Quern requirement and raw material supply in Linearbandkeramik settlements of the Mörlener Bucht, NW Wetterau, Hesse

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Zusammenfassung – Mahl- und Schleifsteine stellen zusammen den Hauptbestandteil aller Steinartefakte in bandkeramischen Siedlungsinventaren dar. Neben technologischen Aspekten sind insbesondere die Bestimmung der verwendeten Rohmaterialien und ihrer Herkunft wichtige Fragen bei der Untersuchung von Steingeräten, denn die Rohmaterialversorgung einer Siedlung oder einer Region stellt einen wesentlichen Aspekt des altneolithischen Wirtschaftslebens dar. In Hessen wurden verschiedene Rohmaterialien zur Herstellung von Mahl- und Schleifsteinen verwendet. Die Entfernung zwischen Vorkommen und Siedlungen ist ebenso wie die Art der Rohmaterialgewinnung maßgeblich bei der Untersuchung von Abbau- und Distributionsmechanismen. Informationen über den Bedarf an Mahlsteinen in den einzelnen Siedlungen sind notwendig, um die Rohmaterialmengen im Zusammenhang mit Abbau- und Produktionsbedingungen auszuwerten. Für die Mörlener Bucht, einer 6 x 12 km großen Mikroregion in der nordwestlichen Wetterau wurde der Bedarf an Mahlsteinrohmaterialien modellhaft berechnet. Selbst bei einem maximalen Getreideverbrauch und einer hohen Abnutzung durch Abrieb und Oberflächenaufrauhung war der Bedarf an Mahlsteinen in bandkeramischen Siedlungen relativ gering.

Schlüsselwörter – Mahlsteine – Linearbandkeramik – Bedarf an Mahlsteinen – Mörlener Bucht (Hessen)

Abstract – Querns and whetstones represent the major part of all recovered stone artefacts in most Linearbandkeramik settlements. Together with technological aspects, the characterisation and provenance of the raw materials are important questions for the analysis of stone tools. The supply of raw materials of a site or a region is a substantial aspect of the economic life in the early Neolithic. In Hesse various rock outcrops were used by early Neolithic populations. The distances between deposits and settlements as well as the kind of extraction are decisive to study exploitation and distribution mechanisms.
Information about the demand of querns in the settlements is necessary to evaluate raw material quantities in conjunction with exploitation and production conditions. For the Mörlener Bucht, a 6 x 12 km micro-region in the northwest Wetterau, central Hesse, the demand of quern raw materials was model-like calculated. Even with maximum grain consumption and high wear by rock abrasion and napping of the work surfaces, the need of querns was relatively small.

Keywords – querns – Linearbandkeramik – demand of querns – Mörlener Bucht (Hesse)

Introduction

The beginning of the European Neolithic brought not only changes in settling and ceramic production but also a complete renewal of the economic system. The transformation of the landscape for agriculture and livestock breeding were pillar of this new economy, followed by major changes of the subsistance and preparation of food. Cereals like emmer, einkorn, wheat and barley were the principal staple together with legumes. The grain could either be cooked and served as mash or ground and baked to bread. For the early and middle Neolithic, remains of bread are still missing except residues of a "leavened piece of dough" in a small basin (Kumpf) found in a Linearbandkeramik grave in Stuttgart-Zuffenhausen (Fundber. Schwaben N. F. 8, 1935, 50). Within Linearbandkeramik settlements (Lüning 2004), findings of oven structures and remains of querns suggest that wheat was not only cultivated and eaten as mash or groats but also ground and consumed as bread. Grinding tools, consisting of a mobile handstone, the rubber stone, and a stationed grindingstone, the quern, were used to produce flour (**fig. 1**). These objects present the major share of all stone artefacts in Linearbandkeramik settlements inventories. In total, 1839 neolithic stone artefacts were recorded in 39 sites in the Mörlener Bucht. Grinding stones together with typological similar whetstones represent about half of the collected stones. Grinding therefore was a significant procedure in the processing of corn within early Neolithic settlements.

Especially for stone tool analysis, the selected raw materials and their origin are from special interest apart from technological aspects. Classifications of raw materials enable dealing with economical and historical aspects of querns. Economic archaeological investigations shall consider the needs of the Neolithic inhabitants and

Fig. 1 Grinding on a reconstructed quern (after LÜNING 2005).

note the social and cultural involvement of these objects. Material goods can, hence, be regarded as equivalent of direct needs of prehistoric people, and by consequence as a mean of expressing their social status, identity or sacred acting (ZIMMERMANN 2001). According to this, logistic mechanisms, rights of use, technological means and division of labour play an important role, as well as social contexts, systems of values and communication networks.

Since the early Neolithic it is assumed that for each settlement an economic area was existing, wherein fields were cultivated, plants and wood collected and cattle grazed at least temporarily (e.g. BAKELS 1978). This natural and cultural spaces are named *„community area"* by E. Neustupný, incorporating forest, waters, cultivation areas, burial sites, meeting places and activity areas like hunting- and fishing stations or mining places for lithic material, stone and clay (NEUSTUPNÝ 1987; 1991). This concept follows a social division of space, which regulates the access to natural resources. The presupposition is the assumption of humans collectively living and cultivating an area and claiming their territory at least since the Neolithic. The raw material supply of a particular site or region is therefore an important aspect of Neolithic economic life. The distance between deposits and settlements as well as the mining methods are essential for the redistribution procedure. In case of rigorous social rules for the using-rights of resources, simultaneous settlements used different deposits or the demand of products was covered by central sites. Such distributor sites should have a surplus of products in their inventories.

Raw material supply

Data about quern demands in each settlement are necessary to appreciate potential surplus production. The Mörlener Bucht - situated in the NW Wetterau between Butzbach in the north and Bad Nauheim in the south-east – is adapted for such a study: within the project *"Besiedlungsgeschichte der Bandkeramik in der Mörlener Bucht"* (BBM) intensive field-surveys and geomagnetic prospections were carried out on several sites. Due to this, the amount of houses is better known than in other Hessian areas. The demand of quern raw materials therefore was calculated model-like for this micro-region. Chr. Schade gives in his publication on Linearbandkeramik settlement history a detailed introduction to the Mörlener Bucht. (SCHADE 2004). Most of this 6 x 12 km micro-region fulfills the conditions for a Neolithic agriculture in relation to water supply and soil quality. In its geological structure the Mörlener Bucht is a continuation of the Usinger Becken, Taunus. Next to isolated deposits of tertiary sediments, containing limonite, hematite and manganese, outcrops of limestone, sandstone and argillaceous shale are covered with rubble alongside the slopes of the Hintertaunus. Tertiary basalt, greywacke and quartzite are found at Butzbacher Becken. The subsoil of Bodenroder Kuppe is constituted by moulded greywacke sandstones and argillaceous shale. Argillaceous shale and limestone are also found in-situ at Münster-Maibach-Schwelle. At the latter area single basalts and greywacke mould the subsoil. In the south a clod shale and sandstone is outcropping and is still exploited today.

Parameter for calculating the querns requirement

Grinding stones represent a major part of stone artefacts on Linearbandkeramik settlements in the Mörlener Bucht like in many other Hessian inventories. They are represented in various quantities in each settlement like other artefacts (RAMMINGER 2003). The quantity is dependent primarily on the number of houses, the duration of the settlement and the degree of artefact fragmentation. According to traditional contortions the quantities of findings due to gathering is subject to fluctuations. While prospecting, grinding stones will be left behind because of their weight, or they will be disposed of by modern farmers. Existing objects in collections represent

Parameter	Minimum	Maximum	Middle Range
Requirement of corn per person and year (in kg)	165	250	200
Percentage of ground corn	50%	90%	75%
Amount of ground corn per person and year (in kg)	82,5	225	150
Effectivity of grinding operation (minutes per kg flour)	150	30	60
Duration of grinding per person and year (in h)	41,3	563	197
Inhabitants per house	6	6	6
Duration of grinding per household and year (in h)	247,8	3378	1182
Weight of quern at the beginning of its use (kg)	8	20	14
Size of working surface of querns (cm^2)	500	1500	1000
Weight of rubber stone at the beginning of use (kg)	3	6	4,5
Size of the working surface of rubber stones (cm^2)	100	600	300
Minimal weight of functional querns (kg)	1	2	1,5
Minimal weight of functional rubber stones (kg)	0,5	1	0,75
Duration of house generation (years)	25	25	25
Duration of LBK (years)	500	500	500
Number of house generations during the LBK	20	20	20
Number of individuals per generation in Mörlener Bucht	345	545	435
Number of indentations per cm^2	5	5	5
Volume per indentation (mm^3)	24,1	24,1	24,1
Loss of stone material per indentation (g)	0,01	0,01	0,01
Amount of abraded stone material per hour (in g)	0,10	1,00	0,50
Frequency of surface roughening per year	4	12	8

Fig. 2 Parameter for calculating the querns requirement (after Ramminger 2007, 102, fig. 76).

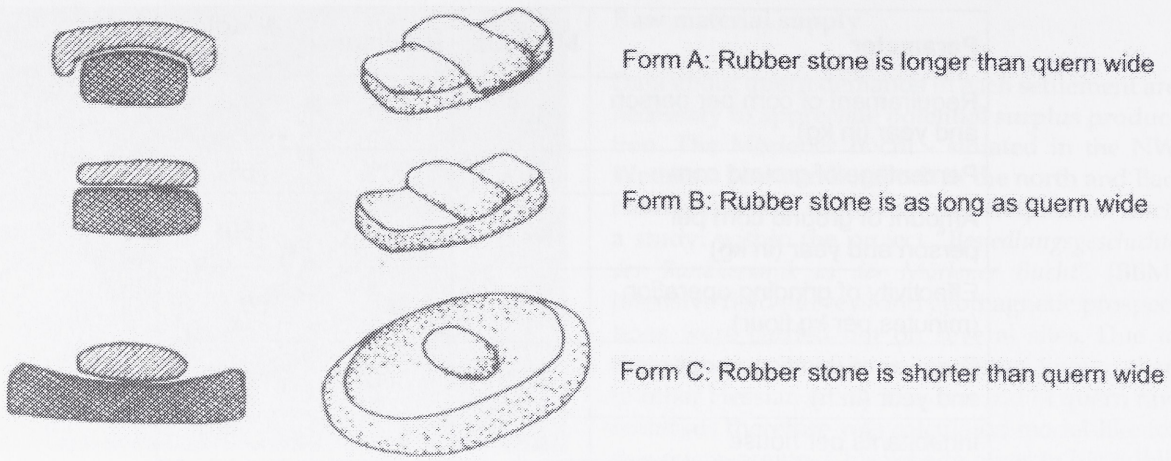

Fig. 3 Forms of grinding stones (after ZIMMERMANN 1988, 725, fig. 640).

therefore only a fractional amount of the potential material and are insufficient to reconstruct former the initial inventory. Even inventories of excavated settlements are in cause of different state of preservation. Ethnographic data providing the amount of grinding stones per household are as rare as data from archaeological findings, leaving not much place for exact calculation of requirements. U. Sommer expected 6,2 querns per house for the later Linearbandkeramik settlement Hanau – Klein-Auheim (SOMMER 1998, 207). Life and durability of Neolithic grinding stones is not easy to define, because it depends on various unknown availabilities' (**fig. 2**).

Size of grinding stones

The efficiency of grinding stones depends on the size of the active surface of the quern and the rubber stone. The subassembly of quern from Eschweiler-Weisweiler, Kr. Aachen, can be used as a benchmark for grindingstones size at the beginning of their use, with a weight of 18,3 kg by a length of 38 cm, a wide of 20 cm and a height of 18 cm (TUTLIES/WEINER 1999, 52). In Hesse another complete quern has a working surface of 1404 cm². Next to smaller objects, the length and width are comprised between 33 x 16 cm and 11 x 8 cm. Model data were calculated after a measure of the size of the working surface, which correspond to a maximum and minimum for calculation. The weight of complete querns varies in Hesse between 3000 and 9100 g, the weight of rubber stones between 387 and 3420 g. All examples show wear-traces and are not at the beginning of their life. The starting weight of a quern will be set by the author - considering the subassembly of a quern from Eschweiler-Weisweiler - minimum 8 kg and maximum 20 kg. The weight of rubber stones averages between 3 and 6 kg at the beginning of its use. For northern and central Hesse, the ratio between quern and rubber stone are of 1:2 in general. This observation fits with descriptions of querns from Sudan, where one quern and two rubber stones from different fabric are used together. The corn is first "pre-ground" by coarse grinding stones, before being ground into "fine-mill" using a fine grained rubber stone (SCHÖN/HOLTER 1988, 159). The examinated Neolithic grinding stones do not allow a classification in coarse and fine grain. The ratio of available quern elements would rather be explained by the smaller size of the rubber stones, which have to be replaced more often.

Amount of flour

With the size of saddle querns and rubber stones the amount of ground flour is a major criterion for the calculation of their durability. Considering the amount of corn ground and necessary for the diet one can calculate the frequency e.g. duration of grinding stones life. For example, J. Lüning estimates corn consumption around 685 g per person per day, corresponding to an annual consumption of 250 kg per person (LÜNING 1979/80; 2004, 23). This can be seen as maximum requirement. C. C. Bakels calculated the calorie needs for the Linearbandkeramik-inhabitants of Hienheim (BAKELS/MODDERMAN 1986, 118). For the annual fulfilment of the demand, between 61 and 176 kg of corn per person were necessary. The author

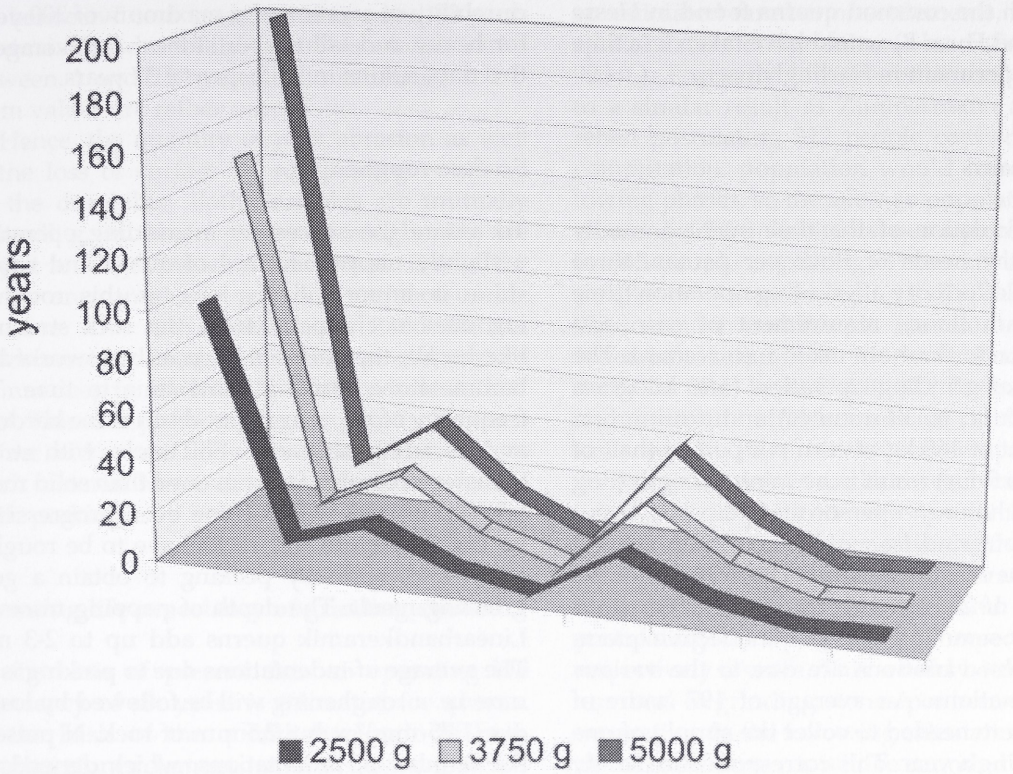

Fig. 4 Life range of rubber stones (after Ramminger 2007, 106 fig. 79.3).

counts with a minimum annual fulfilment of demand of 165 kg corn per person. The quantity of corn consumed as mash or groats or as flour for baking bread is still unknown. Therefore evaluations are used for calculation. 50% of ground corn minimum and 90% of processed corn shall be a basis.

Duration of grinding

For the duration of grinding only few solid results are available. Yet, well documented archeo-experimental tests concerning size, form and different materials are rare. Forms of grinding stones can be differenciated by the width of the rubber stone and the length of the quern (**fig. 3**). In Form A, the rubber stone is longer than the quern width, so that the supernatant ends are not involved directly in the grinding. According to this the medial diameter is reduced in use and the supernatant ends remain in their initial height forming shaped rubber stone with thickened ends. The longer the objects were in use the more the ends became marked. Form B is characterized by a correlation between the length of the rubber stones and the width of the querns. Wear traces on the rubber stones are oriented longitudinally while the wear traces on the querns are parallel to its width. The surfaces stay plan even in lengthy use. The rubber stone is shorter than the quern wide by Form C, therefore the rubber stone shows wear traces over the complete surface while the margins of length show none. By a longer use a hollow depression occurs on the quern (Zimmermann 1988). During an experiment at the Freilichtmuseum Oerlinghausen, 20 g cleaned and dehusked corn was actually ground per grinding operation. 100 g flour with a ratio of 70% bakeable fine flour needed roughly 15 grinding operations of respectively 60 minutes in a "Trogmühle" (Form C) with a small rubber stone. The grinding of one kilogram of flour would require therefore around 10 hours. E. Hennig came to other results: using grinding stones of Form A one kilogram of flour would need a grinding operation of 30-40 minutes. With grinding stones of Form C, the same amount of flour would be ground in 140-180 minutes (Hennig 1966). R. Risch produced during an experiment one kilogram of wheaten flour in two-and-a-half hours using a reconstructed Copper Age grinding stone from Fuente Álamo, Spain. The same procedure took three hours and 40 minutes to grind barley (Risch 2002, 120). The

grinding on the common querns found in Hesse (Form A and Form B) would have taken less time then the experiment in Oerlinghausen.

Working hours

For the calculation of the time spent annually to satisfy the needs of flour per person, three parameters effectivity of grinding operation (time per kilogram flour), requirement of corn and amount corn to flour are taken into account. The effectivity of grinding operation (one kilogram of corn ground in 30 minutes) and a minimum requirement of 165 kg of corn per person (half of it ground to flour) result in an minimum grinding time of 41.3 hours per person and per year. About 563 hours of grinding would have been needed to obtain the maximum annual corn requirement per person of 250 kg corn (producing 90% flour for bread or semolina) using an ineffective quern. The strongest variations are due to the various time designations. An average of 197 hours of grinding were needed to cover the supply of one person during a year. This corresponds to a daily work of an hour and a half.

Stone abrasion

The life expectancy or range of grinding stones depends also on the amount of stone abrasion during grinding operations. Hard rock like quartzite or Lung basalt loses only little substance by abrasion, while soft sandstones produce more rock flour. Experimental comparisons of different rocks are still missing yet. Measurements of abrasion range were carried out only in one experiment in Oerlinghausen (Teegen et al. 1990). Here 0,012 to 0,014 g stone abrasion accrued from 40 minutes grinding. The grinding stone used was granite, an uncommon raw material for the Neolithic. U. Sommer calculated on the basis of experimental data, that by 500 g ground edible corn per person and day the quantity of a grinding stone used by a 5-persons-houshold would shrink about 547 g (Sommer 1998, 205). The recent calculation gives significantly lower loss of material due to shorter estimated working hours. The amount of abraded rubber stone and quern in sandstone would be expected between minimum 0.1 to maximum 1.0 g per hour. In fig. 4 is presented the life range of rubber stones on the basis of their issue weight, duration of grinding and amount of abrasion. That implies a minimum durability of a year and a maximum of 200 years for heavy and tall rubber stones. An average of this data results in a lifespan of 37 years.

Surface roughening

To assure the success of a grinding operation, a slightly napped surface of quern and rubber stone is important. As long as this roughening does not depend from the rock structure, like basalt, the surfaces have to be reworked by hammerstone pecking some time to time. The frequency of napping depends on stone hardness and abrading attributes. Soft rocks with strong abrasion are much faster evened than solid rocks, whose surfaces will become even progressively by use. Therefore soft rocks have to be roughed again and again by pecking to obtain a good grinding result. The depth of napping traces on Linearbandkeramik querns add up to 2-3 mm. The average of indentations due to pecking is 3-4 mm; i.e. a roughening will be followed by loss of $n \times (1.75\ mm)^2 \times ð \times 2{,}5$ mm of rock. N presents the number of indentations, which depends on the surface size and density of indentations. The individual indentations are within 1-2 mm in average, therefore each indentation is $(0.25\ cm)^2 \times ð = 0{,}2\ cm^2$ tall regarding its surrounding distance space. The loss of rock per each indentation is $9.62\ mm^2 \times 2.5\ mm = 24.1\ mm^3$. A specific gravity of 2.3-2.7 g/cm of sandstone will hence result in a material loss of 0.01 g for each indentation per roughening phase. The size and density of indentation lead to a material loss a maximum of 75 g for saddle querns and 30 g for rubber stones per pecking phase.

Frequency of surface roughening

The number of grinding phases, which can be performed before the surface of a quern has to be roughened again, is dependant upon the quantity of abraded material. In Hesse different rocks with miscellaneous strong abrasion were used. The work surfaces were polished in different timesteps. A standard size for the frequency of pecking can therefore not be determined. Basalt, rhyolithe or arkosic rocks are more durable than sandstones and do not need roughening prior to pecking, whereas sandstone surfaces had to be pecked time by time. The quantity of rock abrasion by time is also proportional to the size of the rock surface. The lifespan of querns therefore

lies between 5 to 6 years minimum and 80 years maxima. The durability of rubber stones varies between 4 and 150 years. The estimated maximum values are rather unrealistic.

Hence, the quantity of rock abrasion as well as the loss of surface by roughening is crucial for the durability. Both variables are mutually depending, as the frequency of roughening are subject to length by what time the surface of the querns are completely polished and not usable anymore. The area between each indentation, which must be abraded, has to be placed around 2.5 mm deep to reach the level of the indentation' level. This area presents the discrepancy between surface and area of all indentations. Therefore, as much material has to be abraded as has accrued while pecking.

Operating life expectancy of grinding stones

On the basis of present data an operating life expectancy of six years is estimated for querns. On the basis of the quantitative ratio of both grinding stones elements within Hessian material on minor size and more frequent need of pecking, the rubber stones might have been in use only half as long as the querns. An average durability of 3 years is therefore estimated. Rocks, which did not need prior roughening due to their texture, would have had a longer lifespan. As a result the estimated values represent rather a minimum operating life expectancy. The resulting quantity of raw material measures up to maximal requirement.

Grinding stones requirement during Linearbandkeramik at Mörlener Bucht

For further calculation of requirements, the number of people which had to be provided with flour during the Linearbandkeramik, is a determining factor. A. Zimmermann and K.P. Wendt calculated the population density of the Mörlener Bucht on the basis of ascertained distances determined by Thiessenpolygones with the number of houses and estimated one household (0.8) per square kilometre (Zimmermann/Wendt 2003, 494). With an average number of six persons per household 345 people would have lived in this 72 m² wide Mörlener Bucht. Chr. Schade reconstructed the population density by geomagnetic research and find-distribution plus projection of non-prospected areas, on which he calculated an estimated number of settlements, houses and spatial extent of agricultural land (Schade 2004, 223ff.). For early Linearbandkeramik he comes to a similar result as Zimmermann and Wendt when postulating 322 people coexisting. By his computation, population would increase in following phases, so the average population density would be 7.6 inhabitants per square kilometre or 545 people coexisting. These are at least 200 people more than according to the calculation by Zimmermann and Wendt. Therefore, during the Linearbandkeramik at Mörlener Bucht a minimum of 57.5 households (0.8 household/km²) and maximum of 91 households (1.3 household/km²) would have existed contemporaneously. Subject to the condition that in each case only one quern ensemble would have been in use and each household provided themselves with flour, a six person family of one house generation would have needed 8.3 rubber stones and 4.2 querns, postulating an operating life expectancy of 3 respectively 6 years. This would be the expected numbers of grinding stones per house during an excavation. In the following calculation the quantity of saddle querns will be rounded up to 4, the numbers of rubber stones to 8 per house.

According to 500 years settlement-duration of the Linearbandkeramik at Mörlener Bucht and generations lasting 25 years altogether 7280 querns and 14560 rubber stones would have been required by the population. Hence, the yearly requirement sums maximal 14.6 querns respectively 29.1 rubber stones for the complete Mörlener Bucht. With a maximum starting weight by 20 kg per quern and 6 kg per rubber stone 292 kg raw material for querns and 175.2 kg for rubber stones would on average have been needed annually to cover the demand of every household at the Mörlener Bucht.

Layout of grinding stones and whetstone

A regional comparison between the raw materials used for grinding- and whetstone production shows a preference of fine and middle grained quartzose sandstones. The material used as grinding- and whetstones are quite heterogeneous, and within the individual groups varieties can be discerned. Regional differences of the found raw materials are recordable on small scale basis (Kegler-Graiewski/Ramminger 2003, 33ff.). To determine the distances to sources and pattern of supply, it is necessary to analyse the used rocks found within the settlements. In a relative short

period of three years research within the BBM-project, a comparatively high number of artefacts were collected. On 21 sites 881 grinding - and whetstone fragments were found amounting to a total weight of 321.5 kg along with fragments without wear-traces of 66.8 kg total weight. The latter can be seen as production waste or as non-artificial broken bits. The intensity of the field-survey is reflected by a high amount of small fragments with a low weight and rock fragments without wear-traces. Grinding- and whetstones are found in the same amount as to 370 not certain identified objects. Furthermore four sites will be entered into the following analysis. All four settlements are dated by the ceramic into middle and later Linearbandkeramik. From Fauerbach-4 and Ober Mörlen-2 middle Neolithic artefacts could also be found (Schade 2004).

Fauerbach v. d. H. „Dicknett" (FaB-1)

Fauerbach-1 is one of the richest sites at Mörlener Bucht in terms of grinding- and whetstones. More than 500 fragments were collected from the field-surface on an area of 58 hectare and secured during excavation (Schade 2004, 137f.). The average fragment-weight of 343 g is much higher than from grinding- and whetstones of the other sites. The high quantity of artefacts therefore can not be explained by their degree of fragmentation. Based on the above average high quantity of grinding/whetstones (20.3%), Chr. Schade suspects an overproduction, which was passed on to the smaller settlements in the surrounding (Schade 2004, 140f.). According to him, this site was occupied over 250 years. For the estimated number of 42 houses (Schade 2004, site 8) 336 rubber stones and 168 querns, totalling an average weight of 5376 kg, would have been needed to cover the demand of the inhabitants. Until now only 129 grinding stones and 158 grinding/whetstone identified fragments were found. The average weight of all grinding- and whetstone fragments adds up to 187.9 kg. When assuming each of these fragments to be an individual tool, about half of the former quern requirement is missing. These objects are either still concealed in the ground or were already disposed by modern farmers. By a settlement duration of 10 generations and 5 house places, the postulated scenario by Schade for this site would result in 11 fragments per household as an average. Considering exclusively the 129 certain classified fragments, each generation and house would have possessed in average 2.6 grinding stones. An excess of grinding stones is therefore to exclude. In the process probably several fragments of an implement was recorded as one individual and the quantity therefore has to be once more reduced.

Hard quartzose sandstones respectively quartzite from Taunus dominate the raw material spectrum of grinding stones. Tertiary sandstones are the second most common material used for these implements. Approximately 19% of the grinding stones are made from early Triassic sandstones. Basalts are, like other singular rocks from this site, insignificant. Overall 96 exemplars are whetstones. Raw material of whetstones is mostly Tertiary sandstone with 30%. Taunus quartzite take a part of 27%, 13% are in fine sandstones. Besides 166 rock fragments without wear traces were documented. These might represent production waste or be natural debris. These fragments are mostly composed of hard quartzose sandstone or sandstones with no further classification possible.

The site is located on loess, which today is transformed to brown (forest) soils. On the settlement area itself lots of schist and breccia can be found on the surface. These rock-types are, however, uncommon within the inventories, or show no man-made impact. Close to the site, in the west and southwest are lower Devonian deposits of quartzite and sandstones embedded in Devonian clay and greywacke schist (Geologische Karte 1:25.000 Blatt 5617 Usingen). Basalt deposits are within reach 5-6 km south of the site at Ockstädter and Ober-Rosbacher Wald. Tertiary sandstone can be found 7-9 km away to the northwest and southwest. Sandstones of early Triassic age have to come from farther away. Nearest deposits of early Triassic sandstone are situated about 35-40 km away in Bündiger Wald or 50 km to the next rubble terrace of the river Main, where greater sandstones rubble can be gathered.

Fauerbach v. d. H. „Gerhardsköppel" (FaB-4)

In 1999, middle and early Linearbandkeramik settlement was discovered 1 km away from Fauerbach-1. The site is according to Chr. Schade a "Twin settlement" and was built about 50 years later than Fauerbach-1. Due to distribution density an area of 6.5 hectares is defined as settlement area. Eight generations in 36 houses shall have inhabited the site for around 200 years (Schade 2004, 127ff.). To cover the demand of ground

flour for 216 inhabitants, around 288 rubber stones and 144 querns would have been required. Until now only 44 certain defined querns were found. The average weight of the grinding and whetstones, as well as the rock fragments without wear traces, sums up to 218 g, and thereby lies beneath the average weight of Feuerbach-1. Lots of smaller fragments were classified as grinding/whetstones but could not be assigned to definitely one artefact group. For this settlement no overproduction can, hence, be assumed, even if including uncertain fragments of grinding/whetstones to the classified findings.

The spectrum of rocks used for querns are similar to the spectrum found in the neighbouring settlement of Fauerbach-1. Here hard quartzose sandstones dominate with a quantity of 54%. Furthermore, basalts, early Triassic sandstones and breccias constitute 34%. Whetstones are represented by 39 finds. They were mostly made from quartzose sandstone (41%). 21% of the whetstones are made from fine sandstones. Further, unclassified sandstones were used by 13% and basalts along with sandstones of an early Triassic age both sums up to 8%. Singular raw material is schist of the Taunus area. From Fauerbach-4 the quantity of recorded rock fragments without wear traces is mostly made from quartzose sandstone and unclassified sandstones. The geological bedrock of this site is composed of heavenly eroded brown (forest) soil with Taunus schist in layers, which is exposed on the surface in numerous fragments. The schist is only sporadically used as raw material for grindstones. Quartzose sandstones and lower Devonian quartzite are both found close to the site. For this settlement one can therefore assume a supply with local or regional raw materials. The inhabitants themselves will have satisfied their requirement from the surrounding deposits of appropriate raw material. Only the less used early Triassic sandstone had to be obtained from a distance of 35 km.

Hochweisel „Im Loch" (HoW-1)

This middle and later Linearbandkeramik settlement was detected in 1998. On an area of 20 hectares altogether 1578 findings were collected from the surface. Chr. Schade assumes for this site 19 houses (Schade 2004, 97ff.), thereby limiting their requirement to that of 152 rubber stones and 76 querns. Only 16 certain classified grinding stones and 31 small fragments of grinding/whetstones have been found till now. In comparison to both already mentioned settlements, which have quantities of 17 and 20%, the grinding/whetstones found in Hochweisel-1 only constitute 11% of the total number of findings, that means the quantity of grinding/whetstone in Hochweisel is below the amount from the Fauerbacher' sites. The average weight of grinding/whetstones is 179 g. The degree of fragmentation is considerably higher than in the other site inventories. Selective collecting can therefore be excluded as to explain the minor grinding stone amount. Foreseeing the dispose of grinding stones by today's farmers, a smaller corn production can be considered for this site, which was possibly accompanied by animal husbandry as main economy. An inferior supply leading to greater abrasion of grinding and whetstones and for later disposal is rather implausible due to numerous surrounding deposits of raw material. With reference to the raw material spectrum used for grinding stones, Hochweisel-1 differs only slightly from the two Fauerbach settlement sites. Here also, quartzose sandstones dominate with 56% of the spectrum, next to tertiary sandstones. Whetstones were mostly made from quartzose sandstone (38%) or early Triassic sandstone (33%). Besides they used lower Devonian sandstone (13%) and fine sandstone (11%). Basalt is like in other inventories of the Mörlener Bucht unimportant. In Hochweisel-1, as well as on the other sites, rock fragments without wear-traces were found. They consist also mainly of quartzose sandstone and unclassified sandstones. A direct self-supply with sandstones from deposits in the surrounding of the settlement and an intra-site production of grinding- and whetstones is most likely for this site.

Again the seldom used early Triassic sandstone is an exception, because it had to be obtained from a distance of at least 35 km.

Ober-Mörlen „Am Jakobswäldchen" (OBM-2)

In 1999, the Ober-Mörlen-2 site was discovered yielded 355 findings of different categories on an area of 9.7 hectares. The site can be dated to the middle and later Linearbandkeramik. The remarkable high quantity of rock artefacts (43%) in the inventory is according to Chr. Schade due to the local field-conditions, because the already high natural cover prevented the discovery of smaller artefacts of other categories during the survey (Schade 2004, 161). When assuming 16 houses, 128 rubber stones and 64 querns would

be expected. However, only 73 grinding and whetstone fragments and 61 rock fragments without wear traces, with an average weight of 175 g, were recorded. The degree of fragmentation is therefore higher than compared to the other three sites of the Mörlener Bucht.

The raw materials for grinding stones differ from those of the other mentioned sites. This is first obvious in the rock colour spectrum, which shows a dominance of 60% light-coloured sandstones to red sandstones. Light-coloured sandstones are present on the other sites with a quantity of at most 40%. Looking at the raw materials used for grinding stones, tertiary sandstone dominates with 41%, followed by 33% quartzose sandstone and 17% early Triassic sandstone. Similar is to be recorded for the whetstones. They were made in 52% of tertiary sandstone, in 30% of quartzose sandstone and in 7% of fine sandstone. Basalt, early Triassic sandstone and unclassified sandstones are represented each with a percentage of only 4%. Fragments without wear traces consist of unclassified sandstones as well as of hard quartzose sandstone.

The bedrock exposed on the Galgenberg dome is made up of Oppershofener schist (Geologische Karte 1:25000 Blatt 5618 Friedberg), which is intensely eroded (Schade 2004, 161). Benches of quartzite and greywacke schist can locally be found in-situ. In addition breccia of the Nauheimer gravel can be found at the alteration horizon of the surrounding area of the settlement. Larger deposits of Taunus quartzite and hard quartzose sandstone are found in situ in 3-5 km distance to the south and southeast. Tertiary sandstones can be found 5-6 km away towards the west and southwest. Basalt could be obtained in 5-6 km distance from the east. For Ober-Mörlen 2, like already mentioned for the other three Linearbandkeramik sites in the Mörlener Bucht, in general a direct self-supply with raw-materials from deposits in the surrounding of the settlement is to assume. Only few of the querns are made of early Triassic sandstones coming from 35-40 km far away.

Social economic conclusion

Querns were basic commodities in Neolithic households. They can be found in almost all excavated house-features. The used raw materials could be generally found in the surroundings of the settlements within an area of around 5-6 km, and the effort for the quern-production was relatively low. In terms of value or status these objects did not play a major part within the Neolithic life. But recording querns relating to their function for the every day production of the staple food corn, a kind of symbolic value is to be assumed for these objects (Fendin 2000). Corn as the "new" food of the Neolithic was linked with field-cultivation and therefore with the human dominance over nature. Grinding stones were used within the house and probably by women, because they are mainly buried in female graves (Zápotocká 1972, 295; Peschel 1992). In settlement-inventories we find most of the grinding stones in inoperative state. Besides intense used up and broken fragments, some examples were indeed finished but little used. U. Sommer therefore suggests a deliberately destruction of these objects (Sommer 1998, 205), probably embedded in funeral-rituals after the death of the owner, unless the quern was given as a burial object. Taking such an appreciation into account, an exchange of querns seems possible. In many societies next to production and distribution for personal benefit, there are social exchange patterns, which serve primarily the protection and stabilisation of social relations. Moreover also in non benefit exchange systems, like the tributes of material goods at certain occasions (wedding, funeral etc.) which can be found for example in the Melanesian Big-Man-system, some mechanisms aim to increase the owner's prestige and beyond to influence a group (Sahlins 1963; 1974). Because of the rather low demand, in comparison with the rich resources and the heteronomy of the used raw materials, quern exchange for benefit has to be excluded. A distribution of grinding stones for social events (like f. e. weddings) is however most likely.

In central Hesse larger sandstone deposits belonging to different geological formations are known, from where the Neolithic population could gain raw materials for their grinding and whetstones. A particular importance for these implements in cause of scarce resources or from greater distances imported querns is therefore not to record. Most of the raw materials were possible to get in the closer surrounding of the settlements within a radius of 5 to 6 km. C.C. Bakels describes areas of this range as "site territory", wherein the settlements "own" loess fields were situated, and which was exclusively husbanded by one community (Bakels 1978). To reach the inside resources, a march of less than an hour was necessary and the raw materials were mainly exploited by the settlers holding access due to

spatial nearness to the deposit.

The population density during middle and later Linearbandkeramik, given by the data of the Mörlener Bucht, suggests however smaller settlement territories. In addition it is possible that the availability of larger rock deposits put no limit on territorial usage. For coexistent twin-settlements as Fauerbach-1 and Fauerbach-4, room models of clear limited and exclusive used territories seem to be more than doubtful. These settlements show very similar raw material spectres, which contradicts a partitioning of resources and associated entrance restrictions or rights of use.

For Hesse a more tightly focused mining of rock is not to expect due to the low annual requirement and heterogeneity of the raw materials. No examined site showed a clear overproduction and a self-supply of each Linearbandkeramik settlement with raw materials is in principle reasonable. Hereon indicates also the production waste and rock fragments without wear trades, which were found on each of the intensive surveyed site. A redistribution of querns during social events is in contrast conceivable. The different fine and hard early Triassic sandstones were favoured raw materials for grinding stones as well as for whetstones. These were imported from a distance as far as 40 km into the Mörlener Bucht. A self-supply with these raw materials from farther away is rather unlikely. Different to settlements in other micro-regions, which are situated closer to the deposits, in the Mörlener Bucht inventories no production waste or rock fragments without wear traces consisting of early Triassic sandstones were recorded. An overproduction by the settlements near the greater deposit of early Triassic sandstone of the Büdinger forest, for example in the valley of river Kinzig, is, however, not documented. One can therefore not assume an extensive production of querns for supply of other settler communities, but rather of occasional social contacts between the inhabitants of different micro-regions with occasional exchange of goods. For the context of grinding stone production no specialisation of individual settlements is found, but already with these artefacts we could observe occasional exchange between settler communities living in different micro-regions in central Hesse. With the comparison of other artefacts in further investigations, the network of social interactions between different settler groups could be densified.

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