The organization of chert exploitation in Southeastern Bavaria during the Neolithic

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The article focuses on organizational aspects of chert mining. The author modifies R. Torrence's general model for archaeological inferences about prehistoric exchange.

KEY-WORDS: chert mining, exchange, organization of labour, Neolithic

In recent years several excavations and systematic surveys have provided new and fascinating information on a number of Neolithic mining and quarrying sites in the Franconian Alb region in Southeastern Bavaria (Binsteiner 1989, 1990; Engelhardt and Binsteiner 1988; Moser 1978, 1980; Tillmann 1989a, Weinig 1989b).

This article, however, will not focus on the technicalities of chert quarrying, but on its organizational aspects, i.e. on the ways chert mining was embedded in the socio-economic life of the communities involved (Sahlins 1972). In this context it is extremely important to bear in mind that systematic quarrying was not undertaken for its own sake, but to obtain suitable raw material in a structured way. The ultimate purpose of the process, of course, was to manufacture preforms and (parts of) tools that could be used in a variety of functions, economic as well as social or ritual (McBryde 1986; McBryde and Harrison 1981; Torrence ed. 1989). For a better understanding of the procurement strategies applied, one must study, in an integrated approach, the chert assemblages both of the extraction and workshop sites and of the settlements consuming their output (Torrence 1986).

A modified version of Torrence's (1986) "general model for archaeological inferences about prehistoric exchange" (Fig. 1) has proven to be a valuable heuristic device (De Grooth 1991, 1994a, 1994b) in this type of study.

The first modification was based on the observation that ethnographic and archaeological data alike show that lithic artefacts were often transported not only after the initial acquisition of raw material or as finished tools, but also halfway

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through the reduction sequence, i.e., as prepared cores or blanks. Therefore production was subdivided into two separate activities: production of blanks and production of tools.

Secondly, a distiction was made between “transport and distribution within one’s own group” and “exchange, i.e., distribution between groups” (Fig. 2).

Taking into account the spatial relationships logically possible between these activity-sets, the resulting eight models serve nicely to describe different distribution patterns, and may help to distinguish the underlying procurement strategies (Fig. 3). The two types of transport are possible after each of the manufacturing stages.

In model A, the miners live at the quarry site, and perform all activities there.

In model B, the acquisition and selection, the initial preparation of blanks and preforms, as well as the manufacture of tools are performed at the mines, but the finished tools are transported to be used in settlements elsewhere.

In model C, only acquisition/selection and manufacture of blanks and rough-outs are activities performed at the mines; tools are finished and used in settlements elsewhere.

Model D depicts transport of selected, unworked raw material to settlements, where blanks and tools are made and used.

Model E has a separate activity area (a so-called workshop or flaking floor) where the production of preforms and tools is concentrated, away from both mines and settlements.

In model F, the production of blanks and preforms takes place at a special workshop site, the tools are finished in the settlement where they are to be used.

Model G shows the production of blanks and preforms at the mining site, and the manufacture of finished tools at a separate locality.

In model H, finally, all four activity sets are performed at different localities. With the exception of F and H all these models can be matched with existing ethnographic or archaeological distribution patterns (De Grooth 1994b).

The research reported here started with a study of the chert assemblages at the Neolithic settlement site of Hienheim-am-Weinberg (Ldkr. Kelheim, Niederbayern).
This site was excavated between 1965 and 1974 by the Institute of Prehistory, University of Leiden (The Netherlands). It lies on the left bank of the river Danube in a rather isolated loess-covered region. The main settlement started in the Early Neolithic at 6200 BP (or 5150 cal. BC) and ended c. 5700 BP (or 4600 cal. BC) in the Middle Neolithic (Modderman 1977, 1986; Van de Velde 1979). In the earlier settlement phases Linearbandkeramik (LBK) pottery was in use. Later on we find decorated pottery belonging to the Middle-Neolithic Stich-Strich-Komplex (Van de Velde 1979), also known as the Oberlauterbach Gruppe (Bayerlein 1983) or the “Middle Neolithic of Southeastern Bavaria” (Nadler, Zeeb et al. 1994). This post-Linearbandkeramik group (to be named Middle Neolithic in this article) is to a large extent contemporary with the Großgartach-, Stichbandkeramik-, and Lengyel-horizon, and may also overlap with the earlier stages of the Rössen Culture.

The Hienheim excavation also yielded traces of habitation by the Late Neolithic Münchshöfener, Altheim and Cham groups (Modderman 1977, 1986), dating to c. 4600 – c. 3800 cal. BC, c. 3800 – to c. 3300 cal BC, and c. 3300–2600 cal. BC respectively (Matuschik 1992; Tillmann 1993).

The subsoil of the area around Hienheim consists mainly of Jurassic Chalk deposits, which contain many varieties of chert. The cherts occur in nodular and in tabular form. Within the site territory of Hienheim (i.e., the area exploited on a daily basis, Bakels 1978) no outcrops of chert are known. In its home range (i.e., the area with a radius of six hours’ walking distance, exploited extensively together with other groups, Bakels 1978), however, different kinds of high-quality cherts can be found (Fig. 4). At Schwabstetten, 7.5 km to the west of Hienheim, the alluvial clays contain grey nodular cherts (Bakels 1978). This same type of chert was also available at many other localities in the region. Eleven kilometres to the north, i.e., north of the river Altmühl, lies the area of Baiersdorf, where brown to greyish brown tabular chert was

\[ \text{A} \quad \text{B} \quad \text{C} \quad \text{D} \]

\[ \text{E} \quad \text{F} \quad \text{G} \quad \text{H} \]

Fig. 3. Specific models describing the spatial relationships between different stages in the production process. Arrow — possible transport; A — Acquisition; PB — Production of blanks; PT — Production of tools; U — Use.
exploited (Binsteiner 1989). Finally, 9 km to the west, on the other bank of the river Danube, the outcrops at Arnhofen supplied a very fine-grained, banded grey tabular chert (Binsteiner 1990).

All three types of chert were used continuously by the inhabitants of Neolithic Hienheim. The initial preference for nodular chert changed gradually, and in the Middle Neolithic tabular chert was used almost exclusively. The same change in the use of raw material is seen in the Ingolstadt-Eichstädt region, some 30–60 km to the west, where the inhabitants of the LBK settlement at Attenfeld preferred nodules (Tillmann 1989b). At the adjacent Middle-Neolithic site of Gaimershaim-Am Brunnbuck, however, local tabular cherts were predominant (Weinig 1989a).

During the LBK every settlement exploited a number of different resources, seemingly in a rather haphazard way. All chert was brought into the settlements in an early stage of the reduction sequence, as precores or as initially prepared cores. In other words, at the various extraction sites the raw material was only tested for
suitability: the production of blanks and tools and the use thereof took place in the settlements, in accordance with model D. Access to all regional resources was apparently unrestricted, and if chert was exchanged at all, this occurred over relatively short distances (not exceeding c. 80–100 km, De Grooth 1994b). In socio-economic terms, this procurement strategy corresponds to a domestic mode of production, in which the family, living in a single household, is the main unit of production and consumption (Van de Velde 1979; De Grooth 1987).

Whilst the basic spatial organization of chert production in the Kelheim region remained the same during the Middle Neolithic, i.e., compatible to model D (Fig. 5), important changes occurred as regards both the acquisition of raw material and the regional distribution mechanism.

An increase in the number of settlements was combined with a decrease in the number of extraction sites. At Arnhofen, a large mining complex with shafts up to 8 m deep, investigated by Engelhardt and Bisteiner, dates from this period (Bisteiner 1990; Engelhardt and Bisteiner 1988). The tabular chert at Baiersdorf was probably already exploited by open cast mining at this time (De Grooth 1994b).

The regional distribution mechanism changed as well: unworked cores and substantial amounts ofdebitage (production waste) of Arnhofen chert are present only in settlements located at a distance of less than 20 km from the quarry. Outside this area, Arnhofen striped tabular chert occurs almost exclusively as blades and finished tools (De Grooth 1994b).

The excavation report on the Arnhofen mines allows one to make estimates on both the yearly output of raw material and on the workforce required for its procurement (Bisteiner 1990; Engelhardt 1990). The estimates on the overall duration of deep shaft exploitation vary between 700 years (from c. 5000 cal BC to 4300 cal BC) and 250 years. In the former case, intensive extraction was practised during the younger LBK and the whole Middle-Neolithic period (Engelhardt 1990); in the latter case the period of use is seen as limited to the period of the raw material’s main use at Hienheim (De Grooth 1994b), during which its long-distance distribution was also at its peak (Zimmermann 1991).

In the following discourse it will be assumed that Neolithic chert mining was a male activity, as was the case in all ethnographic examples known to

Fig. 5. Hienheim. Blade core of Baiersdorf chert with refitted borer discarded together in a Middle-Neolithic refuse pit.
me, where women could at most participate in the transportation of quarried material to the settlements (De Grooth 1994b). According to the excavators a minimum of 8333, and a maximum of 18416 shafts would have been exploited during the period of use of the site. It would have taken two men 160 hours each to work such a shaft, which would have yielded an average of 2.68 kg of good quality tabular chert. Owing to the rather unstable sandy soils into which the shafts had to be sunk, working them would have been restricted for safety reasons to a period of four weeks at the most, in the dry season (Engelhardt and Binssteiner 1988).

On the other hand, the evidence from Hienheim and other sites in the Kelheim region may be used for estimates on the available workforce and the rates of chert consumption. The average Middle-Neolithic settlement probably consisted of five contemporary houses at any one time, inhabited by 20 adults and 30 children (Bakels 1978).

Most chert recovered in LBK and Middle Neolithic settlements must be regarded as secondary rubbish (Schiffer 1976), and ideas on its yearly consumption depend mainly on estimates of the amount of material lost owing to both depositional practices and post-depositional processes (among which excavation methods, notably the mechanical removal of topsoil, figure prominently). Attempts to refit Middle-Neolithic assemblages at Hienheim show the loss to have been considerable. Referring to earlier estimates by De Grooth (1987), Löhr and Zimmermann (1977), Modderman (1958/59) and Zimmermann (1991), the amount of material lost at Hienheim was set between 75% and 90%. Actually, in Hienheim only about 40% of the chert came from Arnhofen, the remainder having been extracted in the Baiersdorf area. As most settlements in the Kelheim and Regensburg region did not use alternative resources, the following extrapolations for the whole region were based on Hienheim’s total consumption of chert, not just on its Arnhofen component.

The total consumption, then, of chert in Hienheim during the 250 years of Middle-Neolithic habitation would have amounted to between 904 and 2259 kg, or a minimum of 3.6 kg and a maximum of 9 kg of tabular chert per year. This amount would correspond to the yield of about 1.3 to 3.3 shafts at Arnhofen. At present, at least 30 other MN settlements located less than 20 km from the quarry are known, which brings the yearly regional demand to 108 kg – 270 kg (or the yield of 39–99 Arnhofen shafts).

Combining these different types of estimates gives rather interesting results: if a 90% loss is assumed – necessitating the working of at least 99 Arnhofen shafts a year – one has to accept both the maximum size of the mining area and the short exploitation period. Even if loss were reduced to 75% – resulting in a minimum of 39 shafts each year – the exploitation period of 250 years provides a better fit, especially if the necessity of a substantial surplus production, to be distributed in supra-regional exchange networks, is taken into account (Binssteiner 1990; Lech 1987, 1989).
Given a yearly extraction period of about four weeks – during which a two-man team could have worked a single shaft – the required workforce would have varied between 78 and 198 men, i.e., the adult male population of between 8 and 20 settlements.

Thus, this integrated approach leads to an interpretation in which extraction at Arnhofen was a short-term, seasonal activity, performed jointly by inhabitants of all the small settlements located in the vicinity of the mine. The distribution outside this “production area” was partly directed at immediate neighbours, i.e., at immediate kin. A structural long-distance circulation, however, was clearly present as well.

This type of exploitation can be practised under a lineage mode of production, where the unit of production and consumption is formed by a group of related families belonging to the same lineage or “clan” (Van de Velde 1979; De Grooth 1987) and temporarily aggregated into a larger workforce.

The main technological advantages of tabular chert are twofold: cores need little preparation and it is easy to produce standardized naturally backed blades. The benefit of the spatial and temporal concentration and intensification of quarrying activities may not only be regarded in terms of minimizing expenditure of time and energy, but also of stimulating inter-group activities, controlled sharing of scarce resources and intensification of both regional and long-distance communication.

A number of extraction sites can be connected with the Late Neolithic. Unfortunately, little or nothing is known about chert procurement strategies of the Münchshöfener group. The single radiocarbon date available for Arnhofen (1410 ± 60 BP, Hv-14924) points to some sort of activity at that site (Engelhardt 1990), but corroborative settlement data are still absent. In several settlements of the Altheim and Cham cultures, however, characteristic artefacts made at some of these quarries have been identified, e.g., material from Lengfeld at the Altheim Culture causewayed enclosure of Lengfeld-Alkofen (Rind 1992); material from Baiersdorf in Altheim sites at Hienheim and Ergolding–Fischergasse (De Grooth 1977; Tillmann 1993), and at Cham sites at Dietfurt-Griesstetten (Tillmann 1993), Hienheim (De Grooth 1977) and Pestenacker (Underwood 1991). The other quarries, such as Osterberg bei Pfünz (Weinig 1989a) and Schernfelder Forst (Tillmann 1989b) also served for the manufacture of tools that typologically belong to the Altheim and Cham cultures.

The debris recovered at these extraction sites documents two major changes in technological behaviour. Firstly, the tabular chert was no longer turned into blade cores, but shaped into bifacially worked core implements, such as sickles and knives or daggers. Secondly, both preforms and finished artefacts were made at the quarries, testifying to a shift from model D to model C.

I do not think, however, that this change in technological behaviour must be regarded as evidence for a change in social organization: in terms of expenditure of
raw material, these bifacial tools are no improvement on the Middle-Neolithic blades. Their cutting edge/mass ratio (Torrence 1986) is much lower, as only a single implement can be made from each lump of flint and the risk of failure during manufacturing is high. Technological advantages may have consisted of an increase in length of the actual cutting edge on single artefacts and a possibly higher potential for the resharpening of these cutting edges by consumers. Making them at the quarry sites, then, may have been an efficient strategy to minimize manufacturing risks (Torrence ed. 1989). The main reason for this technological change may have been of a social rather than of a functional nature. The evidence from settlement sites shows that these bifacial tabular artefacts formed only a minor part of the chert assemblage. They circulated, however, over long distances in the same way as did the blades and tools of striped Arnhofen chert, travelling as far as Westphalia and Lesser Saxony, for example (Blank 1994; Werben and Wulf 1992).

The domestic tools meanwhile were still made out of flakes, and in regions close to the resources the raw material for these seems to have been brought into the settlements in the traditional way, as nodules or initially prepared cores (Driehaus 1960).

Thus the bifacial sickles and knives could have functioned as special-purpose tools, forming the reaction of a region lacking in large chert nodules to a pan-European trend in which polished axes and knives or daggers made on long regular blades functioned as prestige objects in long-distance exchange networks.

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