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Chert procurement strategies in the LBK settlement of Meindling, Bavaria

In this paper the chert assemblage of the Linearbandkeramik site at Meindling in southeastern Bavaria is analyzed. The settlement is located at a distance of at least seventeen kilometres from the nearest outcrops of chert bearing rocks. Its inhabitants practised a procurement strategy different from that known at Bandkeramik sites in flint-bearing regions, such as Hienheim. This strategy involved a more careful selection of raw material at extraction sites. However, there was no evidence for a dearth of raw material, nor for parsimonious behaviour once the chert had arrived at the settlement.

1. Introduction

During the trial excavation performed in 1977 at the Linear Bandkeramik (LBK) site of Meindling (Gde. Oberschneiding, Ldkr. Straubing-Bogen) by the Leiden University Institute for Prehistory (Modderman 1978, in press) a total of 236 chert artefacts were recovered. A detailed study of the small assemblage seemed worthwhile, since this could provide insight into the lithic procurement system of a Bavarian LBK settlement located far from raw material sources, thus supplementing previous work on Hienheim (Ldkr. Kelheim), which is situated close to several outcrops of high-quality chert (De Grooth 1977, 1994, in press). Given the small number of artefacts, it was decided to study them only at site-level — individual pits contained 18 artefacts at the most —, and to include the few artefacts recovered from the mechanically removed topsoil as well. This procedure seems justified, as all but one of the artefacts are Linear Bandkeramik in character. The one exception is the fragment of a bifacially worked sickle or knife (fig. 2, M81), made from tabular chert of the Baiersdorf type and characteristic for the regional Late Neolithic Altheim and Cham Cultures (Binsteiner 1989; De Grooth 1977, 76; Driehaus 1960). The reference material from Hienheim used in this study consists of a sample of 754 artefacts stemming from sixteen Early and Middle LBK refuse pits (De Grooth 1994) and made on nodular cherts originating from the surrounding Franconian Alb. Both assemblages were coded using the same list of variables, although for Meindling a number of variables were added, allowing for a more accurate characterization of the kinds of raw material present.

The excavation techniques used in Meindling and Hienheim were similar, as were the amount of erosion, and the general character of the settlements in terms of the density of houses and the frequency of refuse pits. Therefore, assessing the density of artefacts from both excavations provided a suitable starting point for a comparison of the lithic procurement systems of both sites (Torrence 1986).

In Meindling 235 LBK flint artefacts were found in 1400 square metres of excavation (surface finds included), i.e an average of one flint artefact per 6 m^2. The first series of excavations at Hienheim (up till and including 1970), with an excavated surface of 7356 m^2 (Modderman 1977), yielded 2750 LBK flint artefacts from dated pits alone (De Grooth 1977, 69, tab. 1), i.e. at least one flint artefact per 2.7 m^2. Thus, the overall density in Hienheim was at least twice as high as that found in Meindling.

The difference in *tool* density, however, is much smaller, Meindling having 1 tool/14.6 m^2, and Hienheim 1 tool/ 18.0 m^2. This indicates that the inhabitants of Meindling displayed behaviour different from those at Hienheim as regards raw material acquisition and tool *production*, but not in tool *consumption*. The settlement's location, relatively distant from sources of raw material, may be regarded as an obvious cause.

2. Raw material

Meindling is situated in the loess-covered *Gäuboden*, an area without chert-bearing layers in its subsoil. The nearest outcrops occur at a distance of some seventeen kilometres to the north-west, on the other bank of the Danube, where small residual outcrops of Jurassic (more specifically Malm beta) chalks at the Buchberg and the Helmberg near Münster (Ldkr. Straubing-Bogen) contain nodular cherts (fig. 1). Similar exposures occur c. 35 and c. 50 km to the south-east at Flintsbach-Hardt (Ldkr. Deggendorf) and in the Ortenburg (Ldkr. Vilshofen) region (Binsteiner 1990b; Röhling 1987; Weißmüller 1991). Following Weißmüller's suggestion (1991, 35) I shall use the name 'Ortenburger Jurassic chert' (*Ortenburger Jurahornstein*) for this type of raw material. At present, exploitation of the Münster outcrops can only be presumed (Binsteiner 1990b), but at

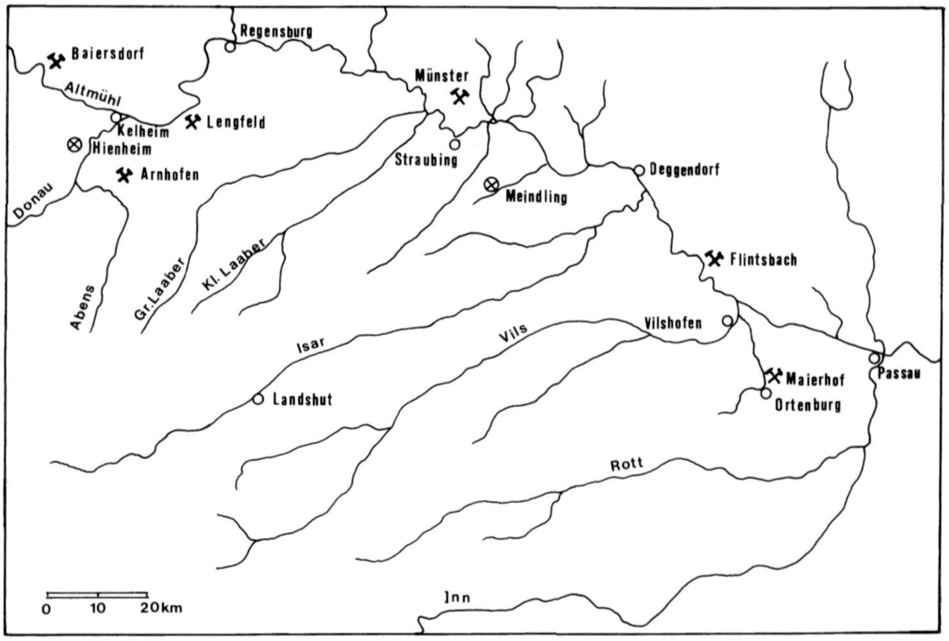

Figure 1. Map showing the location of settlements and chert extraction sites mentioned in the text.

both Flintsbach and Maierhof/Weng (Ldkr. Vilshofen) systematic exploitation of residual deposits of this type of silex has been documented (Moser 1980, 450; Weißmüller 1991).

Other important sources of chert are located to the west of Regensburg, at a distance of more than 65 km from Meindling, in the southernmost part of the Franconian Alb. Some of the concretions extracted here are Cretaceous in age (Birnbach near Hausen, Ldkr. Kelheim; Moser 1980, 451), but most belong to the Jurassic Malm zeta (Binsteiner 1990b, 1992; Moser 1980). They are present not only in the bedrock, but also in residual loams (*lehmig-kieselige Albüberdeckung*), which cover large parts of the region. The investigated Neolithic mines in the Kelheim area all exploited residual cherts: Arnhofen-Abensberg (Binsteiner 1990a; Engelhardt/ Binsteiner 1988), Baiersdorf (Binsteiner 1987, 1989) and Lengfeld (Reisch 1974; Rind 1992).

The varieties of chert present in Meindling can nearly all be assigned to the two provenances described, although in some cases the heavily rolled cortex points to an origin in chert-bearing river gravels, as may be found in the Danube valley close to Straubing (Ganslmeier 1984). Table 1 demonstrates that approximately 50% came from the Ortenburger outcrops and c. 35% from the Franconian Alb. The nearest two Ortenburger outcrops, Münster and Flintsbach, may have been exploited by inhabitants of Meindling during short trips. The material from the Franconian Alb could have been obtained either during longer expeditions or by means of indirect supply. For a more detailed analysis of the prevailing procurement strategies one must first determine whether or not both groups of raw material were treated in different ways and whether the situation in Meindling differs in this respect from that in Hienheim.

3. Technology

The three assemblages under consideration (cherts from the Ortenburger and Franconian Alb at Meindling, as well as material from the Franconian Alb at Hienheim, to be abbreviated as M-ORT, M-ALB, and H-ALB respectively) do not differ as regards the average dimensions of blades and flakes (maximum width, maximum thickness, platform width and thickness), indicating that similar knapping techniques were used at both sites (tab. 2).

Because of the small number of complete blanks in Meindling their average length could not be compared. The degree of fragmentation differs only slighty. The length of flakes and flake fragments is also similar. The mean length of all blades (i.e. including fragments) of both types of chert is somewhat shorter at Meindling.

Between the samples, however, marked differences are found in the frequency of the various categories of artefacts. (tab. 3). Thus, we find in Hienheim for every ALB core/hammerstone twice as many blades, and almost four times as many flakes as in Meindling. In Meindling the proportion of flakes is identical for both types of raw material, but the Ortenburg chert has even fewer blades for every core (tab. 4). In this respect the Meindling figures are

Table 1. Meindling: review of raw materials.

type		provenance	number
1.	Brownish or greyish nodules with many dots (< 2 mm) and/or specks; sometimes with a zoning of lighter and darker areas. Artificial surfaces generally are smooth. The cortex is mostly thin and rough*	Ortenburger Jura	114
2.	Greyish brown homogeneous nodules, again mostly with a rough cortex and smooth artificial fracture surfaces	Ortenburger Jura	6
3.	Whitish-, bluish- or dark grey nodules with a homogeneous structure and predominantly smooth fracture surfaces. The thin cortex is either rough or smooth	Residual loams Franconian Alb	12
4.	Bluish- or dark grey nodules with a gradually zoned structure, smooth artificial surfaces and a thin, smooth cortex**	Residual loams Franconian Alb	30
5.	Bluish-, whitish- or dark grey banded nodules, with sharply defined bands/stripes, smooth or shiny artificial surfaces and a thin, rough cortex	Probably Arnhofen-Abensberg	15
6.	Bluish grey striped tabular cherts with smooth or shiny fracture surfaces, and a thin, rough cortex	Arnhofen-Abensberg	14
7.	Greyish specked, zoned, or striped cherts (mostly nodules, but also some tablets), that have become multi-coloured (reddish, ochre, greenish), perhaps through secondary infiltration of iron- or manganese-hydroxides. In some cases, however, patination or slight thermal alteration cannot be excluded as causes for this colouring	Arnhofen-Abensberg or Lengfeld	10
8.	Miscellaneous. This group comprises single pieces, most of them probably stemming either from residual loams of the Franconian Alb or from river gravels. Remarkable is the fragment of an end-retouched bladelet, reddish in colour with a thin, shiny, dark red cortex	Residual loams or Danube river gravels	18
9.	Unidentifiable, mostly because of thermal alterations		16

* Five cores and one flake show heavily rolled natural surfaces, indicating these originate from river gravels.

** The heavily rolled natural surfaces of three cores in this group, however, indicate a (secondary) river gravel context.

Table 2. Measurements of blanks in Meindling and Hienheim.

	M-ORT flakes	M-ORT blades	M-ALB flakes	M-ALB blades	H-ALB flakes	H-ALB blades
Width (when complete), mm	x=24.5 s=6.0 N=28	x=17.6 s=3.8 N=43	x=24.9 s=6.7 N=16	x=16.8 s=3.7 N=32	x=27.3 s=12.7 N=203	x=16.7 s=5.1 N=153
Thickness (when complete), mm	x=6.4 s=2.3 N=48	x=4.9 s=1.6 N=54	x=7.5 s=4.1 N=27	x=5.4 s=2.1 N=44	x=7.9 s=5.1 N=326	x=5.3 s=2.0 N=301
Platform width (when complete), mm	x=13.9 s=7.4 N=39	x=9.0 s=2.6 N=25	x=12.7 s=7.8 N=23	x=9.4 s=2.7 N=21	x=14.0 s=9.4 N=223	x=9.4 s=3.2 N=151
Platform thickness (when complete), mm	x=4.6 s=2.6 N=39	x=3.5 s=1.5 N=25	x=4.3 s=3.0 N=23	x=4.0 s=1.8 N=21	x=5.4 s=3.8 N=225	x=4.2 s=1.7 N=151
Length (fragments included), mm	x=26.9 s=7.6 N=48	x=29.6 s=9.2 N=54	x=27.1 s=9.3 N=27	x=31.6 s=11.6 N=44	x=30.6 s=12.9 N=323	x=33.4 s=12.1 N=302

Table 3. Meindling and Hienheim, principal artefact categories.

	M-ORT		M-ALB		M-total		H-ALB	
	n	%	n	%	n	%	n	%
Blades, tools	40	33.3	26	32.1	72	30.6	141	18.7
Blades, non-tools	14	11.7	18	22.2	41	17.4	162	21.5
Flakes, tools	14	11.7	10	12.3	26	11.1	68	9.1
Flakes, non-tools	34	28.3	17	21.0	59	25.1	258	34.2
Cores	13	10.8	7	8.6	21	8.9	22	2.9
Chips	0		0		2	0.9	21	2.8
Artefact fragments	5	4.2	2	2.5	12	5.1	81	10.7
Natural blocks	0		1	1.2	2	0.9	1	0.1
total	120		81		235		754	

Table 4. Proportions of cores, flakes and blades in Meindling and Hienheim.

	M-ORT	M-ALB	H-ALB
Core : flake	1:4	1:4	1:15
Core : blade	1:4	1:6	1:14

comparable to those from LBK settlements in the Lower Vils Valley, situated some 20-30 km to the southeast, where Ortenburger Jurassic cherts were the predominant raw material (Schötz 1988).

This could mean that the cherts were transported to Meindling at a later stage of the reduction sequence than that at which they reached Hienheim, i.e. not as unprepared blocks or initially prepared cores (De Grooth 1977, 1994), but as completely prepared or even partially reduced cores. This hypothesis may be tested through a detailed comparison of technological variables for all three assemblages, based on the following propositions:

If the initial stages of the reduction sequence had indeed been performed elsewhere, one would expect to find in Meindling:

1. fewer artefacts with cortex;
2. fewer blanks with striking platforms consisting of cortex and/or natural surfaces.

If at Meindling cores were also worked more intensively (because of a relative scarcity of raw material), one would expect to find:

3. more blanks with a primary or secondary facetted platform, the result either of more careful platform preparation or of a more frequent use of exhausted core faces as striking platforms;
4. more rejuvenation blanks;
5. the average number of striking platforms and core faces on the cores would be higher;
6. the average size of the exhausted cores would be smaller.

If the small amount of blades in the ORT assemblage was caused by smaller dimensions and/or lower quality of the initial nodules, one would expect to find:

7. more cortex on ORT than on ALB blanks;
8. a smaller average number of negatives of removed blanks pro core;
9. a smaller average number of previous negatives on the dorsal faces of flakes and blades.

The data summarized in table 5 clearly support the first three assumptions, the proportion of cortex and natural fracture surfaces being much lower at Meindling than at Hienheim, whilst more facetted platform surfaces are present. Core rejuvenation also seems to have been practised more frequently at Meindling.

The fifth proposition, unfortunately, cannot be evaluated for the Meindling ALB cores, as all but two of them are completely covered by hammerstone traces. It must be rejected for the ORT group, however. Moreover, the average weight of cores of both ORT and ALB chert at Meindling is not lower, but higher than at Hienheim.
In combination with the higher proportion of facetted platforms and core rejuvenation, this could mean that at Meindling cores were not actually worked more intensively, but that a higher proportion of blanks derive from later stages in the reduction sequence, when platforms generally were prepared more carefully (Cahen 1984; De Grooth 1987, 1988). The last three propositions, concerning possible differences between the two groups of raw material, are weakly supported by the slightly lower average number of negatives on the Ortenburger in

Table 5. Comparison of technological data for Meindling and Hienheim nodular chert.

	M-ORT	M-ALB	H-ALB
Artefacts with cortex (%)	49.2	49.4	66.7
Striking platforms on blanks (%)			
– cortex	17.4	16.0	23.6
– smooth	39.1	43.0	45.7
– facetted	37.7	42.0	22.6
– other	5.8	8.0	8.2
Dorsal scars (blanks)	x = 1.9 s = 1.1 N = 83	x = 2.0 s = 1.2 N = 54	x = 2.0 s = 1.1 N = 496
Rejuvenation blanks (%)	6.9%	7.0%	5.1%
Weight of cores (gr)	x = 88.6 N = 13	x = 111.7 N = 7	x = 77.6 N = 22
Negatives on cores	x = 5.8 s = 3.1 N = 9	(x = 7.0 N = 2)	x = 7.2 s = 3.8 N = 15
Core faces/ striking platforms	x = 3.2 s = 1.0 N = 9	(x = 5.5 N = 2)	x = 3.8 s = 1.2 N = 16

Table 6. Meindling, retouched tools and artefacts with macroscopically visible traces of use wear.

type		ORT	ALB	?	n	%
arrowheads		1			1	0.9
borers			1		1	0.9
end-scrapers		7	11		18	15.2
single	11					
double	2					
+ end-retouche	1					
+ side-retouche	4					
sickle blades		21	7	1	29	24.6
single	11					
double	1					
+ end-scraper	1					
+ end-retouch	16					
end-retouched blades		6	5	3	14	11.9
single	11					
double	2					
+ side-retouch	1					
side-retouched blades		6	4	3	13	11.0
single	11					
double	2					
utilised blades		12	7	1	20	16.9
splintered pieces/hammerstones		9	11	2	22	18.7
total		62	46	10	118	

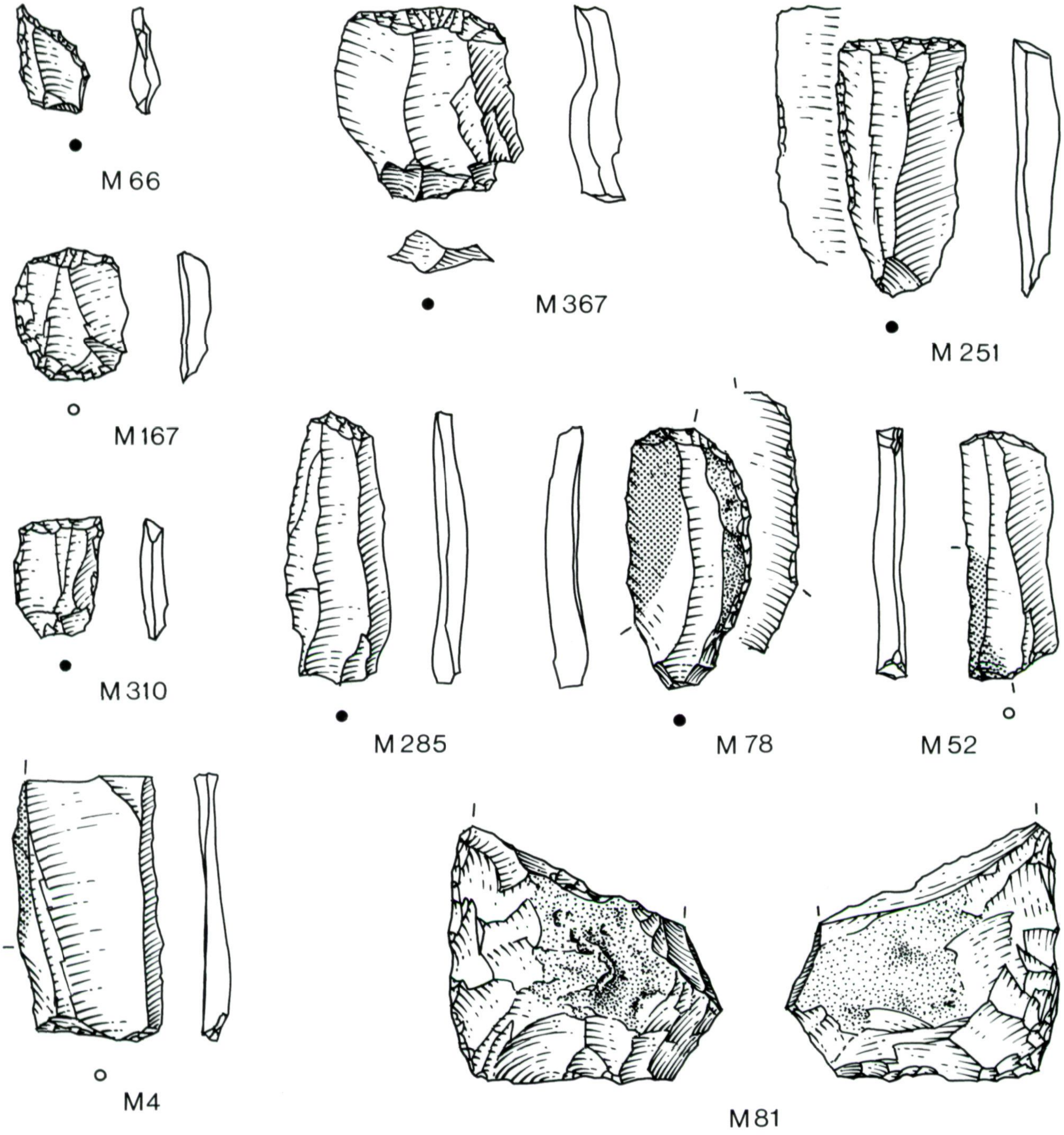

Figure 2. Characteristic tools from Meindling.
M66: borer; M251, 367: end-scrapers; M167: double end-scraper; M285, 310: end-retouched blades; M4, 52, 78: sickle blades; M81: fragment of bifacially retouched knife or sickle (Late Neolithic). M 1:1.

Table 7. Tool frequencies in Meindling compared to those in a sample of 240 LBK tools from sixteen dated pits in Hienheim.

	Hienheim observed (%)	observed	Meindling expected	$(O-E)^2/E$
Arrow / borer / burin	9.6	2	11.3	7.65
End-scraper	11.7	18	13.8	1.28
Sickle blade	11.3	29	13.4	18.16
End-retouch	7.9	14	9.3	2.38
Side-retouched / utilised	33.3	33	36.9	0.41
Splintered pieces / hammerstones	28.3	22	33.3	3.83

Table 8. Average number of modifications on main tool types in Meindling and Hienheim.

tool type	Meindling			Hienheim		
	x	s	N	x	s	N
Sickle blades	4.1	1.6	29	4.0	0.9	26
End-scrapers	3.2	1.2	18	2.6	0.8	23
End-retouched blades	2.5	1.2	14	2.8	1.4	19
Side-retouched blades	3.1	1.3	13	2.8	0.9	44

comparison to Hienheim's ALB cores (again, the two Meindling ALB cores must be disregarded).

Thus, the analysis of technological variables confirmed that both ALB and ORT chert arrived in Meindling in a later stage of the reduction sequence than did the ALB cores in Hienheim. No indications for a more intensive working of cores were found, however.

4. Tools

The tools may offer additional information on the availability of raw material.

Table 6 and figure 2 show that all 'classical' LBK tool types are represented among the 50.2% of the assemblage with intentional retouch or macroscopically visible traces of use-wear. Their relative frequencies are rather remarkable, however: not only are sickle-blades by far the most frequent type, but both borers and arrowheads are represented by only one, rather atypical, specimen (fig. 2).

If we compare these figures with expected values, as derived from the observed frequencies in, once more, the Hienheim sample, the differences turn out to be significant indeed (tab. 7), with a χ^2 value of 33.68 ($p < 0.001$).

Arrowheads, borers and hammerstones/splintered pieces are strongly under-represented, whilst there is a disproportionally high number of end-scrapers, sickle blades and end-retouched blades. This leads to the following interpretation: in the excavated part of Meindling chert tools were used mainly for primary subsistence and household tasks, like harvesting grain and working hides (Van Gijn 1990, 92, 95). Given the relatively small scale of the excavation, it remains unclear whether perhaps a boring machine stood in another part of the settlement, or whether drilling must be considered not to have been a 'basic' LBK activity. Unclear is too whether the inhabitants of Meindling used weapons other than bows with chert-tipped arrows, or indeed did not hunt at all. I intend to pursue these questions further by means of a Principal Components or a Correspondence Analysis in a forthcoming study of the patterns of co-variation of tool types in Hienheim.

The mean length of complete end-scrapers on blades is considerably shorter in Meindling (x = 29.3 mm, s = 9.2, N = 10) than it is in the Hienheim sample (x = 42.1, s = 3.6, N = 7), perhaps indicating a more intensive use of these tools. If one takes into account the general shorter length of the Meindling blades, however, the difference seems to become less significant. Moreover, the intensity of tool maintenance and recycling, as estimated on the basis of the average number of modifications visible on the main tool types, turned out to be very similar to that in Hienheim (tab. 8). Thus, the tools do not support the idea of constrained availability of raw material either.

5. Procurement strategies

As a final step one should ascertain how the acquisition of both types of raw material was organised in terms of the heuristic models developed in previous studies for the analysis of lithic production and distribution mechanisms (De Grooth 1991, 1994, in press).

According to these models, both assemblages could be the result of several procurement strategies:

1. If the inhabitants of Meindling had direct and open access to the sources of raw material, they themselves would have completely prepared the cores at the extraction sites, bringing them home for further reduction (a variety of model C0).
2. In the case of an indirect supply system, two distribution mechanisms would be possible:

2a. People having direct access to the resources worked according to the system described above and subsequently exchanged some of the prepared cores (corresponding to model C2).

2b. The producers transported selected, unworked nodules to their settlements for further reduction, and exchanged some of the cores after preparation, or possibly even after an initial series of blanks was produced (corresponding to model D2).

In general, access to lithic resources present in an LBK settlement's home range (i.e. the area within a six-hour walking distance) is considered to have been unrestricted (Bakels 1978; Bogucki 1988, 126-127; De Grooth 1994; Lech 1987; Zimmermann 1991; but see Cahen *et al.* 1990 for a different view). According to Zimmermann (1991, 100), in the Rhineland the transition zone between direct and indirect supply of Rijckholt-type flint is situated at a distance of c. 30-45 km of the resources. For the striped tabular cherts mined at Arnhofen-Abensberg during the post-LBK Middle Neolithic in the present study area, a direct supply zone of c. 20 km was inferred (De Grooth 1994).

Thus, for the Ortenburger cherts direct acquisition as depicted in the first model would be more probable than the two possibilities involving exchange. The additional evidence supporting this interpretation is rather flimsy: The data from the Lower Vils Valley indicate that people there, living at a distance of 10-15 km from the extraction sites, also adhered to the strategy of performing the initial stages of core reduction elsewhere (Schötz 1988). Moreover, the debris excavated at the Flintsbach quarries shows that a substantial amount of core preparation and blank production was indeed performed in the extraction area, whilst the discarded cores are very similar in type to the cores at Meindling (Weißmüller 1991). However, some caution is called for here, firstly because the mining activities cannot be dated precisely, and secondly, because we do not know, whether the Meindling cherts were actually collected at Flintsbach or at Münster. The considerable distance between settlements and exploitation areas (as well as other factor such as difficulties crossing the Danube or the unpredictability of raw material quality) may have led to the practice of performing the first stages of the reduction sequence at the quarry site, thus reducing the risk of transporting substantial amounts of unsuitable/worthless nodules. A similar strategy was described for the LBK exploitation at the Tomaszów 'chocolate-flint' mines in Poland, located at a distance of more than one day's walk form the nearest settlements (Lech 1989).

Following the same line of reasoning, the cherts form the Alb region would have been acquired indirectly. In this case, the last possibility depicted seems the most plausible, as it is compatible with the procurement strategy practised by the inhabitants of the Southern Franconian Alb, who took unworked nodules home for further reduction (Davis 1977; De Grooth 1977, 1994; Tillmann 1989; Weinig 1989) and thus could conceivably distribute prepared or initially reduced cores through down-the-line exchange networks. The same system of production and exchange is thought to have functioned in other areas where LBK settlements are situated close to outcrops of high-quality silex (Cahen *et al.* 1986; Caspar *et al.* 1989; Kaczanowska *et al.* 1987; Lech 1987; Zimmermann 1991).

This would mean that two types of raw material, even though arriving at the site at the same stage of reduction, were procured through different strategies, based on direct acquisition for the regionally available Ortenburger cherts, and on down-the-line exchange for the material from the distant Franconian Alb. Moreover, the direct acquisition of Ortenburger chert was organised in a way different from that which seems to have been usual in LBK settlements located close to sources of raw material.

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