

GÖNNERSDORF CONCENTRATION III: INVESTIGATING THE POSSIBILITY OF MULTIPLE OCCUPATIONS

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ABSTRACT: In any attempt to understand the settlement structures at the Upper Palaeolithic site of Gönnersdorf, a cardinal problem is the question of multiple, superimposed phases of occupation. This is the case also with Concentration III. In this paper the problem of multiple occupations is investigated in two different ways.

Our first step will be to describe the settlement features in a 'traditional' way. Because six different raw materials were used at Concentration III, some further interesting phenomena could be investigated: firstly, differences between the raw materials in the proportions of stone artefacts in pits; secondly, differences in the tool assemblages, and thirdly, differences in the spatial distributions of tools according to type of raw material.

The second part will deal with two related methods of spatial analysis, the ring and sector methods, bringing out on the one hand differences between the raw materials in the distributions of tools in rings 0.5 m wide around the 'centre' of the concentration, and on the other, differences between the raw materials in the distribution of tools in eight sectors around the 'centre' of the concentration.

One conclusion is that we are dealing with at least two, but possibly three or more phases of occupation: an early one characterized by the use of four raw materials (*Süßwasserquarzit* (sarsen), Chalcedony, Brown flint and North European flint) and associated with a tent, and one or two later phases, during which West European flint and *Kieselschiefer* (lydite) were used in the open air.

RÉSUMÉ: A toute tentative de comprendre les structures d'habitation dans le site du paléolithique supérieur de Gönnersdorf, la question de multiples occupations dans des phases superimposées constitue un problème cardinal. Cela est le cas aussi pour Concentration III. Dans cette publication, la question de multiples occupations sera examinée de deux façons différentes.

La première démarche sera de décrire de manière 'traditionnelle' les 'structures évidentes' d'habitation. Dans Concentration III, six matières brutes différentes ont été utilisées. C'est pourquoi on a également pu étudier d'autres phénomènes intéressants: premièrement, les différentes proportions des diverses matières brutes concernant les artefacts qu'en rencontre dans les fosses; deuxièmement, les différences entre les assemblages d'outils; et troisièmement, les différences entre les répartitions spatiales des outils par rapport à leur espèce de matière brute.

La seconde partie traitera deux méthodes contiguës de l'analyse spatiale: la méthode d'anneau et la méthode de secteur. Elles mettent en évidence, d'une part, les différences entre les matières brutes dans la répartition des outils dans des anneaux de 0,5 m de large qui entourent le 'centre' de concentration, et d'autre part, les différences entre les matières brutes dans la répartition des outils dans huit secteurs autour de 'centre' de concentration.

Une des conclusions est que, dans Concentration III de Gönnersdorf, nous avons affaire à au moins deux, sinon trois ou plus de phases d'occupation: une première phase que est caractérisée par l'emploi de quatre matières brutes (du *Süßwasserquarzit*, du calcédoine, du silex brun et du silex d'Europe du Nord), et qu'on associe avec l'emplacement d'une tente, et une ou deux phases suivantes où du silex d'Europe d'Ouest et du *Kieselschiefer* ont été utilisés en plein air.

KEYWORDS: Upper Palaeolithic, Magdalenian, Gönnersdorf, intrasite spatial analysis, ring and sector method, multiple occupation

1. INTRODUCTION

Recent years have seen the introduction of a new method, or, to be more exact, twin methods, for the global spatial analysis of Stone Age sites with cen-

tral hearths: the ring and sector method (Stapert, 1989; in press a; b). This method employs simple statistical means to investigate artefact frequencies in rings and sectors around the centre of the hearths. Its application to two concentrations at Gönnersdorf

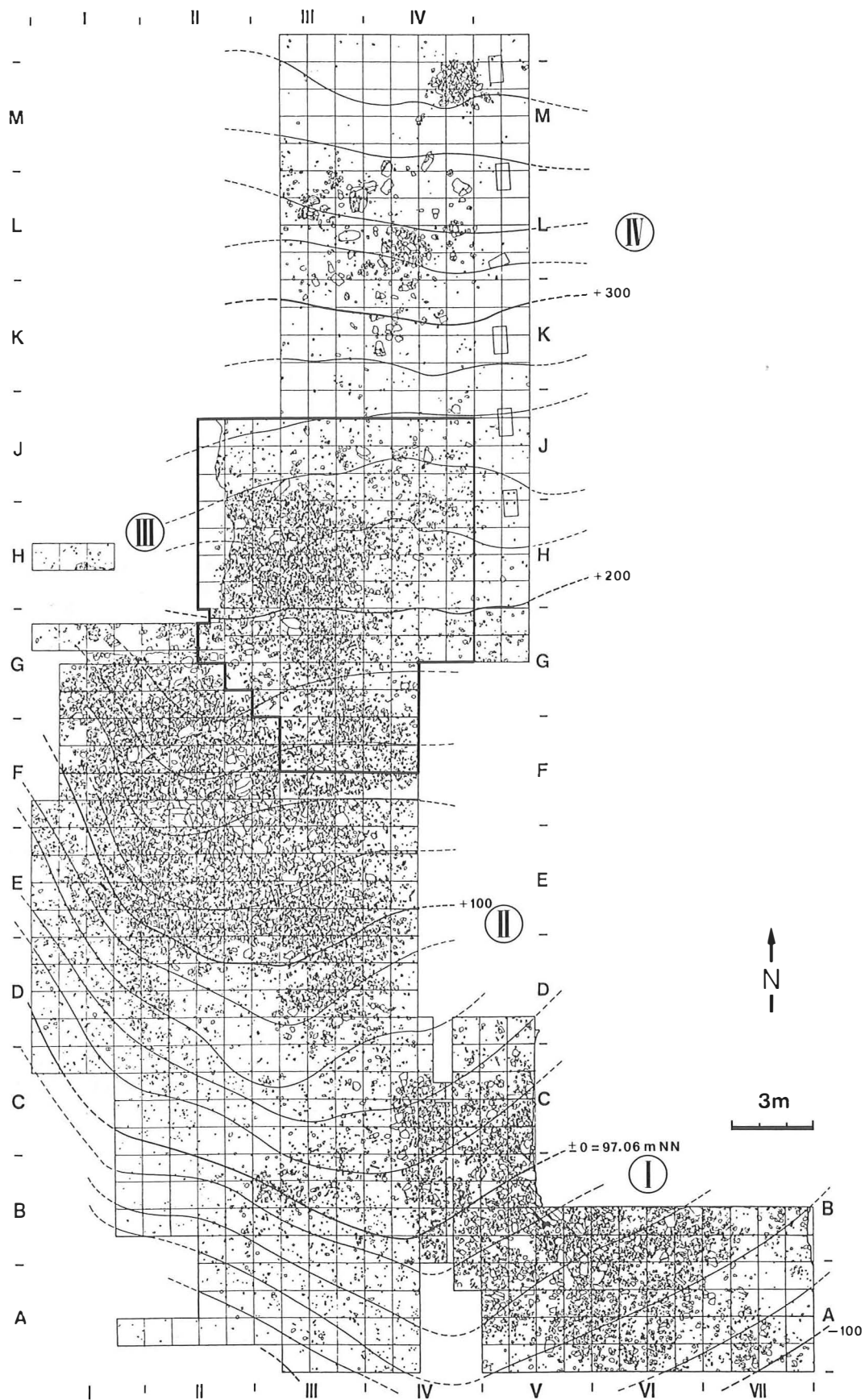


Fig. 1. Gönnersdorf. Level I with Concentrations I-IV.

(I and IV) showed that the ring method was able to reveal whether the hearth lay within a shelter or in the open air. In this paper we shall apply this method to another problem: the possibility of multiple occupation at a single site – in this case, Gönnersdorf Concentration III.

Concentration III is characterized by a dense scatter of stones and cobbles, oval in outline and about 5 m across. The hypothesis that several occupations occurred here was prompted by various circumstances. The very amount of settlement debris makes a single occupation unlikely. Moreover, the identification of various fire zones suggests that the site's settlement history was quite a complex one. The fact that stone artefacts of different raw materials found their way into the pits in widely varying proportions is a further important indication that the site saw several phases of occupation.

The range of raw materials, comprising six different kinds, offers good prospects not only for conventional analysis of the evidence, but also for the ring and sector method. Moreover, the fact that the various raw materials are represented by similar numbers of tools is ideal for statistical comparison.

The aim then is to study the spatial patterns of tools for the different raw materials separately, and to see whether or not groups of raw materials emerge with similar spatial distributions. If the spatial patterns of tools of different types of raw material should be roughly identical, then the hypothesis that these raw materials were used during a single occupation phase would appear to be reasonable. However, if the various raw materials (represented by the tools made from them) should exhibit radically different spatial patterns, then the possibility of multiple occupation deserves serious consideration.

At the end of the paper the results of the 'conventional' analysis and the ring and sector method will be summarized and compared with each other.

2. THE EVIDENCE AT CONCENTRATION III (T.T.)

During the excavations (1968-'76) headed by Gerhard Bosinski at the Middle-Rhenish Magdalenian site of Gönnersdorf, covering almost 700 sq m, several concentrations of settlement remains were brought to light (fig. 1). The main features of the site, which was unusually rich for Central Europe, have been reported on in several publications (e.g. Bosinski, 1979; 1981). Scientific analysis so far has dated Gönnersdorf to the end of the Bölling Interstadial (Brunnacker, 1978), but a somewhat older dating is considered also (Terberger, in press).

The excavations revealed three dense concentrations (Concentrations I-III), of which one (I) has been published in detail. Bosinski was able to recon-

struct its features as the remains of a dwelling with vertical walls and an entrance to the southeast (Bosinski, 1979: *Taf.* 19). A further, less dense concentration (IV) in the extreme north, however, could be identified as a tent-ring with a central hearth (Terberger, in press; Stapert, 1990; in press). In the present article, one of the still unpublished larger concentrations (III) will be discussed in some detail (fig. 1).

Concentration III presents a roundish to oval accumulation of habitation debris with a diameter of 4.5 to 5 m (fig. 2). It is virtually completely preserved; only to the west is it slightly cut off by a disturbance. The settlement remains lie superimposed in several layers, so that during the excavations three levels had to be prepared (Levels I, ZP, and YP; for the method of excavation see Bosinski, 1979: 46 ff). The find layer consists mostly of stones, but the assemblage comprises also a large number of flint artefacts, bones and even ornamental and artistic objects (Bosinski, 1981). Beneath the find layer, which was c. 0.2 m thick, depressions filled with settlement debris appeared in several places. In most cases they could be interpreted as man-made pits (fig. 2).

Altogether, Concentration III appears to be largely undisturbed. The vertical sections show rifts in the find layer, due to frost action (Bosinski, 1979: p. 45; Hahn, 1988: p. 52), but in the levels nothing indicated large-scale displacement, in spite of a slope of c. 8%.

Concentration III is clearly demarcated at its northern and eastern periphery (fig. 2). Only to the southeast is there a continuation of the find scatter, yet with a considerably reduced density of settlement debris. The clear-cut boundary of the concentration, with its southeasterly continuation, suggested to Bosinski that these were the remains of a shelter similar to that of Concentration I, with its entrance to the southeast (Bosinski, 1979: p. 40; 1981: p. 39). This view cannot be maintained unaltered after extensive analysis.

2.1. The stone 'pavement'

The majority of the finds in Concentration III are stones such as quartzite, slate and quartz, deriving mostly from the Rhine gravels lying 40 m below the site. The size of the complete specimens ranges from fist-sized cobbles to a block of 55 kg, but generally the stones are broken. Often flattish pieces were encountered, made from large blocks of slate and quartz (Terberger, 1988a; Leroi-Gourhan & Brézillon, 1972: p. 76). The total weight of the find material from Concentration III and its periphery is over 1000 kg. Transporting the stones to this site must have demanded a great effort. Hence a short-term encampment at the site can be excluded.

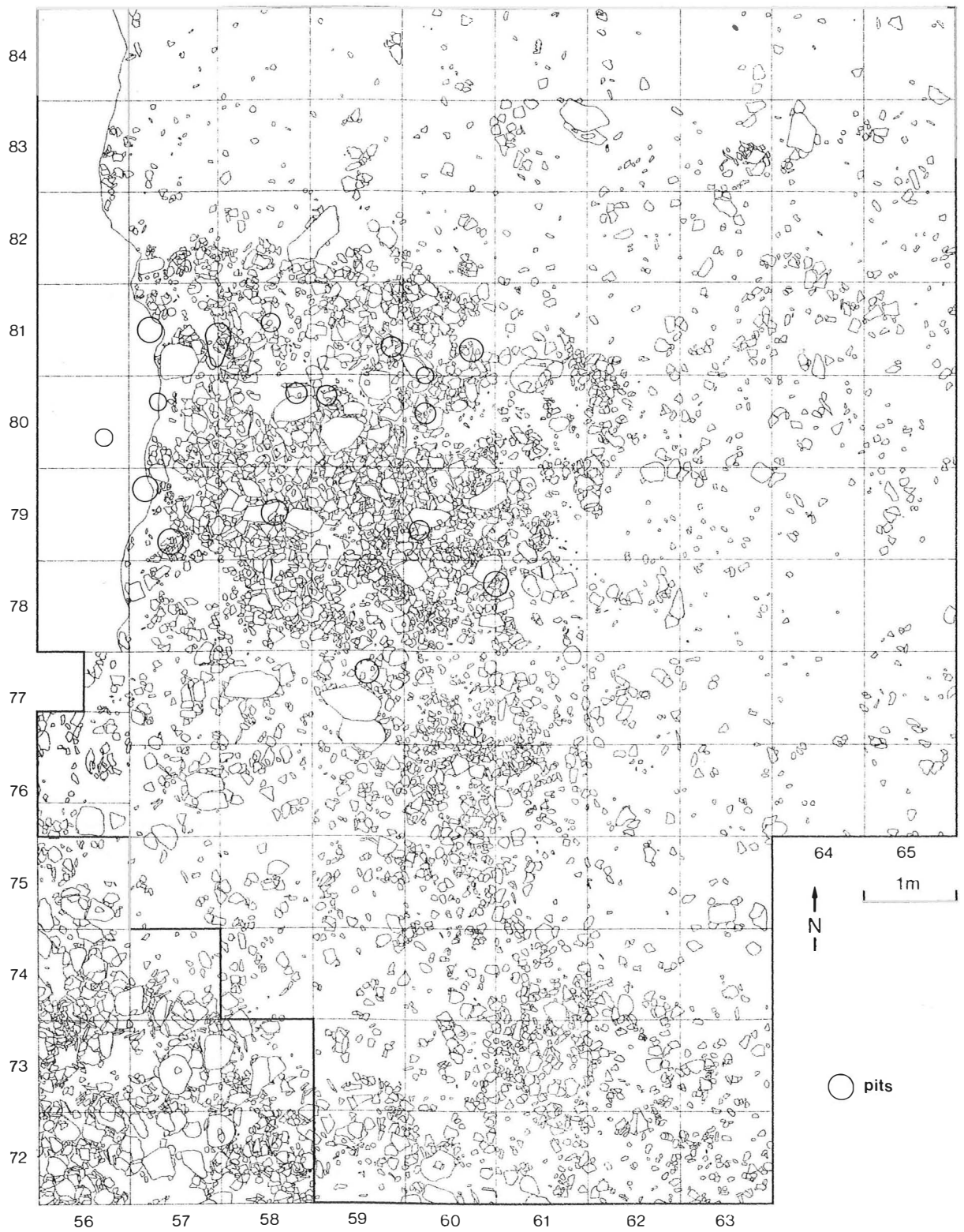


Fig. 2. Gönnersdorf III. Level I with the pits.

Within Concentration III, zones of varying density can be distinguished. The finds are concentrated mainly in the southern half. The northern part is characterized by a thin scatter of finds punctuated with local concentrations. The larger stones display no regular pattern, but lie at the centre as well as in the periphery and outside Concentration III.

One level lower (Level ZP; fig. 5) there are markedly fewer finds, so that the clear-cut distinction between Concentration III and its periphery is lost. From the centre (Squares 58,59/80) a scatter of finds is seen to extend to the southeast. This is enclosed by a virtually empty zone c. 50 cm wide, which also showed in Level I, albeit less distinctly (fig. 2).

Apart from the local find concentrations, which in part represent the pits, a small, circular feature in Square 60/81 in Level ZP needs to be mentioned. In Level I this circle was visible already, with a slightly larger diameter (0.50 m), though less easy to recognize because of an overlying slab of quartzite. It appears to be a small depression, purposely surrounded by stones, with further settlement debris in the close vicinity. The function of this small-scale feature, as indeed of the scatter of stones in general, remains unclear for the time being. In the following it will be investigated whether we may speak of a 'pavement' here in the sense of a floor covering, as was assumed to be the case at Concentration I (Bosinski, 1979; cf. Löhr, 1979: p. 15 ff).

2.2. The problem of the hearths

Without doubt the hearths at Palaeolithic sites deserve special attention (cf. Perlès, 1977; Olive & Taborin, 1989). They are the focus of daily life in a hunting community and therefore play a central role in the structure of a site (Binford, 1983: 144 ff; Stapert, in press).

Although at most Upper Palaeolithic sites the hearths are easily recognized, and belong to the *structures évidentes* (Leroi-Gourhan & Brézillon, 1972), this is not the case at Gönnersdorf Concentration III. Although charcoal remains were found during the excavation, no distinct area with a structure identifiable as a hearth was recognized. Nor was any burnt loam found, though this is often encountered at sites on loess soils. In effect, the position of any hearth(s) remained unclear during excavation, which may be attributed to various natural causes (cf. Laloy, 1980: 99 ff). In the analysis an effort was made to locate the hearth(s) through studying the distribution of charcoal and traces of fire on stones.

2.2.1. Charcoal

Any charcoal remains observed by the excavators, irrespective of size, were marked on the field dra-

wings with an X. These traces of charcoal – identified as predominantly *Salix*, a little lignite, and incidentally *Pinus* (Schweingruber, 1978: p. 78) – when shown in a plan (fig. 3) form a patch of at least 6 sq m in the southern part of Concentration III. A little apart from it, to the north, there are two clearly demarcated concentrations (in Squares 57,58/81 and 60/81).

Apart from that in the contact zone with Concentration II on the south side, charcoal was observed only sporadically outside Concentration III.

The charcoal traces indicate intensive use of fire in the area of Concentration III. Yet the question remains to what extent this result was determined by a better chance of preservation in the parts with a high density of finds, or by possible erosion. Furthermore, the possibility of charcoal being spread by clearing activities should be kept in mind.

2.2.2. Traces of fire on stones

In order to obtain a further criterium for defining any hearth(s), all stones were checked for traces of fire. Problems in this method arise on the one hand through the diversity of materials, which are differentially (or hardly, such as basalt) affected by fire. On the other hand, a fire must have burnt with a certain intensity and duration before it will leave its mark on stone (cf. Taborin, 1989; Hahn, 1989: p. 6).

The mapping of fire traces in Level I (fig. 4) in fact corroborates the assumption that fire played an important role at Concentration III. The find-rich south and southeast part displays the greatest density of fire traces. It remains unclear whether it contained a single large hearth or whether the fire zone subdivides into smaller units. In the northeast part of Concentration III there is a scatter of burnt stones, covering over 1.5 sq m. The plan of the second level (fig. 5) underlines the findings of Level I; besides, some large stones with traces of fire are recorded in the northwest (Squares 57,58/81).

Contrary to charcoal, burnt stones were found in large numbers also outside Concentration III. Clusters of them occur to the southeast of Concentration III and also – less distinctly – in its eastern periphery.

2.2.3. Defining the fire zones

In the context of this article, the demarcation of the fire zones should be regarded as a working hypothesis.

In the southern part of Concentration III the evidence suggests at least one fairly large fire zone. The faint evidence of charcoal in Square 59/79 (fig. 3) is not paralleled by fire traces on stones; hence the charcoal distribution offers no basis for a further subdivision.

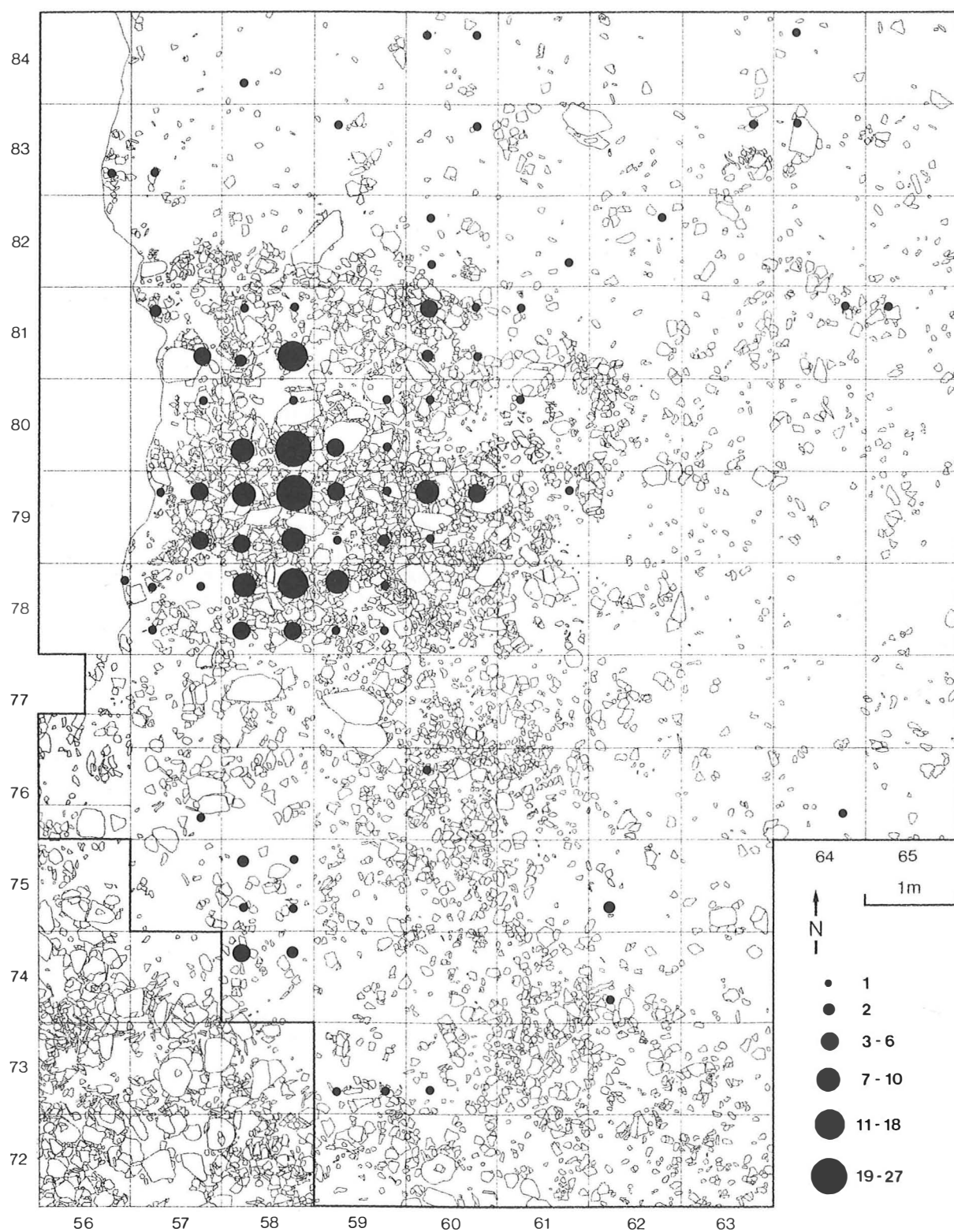


Fig. 3. Gönnersdorf III. Distribution of charcoal particles (only those present in the archaeological find layer).

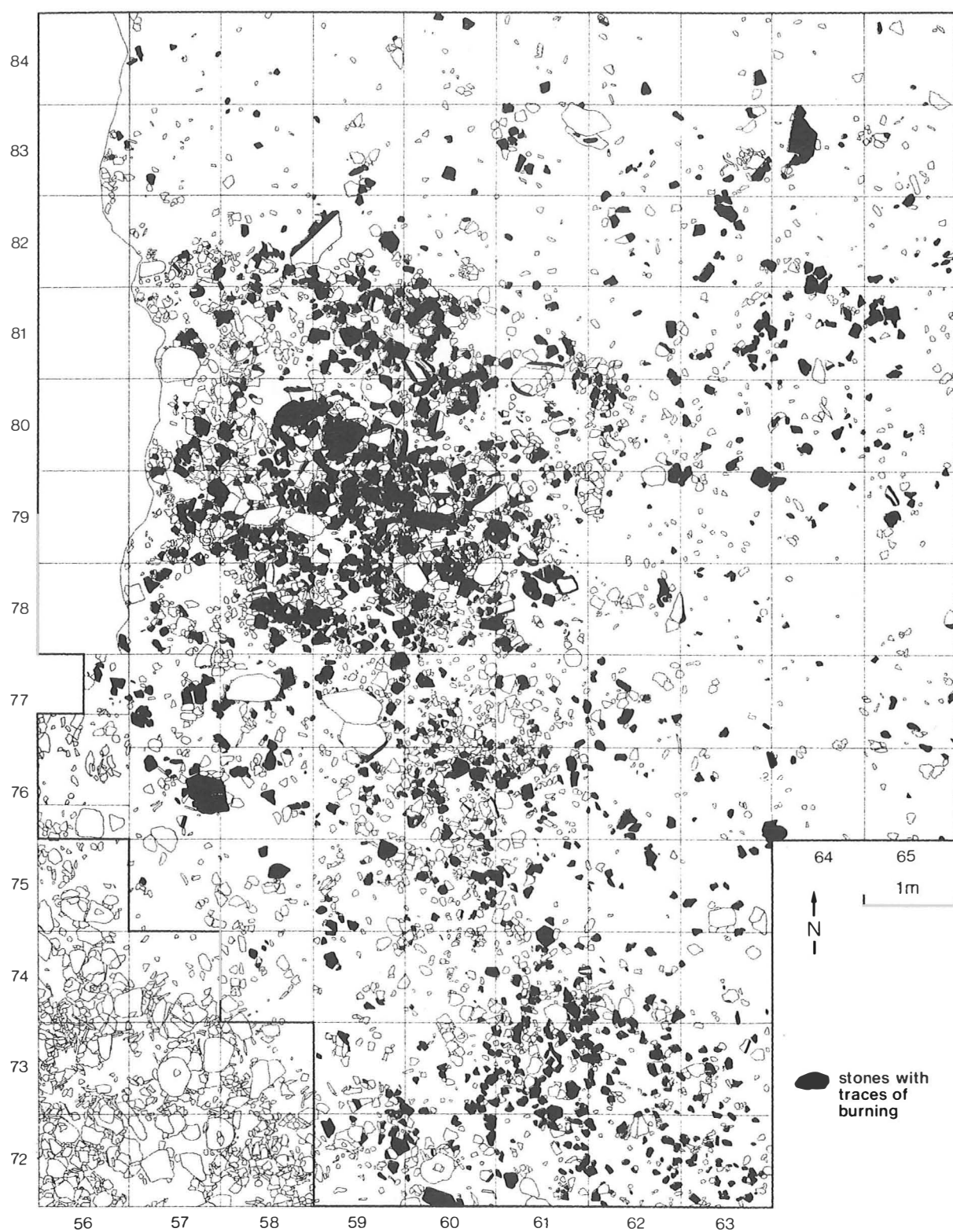


Fig. 4. Gönnersdorf III. Traces of fire on stones in Level I (excluding quartz). The intensity of burning is not indicated, and the extent of the traces only in the case of large specimens.

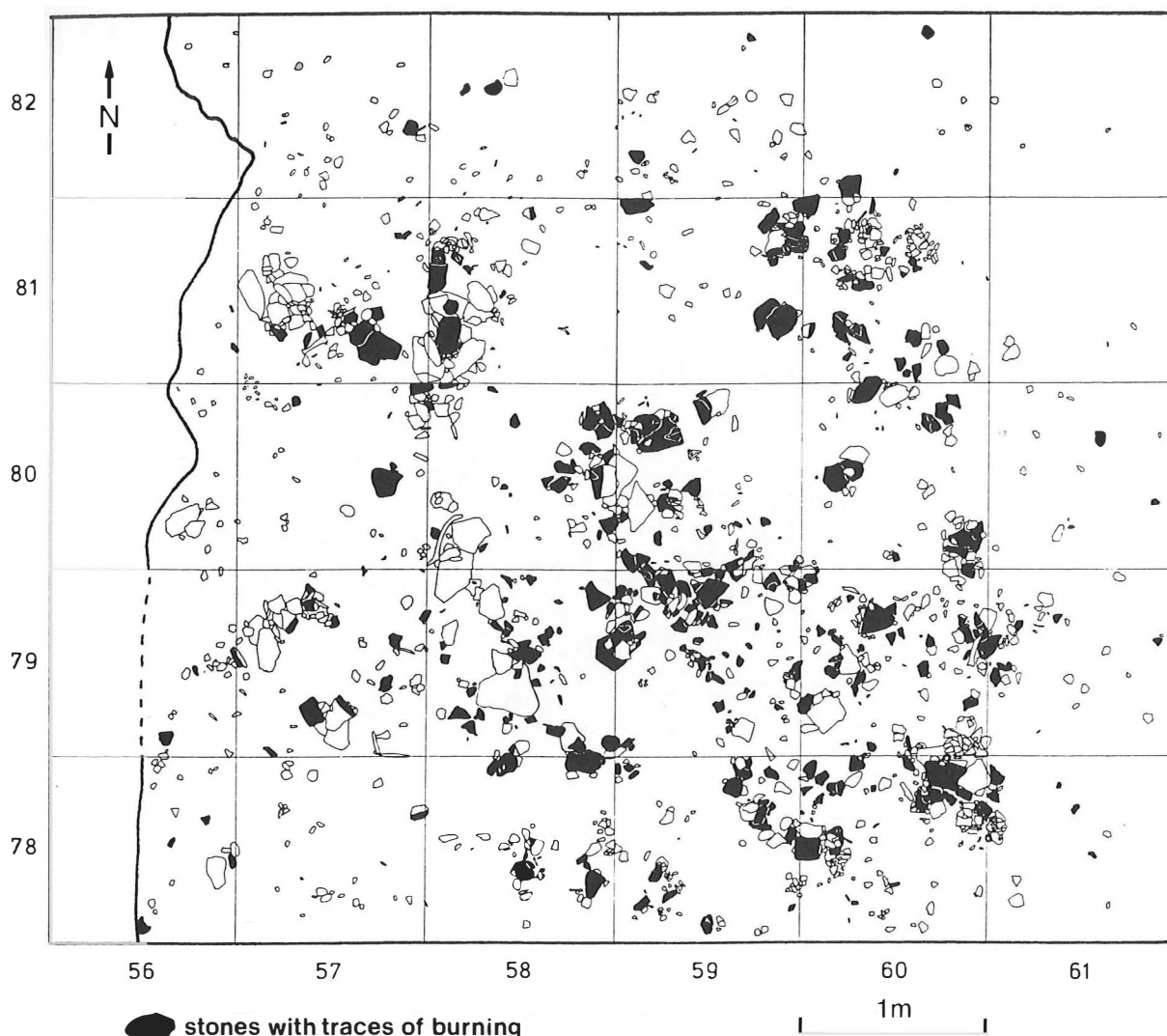


Fig. 5. Gönnersdorf III. Traces of fire on stones in Level ZP.

The structures recognized in Levels I and ZP more readily suggest a subdivision. The part of Concentration III that is particularly rich in finds, extending from the centre towards the southeast (figs 2 and 5) shows the most intensive fire traces. Probably in this area there is a fire zone of c. 2 sq m (58, 59/80; 59/79), even though the actual hearth cannot be clearly identified. The zones to the southeast (59, 60/79; 60/78) and to the west are interpreted as activity areas associated with this hearth.

Evidence from Pincevent shows that as a result of hearth clearance, large numbers of burnt stones may end up in the periphery of a hearth area (Leroi-Gourhan & Brézillon, 1966: p. 328; 1972: fig. 52).

The fact that the hearths cannot be clearly defined is mainly due to the type of hearth. The hearth at Concentration III lay on the surface or in a slight

depression, and was lined or covered with mostly flat stones (cf. Perlès, 1976: fig. 1; Hahn, 1989: Abb. 1). That the fire was covered is suggested by the fairly frequent occurrence of intensive burning traces on the underside of stones.

A definite demarcation or stone setting around the hearths is not in evidence. The stones in general served for the transfer of heat. According to their texture and shape, they may have had a function in food preparation, or in drying and heating (Sarasin, 1918: p. 135; Perlès, 1977; Terberger, 1988a). The pits (fig. 2) with two exceptions lie outside this 'stone-rich' fire zone.

In the vicinity of the hearth (for instance in Square 59/80) there are large slabs and (in Square 60/79) blocks of stone. These probably served as work surfaces, as seats, or for securing objects, while the

slabs may have had the additional function of covering the fire.

Hearths lined or covered with stones are fairly frequently encountered at Upper Palaeolithic sites, e.g. at Mainz-Linsenberg (Neeb & Schmidtgen, 1921-1924: *Taf. II*), Fontgrasse (Bazile, 1985), Abri Pataud, Malta (Perlès, 1977: 83 ff), Oldeholtwolde (Stapert, 1982) and probably also at the Magdalenian site of Alsdorf (Löhr, 1979: p. 18), to name but a few. Yet the most convincing parallels to the hearth of Concentration III are found at the roughly contemporaneous site of Étiolles in the Paris Basin (Terberger, in press). Here four *foyers à forte accumulation de pierres* of up to 6 sq m were uncovered (Julien et al., 1988: p. 87; Olive, Pigeot & Taborin, 1988). Here too, it was impossible to establish the precise extent of the actual hearths. However, no pits were found at Étiolles.

In the northern part of Concentration III there were further accumulations of burnt stones. This raises the question of whether any hearths might remain hidden here. The circular structure (in Square 60/81) especially suggests a small sunken and stone-edged hearth, covered with a flat stone. The small amount of charcoal and fire traces however suggests that if indeed a hearth, it was used only for a short while.

Outside Concentration III too, there are zones with burnt stones. Adjacent to Concentration III on the southeast, are two concentrations (Squares 60/76 and 61/73) of c. 2.5 sq m each, which, given their structure, seem also to have been flat, stone-covered hearths, with a diameter of 0.8 m.

In the eastern periphery (around Square 64/81) there is a thin scatter of stones with fire traces.

2.2.4. The hearths; summary

To summarize the evidence of the hearths, the author feels that at Concentration III and in its vicinity several stages can be identified in the use of hearths of the flat type with stones.

An initial stage of short duration, leaving only a thin scatter of burnt stones, may be represented in the eastern part of Concentration III (around Square 64/81). With longer use of such a hearth more stones would be added, resulting in concentrations such as those in Squares 60/76 and 61/73. The charcoal has not been preserved because of the comparatively scant settlement remains in this area.

The southern half of Concentration III, a large area with numerous, superimposed settlement traces, must represent the remains of a repeatedly and intensively used fire zone. The exact position of the central hearth may of course have shifted somewhat from phase to phase.

Even though it is not possible to identify with certainty each of the hearths, the close association of

stone concentrations with the use of fire is evident. Should the presence of multiple hearths at Concentration III come as a surprise, a glance at other large-scale excavations of encampments, such as Pincevent, Étiolles, Marsangy (Julien et al., 1988), Mezin (Shovkopljak, 1965: fig. 15) or Kostienki I,1 (Veil, 1981), will show that the presence of several hearths is not at all unusual. In this context the single hearth identified at Gönnersdorf Concentration I is more puzzling; presumably that site too actually contained more hearths.

Two conclusions may be drawn at this point:

1. Although multiple hearths are usual in camps of hunters and gatherers (Binford, 1983: 156 ff), the number and nature of the several hearths at Concentration III and in its vicinity cannot be explained by a single phase of occupation. Instead, several settlement phases seem to be superimposed.

2. The provisional interpretation of Concentration III as a 'pavement' no longer holds, and requires adjustment. The relatively clear-cut outline of Concentration III need not necessarily be equated with that of a tent with its entrance to the southeast.

These provisional conclusions will be dealt with in greater detail when the flint artefacts are discussed.

2.3. Stone artefacts

The Neuwied Basin is a relatively poor area as regards good-quality raw materials. Consequently, a wide range of rocks were used, and a large proportion of the material at Gönnersdorf is of non-local origin (Franken, 1983; Floss, 1987). According to a new analysis by Floss¹, six different raw materials can be distinguished at Concentration III:

Süßwasserquarzit (= *Tertiärquarzit*), Chalcedony, Brown flint (= *Kieseloolith*), North European flint, West European flint and *Kieselschiefer*. Two of these were available in the close vicinity (*Kieselschiefer*) and regionally (*Süßwasserquarzit*). The others had been brought in over distances of c. 100 km from the west, north (Franken, 1983: p. 61) and south (Floss, pers. comm.). These various provenances provide an additional argument for multiple occupation phases at Concentration III. If these raw materials were current at different times, this may be reflected in the contents of pits, tool assemblages, and patterns of the spatial distribution.

2.3.1. Stone artefacts in pits

The seventeen pits at Concentration III are man-made depressions created while the site was occupied (fig. 2). The functions they may have served, as post-holes, storage pits, ovens or containers, will not be further discussed here (cf. Bosinski, 1979:

Table 1. Gönnersdorf III. Stone artefacts in pits, disregarding chips. 1. *Süsswasserquarzit*; 2. Chalcedony; 3. Brown flint; 4. North European flint; 5. West European flint; 6. *Kieselschiefer*.

	Pits																Total	
	82	73	72	71	85	86	67	76	87	83	81	84	68	77	74	78	69	
1.	4	2	1	3	12	4	59	5	1	182	5	7	8	34	56	12	13	408
2.	2	2	1	-	1	2	2	5	-	10	-	-	12	11	1	-	3	52
3.	-	-	-	1	1	1	3	12	-	25	1	1	-	13	-	-	2	60
4.	-	-	-	-	-	1	2	2	1	21	-	4	3	27	1	-	-	62
5.	-	-	-	-	-	-	-	-	-	-	1	1	2	1	1	-	3	9
6.	-	-	-	-	-	-	-	-	-	1	1	1	1	2	3	4	5	18
T.	6	4	2	4	14	8	66	24	2	239	8	14	26	88	62	16	26	609

142 ff). Here, an attempt is made to establish, by means of the pits, a micro-chronological sequence for Concentration III.

If we assume that a pit was in use and open only for a limited period of time (a single phase of occupation?), then stone artefacts produced up till its filling-in may have ended up within it. If habitation phases were characterized by stone artefacts made of distinct raw materials, then this will be reflected in the pit's contents. For example, the first phase may have seen the construction of five pits, in which accumulated raw materials a and b. In the second phase three new pits were opened. These three were filled with the now current raw materials c and d, while some stray artefacts of the preceding phase, made of raw materials a and b, also ended up here. This process would be repeated with every subsequent settlement phase.

The composition of the stone artefacts in the pits of Concentration III (table 1) shows that indeed different spectra of raw materials can be identified. *Süsswasserquarzit* is found in every pit, while it is also the most frequent among the pit finds. As there is no pit containing solely *Süsswasserquarzit*, no separate phase can be singled out that might be characterized by this material.

Chalcedony, Brown flint and North European flint together constitute a group. They occur in pits 12, 10 and 9 times respectively, with comparable overall frequencies ($n = 52, 60$ and 62 , respectively). Clearly distinct from these are West European flint and *Kieselschiefer*, which were found in 6 and 8 pits, totalling no more than 9 and 18 artefacts, respectively.

To summarize, the outcome may be interpreted as evidence of at least two habitation phases:

Süsswasserquarzit occurs mainly together with varying proportions of Chalcedony, Brown flint and North European flint. Pits 86, 67, 76 and 83 especially indicate contemporaneous use of these materials; no further subdivision is discernible. Theoretically, initial 'pitless' phases are of course possible, but

these cannot be demonstrated by this method.

Although *Kieselschiefer* and West European flint occur in very large numbers at Concentration III (Franken, 1983), they are seldom found in pits. The occurrence of single pieces, for instance in pits 68 and 74, can be explained by bioturbation (cf. Hahn, 1988: p. 52). In pits 68 and 74 *Kieselschiefer* and West European flint were found only in the upper levels of the fill; hence it can be concluded that at one stage these pits were only partially filled. This means that *Kieselschiefer* and West European flint definitely belong to a later phase, or phases, of habitation. After rigorous testing, four pits remained that can clearly be associated with these two raw materials. Later disturbances, such as unrecognized animal burrows, cannot, however, be entirely excluded as producers of these 'pits'. These few pits are unable to provide any chronological distinction between West European flint and *Kieselschiefer*.

Statistical testing of the differences between the raw materials, in the proportions of tools present in pits, supports the conclusion that at least two occupation phases must have existed (see section 3).

2.3.2. Tool assemblages by type of raw material

Because the tool assemblage of any raw material depends on functional factors, such as tool requirements, quality of material and moment of use, neither a correspondence between raw materials of a single phase, nor a clear difference between various occupations is to be immediately expected.

The six different raw materials partly display quite distinct tool assemblages (fig. 6).² There is not much to distinguish *Süsswasserquarzit*, Chalcedony, Brown flint and North European flint from the West European flint.

Only *Kieselschiefer*, which in the pits manifested itself as a phenomenon of a later phase, can be clearly distinguished on the basis of its remarkably high proportion (79%) of backed bladelets. As backed bladelets apparently served as insets for 'projec-

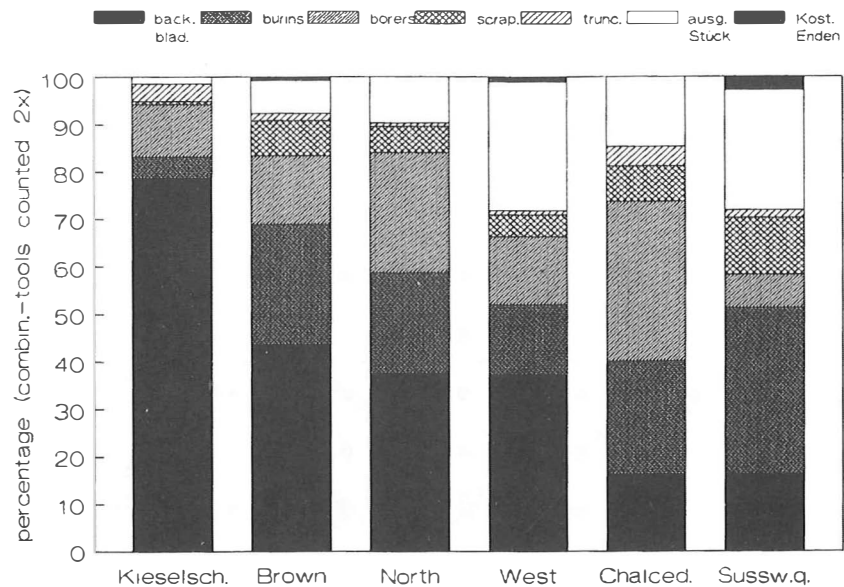


Fig. 6. Gönnersdorf III. Tool assemblages according to type of raw material.

tiles' (probably spears; Julien, 1984: p. 164), the *Kieselschiefer* can be classified as a specialized assemblage associated with hunting or hunting preparations. This nature of the tool assemblage argues in favour of *Kieselschiefer* marking an independent phase. The small number of burins ($n=7$) and scrapers ($n=1$) and of tools in general ($n=155$) makes the *Kieselschiefer* one of the minor components (Löhr, 1979: p. 109 and Abb. 20).

An alternative explanation could be that the nature of this raw material, which is only available in small nodules, made it much more appropriate for the production of the small backed bladelets than of the larger tools.

An argument for the hypothesis that *Kieselschiefer* represents a separate occupation is that this type of raw material was found to show a distinct spatial distribution in the case of Concentration IV (Terberger, in press).

The four raw materials of Phase 1, with 641 tool edges altogether, instead reflect a (single?) longer occupation with a wide range of activities.

Qualitative differences exist between the raw materials, as was evident also at the Magdalenian site of Andernach (Terberger, 1988b): *Süßwasserquarzit* was generally preferred for scrapers, burins and pieces with heavily bifacially splintered edges (*ausgesplitterte Stücke*), while flint and related rocks (North European flint, Chalcedony and Brown flint) were used mainly for the manufacture of backed bladelets and borers.

In summary, the tool assemblages of the various raw materials at Concentration III provide good arguments for at least three occupation phases:

1. *Süßwasserquarzit*, Chalcedony, Brown flint and North European flint were deposited during at least one, fairly long occupation.

2. The tool assemblage of West European flint shows neither a positive nor an inverse relationship with that of *Kieselschiefer*, and apparently represents an independent phase of use of the site.

3. *Kieselschiefer* goes back to at least one short, late occupation, which can be characterized as a hunting camp.

The chronological relationship between phases 2 and 3 remains unclear. If it is assumed that *Kieselschiefer* was especially exploited for very small tools, then its deviating tool assemblage would not necessarily indicate a separate occupation.

2.3.3. Spatial distribution of tools by type of raw material

In the context of this article it is not possible to present each of the raw materials in detail; therefore the four raw materials of Phase 1 will be treated together. The flint artefacts are mapped per $\frac{1}{4}$ sq m.

The distribution of Phase 1 (fig. 7) very distinctly focusses on Concentration III and is clearly demarcated from the periphery to the north and east. However, the scatter of finds is continuous to the south and southeast. By far the greatest accumulation of tools is encountered in two of the pits, so that the central point of this tool distribution lies in the southeastern part of Concentration III.

If we differentiate between the raw materials, then the tools of *Süßwasserquarzit* remain limited almost exclusively to the centre of Concentration

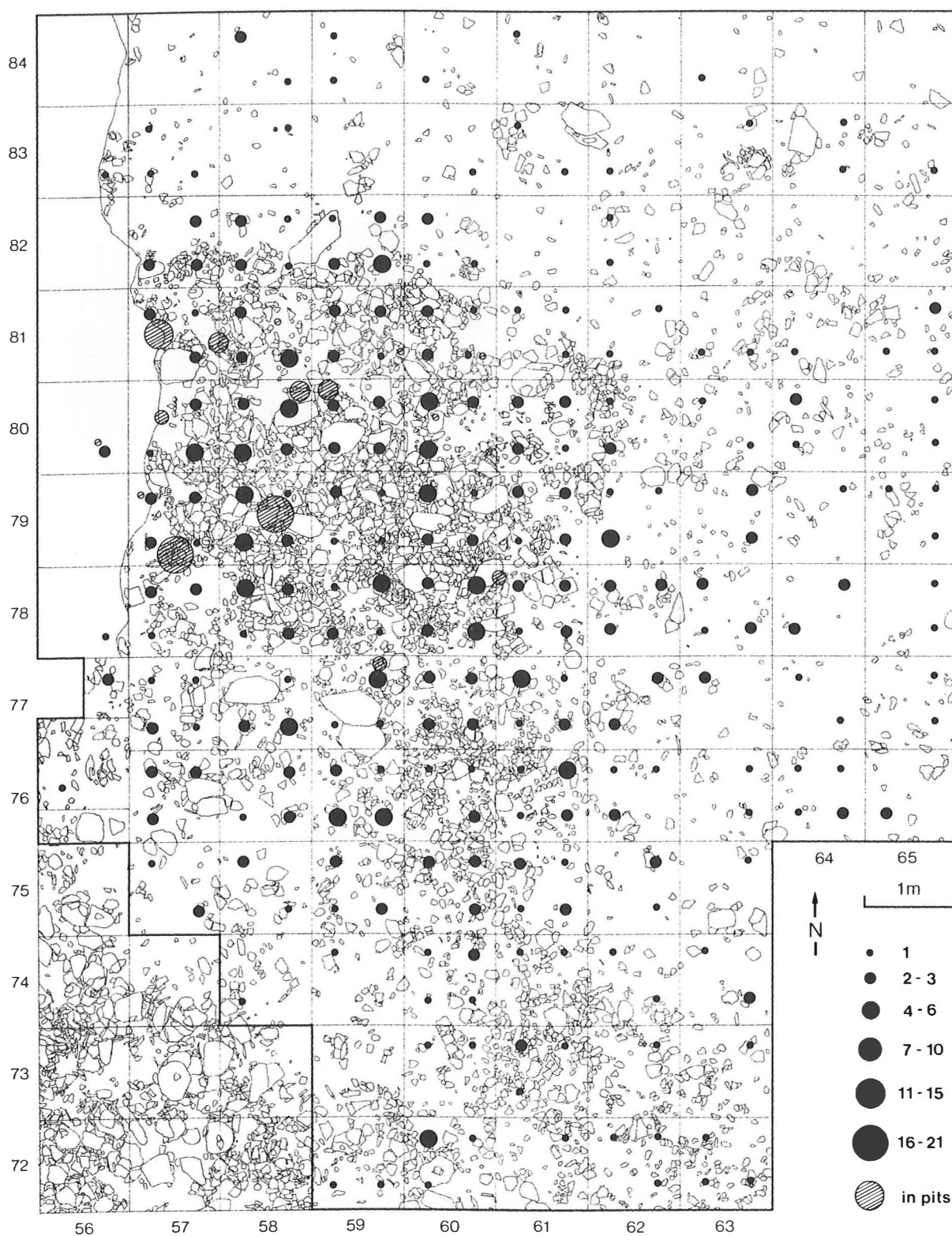


Fig. 7. Gönnersdorf III. Distribution of tools of *Süsswasserquarzit*, Chalcedony, Brown flint and North European flint.

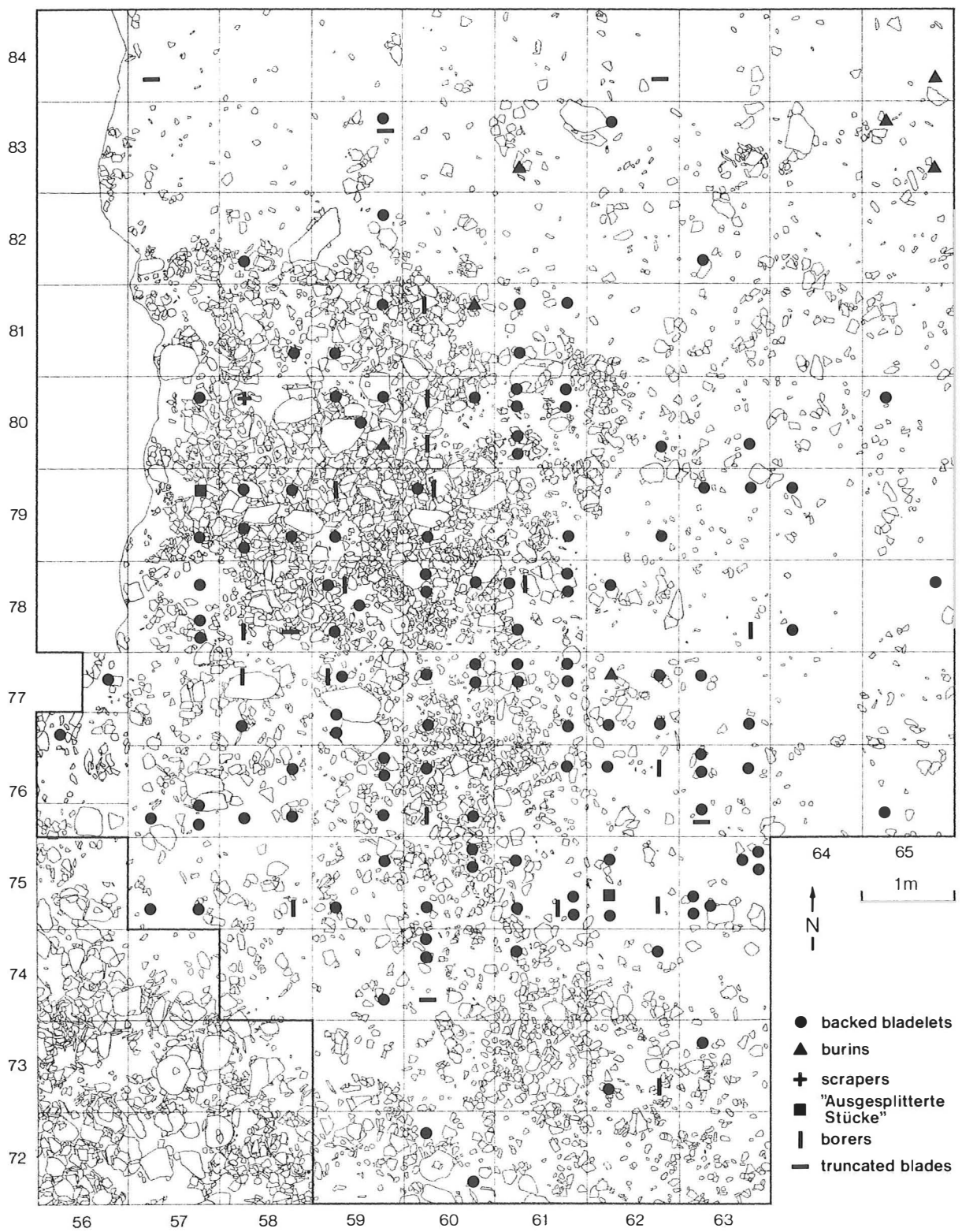


Fig. 8. Gönnersdorf III. Distribution of tools of *Kieselschiefer*.

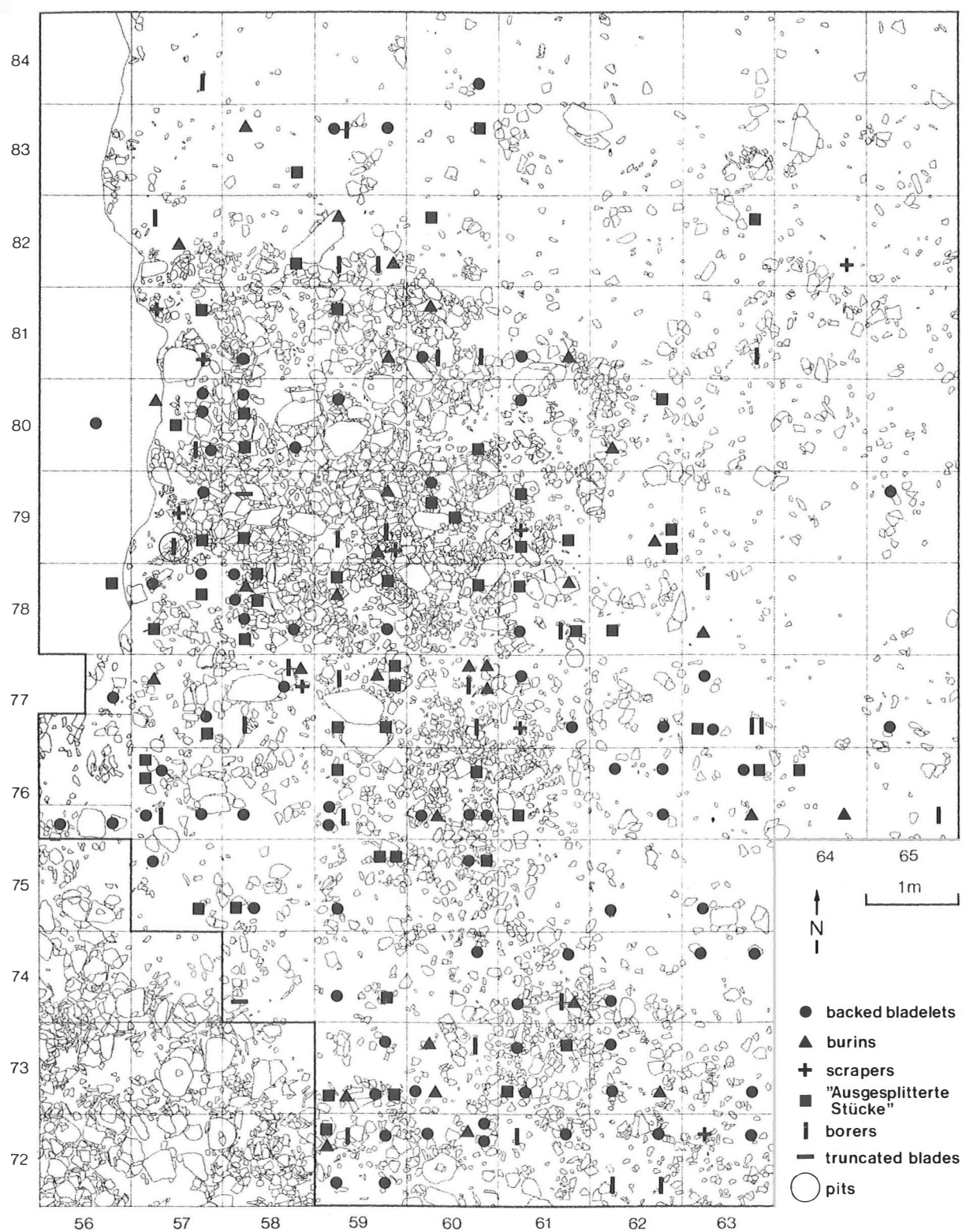


Fig. 9. Gönnersdorf III. Distribution of tools of West European flint (connected symbols represent combination tools).

III, which partly explains the high proportion of this material in pits.

Chalcedony similarly relates to Concentration III. By contrast, Brown flint and North European flint are better represented in the periphery. However, imported flints are more likely to become widely scattered than artefacts of local materials manufactured at a later date.

Because hearths as a rule also constitute centres of activity (Taborin, 1989: p. 78; Binford, 1983: 144 ff), the distribution of tools should be related to the fire zones. Yet it should be kept in mind that hearths without, or with very little stone-tool activity also exist (Julien, 1984: p. 165; Terberger, in press), and that the position of tools is also affected by man's discard behaviour.

In Phase I the main fire zone at Concentration III (Squares 59,60/79) was definitely used. Moreover, a correspondence between Phase I and the hearth to the southeast of Concentration III (Square 60/76) is possible, but West European flint and *Kieselschiefer* too are encountered more frequently here (figs 8 and 9). The indistinct fire zone in the eastern part of Concentration III, if it is one, must belong to Phase I, as the other materials do not appear here.

West European flint is the raw material with the greatest number of tools (n=209), yet its spatial distribution is difficult to understand (fig. 9). This kind of flint in itself is characteristic of Concentration II, which begins c. 4 m to the southwest of Concentration III (fig. 1; Franken, 1983: p. 69; Eickhoff, in press). The number of tools found at Concentration III, however, is too high to interpret Concentration III as the periphery of Concentration II. This is underlined by the find scatter being thinner between the two concentrations (fig. 9).

This means that Concentration III was used independently in the phase marked by West European flint. The tools occur clustered at the centre of Concentration III and to the south and southeast of it. A renewed use of the fire zone in Concentration III is very likely. No clear relation with the adjacent hearth to the southeast (in Square 60/76) can be established, by contrast to the hearth centring on Square 61/73. At the latter, tools of West European flint appear clustered, including a series of backed bladelets, while the other raw materials are present here only in low numbers. This hearth belongs in the context of Concentration II.

Kieselschiefer distinguishes itself from the raw materials of Phase I also in its tool distribution (fig. 8). As backed bladelets are particularly strongly associated with hearths (Keeley, 1982), a close relationship may be assumed between the *Kieselschiefer* distribution and the fire zones. No close correspondence with Concentration III, comparable to that of Phase I, is evident, but yet the central fire zone

appears to have been reused in this phase, as is indicated by some burnt *Kieselschiefer* artefacts in this area.

A large number of backed bladelets were found in the adjacent area to the southeast, which argues for the assignment of the hearth in Square 60/76 to the *Kieselschiefer* phase. The question then arises whether the two relatively close hearths (only 2 or 3 m apart) were used simultaneously, or instead represent two different occupations.

2.4. The evidence; summary

The provisional analysis of the evidence at Gönnersdorf III, which here has been presented only in part, points to a highly complex settlement history with at least two or three habitation phases (depending on whether *Kieselschiefer* is seen as a separate occupation or not).

On the basis of various fire indicators, such as concentrations of charcoal and traces of burning on stones, the presence of several hearths has been made plausible, though they were unidentifiable during the excavations. Apart from one exception (in Square 60/81), these must have been flat or only slightly sunken hearths, which were lined or covered with stones. Moreover, the hearths reflect several use stages, ranging from only a thin scatter of burnt stones, via a roundish concentration, to a multi-layered fire zone covering several sq m. Parallels to such an extended fire zone have been found at Étiolles in several instances (Julien et al., 1988: p. 87).

The hearths thus differentiated, as well as the bulk of the find material, suggest that the site saw several phases of occupation. The diversity of raw materials among the artefacts from the pits permits the identification of at least two phases. The variation of tool assemblages by type of raw material and the spatial distributions of the tools suggest that yet another phase could have existed.

At this point the question arises as to what kind of settlement or encampment is represented by each phase. What can the present interpretation add to the original hypothesis of a shelter with its entrance to the southeast? The existence of a shelter was also suggested by the presence of a few foetal horse bones, indicating a wintertime sojourn³ (cf. Poplin, 1976: p. 51).

The first phase, with four raw materials, focusses on the central part of Concentration III, and features numerous pits.

At Concentration I an outer circle of pits allowed the reconstruction of a wall supported by posts in post-holes (Bosinski, 1979: p. 168). Such an arrangement of pits is not evident at Concentration III, so that a similar reconstruction of any dwelling is not possible.

What remains is the spatial distribution of finds as a possible indicator of the presence of walls. The concentration's regular, roundish shape defined by an abrupt fall in the frequency of finds, is in itself no conclusive evidence of a shelter.

At Étiolles too, several large hearths are surrounded by clearly defined find concentrations. In two cases, where more (at W11) or less (at U5) clear-cut stone circles indicated shelters, these circles lay about 1.5 to 2 m away from the edge of the fire zone (Julien et al., 1988: figs 2 and 3). In each case a relatively empty zone ran between the fire zone and the stone circle. Reconstruction of the Étiolles shelters indicates a diameter of roughly 5 or 6 m. The maximum diameter of the oval shelter of Gönnersdorf Concentration I is even 7 m; here too the shelter wall surrounds a definitely emptier zone (Bosinski, 1979: *Beilage* 6; Stapert, in press).

If these results are related to Concentration III, then the wall, if present, could be expected at c. 1 m from the outer edge of the find concentration. If we look at the distribution of stone artefacts in this light, then possibly the effect of a wall may be visible on the north ($y=82$), the east ($x=62$) and the south ($y=76$) side; the entrance might then be reconstructed to the southeast. All in all, it is impossible to draw any definite conclusions regarding a shelter in Phase 1, because the find distribution in the southeast remains diffuse, and because later occupations have obscured the original features.

Although the excavated features do not permit a definite answer to the question of a shelter, the finds suggest at least one occupation of relatively long duration, to which must be attributed also the excavated remains of antler-working (Tinnes, 1984) and pieces of personal ornament and art. The overall character of this phase makes the presence of a shelter quite likely.

The features of Phase 1 must have remained visible to later groups of visitors. This means that only a limited length of time lies between the phases; there are no typological indications that the West European flint and *Kieselschiefer* tools must be younger.

The phase marked by West European flint, whose chronological relation to the *Kieselschiefer* phase is unclear, is hard to pin down. The close proximity of Concentration II, where almost exclusively West European flint was used, suggests a link with the tools of this material at Concentration III, as seems to be indicated by the hearth in Square 61/73. Possibly the hearth or hearths at Concentration III were used only occasionally, side by side with the occupation at Concentration II. For this phase no shelter can be reconstructed.

During the *Kieselschiefer* phase, both the fire zone within Concentration III, and the hearth to the southeast of it were used. The central point of the

Kieselschiefer distribution does not correspond with that of the find concentration as a whole, but lies somewhat to the southeast. The fairly small *Kieselschiefer* assemblage is strongly dominated by backed bladelets, which possibly indicates a separate occupation of short duration, relating to hunting or its preparations. Indications of a shelter are absent for this phase; if any pits were constructed, they were few.

The hypotheses developed here regarding the various uses of Concentration III during possibly three different phases, will be discussed in the light of the ring and sector method in sections 4 and 5.

3. TOOLS IN PITS: STATISTICS (D.S.)

In the above (section 2.3.1), differences between the various raw materials, regarding the occurrence of artefacts in pits, are discussed (table 1). At the present stage of the analysis, it is not possible to express the numbers of artefacts in pits as *proportions* of the total numbers of artefacts per type of raw material. This would be necessary if one wished to test the differences between the raw materials statistically. However, expressing the numbers of pit finds as proportions is possible if we restrict ourselves to the *tools* only. In table 2 the numbers and

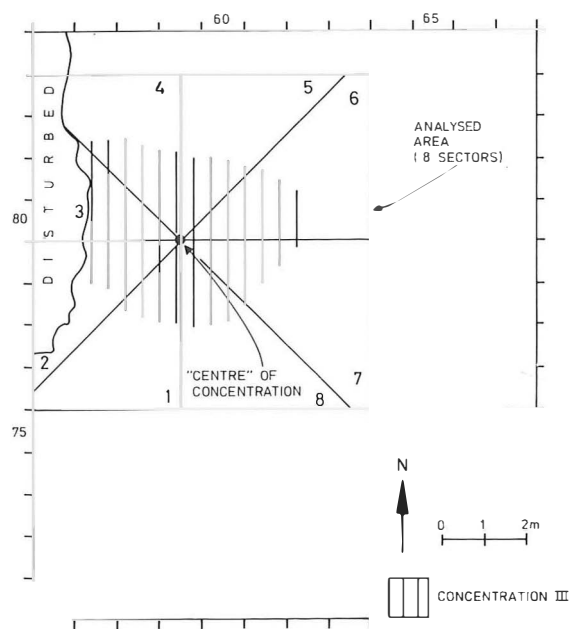


Fig. 10. Sketch of Gönnersdorf III. The area of 8x8 m, selected for the analysis according to the ring and sector method, is indicated, as well as the assumed 'centre' of the main hearth in the middle of the stone pavement, and the eight sectors used in the analysis. Note the disturbance in the western part of the concentration.

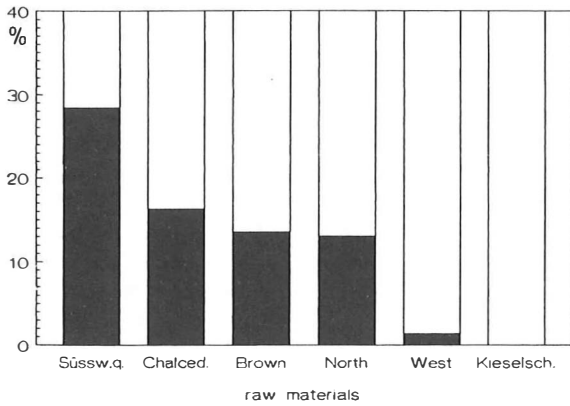


Fig. 11. Gönnersdorf III. Diagram illustrating the percentages of tools found in pits for six raw materials.

Table 2. Gönnersdorf III. Total numbers of tools of six different raw materials in the analysed area, and numbers and percentages of tools found in pits for the same raw materials. See also fig. 11.

Raw materials	Total number of tools	Tools found in pits	
		Number	%
North European flint	115	15	13.0
West European flint	145	2	1.4
Kieselschiefer	111	0	0.0
Chalcedony	92	15	16.3
Brown flint	133	18	13.5
Süßwasserquarzit	102	29	28.4

proportions of tools in pits are given for the six raw materials (see also fig. 11). These figures relate to the area of 8x8 m, selected for the analysis according to the ring and sector method (fig. 10).

There exist great differences between the raw materials in this respect, as noted already. For example, there were no tools of *Kieselschiefer* in the pits, but of the 102 tools made of *Süßwasserquarzit* 29 (28.4%) were found in pits.

If the data of table 2 are taken at face value, it is possible to distinguish three groups of raw materials:

- Few if any tools in pits: *Kieselschiefer* and West European flint.
- Moderate proportions of tools in pits: North European flint, Chalcedony and Brown flint.
- High proportion of tools in pits: *Süßwasserquarzit*.

It was decided to apply a significance test to assess whether the observed differences between the raw materials could have arisen by chance. Significance tests should not be taken too seriously in archaeology. One reason is that their results are strongly dependent on sample sizes (Shennan, 1988: pp. 77-

78). If sample sizes are very different for the variables, probability levels for the association of any pair among them cannot be compared satisfactorily. Fortunately, in the case of Concentration III the numbers of tools of the six raw materials are not very dissimilar, nor are they very small. Therefore, in this case the results of such tests are at roughly the same level of statistical strength. The variable 'raw material' is measured on the nominal scale. Nonparametric tests such as the Fisher exact probability test therefore are appropriate (Siegel, 1956). Each pair of raw materials are compared; for six different types of raw materials this results in 15 combinations. The results can be found in table 3.

The probability levels presented in table 3 demonstrate that the grouping presented above is justified, in the sense that the difference between any pair of raw materials placed in two different groups cannot be attributed to chance. From this we might conclude that at Gönnersdorf III three occupation phases are represented.

However, this is an interpretation which is not proven by the significance test. The test only tells us that the differences between the three different groups are 'real' in a statistical sense, so that it is meaningful to speculate about the possible reasons for these differences; it does not tell us how these differences originated.

Apart from the hypothesis of multiple occupations, we should also look for other possible causes of the observed differences. One alternative theory could be that there were differences in preservation potential between the various raw materials, leading to a proportionally higher occurrence of some types in pits, because in pits the artefacts would have been

Table 3. Gönnersdorf III. Differences in the proportions in which finds occur in pits (Table 2) are tested for each pair of raw materials, using the Fisher exact probability test (Siegel, 1956). Raw materials: 1. North European flint; 2. West European flint; 3. *Kieselschiefer*; 4. Chalcedony; 5. Brown flint; 6. *Süßwasserquarzit*. *: significant ($p < 0.05$).

Pairs of raw materials	p
1/2	0.00 *
1/3	0.00 *
1/4	0.32
1/5	0.53
1/6	0.00 *
2/3	0.32
2/4	0.00 *
2/5	0.00 *
2/6	0.00 *
3/4	0.00 *
3/5	0.00 *
3/6	0.00 *
4/5	0.35
4/6	0.03 *
5/6	0.00 *

protected better from weathering than on the surface. One of the six types of raw materials represented at Concentration III is much more susceptible to weathering than all the other types: *Süsswasserquarzit*. The other raw materials are more or less similar in resistance. Therefore, it is possible that the higher proportion of tools of *Süsswasserquarzit* in pits only reflects the circumstance that this material is more prone to weathering than the other raw materials. Another aspect in this connection is that this type of raw material seems to be clustered more tightly in the central part of Concentration III, where most of the pits are, than the other types (see section 2.3.3). It is possible that the exogenous materials were used in the first stages of the occupation, while the local material, *Süsswasserquarzit*, was used later and therefore became less scattered over the area.

These considerations lead us to the conclusion that the difference between groups b and c possibly is not meaningful in any archaeological sense. Thus, the interpretation of the data in tables 2 and 3 should be: two groups of raw materials can be shown to be different from each other with regard to the occurrence of tools in pits:

Group 1. Few if any tools in pits: *Kieselschiefer* and West European flint.

Group 2. Moderate to high proportions of tools in pits: *Süsswasserquarzit*, Chalcedony, Brown flint and North European flint.

Hence, it is now a reasonable proposition, based on the proportions of tools in pits, that at least two occupations must have existed at Concentration III, which can be placed in chronological order: the phase characterized by group 2 is older than that of group 1. This by no means excludes the possibility that the raw materials of, for example, group 2 in fact represent several occupations. If these occupations were not separated very much in time, this could have resulted in similar proportions of tools ending up in the pits. Nor can it be excluded that any one type of raw material was exploited during a number of occupations.

4. RING DISTRIBUTIONS (D.S.)

4.1. Theoretical considerations

The ring method is a simple technique developed for studying spatial patterns of artefacts with respect to a central hearth. Frequencies of artefacts are counted in rings around the centre of the hearth. In most cases rings of 0.5 m width are satisfactory, but when the number of artefacts is very high, rings of 0.25 m can be used to gain more detail. In this paper we will only use rings of 0.5 m. It is important to note that we are not discussing densities here (in terms of num-

bers of tools per square metre). The rings increase in surface area from the centre outwards. In applying the ring method, however, we are interested in the absolute frequencies per ring, and it does not matter where exactly the tools are located, nor whether they occur locally concentrated or scattered. The rings only serve as a graphical illustration of the method, and in fact it would be more precise to speak of distance *classes*. The distribution of the tools in the space around the centre is investigated by means of the sector method, to be discussed in section 5.

As explained earlier (see section 2.2), the precise location of hearths in Concentration III cannot be established. Therefore, in this case the probable centre of the main hearth was chosen as the 'centre' for the analysis by the ring method. For the analysis according to the ring and sector method an area of 8x8 m was selected (see fig. 10). The flint artefacts are not mapped individually, but per $\frac{1}{4}$ sq. m. This proved to be adequate for the ring and sector method, but it should be noted that the method works best when all flint locations are mapped individually.

The distributions of artefact frequencies in the rings can be illustrated in the form of bar charts (histograms), in which 0 on the X-axis is the assumed 'centre'. It has been shown elsewhere (Stapert, 1990; in press) that ring distributions of tools can be unimodal or bimodal. In general, bimodal tool distributions are associated with find concentrations that were created inside a tent, while unimodal distributions were probably produced in the open air. For Concentrations I and IV at Gönnersdorf bimodal distributions were obtained, indicating dwelling structures with in both cases diameters of 5-6 m. The second peak (counting from the centre) is thought to be the result of the 'barrier effect' caused by the tent wall, which intercepted centrifugal movements of tools. For more details concerning the use of the ring method, and the interpretations of unimodal and bimodal distributions, the reader is referred to the texts mentioned above.

If several raw materials were in use during the same occupation of a tent, it is to be expected that the ring distributions of the tools made of these raw materials will all show the same type of bimodal distribution. If raw materials should show unimodal distributions, this would indicate that at least one occupation on this spot occurred in the open air. However, it is possible that several occupations took place in the same tent, or in a tent that was rebuilt several times. This means that when several raw materials show bimodal distributions it does not necessarily follow that these raw materials were all used during one and the same occupation. Similarly, the existence of several raw materials showing unimodal distributions does not prove that they were all exploited during a single occupation. Furthermore, we have to consider the possibility that any one type

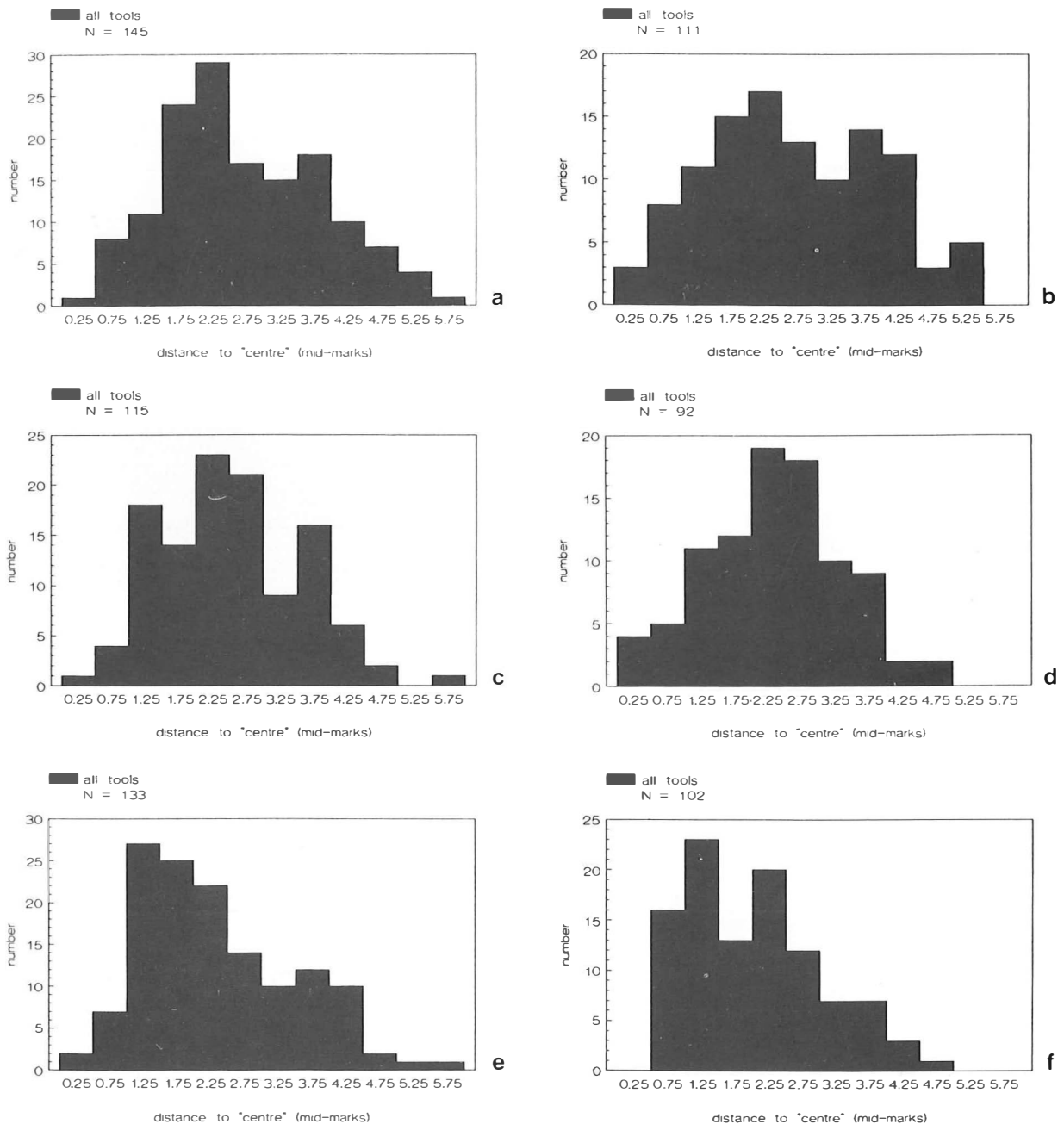


Fig. 12. Gönnersdorf III. Ring distributions for all the tools, including those found in pits, of six raw materials: a. West European flint; b. *Kieselschiefer*; c. North European flint; d. Chalcedony; e. Brown flint; f. *Süßwasserquarzit*. For all histograms the following applies. Distances to the 'centre' are presented in classes of 0.5 m, which are indicated in the diagrams by their midpoint values. Thus, on the X-axis from left to right one finds the following classes: 0-50, 51-100, 101-150 cm, etcetera. Complete and broken tools are all counted as one, irrespective of whether fragments may fit together.

of raw material could have been used during several occupations. All this means that it is inadvisable to rely heavily on interpretations based on spatial analyses of sites that appear to have been occupied several times.

Moreover, if several occupations indeed took

place, we must anticipate disturbance of the spatial patterns left by the earlier habitations. Many artefacts left during earlier occupations will have been moved from their original locations during later occupations, and perhaps were partly re-used. We feel it is advisable to take a cautious line concerning

the ring method analysis in such cases. Original, bimodal distributions of tools could easily have become blurred during later occupations, especially if their bimodal character was not very strong. Therefore, if bimodality is absent this should not be taken as proof that the material in question was not in use during the occupation of a tent. In other words: if bimodality is found, then it may be assumed that the material was exploited during at least one occupation of a tent, but one cannot attach any definitive conclusions to a lack of bimodality.

4.2. Methods and problems

As a first step frequency distributions were produced for each raw material, in which tool distances are represented in classes of 0.5 m, using an assumed 'centre' of the main hearth in the middle of the find concentration (fig. 10). The results are shown in figure 12. It can be seen that bimodality, in tool distances within 3 m from the 'centre', is suggested for two raw materials: *Süsswasserquarzit* and North European flint. In several cases additional peaks can be seen for distances larger than 3 m, which will be discussed later.

This result can be nothing more than a first impression from the data. There are several problems that should be discussed. In the first place, it is true for both of these raw materials that relatively many tools were found in pits (see table 2). Pits can be considered as 'traps', in which tools could accumulate during the period of occupation. In some cases quite a number of tools were present in a single pit, and these will all fall in the same ring. This will presumably lead to spurious 'peaks' in the histograms, and consequently to a bimodality that has nothing to do with the former existence of a tent wall, but which simply reflects the presence of several artefact-rich pits. Therefore, it is advisable to use histograms in which finds from pits are omitted.

Another problem is the fact that, due to the rectangular form of the area selected for analysis and the presence of a disturbance in the western part, the successive rings do not grow regularly in surface area. Up to 2.5 m from the 'centre' the rings are complete. Between 2.5 and 4 m from the 'centre' about 20% of the rings is missing because of the disturbance in the western part. More than 4 m away from the 'centre' the rings become increasingly fragmentary, because of the rectangular shape of the area selected for analysis. If all the rings up to 6 m away from the 'centre' were complete, their surface areas would grow regularly from the 'centre' to the periphery, as illustrated in figure 13:a. In the case of Gönnersdorf III the rings more than 4 m away from the 'centre' are better omitted, as their information is very limited. For the rings up to 4 m it is possible

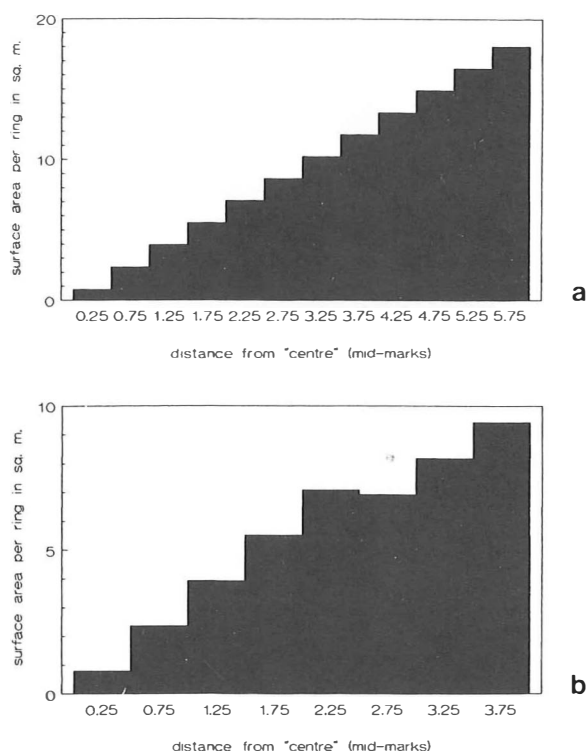


Fig. 13. a. Diagram illustrating the surface areas of rings 0.5 m wide, in square metres, if all the rings are complete. b. Diagram illustrating the surface areas of the rings up to 4 m from the 'centre' at Gönnersdorf III. The rings between 2.5 and 4 m from the 'centre' are incomplete, due to the disturbance in the western part of the analysed area. If artefacts should be spatially scattered in a regular (or random) way in the analysed area, their ring distribution would look approximately like this.

to produce a diagram similar to that of figure 13:a, in which the disturbance in the western part has been taken into account: figure 13:b. If tools are spatially distributed in a random or regular way within 4 m from the 'centre', chances are that they will show a ring histogram like that of figure 13:b. Therefore, it was decided to produce diagrams in which the ring distributions for all six raw materials (only tools found outside pits) are compared with the theoretical distribution of figure 13:b, which is based on the assumption of random or regular spatial scattering. The results are presented in figure 14.

The most striking phenomenon in figure 14 is that all raw materials show a strong under-representation for distances larger than 3 m, when compared with the theoretical distribution. This is caused by the fact that the tool distributions respect the outer limit of the stone pavement in the north and in the east, where there is a sharp drop in density. This is not the case in the southern part, where relatively many tools occur outside the pavement. This is true for all types of raw material, including *Kieselschiefer*, and

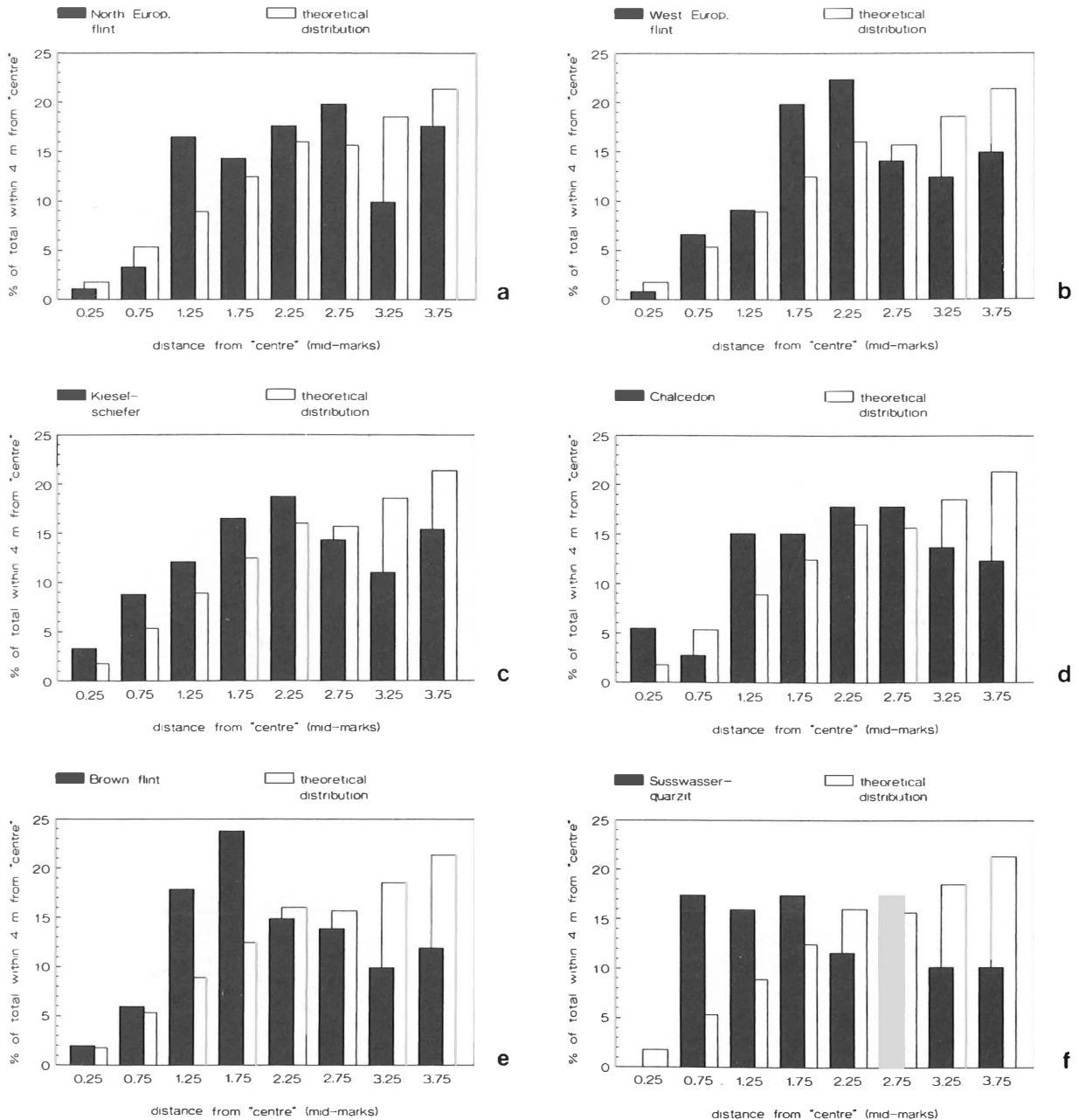


Fig. 14. Gönnersdorf III. The ring distributions for the tools within 4 m from the 'centre', excluding finds from pits, are compared with the theoretical distribution presented in figure 13 (b). In this diagram the Y-axis gives percentages, in order to make the histograms for the various raw materials comparable with each other.

this indicates that none of the raw materials has a spatial distribution that is completely independent of the stone pavement. This means that if several occupations existed, the pavement was (re)used as the central habitation area in every case, irrespective of whether a tent was erected. Therefore, the pavement must have been created during the first occupation phase.

One way to take into account the disturbance in the western part is to 'correct' the frequencies in the rings between 2.5 and 4 m. As noted before, about 20% of these three rings is missing. A reasonable estimation of the original frequencies in these rings could therefore be attained by multiplying the observed frequencies by 1.25.

The above discussion leads us to the conclusion

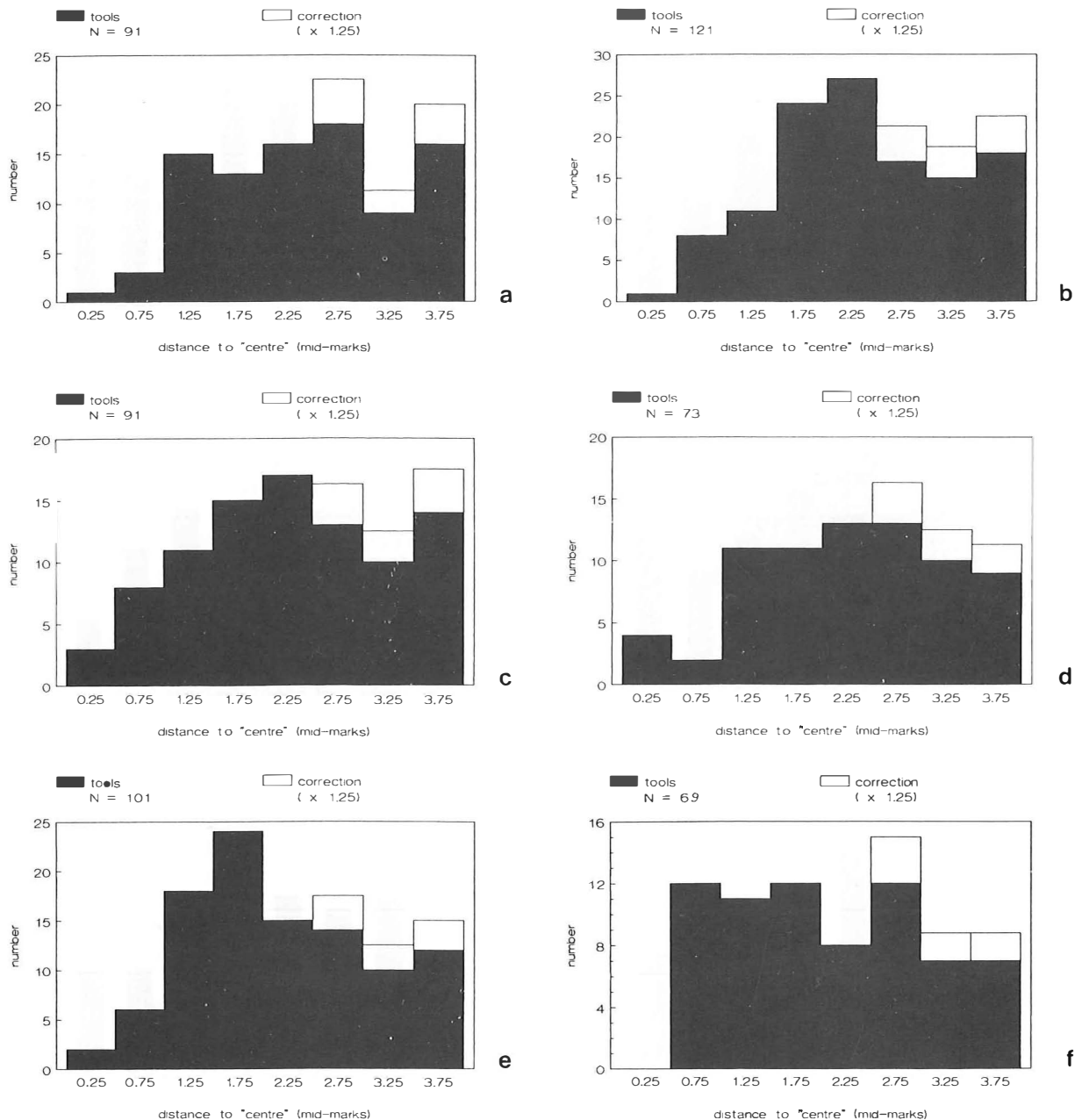


Fig. 15. Gönnersdorf III. Ring distributions for the tools of six raw materials, within 4 m from the 'centre': a. North European flint; b. West European flint; c. *Kieselschiefer*; d. Chalcedony; e. Brown flint; f. *Süsswasserquarzit*. Tools found in pits are omitted. For the rings between 2.5 and 4 m both observed and corrected frequencies are indicated.

that in this case a more realistic picture can be obtained when the ring distributions are subjected to the following conditions:

1. Finds from pits are omitted.
2. Only rings within 4 m from the 'centre' are used.
3. For the rings between 2.5 and 4 m, both observed and 'corrected' frequencies are given.

In figure 15 the resulting frequency distributions for all six raw materials are presented. It is satisfying that North European flint and *Süsswasserquarzit* again clearly show bimodality within 3 m from the 'centre'. But now in both cases the second peak is one ring farther out from the 'centre' than in the diagrams of figure 12, which included the finds from pits.

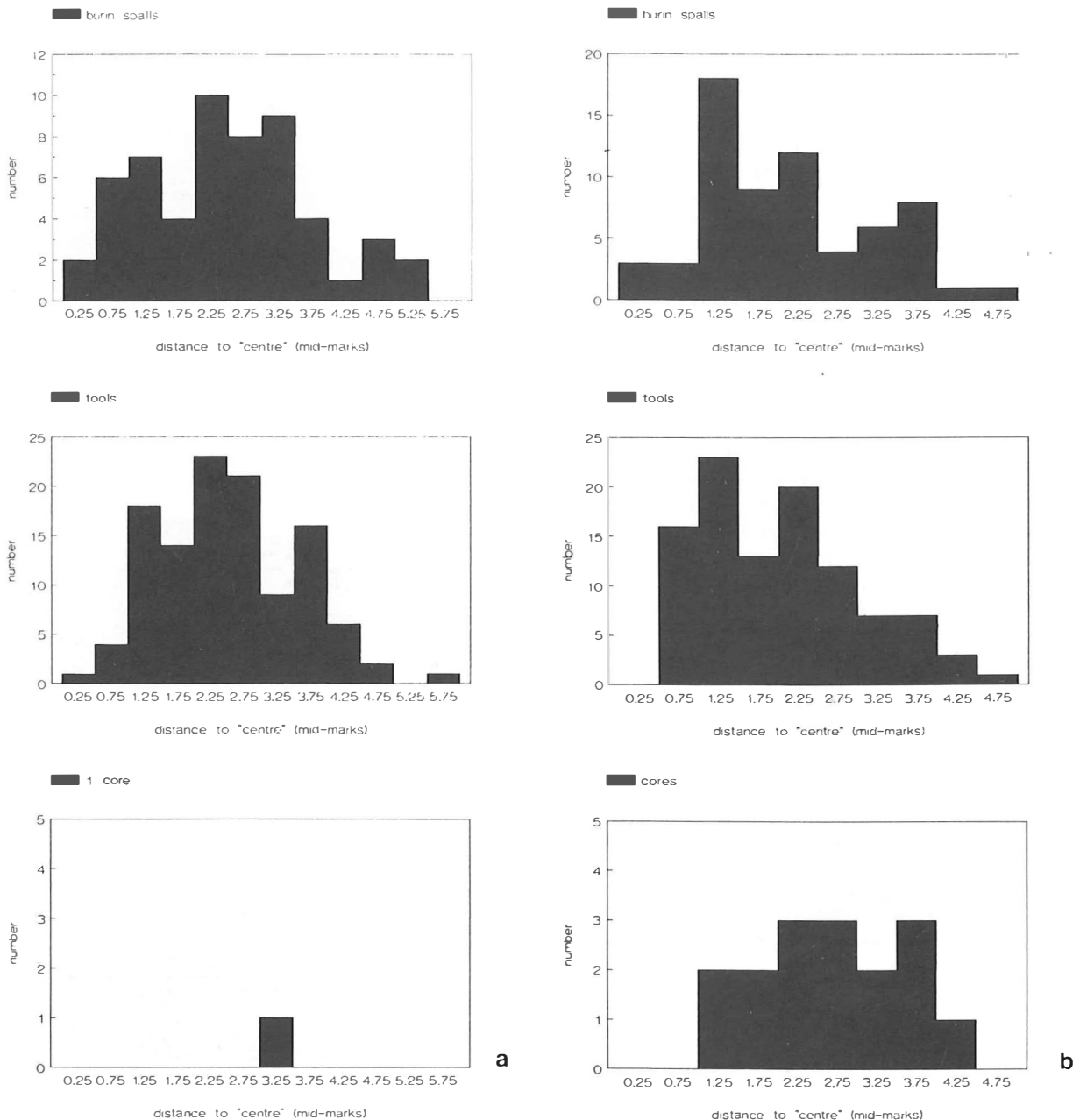


Fig. 16. Gönnersdorf III. a. Ring distributions of burin spalls, tools and the only core made of North European flint. b. Ring distributions of burin spalls, tools and cores made of *Süsswasserquarzit*. For this figure all tools within the analysed area were used, including finds from pits.

This can be understood if a centrifugal effect was indeed operative during the occupation of a tent: when tools were caught in pits they could not move any farther to the periphery, while the tools that remained on the surface were subject to clearing activities during the full period of habitation. Therefore, this difference supports the interpretation that these two raw materials were indeed exploited du-

ring occupation or occupations of a tent.

Nevertheless, it was decided to further test this idea by looking also at the ring distributions of burin spalls and cores made of the same two raw materials (fig. 16; for this figure all the artefacts were used, including finds from pits). If these raw materials were indeed in use during occupation of a tent, it should be expected that burin spalls will show the

same bimodality, while the cores should, on average, be farther away from the 'centre' than the tools and the burin spalls (because we know that the centrifugal effect is rather strong within a tent: Stapert, in press). Unfortunately, there is only one core of North European flint inside the analysed area. Still, our expectations are met quite nicely. Especially the fact that the burin spalls show the same bimodality as the tools supports the conclusion that these two raw materials were in use during one or more sojourns in a tent.

Apart from North European flint and *Süsswasserquarzit*, Brown flint also shows bimodality in figure 15, when the corrected frequencies for the rings farther than 2.5 m away from the 'centre' are considered. Furthermore, Chalcedony shows a peak in the 2.5-3 m ring, just as North European flint and *Süsswasserquarzit* do. For Brown flint, therefore, and perhaps also for Chalcedony, the possibility that they were used during the occupation of a tent is worth further consideration (see below).

West European flint and *Kieselschiefer* remain unimodal within 3 m from the 'centre', also when corrected frequencies for the rings between 2.5 and 4 m are adopted. Moreover, they are very similar to one another, and show a peak in the 2-2.5 m ring, not in the 2.5-3 m ring as the other four raw materials do.

Yet another problem to be tackled here is posed by the great differences between the raw materials in the proportions of backed bladelets (*Rückenmesser*; see section 2.3.2). We know from other analyses employing the ring method that the centrifugal effect is more pronounced for larger artefacts than for small ones; backed bladelets are very small (see Stapert, in press). When the proportion of backed bladelets is very high, and the number of other – larger – tools low, it is possible that bimodality, displayed especially by the larger tools, will be so weak that it fails to show up in a diagram presenting all the tools. Therefore, it was decided to have a closer look at the ring distributions of tools made of Brown flint, as the proportion of backed bladelets is relatively high for this type of raw material (see fig. 6). A histogram was prepared for the burins (*Stichel*); borers (*Bohrer*) and scrapers (*Kratzer*) of Brown flint together, on the basis of the idea that if bimodality exists it should show up for these tools more clearly than when all tools, dominated by the small backed bladelets, are grouped together. The result is shown in figure 17a, in which tools found in pits are omitted. It can be seen that now bimodality is clearly visible, and that the second peak again falls in the 2.5-3 m ring. A diagram of all burin spalls (not illustrated) shows the same bimodality as in the case of the three tool-classes of figure 17a. Therefore, the conclusion of this exercise should be that Brown flint too probably was in use during the occupation of a tent. Brown flint could represent the situation of a rather

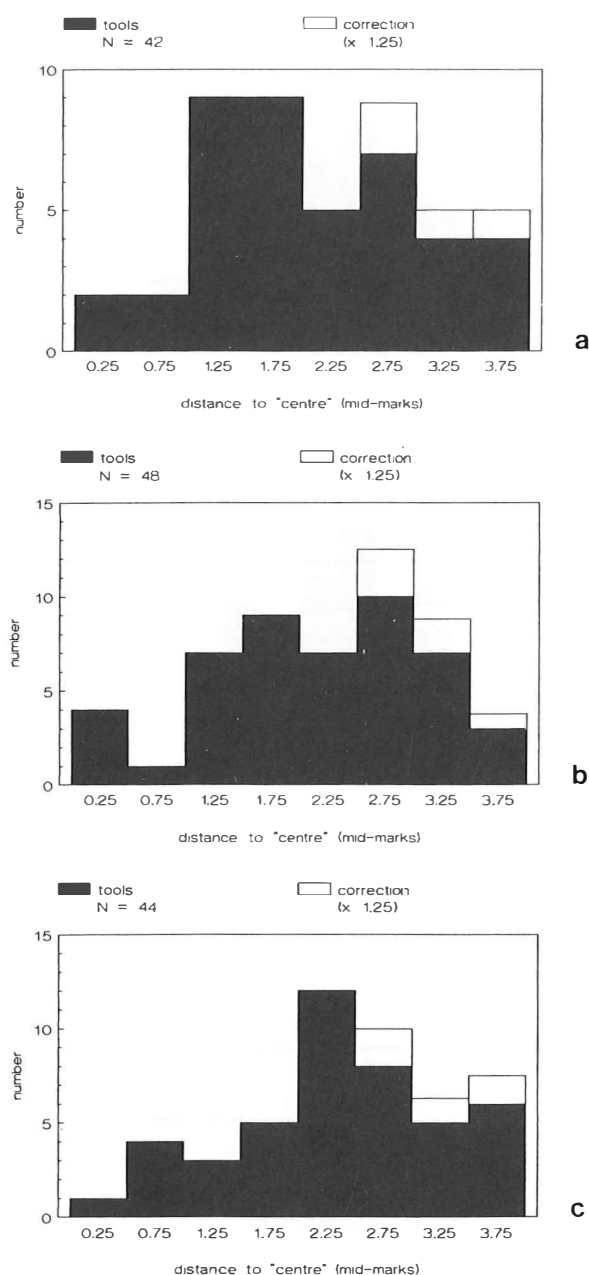


Fig. 17. Gönnersdorf III. The ring distributions of burins, scrapers and borers taken together, for three raw materials: a. Brown flint; b. Chalcedony; c. West European flint. Finds from pits are omitted. A weak bimodality is visible in the cases of Brown flint and Chalcedony. West European flint remains unimodal.

weak bimodality being obscured by a relatively high proportion of backed bladelets (and by disturbances resulting from later occupations).

We repeated this exercise for Chalcedony (fig. 17:b). Again a weak bimodality resulted, and also in this case the second peak emerges in the 2.5-3 m ring. However, the proportion of backed bladelets is

relatively low in this case. Therefore, we can only conclude that Chalcedony was possibly used during occupation of a tent.

Finally, we did the same for West European flint (fig. 17:c). No clear bimodality is visible, and the only peak remains in the 2-2.5 m ring. It is probable that West European flint was not used inside a tent. The same holds true for *Kieselschiefer* (the number of tools of type-classes other than backed bladelets is too low for a reliable diagram of the type used above, which is therefore omitted).

4.3. Discussion

Analysis by means of the ring method has shown that two raw materials, *Süsswasserquarzit* and North European flint, presumably were in use during one or several occupations of a tent, while this was probably also the case with Brown flint. Furthermore, it is at least possible that Chalcedony was also used during occupation of a tent. This does not necessarily imply that these raw materials were in use during the same occupation or occupations, though this is certainly possible (see section 5).

For the remaining two raw materials, West European flint and *Kieselschiefer*, it is probable that they were used in the open air. It has been noted before that we should not feel wholly convinced of this, because it is possible that bimodal distributions became blurred during later occupations. We have seen, however, that it is probable that West European flint and *Kieselschiefer* were in use later than the other four raw materials (see section 2), and thus had less chance of becoming disturbed; and this in fact supports the hypothesis that they were used in an open-air encampment.

The bimodal distributions found for North European flint and *Süsswasserquarzit* allow the reconstruction of a tent with a diameter of 5.5-6 m, just as in the cases of Gönnersdorf I and IV. The histograms for Chalcedony and Brown flint presented in figure 17 lead to the same conclusion, if they are accepted as convincing examples of bimodal ring distributions.

In several histograms peaks are also present between 3 and 4 m from the assumed 'centre'. Inspection of the distribution maps shows that these peaks are created especially by tools to the south and southeast of the concentration. We are probably dealing here with an area just outside the entrance of the tent, where many of these tools were left in 'door dumps' (Binford, 1983). For West European flint and *Kieselschiefer* it seems that an (additional) activity area was present in this area (see section 2.3.3, and Eickhoff, 1989). For the present discussion regarding the possible presence of tents associated with the stone 'pavement', these distant peaks do not concern us very much, and consequently we shall not pursue this matter here.

If we wish to derive the minimum number of occupations on the basis of the ring method analysis, we again arrive at a number of two:

1. Occupation of a tent: North European flint, Chalcedony, Brown flint and *Süsswasserquarzit*.

2. Occupation in the open air: West European flint and *Kieselschiefer*.

These are the same two groups that we found in section 3.

4.4. The minimum solution: two occupations

If the minimum solution of two occupations is accepted as a real possibility, it is of interest to summarize the ring distributions for both groups of raw materials. This is done in figure 18, following the same principles as outlined under 4.2. The two diagrams are very different from one another. If the corrected frequencies are taken into account, the second peak for the group of four raw materials is clearly visible in the 2.5-3 m ring. This picture is very similar to several diagrams obtained for Gön-

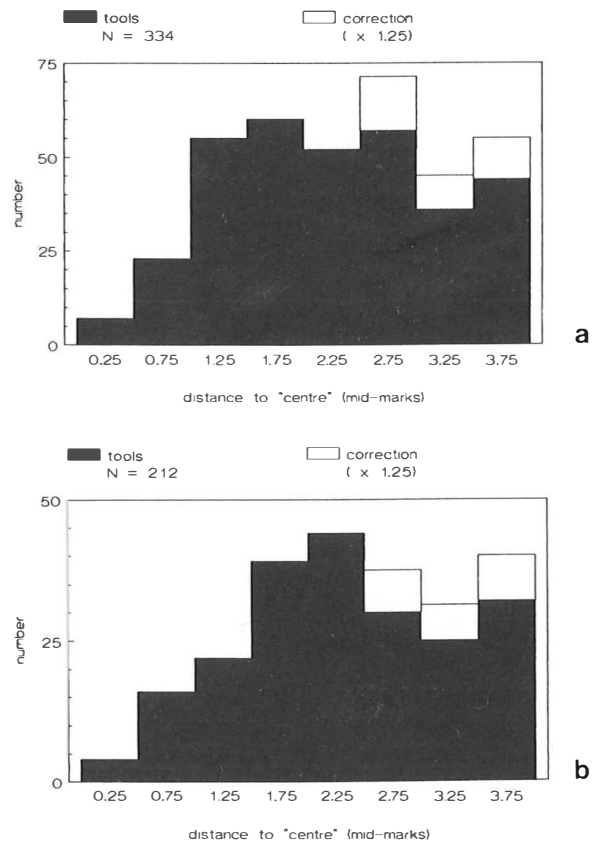


Fig. 18. Gönnersdorf III. Summarized ring distributions for two groups of raw materials: a. North European flint, Chalcedony, Brown flint and *Süsswasserquarzit* taken together; b. *Kieselschiefer* and West European flint taken together. Tools found in pits are omitted.

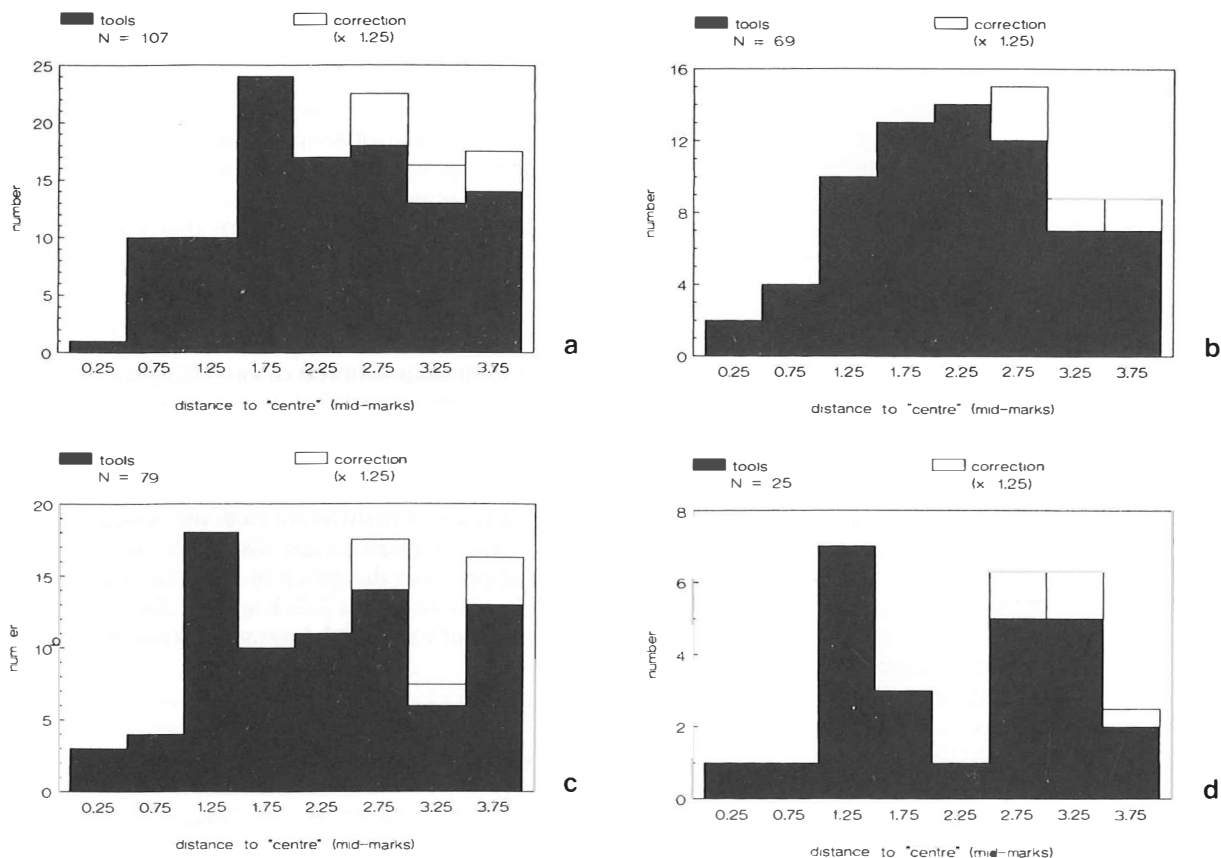


Fig. 19. Gönnersdorf III. Ring distributions for four separate type-classes: a. Backed bladelets; b. Borers; c. Burins; d. Scrapers. Tools made of North European flint, Chalcedony, Brown flint and *Süsswasserquarzit* are taken together. Tools found in pits are omitted.

nersdorf I (Stapert, in press). The diagram for the group of two raw materials is unimodal (except for a peak in the 3.5-4 m ring noted above, which is also present in the diagram for the group of four raw materials).

We concluded that North European flint, *Süsswasserquarzit*, Brown flint and Chalcedony probably were used during the occupation of a tent. If it is assumed that we are dealing here with a single occupation (see also section 5), it is of interest to study the ring distributions for several type-classes separately, for the purpose of comparison with the results of, for example, Gönnersdorf IV. We selected the following type-classes for illustration: borers, burins, scrapers and backed bladelets. In the diagrams (fig. 19) the tools of the four raw materials are lumped together, disregarding finds from pits. In most cases the bimodality shows up well. The first peak generally occurs between 1 and 2 m. The second peak, which is believed to be caused by the tent wall, is generally found in the 2.5-3 m ring. A third peak, between 3.5 and 4 m, is visible especially in the diagram for the burins, which ended up in door

dumps, or were perhaps used outside the tent, more often than the other types. The borers form the only type-class that does not show a clear bimodality. However, if only North European flint and *Süsswasserquarzit* are considered (diagram not illustrated), bimodality is also clearly present for the borers.

5. SECTOR DISTRIBUTION (D.S.)

5.1. Theoretical considerations

The sector method investigates frequencies in sectors around the centre, and is independent of the ring method. The choice of the number of sectors employed is arbitrary; in our experience a number of eight in most cases works best. Similarly, the placing of the sector boundaries is also arbitrary. We think it is advisable to use the main axes of the excavation trench for placing the boundaries, because it is neutral and practical.

The analysis of sector frequencies is based on the same assumption as made when using the ring me-

thod: it is to be expected that if several raw materials were in use simultaneously during one occupation they will show similar sector distributions. This expectation is independent of whether or not a tent was present.

The sector method is perhaps more suited, theoretically, than the ring method for revealing multiple occupation. For example, if several occupations took place on the same spot it is not impossible that the ring distributions should be roughly similar, if all of these occupations occurred either in a tent or in the open air. Thus, we have shown with the ring method that *Süsswasserquarzit* and North European flint were both in use during occupation of a tent. Yet if two separate occupations both made use of a tent of similar construction and diameter, on the same spot, the ring distributions could very well be about the same. Therefore, the ring method does not really allow the conclusion that the two raw materials mentioned above were in use during a single occupation, though this certainly is a reasonable proposition.

If there had indeed been two separate occupations it would, however, be extremely unlikely that the sector distributions also should turn out to be similar. Only if we should find that *Süsswasserquarzit* and North European flint have similar ring distributions as well as similar sector distributions, would the hypothesis that they were in use simultaneously be supported.

Unfortunately, if several occupations took place on approximately the same spot, spatial patterns left by earlier occupations are sure to have become distorted and blurred during later occupations. However, these disturbances would be operative in the same way on all artefacts already present, independent of the raw materials from which they were manufactured, because it is unlikely that these distortions would be selective in terms of raw material. Nevertheless, even if several raw materials originally possessed similar sector distributions, this resemblance will have become increasingly faint in the

course of time, especially if a succession of later occupations occurred. Therefore, more or less identical sector distributions should not be anticipated, even if various raw materials were in use simultaneously. On the other hand, even if several later occupations took place, one would not expect originally similar sector distributions to have become radically different from each other. Hence, it would be more realistic to look for significant differences between the various raw materials than to search for significant resemblances. If two raw materials were to show very different sector distributions, we could conclude that they reflect separate occupations. In other words, we should not so much hope that the analysis of sector distributions will result in a reliable demonstration of multiple occupations and the raw materials characterizing them, as expect that it will show us which raw materials were not in use simultaneously. If we have such knowledge for every combination of two raw materials, it will then be possible to estimate the minimum number of occupations.

5.2. Methods and problems

Given the above considerations, it was decided first of all to compare each pair of raw materials by means of a significance test. In this case the null hypothesis is that the two raw materials do not deviate more than could be the result of chance. If the null hypothesis must be rejected, on the basis of a level of significance selected beforehand, the alternative hypothesis is supported, which states that the difference between the two raw materials is too large to be attributable to chance. Since sector membership and type of raw material are both nominal variables, nonparametric statistics are appropriate in this case. The sector frequencies for all six raw materials are presented in table 4. It can be seen that the numbers are sufficiently high for a valid use of the chi-square test. Moreover, the total numbers of tools per raw material do not deviate very much from

Table 4. Gönnersdorf III. Distributions of tool frequencies in 8 sectors for six raw materials. All tool locations within the area selected for analysis are used. Note: sectors 2 and 3 are partly disturbed. Raw materials: 1. North European flint; 2. West European flint; 3. *Kieselschiefer*; 4. Chalcedony; 5. Brown flint; 6. *Süsswasserquarzit*.

	Sectors								Total
	1	2	3	4	5	6	7	8	
1.	25	19	9	18	8	5	12	19	115
2.	30	17	15	10	10	8	30	25	145
3.	20	12	2	5	13	13	22	24	111
4.	6	17	16	7	9	8	14	15	92
5.	11	21	11	18	9	14	24	25	133
6.	10	18	10	15	8	10	13	18	102
Total	102	104	63	73	57	58	115	126	698

Table 5. Gönnersdorf III. Each pair of two different raw materials is compared with respect to sector frequencies, using the chi-square test. All tool locations within the 8x8 m area are used. Raw materials: 1. North European flint; 2. West European flint; 3. *Kieselschiefer*; 4. Chalcedony; 5. Brown flint; 6. *Süsswasserquarzit*. *: significant (two-tailed $p < 0.05$).

Pairs of raw materials	Chi-squared	p(two-tailed)	
1/2	10.51	0.1	<p <0.2
1/3	22.20	0.001	0.01*
1/4	17.54	0.01	0.02*
1/5	13.63	0.05	0.1
1/6	7.77	0.3	0.5
2/3	13.08	0.05	0.1
2/4	13.84	0.05	0.1
2/5	13.97	0.05	0.1
2/6	13.29	0.05	0.1
3/4	23.79	0.001	0.01*
3/5	17.72	0.01	0.02*
3/6	19.40	0.001	0.01*
4/5	7.24	0.3	0.5
4/6	5.38	0.5	0.7
5/6	1.73	0.95	0.98

each other. This is a fortunate circumstance, because the results of the chi-square test are strongly influenced by sample sizes, as noted before. In the present case it would not be absurd to compare the chi-square values among each other.

Chi-square values and associated levels of significance are presented in table 5, for each possible combination of two raw materials. We selected the level of the two-tailed $p = 0.05$ for deciding whether or not the null hypothesis should be accepted. The outcome is that five pairs of raw materials show significant differences with regard to sector distributions. Four cases out of these five involve *Kieselschiefer*, which is significantly different from all other raw materials except West European flint. The fifth case is formed by North European flint and Chalcedony. From these results it could be concluded that a minimum number of three occupations must have taken place:

1. *Kieselschiefer* (perhaps together with West European flint).
2. North European flint (perhaps together with Brown flint and/or *Süsswasserquarzit*).
3. Chalcedony (perhaps together with West European flint, Brown flint and/or *Süsswasserquarzit*).

It should be noted that this analysis results in a minimum number of occupations, that for each of them only one raw material can be given as a characteristic element, and that it is not possible to assign the remaining three raw materials to any particular one of the three occupations.

If we wish to know which raw materials possibly 'belong together', we have to look at the level of resemblance between each possible pair. One way to

Table 6. Gönnersdorf III. Each pair of raw materials is compared with respect to sector frequencies, using correlation coefficients (r), and coefficients of determination (r squared). All tool locations within the area selected for analysis are used. Raw materials: 1. North European flint; 2. West European flint; 3. *Kieselschiefer*; 4. Chalcedony; 5. Brown flint; 6. *Süsswasserquarzit*.

Pairs of raw materials	r	Coeff. of determination
1/2	0.59	0.35
1/3	0.34	0.12
1/4	-0.07	0.00
1/5	0.30	0.09
1/6	0.52	0.27
2/3	0.74	0.55
2/4	0.21	0.04
2/5	0.43	0.18
2/6	0.23	0.05
3/4	0.01	0.00
3/5	0.48	0.23
3/6	0.22	0.05
4/5	0.51	0.26
4/6	0.51	0.26
5/6	0.86	0.74

do this is by calculating correlation coefficients, using the eight sectors as cases. However, as we have already noted, sector membership and raw material are both nominal variables, so that strictly speaking the use of correlation coefficients is not valid. Nevertheless, we calculated correlation coefficients (r) for each pair of raw materials, to see whether clear patterns would show up. The results are given in table 6. In this table coefficients of determination are also given, which are calculated by squaring r , and give an indication of how much of the variation is 'explained' by the correlation (like r , it has a range of 0 to 1). The correlation coefficients should not be given too much weight. Much more important for understanding the relationships between pairs of raw materials are scatter diagrams (Shennan, 1988: p. 114); these are presented in figure 20.

The correlation coefficients in table 6, and also the scatter diagrams, show that most relationships are positive, though only a few significantly so. This trend towards positive correlations should make us very cautious, as this often is an indication that some source of systematical error is present in the data. This is indeed the case. The problem is the fact that the sectors are not equally large. Both sectors in the western part are quite small compared with the others, because of the disturbance in that area, while the sectors in the eastern part of the analysed area are relatively large. This situation implies that even if all raw materials had random spatial distributions, moderate positive correlations would still be produced, as chances are that low or high sector frequencies for any pair of raw materials would go together. This kind of problem is quite common in archaeolo-

gy, and one can easily imagine better sites than Gönnersdorf III for this kind of spatial analysis. However, such sources of error are mostly systematic, and once they are recognized their effects can be taken into account. In this case the conclusion must be that only cases of very strong positive relationship between any pair of raw materials should be relied on. (One way to cope with unequally large sectors might be to use partial correlation coefficients (Shennan, 1988), where the third variable is constituted by the surface areas of the sectors.)

The strongest relationship, in terms of correlation coefficients, exists between Brown flint and *Süsswasserquarzit*. Also the scatter diagram shows a striking relationship that can hardly be coincidental. This should lead us to conclude that these two types of raw material were in use during one and the same occupation.

The second strongest relationship is that between West European flint and *Kieselschiefer*. A positive relationship is also shown by the scatter diagram, yet this relationship cannot be very strong (the chi-square value is relatively high: see table 5).

Most of the other relationships are rather weak, though several are worth considering. The correlation between North European flint and *Süsswasserquarzit* is quite strong except for one outlier. The same is true for the relationship between North European flint and Brown flint.

In conclusion it can be said that two relationships seem to be clearly positive: Brown flint/*Süsswasserquarzit* and West European flint/*Kieselschiefer*. Five combinations show weaker positive relationships: North European flint/*Süsswasserquarzit*, North European flint/Brown flint, Chalcedony/Brown flint, Chalcedony/*Süsswasserquarzit*, and North European flint/West European flint.

These relationships can now be used to finish the scheme we presented above on the basis of the chi-square values. The result would be that two different groups definitely exist, and possibly three:

1. *Kieselschiefer* and West European flint.

2a. North European flint, Brown flint and *Süsswasserquarzit*.

2b. Chalcedony.

In other words, *Kieselschiefer* and West European flint can be associated with each other, while of the remaining raw materials either all four can be grouped together, or Chalcedony can be isolated from the other three, depending on how much importance one attaches to the high chi-square value for North European flint/Chalcedony.

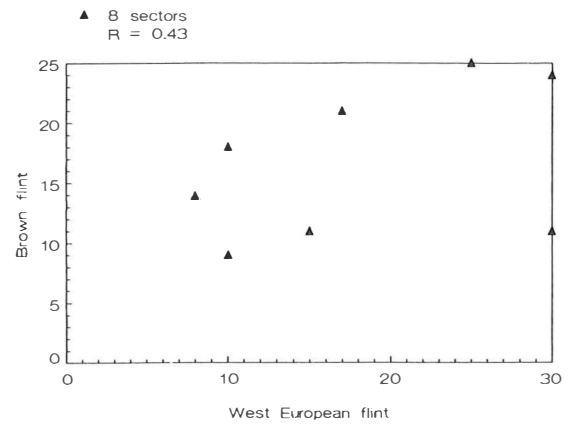
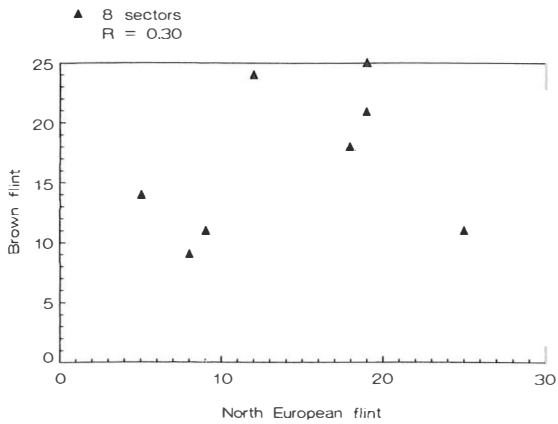
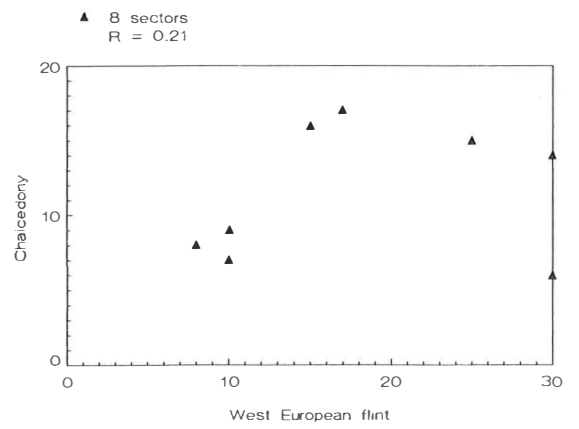
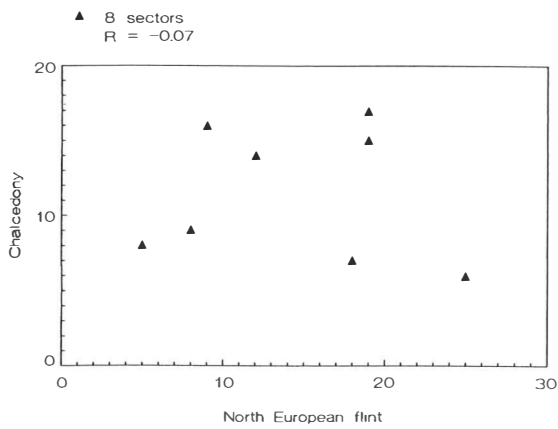
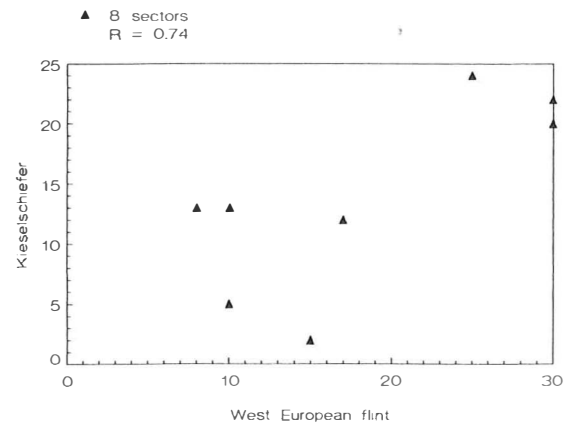
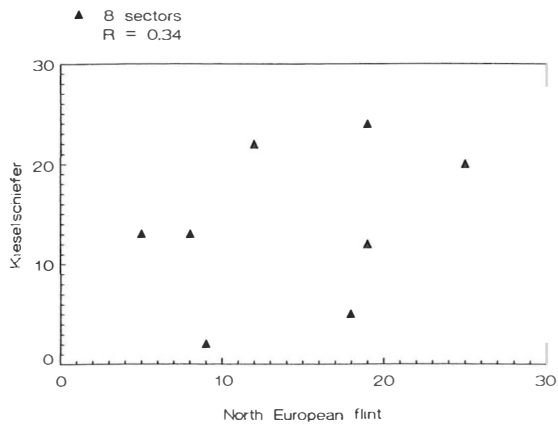
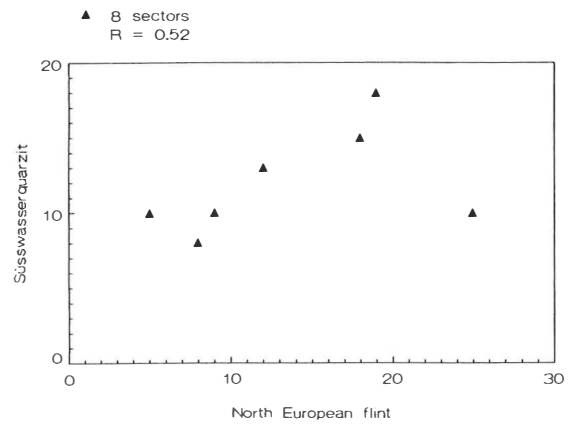
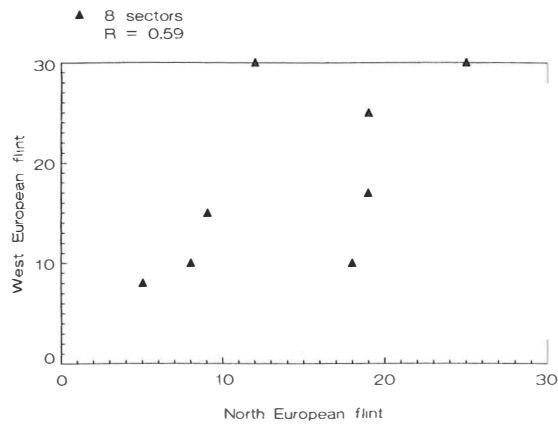
5.3. The case of equally large sectors

Above, it was noted that a really reliable analysis of sector distributions is possible only if the sectors are all complete and equally large. In the case of Gönnersdorf III this would imply that only tools within 2.5 m from the 'centre' can be used. This area approximately coincides with the stone pavement: it would restrict the analysis to the space within the tent that once must have covered the pavement. Therefore it makes sense to repeat our analysis, now using only tool locations within 2.5 m from the 'centre'. The resulting sector frequencies can be found in table 7.

Yet this second analysis has certain disadvantages, despite the fact that we gain in precision. The number of tools is reduced almost by a factor 0.5. The tool locations within 2.5 m from the 'centre' total only 394, which is 56.4% of the total number in the 8x8 m area. One of the consequences is that we come dangerously close to the limits of a valid application of the chi-square test, which requires that not more than 20% of the cells have an expected frequency of less than 5. However, in all cases but one it is just possible to use the chi-square test. Because of the low frequencies its value is of course greatly reduced. Nevertheless, the analysis seems worth performing. The main goal is to see whether the conclusions based on the 'complete' analysis will be supported, and thus to gain an impression

Table 7. Gönnersdorf III. Distributions of tool frequencies in 8 sectors for six raw materials. In this case only tool locations within 2.5 m from the 'centre' are used. Raw materials: 1. North European flint; 2. *Kieselschiefer*; 3. West European flint; 4. Chalcedony; 5. Brown flint, 6. *Süsswasserquarzit*.

Raw mat.	Sectors								Total
	1	2	3	4	5	6	7	8	
1.	8	15	5	12	4	2	6	8	60
2.	13	12	12	4	7	3	11	11	73
3.	9	10	2	4	8	9	7	5	54
4.	2	14	9	2	6	6	5	7	51
5.	3	20	9	13	8	10	9	11	83
6.	6	16	8	13	6	7	8	9	73
Total	41	87	45	48	39	37	46	51	394



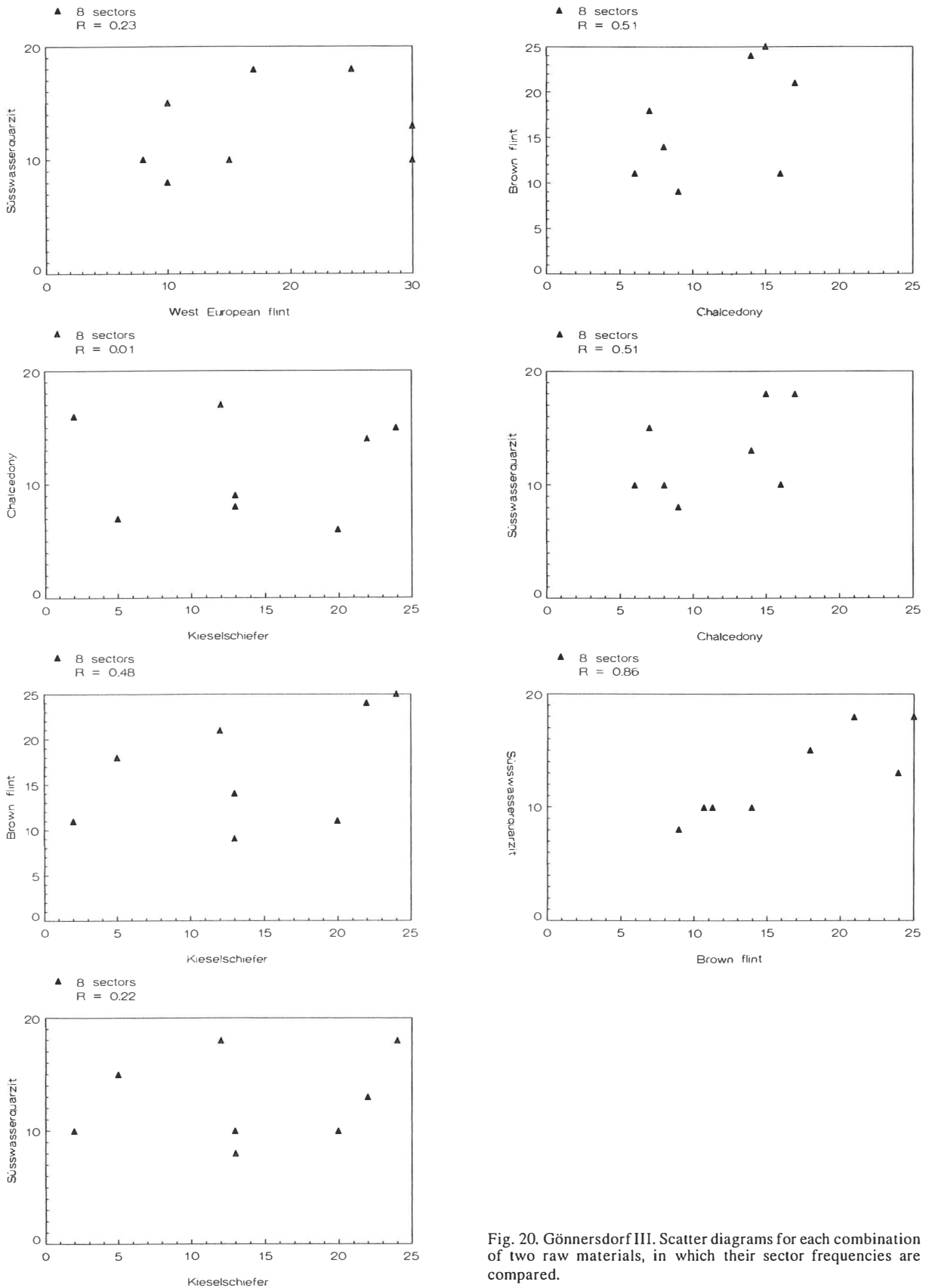


Fig. 20. Gönnersdorf III. Scatter diagrams for each combination of two raw materials, in which their sector frequencies are compared.

Table 8. Gönnersdorf III. Each pair of raw materials is compared with respect to sector frequencies, using the chi-square two-sample test. In this case only tool locations within 2.5 m from the 'centre' are used. Raw materials: 1. North European flint; 2. West European flint; 3. *Kieselschiefer*; 4. Chalcedony; 5. Brown flint; 6. *Süsswasserquarzit*; (a). Four cells (25%) have an expected frequency smaller than 5 (Note: if more than 20% of the cells have expected frequencies smaller than 5, the chi-square test is strictly speaking not valid); * Significant (two-tailed p smaller than 0.05).

Pairs of raw materials	Chi-squared	p(two-tailed)		
1/2	10.36	0.1	<p	<0.2
1/3	12.60	0.05		0.1
1/4 (a)	13.77	0.05		0.1
1/5	8.39	p = c. 0.3		
1/6	3.43	0.8		0.9
2/3	11.78	0.1		0.2
2/4	10.06	0.1		0.2
2/5	16.99	0.01		0.02*
2/6	11.08	0.1		0.2
3/4	11.68	0.1		0.2
3/5	12.56	0.05		0.1
3/6	9.47	0.2		0.3
4/5	5.25	0.5		0.7
4/6	7.72	0.3		0.5
5/6	2.00	0.95		0.98

Table 9. Gönnersdorf III. Each pair of raw materials is compared with respect to sector frequencies, using correlation coefficients (r), and coefficients of determination (= r squared). In this case only tool locations within 2.5 m from the 'centre' are used. Raw materials: 1. North European flint; 2. West European flint; 3. *Kieselschiefer*; 4. Chalcedony; 5. Brown flint; 6. *Süsswasserquarzit*.

Pairs of raw materials	r	Coeff. of determination
1/2	0.28	0.08
1/3	0.08	0.01
1/4	0.30	0.09
1/5	0.67	0.45
1/6	0.89	0.79
2/3	-0.01	0.00
2/4	0.34	0.12
2/5	-0.09	0.01
2/6	0.02	0.00
3/4	0.15	0.02
3/5	0.09	0.01
3/6	0.02	0.00
4/5	0.71	0.50
4/6	0.51	0.26
5/6	0.92	0.85

about how 'robust' the technique is and to what degree it is vulnerable to unequal sectors.

The results of the chi-square tests can be found in table 8. As expected, there are far fewer cases with a probability level below 0.05 than when all locations are used. In fact there is only one: West European flint and Brown flint now prove to be signifi-

cantly different from each other. At least four cases show a very high level of probability, indicating that these pairs of raw materials have similar sector distributions: North European flint/*Süsswasserquarzit*, Chalcedony/Brown flint, Chalcedony/*Süsswasserquarzit* and Brown flint/*Süsswasserquarzit*. Thus, the four raw materials mentioned (North European flint, Chalcedony, Brown flint, *Süsswasserquarzit*) could very well belong together, and at least one of them is very different from West European flint.

To investigate the degree of resemblance between any pair of raw materials, again r's were calculated (table 9). The results support the impression obtained by the chi-square tests. Four combinations show high positive r's (with 'high' we mean that the accompanying coefficients of determination are above 40%): North European flint/Brown flint, North European flint/*Süsswasserquarzit*, Chalcedony/Brown flint and Brown flint/*Süsswasserquarzit*. This once again supports the proposition that these four raw materials really belong together. Nevertheless, the case of Chalcedony is somewhat problematic. For example, it shows a rather high chi-square value, though not significantly high, when compared with North European flint. It will be remembered that in the case of the 'complete' analysis it was found to be significantly different from North European flint. On the other hand, it has relatively high positive r's with both Brown flint and *Süsswasserquarzit*.

West European flint and *Kieselschiefer* no longer show a clear positive correlation, which they did in the case of the 'complete' analysis, nor are they radically different from each other.

We decided in this case not to illustrate the relationships between pairs of raw materials by means of scatter diagrams, as we did in the 'complete' analysis. Because now the sectors are all complete and equally large, it is appropriate to choose a more graphic method for comparing the various raw materials as to their sector distributions. We calculated the percentages per sector of all the raw materials, and illustrated these in the form of polygons (fig. 21). In these diagrams one moves, so to speak, from sector to sector (clockwise), and sequences of high or low proportions show up very well. In the diagrams a horizontal line is drawn at 12.5%, this being the average proportion per sector.

The raw materials can now be compared with each other, using the shape of their percentage polygons.

The resemblance between the curves of North European flint, Brown flint and *Süsswasserquarzit* is remarkable. All three show a similar and striking sequence in the first four sectors of low, high, low and high proportions. We can conclude that in any case these three raw materials were used during one and the same occupation, as was suggested already by the chi-square tests and the correlation coeffi-

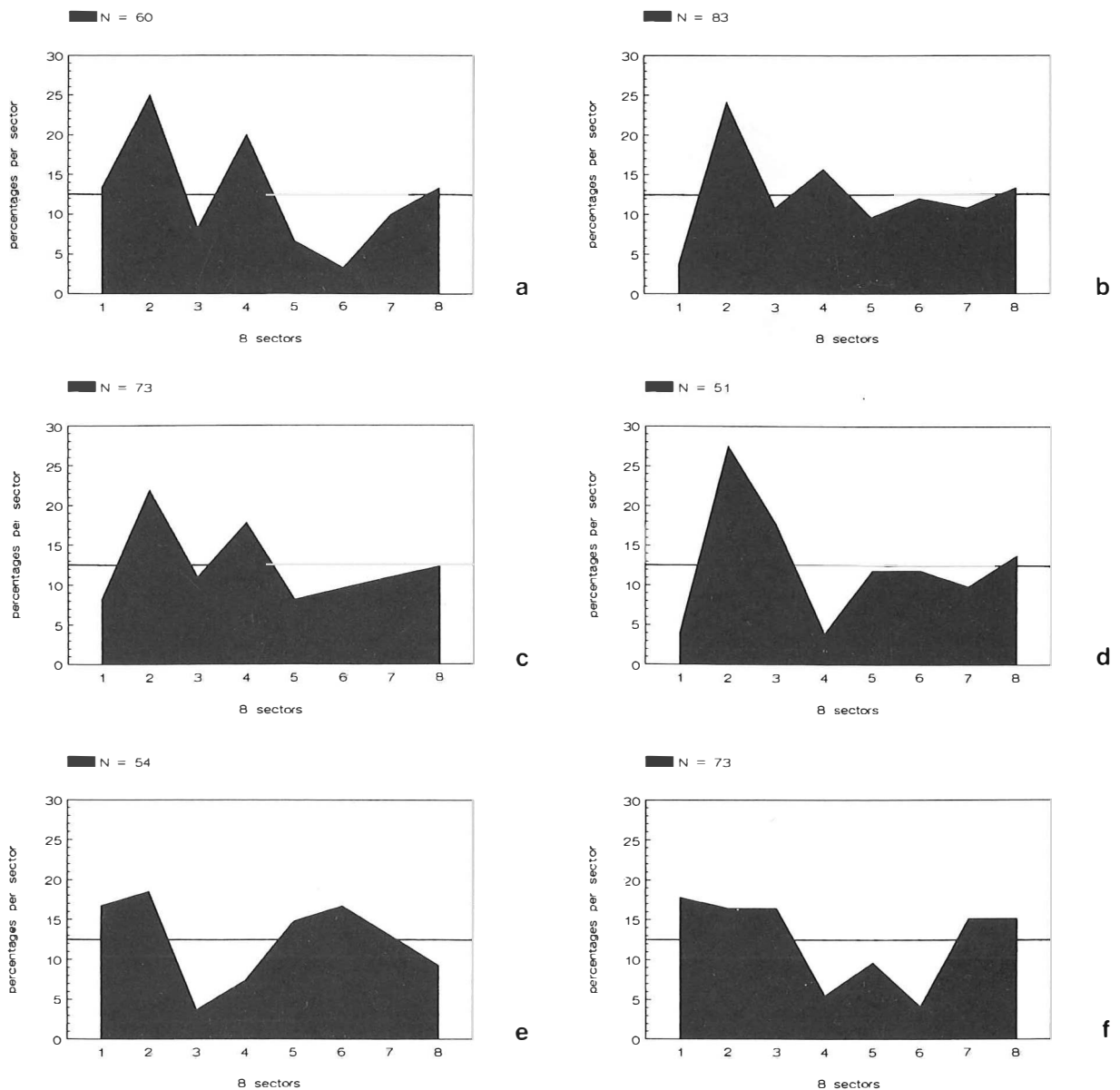


Fig. 21. Gönnersdorf III. Diagrams, showing the percentages per sector of six different raw materials: North European flint; b. Brown flint; c. Süßwasserquarzit; d. Chalcedony; e. Kieselschiefer; f. West European flint. Only tools present within 2.5 m from the 'centre' are included.

cients. Once again, Chalcedony presents us with a somewhat problematic picture. However, its only difference from the three raw materials just mentioned is that sector 4 shows a low proportion instead of a high one, but it has the same characteristic sequence of low, high and low proportions in the first three sectors. It is therefore reasonable to suppose that Chalcedony was used during the same occupation as North European flint, Brown flint and Süßwasserquarzit.

Especially the fact that Chalcedony has a low pro-

portion in sector 1 distinguishes it from West European flint and Kieselschiefer, which have high proportions in both sectors 1 and 2. West European flint and Kieselschiefer are not very similar to each other in the remaining sectors. One reason for the difference between these two raw materials could be the fact that they are very different in their tool inventories, as noted above. If we suppose, for example, that backed bladelets were handled exclusively by men, and at least a proportion of the other tools by women, and that men and women occupied different areas

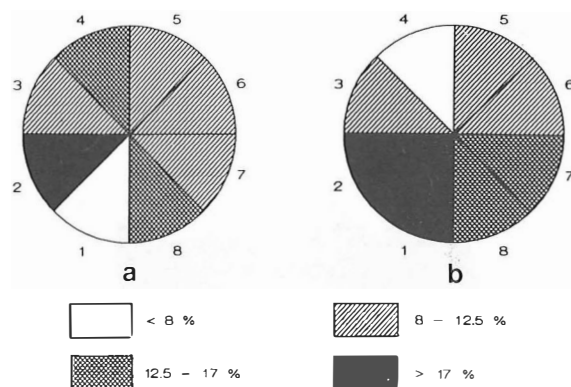


Fig. 22. Gönnersdorf III. Summarized diagrams for the sector distributions of two groups of raw materials: a. North European flint, Chalcedony, Brown flint and *Sißwasserquarzit*; b. *Kieselschiefer* and West European flint. The proportions per sector are expressed as percentages grouped into four classes.

within the habitation (see Stapert, in press), this would result in different sector distributions for these two raw materials, because *Kieselschiefer* has a very high proportion of backed bladelets (see fig. 6). Unfortunately, it is not well possible to check this possibility, because the numbers of backed bladelets made of West European flint are too low for a reliable sector-wise comparison with those of *Kieselschiefer*.

Taking together all the evidence presented in this section, the minimum number of occupations can, once again, be estimated at two:

1. North European flint, Chalcedony, Brown flint and *Sißwasserquarzit*.

2. West European flint and *Kieselschiefer* (with some reservation).

Using equally large sectors should, of course, be preferred. Nevertheless, the method seems to be quite robust; it is not very susceptible to distortions due to unequal sectors. For example, the group of four raw materials showed up reasonably well in both cases. The association between West European flint and *Kieselschiefer*, however, could not be supported in the case of equally large sectors. We have noted, however, that large differences in tool assemblages could prevent us from seeing associations by means of the sector method, even if the raw materials had been used during a single occupation. Therefore, in the case of *Kieselschiefer* the results of the ring method should perhaps be given more weight than those of the sector method; we have observed that West European flint and *Kieselschiefer* possess similar ring distributions.

5.4. The minimum solution: two occupations

If we adopt the possibility of only two occupations

as a real one, it is of interest to summarize their combined sector distributions. First, however, we will consider the question whether the two resulting sector distributions are really different from each other. If they cannot be shown to be statistically different, there is little sense in continuing the discussion. A chi-square two-sample test was performed, and the difference proved to be significant: $0.01 < p$ (two-tailed) < 0.02 .

The two combined sector distributions are summarized in figure 22. The group of four raw materials has a low proportion of tools in sector 1, and a (very) high one in sector 2. Also sectors 4 and 8 show relatively high proportions. We have no convincing explanations for this pattern. For example, tool assemblages in sectors 2, 4 and 8 do not deviate significantly from each other, apart from the fact that sector 8 shows a higher proportion of backed bladelets than the other two sectors.

The second group of raw materials (*Kieselschiefer* and West European flint) shows a different picture. The most important differences with respect to the first group are that in this case sector 1 shows a high proportion of tools, and sector 4 a low one.

We have concluded above (under 4) that the occupation characterized by the use of *Kieselschiefer* and West European flint probably occurred in the open air. We know from other analyses using the sector method, especially at the site of Pincevent (Stapert, in press), that open-air occupations almost always

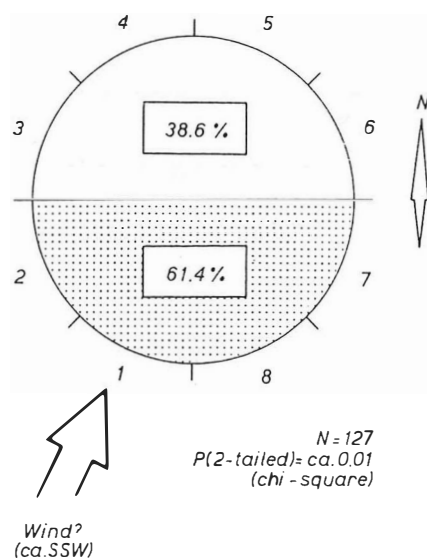


Fig. 23. Gönnersdorf III. *Kieselschiefer* and West European flint taken together. The area within 2.5 m from the 'centre' is divided into two halves, so as to maximize the difference between the two halves in terms of tool frequency. The difference is tested by the chi-square one-sample test, and is found to be significant. The observed asymmetry can be explained by assuming a prevailing wind direction from roughly the SSW.

show a marked asymmetry, in that on one side of the central hearth many more tools are found than on the opposite side. This phenomenon can be explained by assuming a prevailing wind direction: people sat on the windward side to avoid the smoke. It is at least worth noting that an asymmetry also exists in the distributions of *Kieselschiefer* and West European flint. The southern half (sectors 1, 2, 7, 8) is much richer in tools than the northern half. A chi-square one-sample test shows that this difference is significant (see fig. 23): p (two-tailed) = c. 0.01. Since sectors 1 and 2 are richer than sectors 7 and 8, this leads to the hypothesis that the prevailing wind direction during habitation was roughly from the SSW.

6. DISCUSSION AND SOME CONCLUSIONS

In this section we shall confront the results of the various analyses with one another. The outcomes of the analyses have been summarized in table 10.

Concentration III, which at first sight appears to be a homogeneous round stone floor, at close inspection turns out to be quite a complex structure. The distribution of the finds differentiates the find-rich southern half from the relatively poor northern part. The distributions of charcoal and burnt stones demonstrate the important role of fire in Concentration III. The presence of several shallow, stone-edged hearths could be made plausible: one within Concentration III and possibly three in its periphery. The closest parallel to this situation is found at Étiolles. Even at this point in the analysis it seemed likely that several phases of occupation had occurred at the site.

The stone artefacts, which at Concentration III consist of six different raw materials, allow a closer definition of the various settlement phases. On the

basis of differences between raw materials in the proportions in which tools ended up in pits, it was concluded in sections 2 and 3 that two groups can be distinguished: raw materials with few if any tools in pits (*Kieselschiefer* and West European flint), and raw materials with moderate or high numbers of tools in pits (North European flint, Chalcedony, Brown flint and *Süsswasserquarzit*).

On the basis of differences between raw materials in their tool assemblages, it was concluded in section 2 that *Kieselschiefer* is distinguished by an unusually high proportion of backed bladelets, and therefore possibly represents a separate phase (connected with hunting activities?) from that marked by West European flint. (However, one of the authors (D.S.) believes that an alternative explanation could be that the low quality of this type of raw material made it suitable for the production of very small implements only.)

Thus the hypothesis based on the 'conventional' analysis is that at Concentration III three phases of occupation occurred. An initial phase marked by four raw materials (*Süsswasserquarzit*, Chalcedony, Brown flint and North European flint) and possibly a dwelling structure, was followed by two later phases, characterized by West European flint and *Kieselschiefer*, whose relative chronology remains uncertain.

Independently, the distribution of tools made of the six raw materials was investigated, using the ring and sector method. This produced the following results (see table 10).

On the basis of the ring distributions of the tools made of the six raw materials, it was concluded in section 4 that two raw materials show clear bimodal distributions (North European flint and *Süsswasserquarzit*), while Brown flint and Chalcedony show a weak bimodality. It is probable that these four raw materials were in use during the occupation of a tent. For the remaining two raw materials, West European flint and *Kieselschiefer*, no clear bimodality could be demonstrated; their ring distributions are similar. It is probable that these two raw materials were exploited during one or several occupations in the open air.

On the basis of the sector distributions of the tools made of the six raw materials, it was concluded in section 5 that two or three groups can be defined. One group is quite distinct and comprises North European flint, Chalcedony, Brown flint and *Süsswasserquarzit*. The remaining two raw materials, *Kieselschiefer* and West European flint, can be either grouped together, or isolated from each other. However, it was noted that because of the fact that *Kieselschiefer* has a tool assemblage that is very different from those of the other raw materials, it does not lend itself very well for comparison with other raw materials in terms of sector distributions.

Table 10. Gönnersdorf III. Comparing the results of four analyses of six raw materials in terms of multiple occupations: differences in the proportions of tools found in pits ('pits'), differences in tool assemblages ('tools'), differences in the ring distributions of the tools ('rings'), and differences in the sector distributions of the tools ('sectors'). The most likely grouping of raw materials resulting from each analysis is indicated. Raw materials: 1. North European flint; 2. West European flint; 3. *Kieselschiefer*; 4. Chalcedony; 5. Brown flint; 6. *Süsswasserquarzit*.

'Pits'	'Tools'	'Rings'	'Sectors'
1,4,5,6	1,4,5,6	1,5,6	1,4,5,6
		4?	
2,3	2	2,3	2
	3		3?
—			

If these results are compared, we see that both analyses produce an initial phase characterized by four raw materials (*Süßwasserquarzit*, Chalcodony, Brown flint and North European flint). Apparently it was in this initial phase that the main hearth in Concentration III with its surrounding area was laid out and used in its present form. In the first part of this study, a dwelling structure was postulated for this phase, which was probably somewhat larger than the stone-paved area. The outcome of the ring method corroborates this hypothesis; hence we may assume for Phase I the presence of a tent, 5-6 m in diameter, its entrance facing southeast.

As regards the relationship between West European flint and *Kieselschiefer*, no unanimous result was attained. While the high proportion of backed bladelets in *Kieselschiefer* argues in favour of regarding this raw material as a separate assemblage, the ring and sector method yields no significant difference from West European flint. Both assemblages were in all probability produced in the open air. This circumstance may partly explain the correspondence between *Kieselschiefer* and West European flint: the still visible hearth of Phase I was possibly reused consecutively by two independent groups of people.

The use of the ring and sector method proves to be a useful addition to the conventional analysis of Palaeolithic settlement structures.

At the end of this paper we should like to stress that analyses such as these are not without pitfalls when applied to sites that probably saw several occupations. Therefore, we do not claim that the resulting hypotheses are proven; we consider them as useful pointers and material for further study. For example, it would be interesting to repeat this study for the other large concentrations with stone pavements at Gönnersdorf, Concentrations I and II. If the patterns found at Gönnersdorf III were to show up again, this would greatly increase our confidence in their validity. Therefore, we consider the work reported on in this paper largely as a methodological exercise; and it is fair to say that much more work needs to be done before the methods employed here are ready for general application.

7. ACKNOWLEDGEMENTS

The authors both should like to thank Professor G. Bosinski, for the interest he showed in our work, and for critically reading a first draft of this paper. Thanks are also due to Professor G.J. Boekschoten (Vrije Universiteit, Amsterdam) for his comments on a first draft of the paper. We thank L.Th. van der Weele of the Computer Centre of the University of Groningen for his comments on our use, and sometimes mis-use, of statistics. The first author is grate-

ful to Karin Terberger for the warm reception during his stay in Eltville, November 1989. We thank H.R. Roelink (B.A.I., Groningen) for his assistance in preparing the figures. Thanks are due to Marianne Gaasbeek (Groningen) for translating the abstract into French. Finally, we are grateful to Xandra Bardet for expertly translating part of the text into English, and correcting the rest.

8. NOTES

1. The raw materials used at Gönnersdorf were reanalysed and extensively treated in a doctoral thesis by H. Floss.
2. The information on the stone tools is based on work by S. Veil (1983), but has since been largely revised. The following numbers for tools include a few pieces from the area to the east of the illustrated plans (66/76-67/84; see figs 1 and 2).
3. The faunal remains from Concentration III are to be analysed by M. Street. One of the present authors (T.T.), looking them over, chanced upon the foetal bones singled out earlier by F. Poplin.

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