most dominantly provide cherts (Löhr & Schönweiß 1987: 130) and chalcedony (sensu Zimmermann 1995: 44). Lydites originate from the Silurian layers, which emerge in the area of the Franconian Forest, north of the study area. The most likely point of collection by the Late Glacial foragers does not seem to be the primary outcrop but rather the gravels of the Main River and, in a less intense fashion, those of the Naab River, since almost all of the pieces identified carry a cortex associated with the relocation by water.

The secondary deposits of the tabular cherts lie in the Danube Valley, south of the study area. They are best known from the Neolithic chert-mines near Arnhofen-Abensberg, but they can also be procured throughout the downstream gravels of the Danube. Besides these Jurassic cherts, the region provides alpine radiolarites, which also originate from the fluvial deposits.

Besides these locally or regionally accessible lithic resources, other raw materials were identified which originate from outcrops or secondary deposits at a much greater distance. The most important of these is the erratic flint, which can be procured in the gravels of the end moraines of the Saalian and the Elster Glaciation. They comprise the so-called flint-line that is crossing Germany to the north of the german low mountain range (Harz, Rhön, Thuringian Forest, Fichtelgebirge) from east to west. The sections of particular interest for the Northern Bavarian study area are those of Thuringia and Saxony because they are closest to the area of interest at a distance of ca. 110 km. These flints have a rather characteristic dark-blue or blackish and translucent color and a cortex typically associated with their transportation in the glaciers. Therefore pieces showing parts of the cortex can be assigned to this raw material category without any doubt.

The last category is the Quartzites, which show a close connection to the Northeast of Bohemia. In some selected cases, the raw material showed the typical characteristics (glossy surface texture and very fine grained material) for Quartzite originating from the outcrop of Tušimice. This raw material plays an important role in many of the Late Palaeolithic sites of Bohemia and therefore a connection towards Bavaria seems likely.

General use of raw materials

The aforementioned lithic resources are used in varying intensity in different sites throughout the area of interest (Fig. 2). All assemblages are dominated by Jurassic chert which usually comprises >60 % of the pieces. The use of chalcedony, Triassic cherts, and lydite is evident in the region surrounding the site-cluster of Kemnath and the Fichtelgebirge. Apparently these raw materials were used only within this local context and are rarely transported beyond its borders. Procurement seems to be limited to the respective sites' territory. When specific raw materials cannot be obtained within this area of high-accessibility, their frequencies decrease to very low values.

Given the presence of various lithic materials originating from a much greater distance, the local situation has to be described. The varying procurement patterns of low quality local raw material and high quality exogenous raw materials suggest that the use of lithic resources in the area was not as indifferent to the materials' characteristics as it is assumed for other areas during the Late Palaeolithic (Valentin 1995, 2008).

The most striking raw material in terms of exoticness is the erratic flint, which has its closest point of origin at a distance of at least 110 km, measured from the northernmost site. It is present even in the South of the study area, roughly 180 km from the outcrop, which makes it an extraordinarily long-transported resource when compared to the other variants. The distance may have been even longer, if an indirect

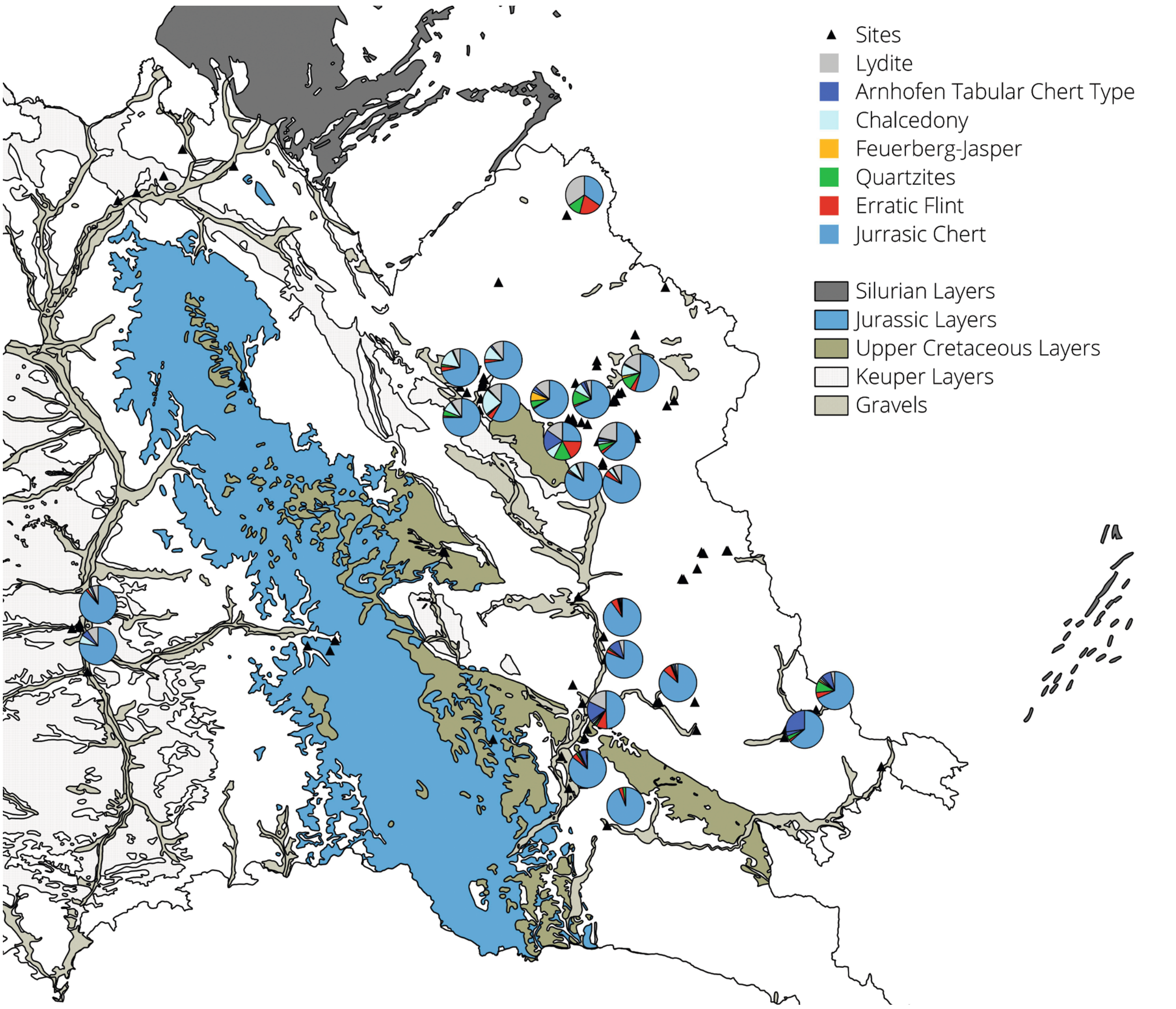


Fig. 2. Relative Frequencies of the various raw materials in the different Late Palaeolithic sites in the study area and the related geological layers.

Abb. 2. *Relative Häufigkeiten der unterschiedlichen Rohmaterialien in den verschiedenen spätpaläolithischen Fundstellen im Untersuchungsgebiet und die geologischen Schichten.*

route was taken. The flint is present at all of the sites in the study area with frequencies apparently rising slightly towards the East (Klíma 1966).

This indication of an eastward connection of the sites is supported by the quartzite, which at least in some cases could be confidently assigned to outcrops in the North of Bohemia based on its macroscopic features (Tušimice-type Quartzite). In this paper it is assumed that all of the quartzite types in the study area originate from beyond the range of the Upper Palatinate Forest.

Rate of discard of the raw materials

A comparison of the different discard rates as they are represented in the model clearly shows variation in the way the different materials were transported, depleted, and discarded (Fig. 3, Fig. 4). While the Jurassic cherts show a high initial frequency combined with a fast decrease and a rather short maximum cost distance value of only 47.2 h, other toolstones such as the Triassic raw materials or the plated cherts from the Danube Region play a less dominant role in the Late Glacial context. The low-quality lithic raw materials procured locally show a very short modelled maximum distance of only 22.4 h. In fact, the example of the Triassic cherts shows that the raw material was only procured when it was obtainable within the limits of the foraging radius which is set at a maximum of 4 h (compare Uthmeier et al. 2008). A similar situation is evident with the lydites that are linked to the northeastern part of the study area, close to the primary deposits of this raw material. The rather flat negative inclination of the regression fitted to the point cluster of these local variants suggests a rather limited exploitation and low discard intensity, especially in comparison to the chert types.

The situation is different among the exotic erratic flints. This material shows a clear tendency for long-distance transportation. Its frequency clusters around ca. 5 %, regardless of the distance to the outcrop. This is peculiar regarding the fact that the raw material is not of a particularly high quality, especially when it is compared to the easily obtainable Jurassic types. With a modelled y-axis intercept of more than 300 h its maximum cost distance is more than 13-fold than that of the cherts. The flat regression line is again seen to reflect rather low exploitation intensity.

On the basis of this analysis, the toolstones can be separated into two groups. While one contains such variants that are used only in a highly local context, the others show transportation over long distances into and out of the study area. Whether these variations also entail variability in exploitation is to be examined in the next section.

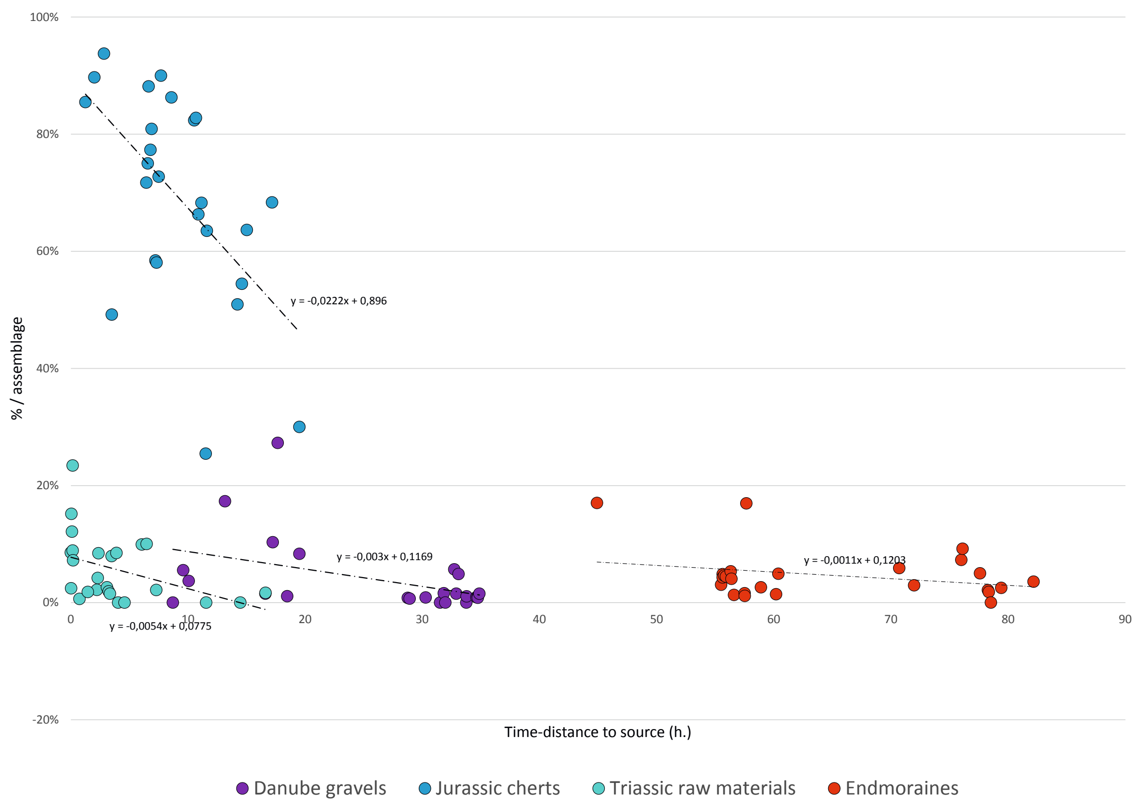


Fig. 3. Raw material frequencies of the various raw materials in the different assemblages, related to their respective cost-distance to the outcrop. Dotted line: Linear trend of the various clusters.

Abb. 3. *Häufigkeiten der unterschiedlichen Rohmaterialien in den unterschiedlichen Inventaren in Bezug zu Kostendistanz zur Rohmaterialquelle. Gepunktete Linie: Linearer Trend der unterschiedlichen Cluster.*

Fundstelle	Danube gravels (Time distance in hours)	Relative frequency (%)	Jurassic cherts (Time distance in hours)	Relative frequency (%)	Triassic raw materials (Time distance in hours)	Relative frequency (%)	Endmoraines (Time distance in hours)	Relative frequency (%)
Weißenhof	8.7	*0*	1.2	*85*	0.0	*9*	55.5	*3*
Straßäcker	9.6	*6*	2.8	*94*	0.0	*2*	55.6	*5*
Lindenlohe	13.2	*17*	3.5	*49*	0.1	*15*	55.6	*4*
Uckersdorf	16.6	*2*	6.4	*72*	0.1	*12*	55.8	*5*
Perschen	17.2	*10*	6.6	*75*	0.2	*9*	55.9	*4*
Schönthal 7	17.7	*27*	6.6	*88*	0.2	*23*	56.3	*5*
Pfreimd	18.5	*1*	6.8	*77*	0.2	*7*	56.4	*4*
Waldmünchen-Hocha	19.5	*8*	6.9	*81*	0.7	*1*	56.6	*1*
Ketzerrang	28.8	*1*	7.2	*58*	2.2	*2*	57.5	*2*
Wurz-Schlattein	28.9	*1*	7.3	*58*	2.3	*4*	57.5	*1*
Neuhaus-Johannistal	30.3	*1*	7.5	*73*	2.4	*8*	57.7	*17*
Trautenberg-Aspenäcker	31.5	*0*	7.7	*90*	3.1	*3*	58.9	*3*
Lehenrang	31.8	*2*	8.6	*86*	3.2	*2*	60.2	*1*
Steigäcker	32.0	*0*	10.5	*82*	3.3	*2*	60.4	*5*
Atzenhof	32.7	*6*	10.7	*83*	3.5	*8*	70.7	*6*
Flexdorf	32.9	*2*	10.9	*66*	3.9	*8*	72.0	*3*
Kapellenfeld	33.1	*5*	11.2	*68*	4.0	*0*	76.0	*7*
Bärensteinerin	33.8	*0*	11.5	*25*	4.6	*0*	76.1	*9*
Schrollenbühl	33.8	*1*	11.6	*63*	6.1	*10*	77.6	*5*
Gartenäcker	34.6	*1*	14.2	*51*	6.5	*10*	78.3	*2*
Pferchleite	34.7	*1*	14.6	*54*	7.3	*2*	78.3	*2*
Lindenäcker	34.7	*1*	15.0	*64*	14.5	*0*	78.5	*0*
Sommerheu	34.9	*2*	17.2	*68*	16.6	*2*	82.2	*4*
Oberweiherhaus	10.1	*4*	2.0	*90*	1.5	*2*	79.4	*3*
Hendelhammer	44.6	*0*	19.5	*30*	11.6	*0*	44.9	*17*

Fig. 4. Relative frequencies and time distances of the different assemblages represented in Fig 3.

***Abb. 4.** Relative Häufigkeiten und Zeitdistanzen der verschiedenen Inventare wie sie in Abb. 3 dargestellt sind.*

Exploitation patterns of the raw materials

In theory the lithic raw material variants related to greater transportation distance should show a different exploitation pattern, given that a down-the-line production of tools from these raw materials should influence the appearance and size of the lithic artifacts. The question remains whether the opportunistic way of obtaining end products from these toolstones – which is typical for the Late Palaeolithic – can also be observed in the study area and whether this generic and flexible approach is applied to the local and exotic toolstone varieties in the same fashion. Intuitively, one would assume that a raw material which is being moved over great distances would require greater energy investment and would also be treated differently.

It has to be kept in mind that the collections most likely represent palimpsests of numerous occupations. Therefore, the assumption is made that the generally unchanging climatic and vegetational conditions in the study area paired with the homogeneous characteristics of both the settlement and the land use pattern would lead to limited changes in the general raw material procurement and exploitation pattern. Nevertheless, excavated sites could reveal a more pronounced pattern. Results presented here should only be regarded as general tendencies.

Different proxies for the exploitation of toolstones were examined. Given that the artifacts were entered in the database at a relatively coarse resolution, investigations of the material exploitation must also remain relatively simple. The lithic artifacts created out of the different raw materials do not seem to vary on a level exceeding the variation that is expected given the geometry of the individual nodules (Fig. 5). This is most clear in the case of the tabular chert, whose plated shape forces the production of elongated products as well as a high percentage of secondary crested blades with a cortical side. Overall, the forms created do not differ significantly depending on

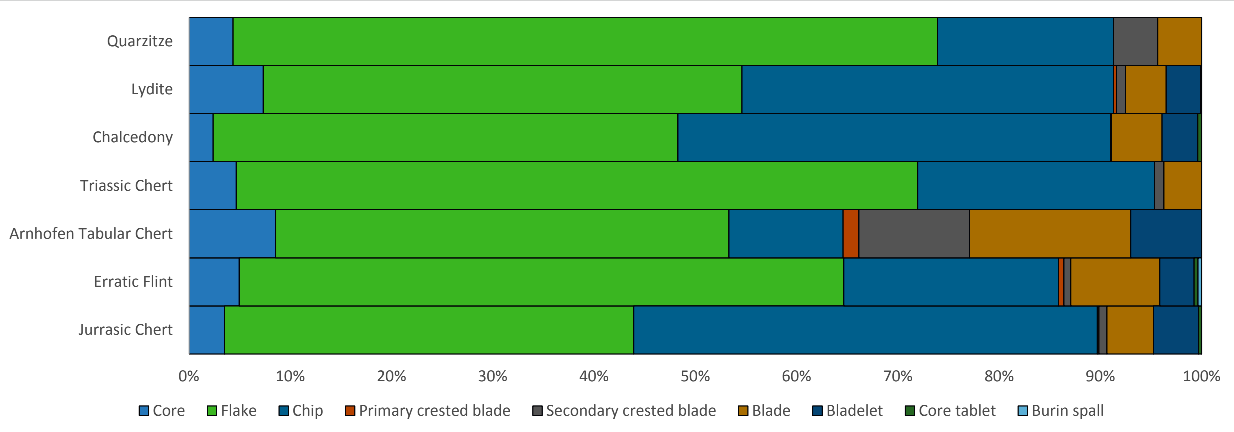


Fig. 5. Frequencies of the various artefact forms in relation to the different raw materials in the study area.

Abb. 5. *Häufigkeiten der verschiedenen Grundformen in Bezug zu den verschiedenen Rohmaterialvarianten im Untersuchungsgebiet.*

toolstone variant. In fact, the locally procured and intensively used chert shows a near identical product range compared to the exotic erratic flint.

The same is true for the frequencies of cortical surfaces on the different toolstones (Fig. 6). Again, the tabular chert deviates strongly due to its geometrical shape. And yet again, a clear difference between the exogenous flint and the local variants cannot be stated. The uniformity of the cortex coverage seems to be especially counterintuitive. Given a down-the-line exploitation of the raw materials, the exogenous variants should provide lower frequencies in cortical products. When the frequency of cortex-bearing pieces is set in relation to the distance to the closest potential point of origin, the picture remains the same. Across all sites that could be examined in terms of this proxy no clear pattern becomes visible, suggesting a down-the-line exploitation did not happen with the raw materials. When examining the mean core weights of the varying toolstones in the different sites, no pattern is evident. With the Jurassic chert's coefficient of determination (R^2) of only 0.17 and with the erratic flint's value of 0.07, the distributions are not following a linear pattern.

Another factor that may reflect distinct patterns of exploitation of different raw materials is the core/tool ratio within the individual assemblages (e.g. Henry 1989). While more and more cores are discarded with increasing distance to the outcrop, the tools produced from said cores remain in use for a longer period of time. This way – in theory, at least – the ratio of tools/core made from the respective raw materials should increase with the distance covered. The Jurassic chert shows a signal that clearly supports such a relationship. While all the other raw materials show no pattern whatsoever, the ratio increases threefold for chert along a transect from the sites closest to the outcrop to the sites farthest away. This supports the interpretation of the rate of discard above. Jurassic chert was apparently intensively exploitated and this is reflected in several proxies.

Discussion

The data presented here does not suggest that raw materials from different sources were treated differently in the Late Palaeolithic sites of Bavaria. Neither the local nor the exotic variants show signs of a down-the-line exploitation pattern. Instead, an opportunistic use of various raw materials as it already has been proposed

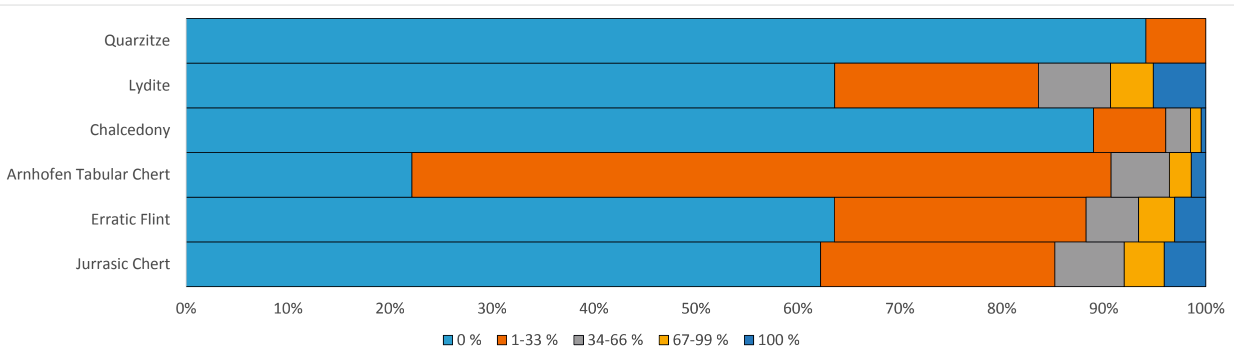


Fig. 6. Relative frequencies of the different cortex coverages on the artefacts created from the different raw materials.

Abb. 6. *Relative Häufigkeiten der unterschiedlichen Kortexanteile an den Artefakten aus den verschiedenen Rohmaterialvarianten.*

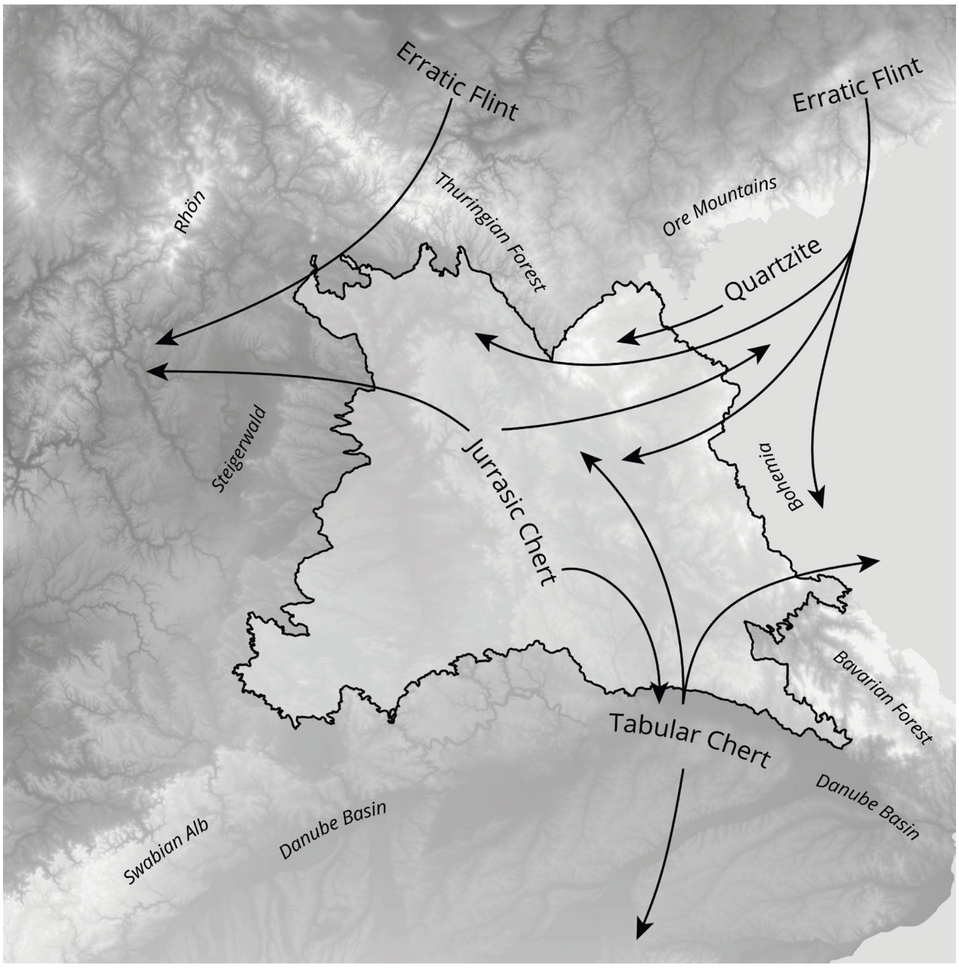


Fig. 7. Routes of procurement in the study area; The strong connection of the sites in Northern Bavaria towards the East is clearly shown by the bidirectional transportation of cherts, quartzites and erratic flint.

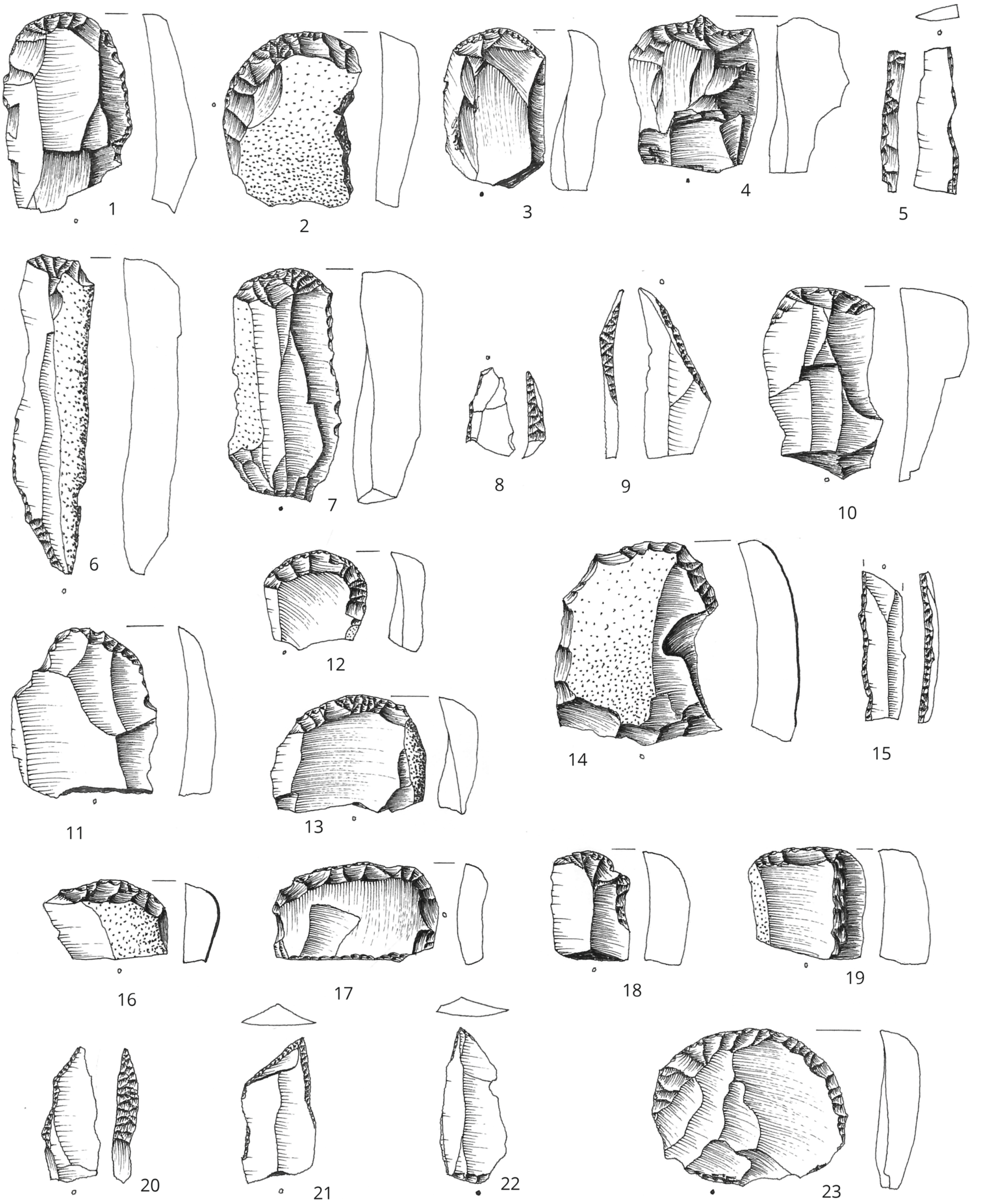
Abb. 7. Bezugsrouten im Untersuchungsgebiet; Die starke Verbindung der nordbayerischen Fundstellen nach Osten wird durch den bidirektionalen Transport der Hornsteine, Quarzite und Kreidefeuersteine deutlich.

for other regions like the Paris Basin and as it is generally assumed to be a typical characteristic of the Late Glacial hunter-gatherers, is also apparent in the Bavarian assemblages. It remains peculiar, however, that even those raw materials that were transported over long distances and the procurement of which almost certainly entailed the expenditure of additional energy were not treated differently than the locally procured low-quality types. Economic value alone may not be the only factor explaining the presence of exotic toolstones in the region.

The tendency for opportunistic core depletion in this period and in the study area is best captured at the sites of Sarching (Heinen 2005; Werner & Schönweiß 1974). The assemablges from this short-term hunting camp shows a chaîne opératoire ranging from the exploitation and discard of cores to the production of implements for mending arrows. The generic and ad-hoc fashion of production was not only executed in the larger camps that are represented by the surface collections in the study area, but also in the context of specialized tasks where the taking along of replacement points would have sufficed.

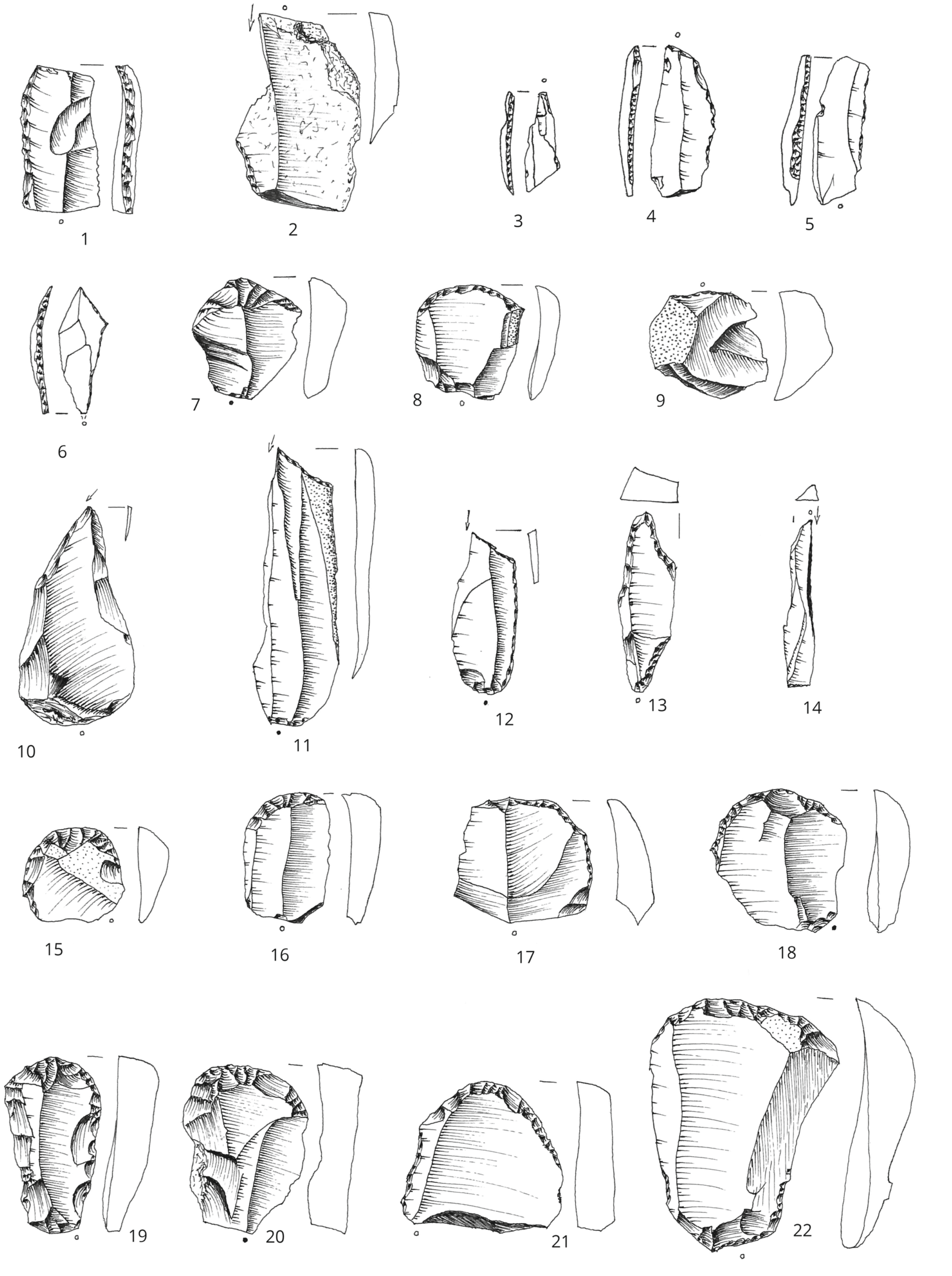
Late Glacial foragers clearly distinguished between locally procured toolstones of rather low quality and variants, which merited transportation over longer distances. Local, low quality raw materials were rarely transported beyond the borders of the foraging radius, as it is reflected by their clustered presence in sites whose foraging radius covered the respective outcrops.

In conclusion, the data presented here show that Final Palaeolithic hunter-gatherers were highly mobile people, frequently moving between the North German Plains and the Danube Basin (Fig. 7). Based on the presence of quartzites from Bohemia, movement went in an eastward direction via a route that was not the path of the least cost (which would be a crossing of the Rhön in a northward direction). Transportation also occurred through the Cham-Furth Lowlands were tabular cherts were transported into Southern Bohemia. The various raw materials in the different regions within and around the study area show clearly that the movement patterns were complex and extensive and that the hunter-gatherers accessed a variety of landscapes with changing opportunities and limitations.



Appendix, Plate 1. Modified lithic artefacts from the site of Oberweiherhaus, Schwandorf district; 1–4, 6, 7, 10–14, 16–19, 23 scrapers; 5, 15 backed knifes; 8 backed fragment; 9 end-retouched piece; 20–22 backed points; drawings: R. Graf; scale 1:1.

Appendix, Tafel 1. *Modifizierte Stücke aus der Fundstelle Oberweiherhaus, Ldkr. Schwandorf; 1–4, 6, 7, 10–14, 16–19, 23 Kratzer; 5, 15 Rückenmesser; 8 rückengestumpftes Fragment; 9 Endretusche; 20–22 Rückenspitzen; Zeichnungen R. Graf; Maßstab 1:1.*



Appendix, Plate 2. Modified lithic artefacts from the site of Lindenhof, Kemnath district; 1 retouched blade; 2, 10–12, 14 burins; 3–6 backed points; 7–9, 15–22 scrapers; 13 end-retouched piece; drawings: R. Graf; scale 1:1.

Appendix, Tafel 2. *Modifizierte Stücke aus der Fundstelle Lindenhof, Ldkr. Kemnath; 1 kantenretuschierte Klinge; 2, 10–12, 14 Stichel; 3–6 Rückenspitzen; 7–9, 15–22 Kratzer; 13 endretuschiertes Stück; Zeichnungen R. Graf; Maßstab 1:1.*

Literature cited

Aubry, T. & Luís, L. (2015). Adaption to Resources and Environments during the Last Glacial Maximum by Hunter-Gatherer Societies in Atlantic Europe. *Journal of Anthropological Research* 71 (4): 521-544.

Baales, M. (2001). From lithics to spatial and social organization: interpreting the lithic distribution and raw material composition at the Final Palaeolithic site of Kettig (Central Rhineland, Germany). *Journal of Archaeological Science* 28 (2): 127-141.

Baales, M. (2004). Local and Regional Economic Systems of the Central Rhineland Final Paleolithic. In: L. S. d. Congrès (Ed.) *Le Mésolithique / The Mesolithic.* Société royale belge d'anthropologie et de préhistoire, Oxford 2004, 3-9.

Beck, M., Beckert, S., Feldmann, S., Kaulich, B. & Pasda, C. (2009). Das Spätpaläolithikum und Mesolithikum in Franken und der Oberpfalz. *Bericht der Bayerischen Bodendenkmalpflege* 50: 269-291.

Floss, H. (1994). *Rohmaterialversorgung im Paläolithikum des Mittelrheingebietes*. Dr. Rudolf Habelt GmbH, Bonn.

Frenzel, B. (1983). Die Vegetationsgeschichte Süddeutschlands im Eiszeitalter. In: Müller-Beck, H. (Ed.) *Urgeschichte in Baden-Württemberg*. Theiss Verlag, Stuttgart, 91-166.

Heinen, M. (2005). Sarching '83 und '89/90. *Untersuchungen zum Spätpaläolithikum und Frühmesolithikum in Südost-Deutschland*. Welt und Erde Verlag, Loogh.

Henry, D. O. (1989). Correlations between reduction strategies and settlement patterns. *Archeological Papers of the American Anthropological Association*, 1 (1): 139-155.

Ikinger, E.-M. (1998). *Der endeiszeitliche Rückenspitzen-Kreis Mitteleuropas.* Lit Verlag, Münster.

Klíma, B. (1966). Epipaläolithikum im oberen Egertal. *Quartär* 17: 91-116.

Knipping, M. (1989). *Zur spät- und postglazialen Vegetationsgeschichte des Oberpfälzer Waldes*. Schweizerbart, Berlin, Stuttgart.

Löhr, H. & Schönweiß, W. (1987). Keuperhornstein und seine natürlichen Vorkommen. *Archäologische Informationen* 10 (2): 126-137.

MacMillan, R. A. & Shary, P. A. (2008). Landforms and Landform Elements in Geomorphometry. In: Hengl, T., Reuter, H. I. (Eds.) *Geomorphometry: concepts, software, applications.* Elsevier, Amsterdam, Boston, Heidelberg, London, New York, Oxford, Paris, San Diego, San Francisco, Singapore, Sydney, Tokyo.

Meynen, E., Schmithüsen, J., Gellert, J., Neef, E., Müllerminy, H. & Schultze, J. (1962a). *Handbuch der naturräumlichen Gliederung Deutschlands*. Selbstverlag Institut für Landeskunde, Bad Godesberg.

Meynen, E., Schmithüsen, J., Gellert, J., Neef, E., Müllerminy, H., Schultze, J. (1962b). *Handbuch der naturräumlichen Gliederung Deutschlands*. Selbstverlag Institut für Landeskunde, Bad Godesberg.

Risetto, J. (2012). Using Least Cost Path Analysis to Reinterpret Hunter-Gatherer Procurement Zones. In: D. White, D., Surface-Evans, S. (Eds.) *Least Cost Analysis of Social Landscapes. Archaeological Case Studies.* University of Utah Press, Salt Lake City, 11-31.

Schönweiß, W. (1974). Fränkisches Epipaläolithikum - Die Atzenhofener Gruppe. *Bonner Hefte zur Vorgeschichte* 8: 17-108.

Schönweiß, W. (1992). *Letzte Eiszeitjäger in der Oberpfalz. Zur Verbreitung der Atzenhofener Gruppe des Endpaläolithikums in Nordbayern*. Bodner, Grafenwöhr.

Stalling, H. (1987). *Untersuchungen zur spät- und postglazialen Vegetationsgeschichte im Bayerischen Wald*. Schweizerbart, Göttingen.

Süß, E. & Thomann, E. (2009). *Vorgeschichtliche Funde aus dem Landkreis Schwandorf*. Selbstverlag, Nabburg.

Uthmeier, T., Ickler, S. & Kurbjuhn, M. (2008). Site Catchment Analysis in the Late Middle Palaeolithic of Crimea: a GIS Based Approach. In: Chabai, V., Richter, J., Uthmeier, T. (Eds.) *Kabazi V: Interstratification of Micoquian and Levallois-Mousterian camp sites, Part II*. Shlyak, Simferopol.

Valentin, B. (1995). *Les groupes humains et leurs traditions au Tardiglcaiaire dans Bassin Parisien. Apports de la technologie lithique comparée.* Thèse de Doctorat de l'Université Paris I. Paris.

Valentin, B. (2008). Magdalenian and Azilian Lithic Production in the Paris Basin: Disappearance of a Programmed Economy. *The Arkeotek Journal* 2 (3).

van Wagtendonk, J. W. & Benedict, J. M. (1980). Travel time variation on backcountry trails. *Journal of Leisure Research* 12 (2): 100-106.

Watts, R. D., Compton, R. W., McCammon, J. H. & Ouren, D. S. (2003). Intensity of human use, backcountry roads, and analysis of human accessibility. *Tahoe Research Group/ Tahoe Environmental Research Center.*

Weißmüller, W. (1995). *Sesselfelsgrotte II. Die Silexartefakte der Unteren Schichten der Sesselfelsgrotte. Ein Beitrag zum Problem des Moustérien*. Franz Steiner Verlag, Saarbrücken.

Werner, H. & Schönweiß, W. (1974). Eine epipaläolithische und mesolithische Wohnanlage von Sarching, Ldkr. Regensburg. Eine Fundstelle der "Atzenhofener Gruppe" im Donautal? *Bonner Hefte zur Vorgeschichte* 8: 109-120.

Zimmermann, A. (1995). *Austauschsysteme von Silexartefakten in der Bandkeramik Mitteleuropas*. Verlag Dr. Rudolf Habelt, Bonn.