MIDDLE PALAEOLITHIC DWELLINGS: FACT OR FICTION? SOME APPLICATIONS OF THE RING AND SECTOR METHOD

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ABSTRACT: Three Middle Palaeolithic sites are analysed by the ring and sector method. This is a simple method for intrasite spatial analysis, based on the use of rings and sectors around hearths. The main goal is to establish the presence or absence of dwellings, independently of *structures évidentes*. At Buhlen (Lower Site, Layer 4: Fiedler & Hilbert, 1987), a tent ring consisting of large stones was excavated, and the existence of a dwelling is confirmed by the ring and sector method. At Belvédère (Site C, Southern Concentration: Roebroeks, 1988), the analysis indicates that the hearth must have been in the open air. At Rheindahlen (*Westwand*, Northern Concentration: Bosinski, 1966) no hearth was present; here the existence of a dwelling ('*Behausung* I') was postulated by Thieme (1983). Using the middle of this postulated dwelling as the 'centre' for the ring and sector method, it can be shown that this concentration must have originated in the open air.

KEYWORDS: Intrasite spatial analysis, ring and sector method, dwelling structures, Middle Palaeolithic.

1. INTRODUCTION

Unambiguous dwelling structures dating from the Palaeolithic are quite rare. This is true for the Upper Palaeolithic, but even more so for older phases. In many cases the evidence presented for dwellings postulated at Early or Middle Palaeolithic sites is either unconvincing or inconclusive. One can only agree with Gamble (1986: p. 263) that it is not very useful to accept uncritically the many published site interpretations involving huts or tents (e.g. Newell, 1981; Sklenár, 1975; 1976). Arguments that could have been directed against the existence of tents or huts have not often been evaluated. In other words: serious attempts at disproving ('falsifying') such hypotheses are rare (Popper, 1959; 1963). It seems that archaeologists feel very much attracted to postulating dwelling structures on their sites, and it cannot be denied that such a feature, if demonstrated conclusively, is a very important piece of evidence in the interpretation of any site. However, if such a hypothesis cannot be rigorously tested, it may easily fossilize into an accepted 'fact' in the literature, and will no longer be seen as only one of several possibilities.

Even with seemingly obvious 'structures', for example stones and/or large bones arranged in circles, their interpretation as dwellings often poses problems. As an example of this uncertainty the site of Molodova can be mentioned. The Middle Palaeolithic site of Molodova I (Horizon 4) shows a clear ring of large mammoth bones, about 8 x7 m in diameter (Klein, 1973: p. 70; Soffer, 1989: p. 735; after Chernysh, 1965). It is interpreted as the remains of a large dwelling. Inside the ring of bones an enormous amount of cultural material was present, including some 29,000 flints (Klein, 1973: p. 69). One of the difficulties in this case is the astounding number of hearths (fifteen), several of which are located within, or right up against the inside of the presumed walls. The very high number of artefacts and the occurrence of so many hearths seem to indicate multiple occupations. Moreover, the presence of hearths in the wall of any palaeolithic dwelling is difficult to understand. Ethnoarchaeologically, we know of hearths in the walls of windbreaks at hunting stands. Binford (1983: pp. 128-130) describes several of these. The walls of these windbreaks consist of stones, which are heated by the fire and provide warmth for a long period after the fire has been extinguished. Binford (1983: pp. 128; 237) suggests that structures like that at Molodova I could have been windbreaks, connected with hunting activities. In the case of Molodova I, however, the wall consisted not of stones but of bones. Moreover, the amount of cultural material left at Molodova I seems very large for a hunting stand.[1] We are thus left without a clear explanation of the observed features; it seems that the structure at Molodova I had several different functions in the course of a series of occupations.

Another example is the site of Terra Amata (De Lumley, 1969). In one of its levels De Lumley postulated the presence of a large hut with a diameter of 8x4 m. However, it has been shown that artefacts from this level can be refitted with artefacts from various levels above and beneath (Villa, 1982), so that serious doubt is cast on De Lumley's interpretation. Other sites with problematical 'dwelling structures' are Bilzingsleben (Mania, 1986) and Ariendorf (Bosinski et al., 1983).

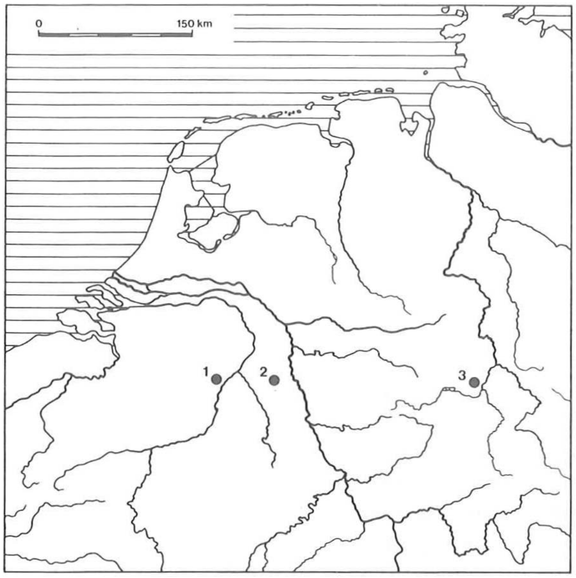

Fig. 1. Map showing the locations of the three sites discussed in this paper. 1. Belvédère, 2. Rheindahlen, 3. Buhlen.

One problem seems to crop up regularly in the literature concerning palaeolithic dwelling structures: ancient treefalls produced soil traces that are easily taken for remains of huts. There are many examples of this problem in the Late Palaeolithic and Mesolithic. One possible example at a Middle Palaeolithic site is the feature at the *Westwand* site of Rheindahlen (Bosinski, 1966; see also Löhr, 1973; Thieme, 1983).

It is obvious that we need an empirical method to help us determine whether a dwelling structure was indeed present at any given site. Preferably such a method should be based on the *structures latentes* (as defined by A. Leroi-Gourhan, e.g. Leroi-Gourhan & Brézillon, 1972): recognizable patterns in the spatial distributions of artefacts, because the latter are almost always present. In other words, we are looking for a way to demonstrate the presence or absence of dwellings independently of directly observable features (*structures évidentes*). As noted, the presence of suggestive features does not in all cases imply that a dwelling must have been present.

The results of such a method could then be evaluated as either corroborating or disproving any dwelling hypothesis derived from the archaeologically visible features. By contrasting two independent methods we may hope to attain a higher degree of reliability for any dwelling hypothesis.

An important reason why it is desirable to have an independent method for establishing the presence or absence of dwellings, based on the *structures latentes*, is the circumstance that palaeolithic dwellings might easily leave no archaeologically visible traces, even in sites with perfect in situ preservation. For example, if the hides forming the walls of a tent were secured to the ground with loose soil or sods, instead of large stones or bones, such a dwelling would in most cases remain completely invisible to archaeologists.

In this paper the ring and sector method is applied (Stapert, 1989; 1990; in press; Stapert & Terberger, 1989). It is believed that this method can at least provide us with reliable conclusions concerning the presence or absence of walls of whatever kind. Of course, even if the former existence of a wall can be established, we cannot simply conclude that it belonged to a dwelling. Above, it was noted that windbreaks are also a possibility. However, if the hypothesis of a dwelling structure at a given site is to be upheld, it should in any case be possible to confirm the presence of a wall. Thus, the method can at least be used in an attempt at disproving a dwelling hypothesis.

Below, the ring and sector method is applied to (parts of) three Middle Palaeolithic sites in northwestern Europe: Buhlen and Rheindahlen in Germany, and Belvédère in the Netherlands (fig. 1). At the first two of these, archaeologists have postulated dwellings, though only one (Buhlen) has an archaeologically visible structure. At the last-mentioned site the presence of a dwelling was considered unlikely. I shall also present artefact density maps of these sites, according to the

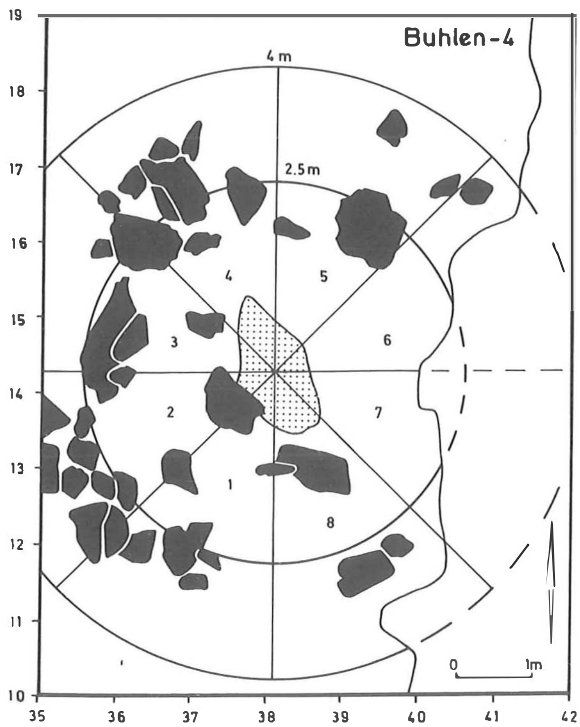

Fig. 2. Buhlen, Lower Site, Layer 4. The tent ring of large stones, with the central hearth. The ring and sector system is indicated; note the disturbance in the eastern part. Based on Fiedler & Hilbert (1987).

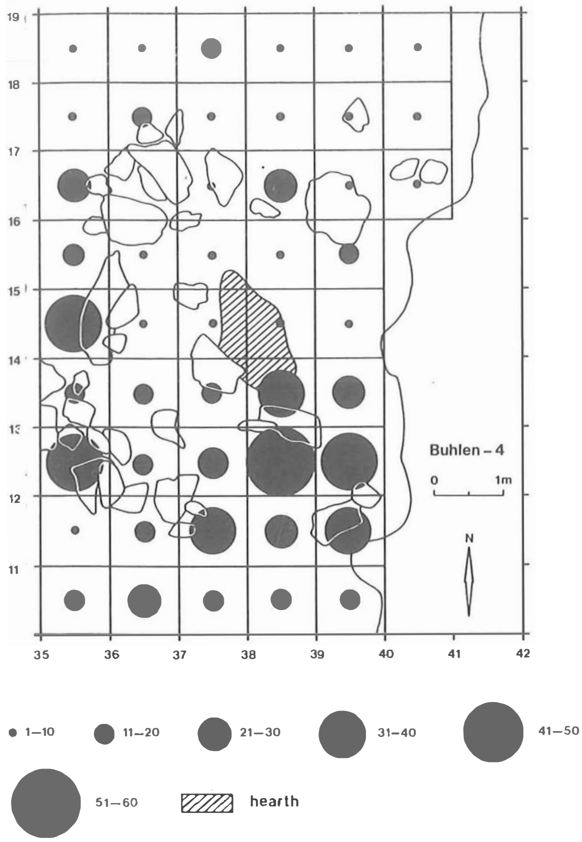

Fig. 3. Buhlen, Lower Site, Layer 4. Artefact density map, organized according to the principles outlined by Cziesla (1990). Based on data in Fiedler & Hilbert (1987).

principles outlined by Cziesla (1990). This is in order to investigate whether such maps may provide additional evidence of any dwelling structures.

2. THE SITES

2.1. Buhlen, Lower Site, Layer 4, Tent ring

In the sixties several excavations were carried out at Buhlen by Bosinski (Bosinski, 1969; 1971; Bosinski & Kulick, 1973). These took place at what is now known as the Upper Site. In the eighties, several excavations of the Lower Site resulted in spectacular new data (Fiedler, 1982; 1990; Fiedler & Hilbert, 1987; Hilbert & Fiedler, 1990). Layer 4 at the Lower Site is dated to the Weichselian. The archaeological material from this level can be placed in a late phase of the Middle Palaeolithic, in which quite a lot of blade-like flakes were produced (*Moustérien à lames*?: Fiedler & Hilbert, 1987: p. 136). Side-scrapers are the most numerous tool type; some of these were worked according to the *Pradnik* technique, as described by Bosinski (1969) for the Upper Site. Furthermore, there are *couteaux à dos*, borer-like tools, burins and choppers (see drawings in Fiedler & Hilbert, 1987).

In Layer 4, a feature was observed, consisting of large dolomite boulders set in a circle with a diameter of about 5 m (figs 2 and 3). This layer also features many small dolomite pebbles, which seem to be distributed in a random way. The large boulders, some of which have diameters of over 1 m, however, seem to have been intentionally arranged in a circle. Unfortunately, the structure is incomplete in the eastern part of the excavated terrain. There are several concentrations of burnt bone. Some of these are under the dolomite boulders, indicating remains of hearths from occupations dating from before the construction of the stone circle. At the centre of the stone circle a large hearth is present, which is thought to have been in use during the occupation of the stone circle (Fiedler & Hilbert, 1987: p. 139). The circle of large stones is interpreted as a tent ring. The postulated tent, with a diameter of 4 to 5 m, is thought to have had its entrance to the south or southeast, facing the river Netze.

In the middle of the stone circle, near the central hearth, there are a few additional large boulders. These could have been used as seats or as 'tables' (e.g. Leroi-Gourhan & Brézillon, 1966; Binford, 1983).

2.2. Belvédère, Site C, Southern Concentration

Since 1981, many sites have been excavated in several levels in the Belvédère quarry near Maastricht (van Kolfschoten & Roebroeks, 1985; Roebroeks, 1988). Site C is one of the largest. Stratigraphically it was located in fluviatile loamy sands (Unit IV-C-I). The site is dated by TL to about 250,000. In terms of the Dutch chronostratigraphical sequence, the site can be dated to an intra-Saalian interglacial, which probably can be correlated with the Hoogeveen Interstadial, defined by Zagwijn (1973).

The finds include somewhat more than 3000 flint artefacts, of which about 74% are smaller than 2 cm. The Levallois technique is clearly represented. Tools are scarce: only three side-scrapers were found. On the basis of refitting, the flints could be attributed to six raw material units.

Site C contained three separate flint concentrations, labelled Southern (S), Northern (N) and Eastern (E) in figure 4. None of these produced any evidence for the existence of a dwelling structure. Regarding the presence of hearths, the situation is somewhat confusing at first sight. There is almost an inverse relationship between the occurrence of charcoal and burnt artefacts:

Concentrations	Burnt artefacts	Charcoal
Southern	Many	Hardly any
Northern	A few	Hardly any
Eastern	None	Relatively much

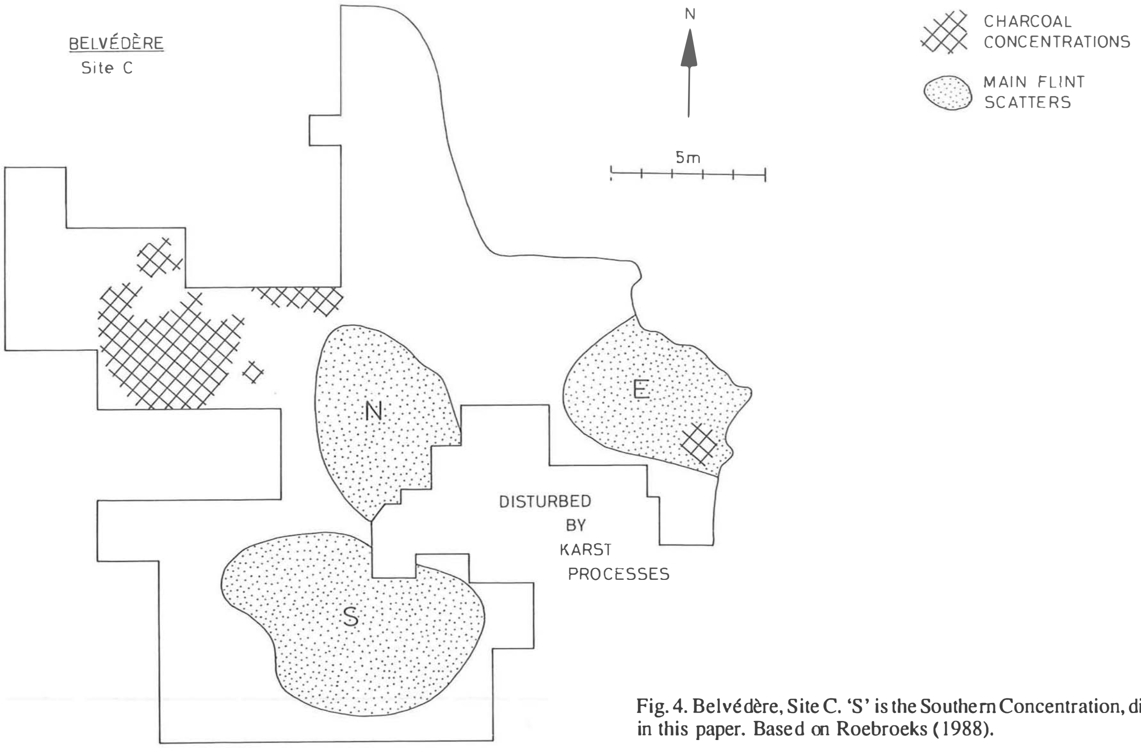

Fig. 4. Belvédère, Site C. 'S' is the Southern Concentration, discussed in this paper. Based on Roebroeks (1988).

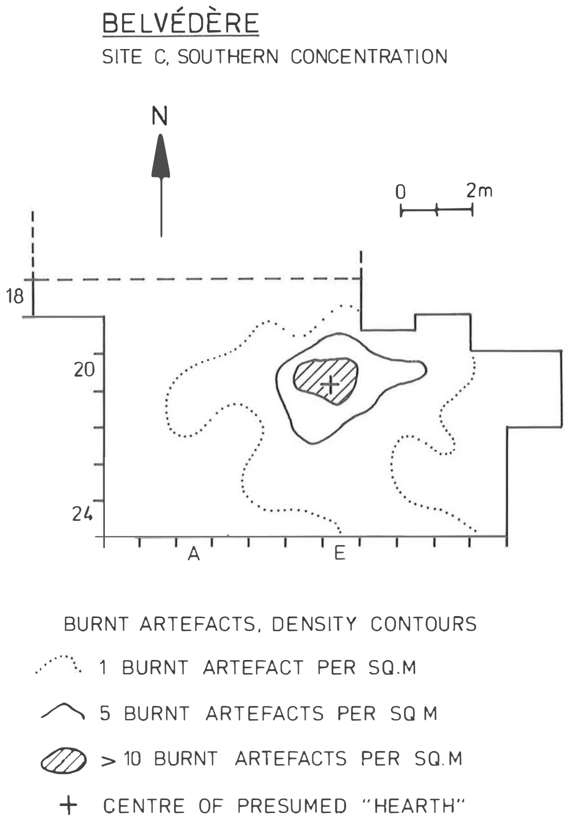

Fig. 5. Belvédère, Site C, Southern Concentration. Distribution of burnt artefacts. Based on data in Roebroeks (1988).

Only in the Southern Concentration were there many burnt artefacts. A density contour map shows that they occurred clustered (fig. 5). The centre of the cluster of burnt artefacts is in Square E20; this is approximately at the centre of the artefact concentration as a whole (figs 6 and 7). But there was hardly any charcoal; only a few scattered particles were found, mostly outside the main artefact concentration. At the periphery of the Eastern Concentration, in Square P15, there was a charcoal concentration, about 1 m in diameter. In this place, however, no burnt artefacts were found at all, though several flints were found within the charcoal cluster. In the Northern Concentration there were a few burnt artefacts as well as a few charcoal particles, but they are not closely associated in space.

It is probable that the burnt flints in the Southern Concentration resulted from a fire stoked by palaeolithic man. An important argument for this hypothesis was produced by the refitting analysis. Two raw material units (RMU's) are represented in the Southern Concentration: RMU 5 and RMU 6. The core of RMU 5 was brought to the site in an already partly reduced state; it was further exploited here, but the residual core was not found. Of the 162 conjoining flints of this RMU about 10% are burnt. The exploitation of the core of RMU 6 only partly took place in the Southern Concentration. The interesting thing is that none of the flints belonging to this RMU are burnt, though many of them occur within the scatter of burnt flints belonging to RMU 5. This state of affairs allows the following

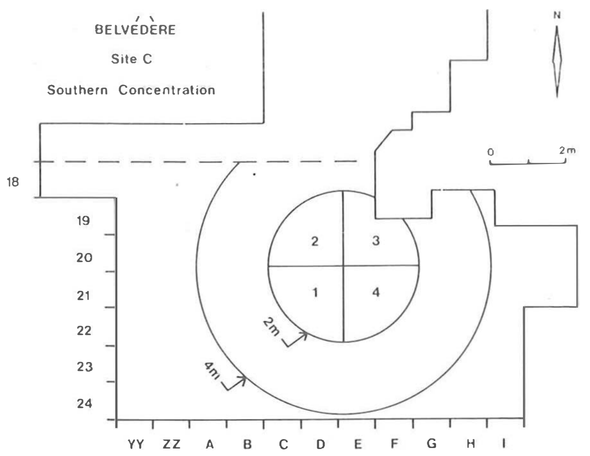

Fig. 6. Belvédère, Site C, Southern Concentration. The ring and sector system.

reconstruction of the sequence in which some of the activities at this Concentration took place: working of the core of RMU 5; construction and use of a hearth at the same period or later; working of the core of RMU 6. Thus, it is unlikely that the fire had a natural cause. Since there was hardly any charcoal here, we have to suppose that it was subsequently removed by natural processes. Most probably it was carried away by flowing water after abandonment of the site. It seems that the flowing water did not have a strong erosive effect, because it left the flint concentration, including many tiny chips, in place (see Roebroeks, 1988, for a further discussion of natural site formation processes).

Apart from flintworking, most probably butchering work was done at the Southem Concentration; one large flake shows meat use-wear (see van Gijn, 1988). Several faunal remains were present (see also van Kolfschoten, 1985), especially in the NW periphery. In summary it can be said that the Southem Concentration probably was a site used for a few specific tasks during a short period of time; it is improbable that we are dealing here with a 'base camp'. Occupation seems to have taken place in the open air. A hearth was present during at least one use episode.

2.3. Rheindahlen, *Westwand*, '*Behausung* I'

In the quarry at Rheindahlen about 9 m of loess deposits are exposed. Archaeological material has been found in ten different levels, and since the sixties several excavations have been carried out here (Thieme, 1983; see also Thissen, 1986). One of the most important sites is called *Westwand*. It was excavated by G. Bosinski in 1964/1965, and a publication appeared shortly afterwards (Bosinski, 1966). Almost 1500 artefacts were collected; bones had not been preserved. The find level has been labelled B1 (Thieme, 1983); stratigraphically it is located immediately on top of a buried soil that is dated as Eemian. Consequently, the site has been dated to an early part of the Weichselian (Brunnacker, 1966). According to Thieme (1983; 1990), however, it might date from the last part of the Saalian. The material can be placed in the Middle Palaeolithic. The Levallois technique is in evidence, and there are quite a lot of blades, some of which are retouched. The tool inventory mainly consists of thin scrapers.

Bosinski (1966) described a depression in the western

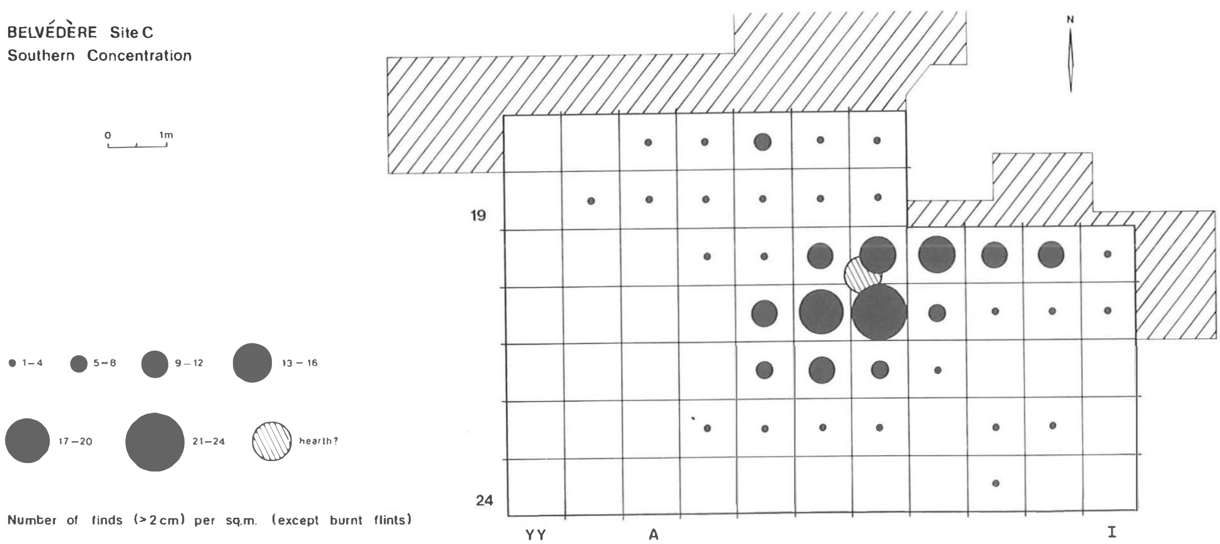

Fig. 7. Belvédère, Site C, Southern Concentration. Artefact density map, organized according to the principles outlined by Cziesla (1990). Based on data in Roebroeks (1988).

part of the excavated terrain; its diameter was about 3.7x2.9 m. It was clearly visible because of a differently coloured fill. To the west of this feature twelve or thirteen small stains (diameter mostly about 10 cm) of the same colour were present. The whole constellation was interpreted as the remains of a dwelling structure with postholes. H. Löhr (1973) has expressed doubts concerning this interpretation; he is of the opinion that natural processes could have been responsible for this feature. H. Thieme (1983; 1990), who reinvestigated the *Westwand* site, supported Bosinski's dwelling interpretation, on the basis of the feature's apparent spatial relationship to the artefact concentration to the east of it. Accordingly, he labelled this feature '*Behausung* II'.

Bosinski could refit fairly many artefacts from the *Westwand* site. This work was later expanded by Thieme; he reported exhaustively on the results (Thieme, 1983). In the northern part of the site, a relatively compact and more or less circular concentration of flints, 6 metres across, was shown by Thieme to consist largely of knapping products from four nodules. A small empty space in the middle of this concentration, with a diameter of about 0.5 m, stands out; it is located close to a patch with a high density of artefacts. Thieme believes that the concentration as a whole was created inside a dwelling structure; hence he calls it '*Behausung* I'. One of his main arguments is the fact that the concentration is quite compact; hardly any waste of the above-mentioned four nodules was found outside it. The concentration therefore appears to be 'contained' within a circular boundary. The empty space in the middle could then, according to Thieme, be interpreted as the location of the central tent pole. The presumed tent had a diameter of somewhat more than 6 m, according to Thieme's reconstruction (figs 8 and 9). Thieme (1983: p. 107) thinks that the best reconstruction would be a tent of the 'yaranga' type (see for descriptions e.g. Faegre, 1979). Thieme furthermore hypothesized (1983: p. 116) that *Behausung* I was a winter dwelling, because almost all the artefacts were found inside the postulated dwelling (according to the same type of reasoning, *Behausung* II, with hardly any artefacts, would have been a summer dwelling). However, inside the postulated dwelling no. I, there were no traces of the hearth we would expect if it was indeed a winter dwelling. Traces of two possible hearths were found about 3 and 5 m to the SSW of '*Behausung* I', which are not necessarily contemporaneous with it.

In a later section of this paper I shall critically investigate the dwelling hypothesis relating to '*Behausung* I'. As the second presumed dwelling structure ('*Behausung* II') contained hardly any flints, the ring and sector method cannot be applied there.

Interestingly, Thissen (1986) too postulated a dwelling structure, at another site of Rheindahlen, in the same level (B1) as Bosinski's *Westwand* site. In this case, a relatively empty zone within the flint concentration is interpreted as the location of a dwelling. In my opinion, Thissen's arguments are rather weak; one can easily imagine several other processes that might have resulted in such a pattern. The site was only partially excavated, and will not be analysed in this paper.

3. THE RING AND SECTOR METHOD

3.1. Introduction

The ring and sector method is a simple method for intrasite spatial analysis, based on the use of rings and sectors around hearths (Stapert, 1989; 1990; in press; Stapert & Terberger, 1989). The idea behind this method is that the hearth was a focal point, attracting many activities – irrespective of whether it was inside or outside a dwelling. The ring and sector method is therefore feature-oriented. It should be clear that this method does not claim to detect all possible spatial patterns in sites. It is directed at describing and interpreting global spatial patterns that relate to the hearth. It is essentially a way of partitioning space that seems more suited than any regular grid structure to analyse sites where the global spatial 'organization' is determined by the presence of a central hearth. In exceptional cases the method can also be applied at sites where no central hearth is present, but another suitable 'centre' (see 3.3). So far, the method has been applied to twelve concentrations of Pincevent (Late Magdalenian), four concentrations of Gönnersdorf (Late Magdalenian), and to several other Late Palaeolithic and Mesolithic sites in northwestern Europe.

If the hearth is taken as the focal point, two ways of partitioning space are appropriate: using rings and sectors around the centre of the hearth. The ring method is extremely simple: frequencies of artefacts are counted in rings of 0.5 m width around the hearth centre. It is advisable to count the ring frequencies per sector, because it may be fruitful to combine the ring and sector approaches. However, if artefact frequencies are low this is not possible, and in such cases one has to be content with a global analysis. The distribution of artefact frequencies in the rings can be illustrated in the form of histograms, in which 0 on the X-axis is the centre of the hearth. It is important to note that we are not discussing densities here, in terms of numbers of artefacts per square metre. 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 distance between an artefact location and the centre of the hearth is called 'D'.

3.2. Unimodal and bimodal ring distributions

When we consider their ring distributions, the sites investigated so far seem to fall into two groups: those with unimodal and those with bimodal ring distributions. Most of the analysed sites show unimodal ring distributions; this applies for example to all twelve analysed concentrations at Pincevent (Leroi-Gourhan & Brézillon, 1966; 1972), Oldeholtwolde (Stapert et al., 1986), Bro I (Andersen, 1973), Marsangy N19 (Schmider, 1984), Olbrachcice 8 East (Burdukiewicz, 1986) and Concentrations I and IV of Niederbieber (Bolus et al., 1988; Winter, 1987). As an example, the unimodal distribution of Niederbieber I is illustrated in figure 10:A. At none of the sites for which I have obtained unimodal ring distributions were any archaeological traces of tents or huts observed.

At the site of Gönnersdorf, two concentrations occur with clear traces of tents. At Gönnersdorf I the presence of a tent is evident from a circular arrangement of postholes (Bosinski, 1979), at Gönnersdorf IV from the presence of a ring of large stones around the hearth, which can be interpreted as a tent ring (Bosinski, 1981; Stapert, 1989; 1990; Terberger, 1988). When we consider the ring distributions of all tools combined in Gönnersdorf I and IV, their bimodal character is immediately apparent (see fig. 10:B for the distribution of Gönnersdorf IV).

The first peak (reckoning from the centre) can be interpreted as the drop zone near the hearth (Binford, 1983). The second peak is generated mainly by the larger tools, and it coincides with the tent ring. In my opinion, the second peak results from the combined centrifugal and barrier effects.

The centrifugal effect manifests itself as a tendency for larger objects to end up farther from the hearth than small debris. In sites with archaeologically visible dwelling structures, the centrifugal effect is found to be very strong. Within a dwelling, the centrifugal movements are of course restricted by the walls. Therefore, one may expect much of the refuse to be carried outside and dumped en masse. One type of dump is characteristic of dwellings: the door dump (Binford, 1983). People simply throw their larger pieces of rubbish out through the entrance, to the left or to the right. However, inside the dwelling the centrifugal effect will also be operative. The walls of the dwelling then serve as a barrier. The refuse gradually accumulates against them in the course of the occupation, with a relatively high proportion of coarse material. This is called the 'barrier effect'. In other words: my interpretation of the second peak in bimodal ring diagrams is that the centrifugal movements occurring inside a dwelling with a central hearth are stopped by the walls, in due time resulting in a second peak that roughly coincides with the walls of the dwelling.

More than 3 to 4 m away from the hearths, we often see a third peak at Gönnersdorf (not illustrated in figure 10:B), which can be interpreted as resulting largely from the door dumps (Stapert & Terberger, 1989). In some cases, however, activity areas located outside the dwelling might have resulted in a third peak.

The analysis of the dwellings at Gönnersdorf has provided us with a method of demonstrating the presence of a dwelling with the help of the ring method. We can now classify archaeological residues with a central hearth into two types: those with unimodal and those with bimodal (or trimodal) frequency distributions of distances between artefact locations and the hearth centres. In the case of bimodal distributions we are dealing with hearths inside dwellings. Unimodal distributions will in general be characteristic of hearths in the open air. Of course, there are various complications. For example, if the hearth was located eccentrically inside a dwelling, we would need ring distributions per sector to demonstrate the presence of walls, and it will usually be profitable to study such distributions. For this, however, the numbers of artefacts per sector should not be too low. For the sites discussed in this paper, this approach is not possible, but it is reasonable to study the ring distributions per site-half. For a more detailed discussion and examples, the reader is referred to previous publications (Stapert, 1989; 1990; in press).

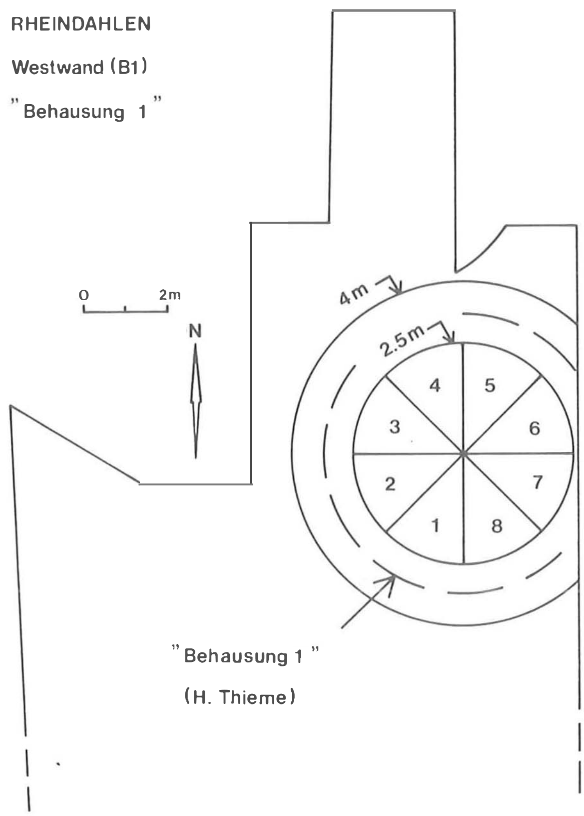

Fig. 8. Rheindahlen, *Westwand* (B1), '*Behausung* I'. The placement of the ring and sector system. The outline of the dwelling as postulated by Thieme (1983) is indicated.

3.3. Defining the 'centre'

As noted above, the ring and sector method was created for the analysis of artefact concentrations around a central hearth. In the case of Buhlen the situation is simple: there is a central hearth, approximately in the middle of the tent ring. Thus, we have no problems in putting the ring and sector system in place. The rings are centred on the middle of the central hearth (fig. 2).

At the site of Belvédère, the situation is somewhat more complicated, as a hearth structure, with charcoal, was not observed. However, as we have seen above (2.2), it is possible to pinpoint the location of the hearth by the cluster of burnt artefacts (fig. 5). Thus, the middle of the reconstructed hearth can be used as the centre for the ring and sector method (fig. 6).

At the northern concentration of Rheindahlen *Westwand* (Thieme's *Behausung* I), no traces of a hearth were observed, and virtually no burnt flints. It is unprobable that a hearth was present here. In such cases, there would in principle be no ground for applying the ring and sector method. However, in this case a theoretically sound basis for applying the method is provided by Thieme (1983). As noted above, he postulates a dwelling structure at this concentration. Moreover, an empty area in the middle of the postulated dwelling is interpreted as the location of the central tent pole. Therefore, it is legitimate to use the middle of this empty area as the 'centre' of the ring and sector system (fig. 8). In this way the ring and sector method can be used in an attempt to corroborate or falsify Thieme's dwelling hypothesis.

3.4. Incomplete rings

It can be seen in figures 2, 6 and 8 that at all three sites, rings farther away than 2 or 2.5 m from the 'centre' are incomplete. This would seem to preclude a valid application of the ring and sector method, because at these sites we need to investigate an area with a radius of at least 4 m, in order to arrive at reliable conclusions concerning the presence or absence of any dwelling. Unfortunately, such problems are quite common, either due to the circumstance that the excavated areas were relatively small, or because of the presence of disturbances. Therefore we have to find a way to deal with such situations. In another paper, I have proposed to use 'corrected' frequencies for the incomplete rings (Stapert & Terberger, 1989). For example, if 20% of a ring is missing, the best estimate of the original frequency will be to multiply the observed frequency with 1.25. Of course, this estimation assumes that the artefacts have a random or regular spatial distribution, which mostly is not the case. Still, it is believed that this 'correction' is reasonable if not more than half of a ring is missing. In all the ring diagrams presented in this paper, observed and estimated frequencies for the incomplete rings are indicated separately, in black and white respectively.[2]

In other words: in the ring histograms, the white part of any bar (representing a 0.5 m distance class) indicates what proportion of the area of the respective ring is missing.

3.5. Artefact classes

In this section, the data available to me for the three sites, in the form of published distribution maps, will be introduced.

In the case of Buhlen, use will be made of two types of maps. The first of these refers to the numbers of artefacts per square metre, graphically represented as squares (Fiedler & Hilbert, 1987: *Abb.* 9) or as circles (Hilbert & Fiedler, 1990: fig. 7) in each square metre, the size of which proportionally reflects the number. Moreover, in these sophisticated maps also the percentage of the tools per square metre is indicated. These maps are based only on the artefacts larger than 2 cm (Hilbert & Fiedler, 1990). The richest square contained 60 artefacts larger than 2 cm. I have calculated the artefact frequencies per square metre, and plotted them

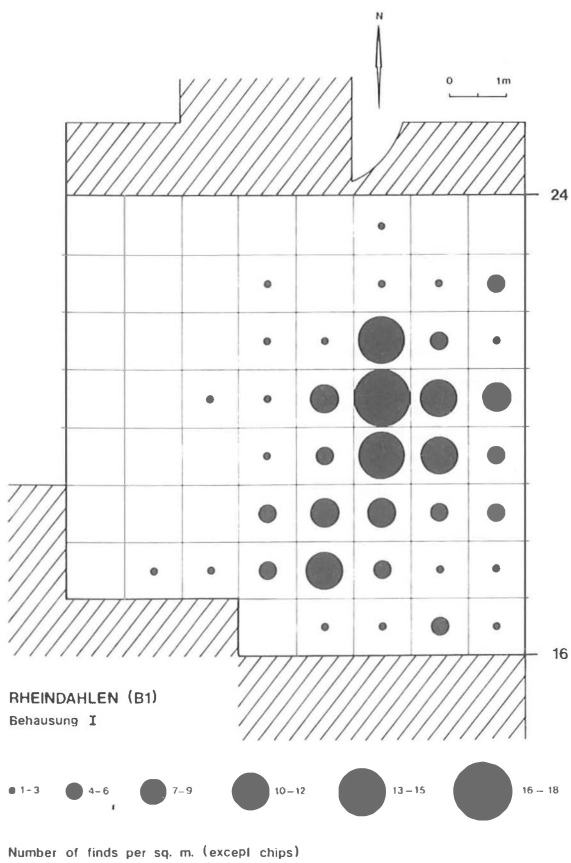

Fig. 9. Rheindahlen, *Westwand* (B1), '*Behausung* I'. Artefact density map, organized according to the principles outlined by Cziesla (1990). Based on data in Bosinski (1966).

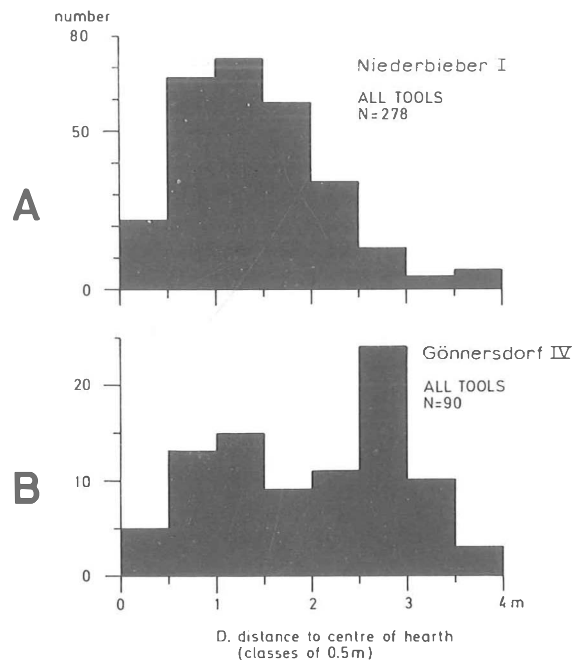

Fig. 10. Examples of unimodal and bimodal ring distributions of tools within 4 m from hearth centres. Unimodal distributions, such as A, are thought to be characteristic of open-air hearths, while bimodal ones, such as B, are associated with hearths inside dwellings (see section 3.2).

in a density map according to the principles outlined by Cziesla (1990): fig. 3.

In a second map, Fiedler & Hilbert (1987: *Abb.* 10) have indicated the locations of the 'retouched tools'. Within 4 m from the hearth centre these comprise:

Borers and becs	5
Burins and Pradnik sharpening flakes	6
Side-scrapers	59
Scraper-like and plane-like tools	4
Bifacial tools	3
Backed knives	5
Choppers	3
Hammerstones	5
Total	90

Side-scrapers and scraper-like or 'plane-like' tools especially are very numerous: 70% of the total of 90 within 4 m from the hearth centre. These 90 artefact locations will be used for the analysis according to the ring and sector method (see 4).

For Site C at the Belvédère site, a distribution map was published by Roebroeks (1988: fig. 27). In this map, locations are given for all flint artefacts, divided into three size-classes: 0-2 cm, 2-5 cm, and larger than 5 cm. This is a good idea, but it is unfortunate that cores and tools are not indicated by separate symbols. However, at the Southern Concentration of Site C only very few tools were found: one or two side-scrapers. Furthermore, burnt flints are mapped separately (discussed above: 2.2). It was decided to use all artefacts larger than 2 cm (except burnt flints) and found within 4 m from the centre of the hearth for the analysis by the ring and sector method; this produces a total of 186 artefact locations (see 5).

Bosinski (1966: fig. 4) published a distribution map for the *Westwand* site at Rheindahlen. The following categories are mapped separately; the numbers refer to the frequencies within 4 m from the centre of *Behausung* I, as postulated by H. Thieme (see 3.3):

Tools (*Werkzeuge* and *partiell retuschierte Artefakte*)	13
Blades	6
Flakes (larger than 3 cm)	106
Blocks (*Trümmerstücke*)	54
Cores	3
Large nodule (unworked)	1
Total	183

These 183 artefact locations are used for the analysis according to the ring and sector method (see 6). It will be noted that the tools are not specified by type on Bosinski's map; moreover, they are relatively few in number. Therefore, they will be treated as one category. On Bosinski's map, also many chips (*Absplisse*) are indicated; these are pieces smaller than 3 cm (Bosinski, 1966: p. 320); they are not included in my analysis. Furthermore, only one burnt flint is indicated. It is located at the southwestern periphery of the *Behausung* I concentration, and could therefore 'belong' to the hearth areas in the middle parts of the *Westwand* site, to the south of *Behausung* I. In the central part of the rich concentration of *Behausung* I no burnt flints occurred. Therefore, this isolated burnt flint was omitted from my analysis.

In the following sections I shall discuss the results of the analysis with the ring and sector method. My main concern will be the question of dwelling structures: can their presence or absence be demonstrated independently by this method? More detailed analyses concerning other questions will be discussed briefly.

4. BUHLEN, LOWER SITE, LAYER 4, TENT RING

In figure 3, an impression is given of the spatial distribution of all artefacts larger than 2 cm. These include tools, but such maps largely reflect the distribution of flint-working waste. It can be seen that most artefacts are concentrated near the supposed entrance of the tent, to the south. Richer squares also occur outside the entrance, and in the extreme north, outside the tent ring. The northern half of the space inside the supposed dwelling is relatively empty.

This pattern is what we should expect if the dwelling

Table 1. Buhlen, Lower Site, Layer 4, Tent ring. Frequencies of artefacts in rings of 0.5 m width around the centre of the hearth. Note that rings farther than 2 m from the hearth centre are incomplete (fig. 2). Based on data in Fiedler & Hilbert (1987). Artefact groups: 1. Borers and becs; 2. Burins and Pradnik sharpening flakes; 3. Scraper-like and plane-like tools; 4. Side-scrapers; 5. Bifacial tools; 6. Backed knives; 7. Choppers; 8. Hammerstones.

Rings	Artefact groups								Total
	1	2	3	4	5	6	7	8	
0-0.5 m	0	1	0	1	0	0	0	0	2
0.5-1	0	0	0	4	0	0	0	1	5
1-1.5	2	1	0	15	1	0	1	1	21
1.5-2	1	1	0	6	0	2	1	0	11
2-2.5	0	1	2	10	1	2	0	1	17
2.5-3	0	1	0	7	1	1	1	1	12
3-3.5	1	1	1	10	0	0	0	0	13
3.5-4	1	0	1	6	0	0	0	1	9
Total	5	6	4	59	3	5	3	5	90

Table 2. Buhlen, Lower Site, Layer 4, Tent ring. Frequencies of artefacts in eight sectors around the centre of the hearth, within 4 from it. Note that some sectors are incomplete; for sector boundaries, see fig. 2. Based on data in Fiedler & Hilbert (1987). Artefact groups: 1. Borers and becs; 2. Burins and Pradnik sharpening flakes; 3. Scraper-like and plane-like tools; 4. Side-scrapers; 5. Bifacial tools; 6. Backed knives; 7. Choppers; 8. Hammerstones.

Sectors	Artefact groups								Total
	1	2	3	4	5	6	7	8	
1	0	0	1	8	1	3	1	0	14
2	1	0	1	8	0	0	0	1	11
3	0	0	1	5	1	0	0	0	7
4	1	0	1	3	0	1	0	0	6
5	0	2	0	11	0	0	1	2	16
6	0	3	0	6	0	0	0	0	9
7	0	1	0	7	1	0	1	1	11
8	3	0	0	11	0	1	0	1	16
Total	5	6	4	59	3	5	3	5	90

Table 3. Buhlen, Lower Site, Layer 4, Tent ring. Artefact frequencies inside and outside the tent: 0-2.5 m and 2.5-4 m from the hearth centre, respectively. Artefacts are divided into three groups: A. Borers, becs, burins, Pradnik sharpening flakes and backed knives; B. Side-scrapers, scraper-like tools and plane-like tools; C. Choppers, bifacial tools and hammerstones. Differences between pairs among these three artefact groups are tested by the Fisher Exact Probability Test (Siegel, 1956).

Distance	Artefact groups			Total
	A	B	C	
0-2.5 m	11	38	7	56
2.5-4 m	5	25	4	34
Total	16	63	11	90

Pairs of artefact groups	p (Fisher Test)
A/B	0.38
A/C	0.55
B/C	0.56

hypothesis were correct. Also in the case of the tents at Gönnersdorf, we see that the area opposite the entrance has remained relatively empty. Probably several processes, separately or combined, were at work to produce this pattern. The first of these is that opposite the entrance the sleeping area may have been. A second factor is that cleaning out the tent would result in a movement of refuse towards the entrance and the door dump located outside it. A third factor might be that, if flint-working was done inside the tent, a location near the entrance was preferred.

In the case of the tents at Gönnersdorf, this density asymmetry can also be observed in the distribution of the tools. At Buhlen, however, the tools seem to be distributed fairly evenly over the floor of the supposed tent. Within 2.5 m from the hearth centre, the northern half has 25 tools, and the southern half 31 (table 4). This difference is not significant (according to the chi-square

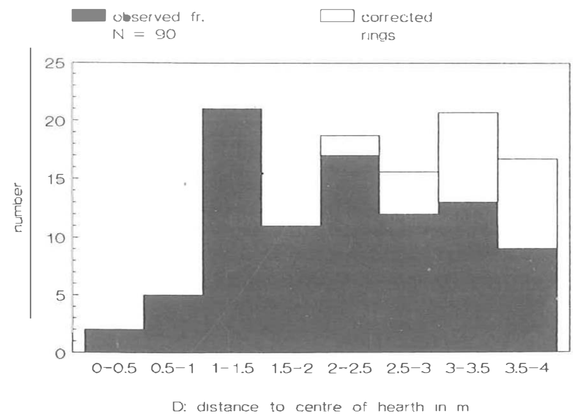

Fig. 11. Buhlen. Ring distribution of all 'retouched tools' (Fiedler & Hilbert, 1987) within 4 m from the hearth centre. Artefact frequencies are given in classes of 0.5 m (class boundaries are as follows: 0-0.50 m, 0.51-1.00 m, etc.). On the X-axis, 0 is the centre of the hearth. Incomplete rings are represented in two parts: observed frequencies (black) and estimated original frequencies (white). For correction factors, see Note 2.

one-sample test (Siegel, 1956): 0.3 < p (two-tailed) < 0.5). Thus the spatial distribution of the tools is very different from that of flint-working waste. This can also be seen in the map by Hilbert & Fiedler (1990: fig. 7), in which the percentages of tools per square metre are indicated. Therefore we may conclude the following. Tool use took place especially inside the tent, over the whole of the area. Flint-working was done especially near the entrance, or, alternatively, clearing up took place especially after episodes of flint-working.

A very interesting pattern, shown in figure 3, is that the tent ring of large stones is accentuated by the artefact distribution: the supposed tent wall coincides with somewhat richer squares roughly in the form of a circle. This is a strong argument for the existence of a dwelling. As described above (see 3.2), this pattern would have resulted from the combined centrifugal and barrier effects. We shall now see whether or not the ring distributions support the dwelling hypothesis.

In figure 11, the ring distribution of all 90 artefacts included in the analysis is presented (the data can be found in table 1). A first peak is present in the 1-1.5 m class, which can be interpreted as the (remains of the) drop zone near the hearth. A second peak is located in the 2-2.5 m class. It roughly coincides with the tent ring of large stones. Thus, we may conclude that at Buhlen a tent was indeed present, with a diameter of about 4.5-5 m.

In the 3-3.5 m class a third peak is indicated, especially if we take into account the estimated frequency of this incomplete ring. This peak partly results from the door dump outside the entrance, but especially from a concentration of tools (exclusively scrapers) located outside the tent ring in the north. The ring distribution as a whole is remarkably similar to several diagrams obtained for the site of Gönnersdorf.

It is of interest to study the ring distributions for different size-classes of artefacts. As 'larger' artefacts, I have grouped together choppers, bifacial tools and hammerstones. Unfortunately, their number is rather small, a total of 11. Still, their ring distribution (fig. 13) is characteristically bimodal. The first peak again falls in the 1-1.5 m class. The second mode is in the 2.5-3 m class. This is one ring further from the hearth than in the case of all the other artefacts taken together: borers/becs + burins + Pradnik sharpening flakes + side-scrapers + scraper-like/plane-like tools + backed knives (fig. 12), where the second mode occurs in the 2-2.5 m ring. This difference illustrates that the centrifugal effect was operative inside the tent of Buhlen.

As noted in section 3.2, it is a good idea to study the ring distributions per sector. Unfortunately, in the case of Buhlen, the number of tools is too small for this. It is reasonable, however, to investigate ring diagrams for two site-halves. For this, I have selected the northern half (sectors 3,4,5,6) and the southern half (sectors 1,2,7,8): figures 14 and 15. Both diagrams show a first peak in the 1-1.5 m ring. In the northern half, we see a second peak in the 2-2.5 m ring, reflecting the tent wall, and a third one in the 3-3.5 and 3.5-4 m rings. This last peak is mainly caused by a concentration of tools outside the tentring, consisting of ten side-scrapers. It is possible that an activity involving the use of scrapers took place here, outside the tent. However, flint-working waste is also present (fig. 3). Therefore, an alternative explanation might be that the back of the tent had a second opening, with a door dump located outside it. The diagram for the southern site-half has the second peak in the 2-2.5 and 2.5-3 m rings. This second peak is broader than that of the northern site-half, reflecting the artefact-rich entrance zone and the door dump.

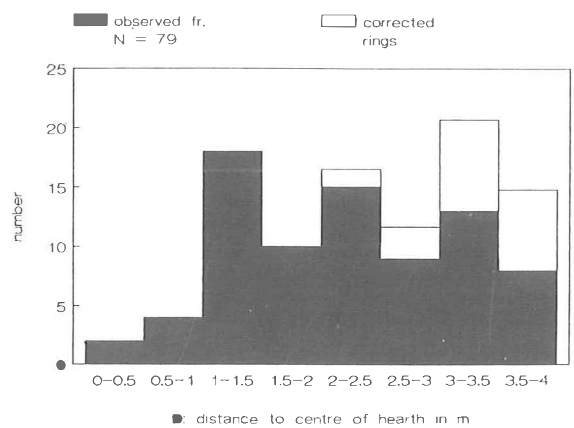

Fig. 12. Buhlen. Ring distribution for the following types taken together: borers and becs, burins and Pradnik sharpening flakes, side-scrapers, scraper-like and plane-like tools, backed knives.

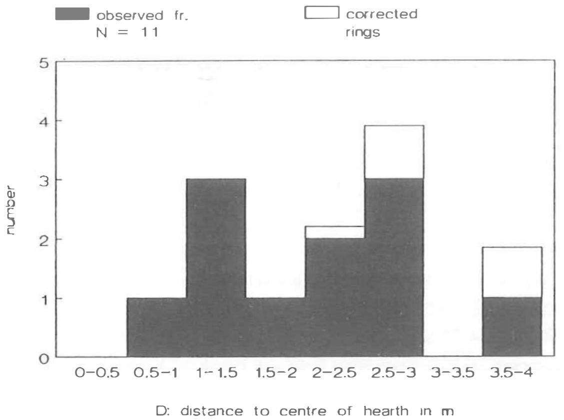

Fig. 13. Buhlen. Ring distribution for the following types taken together: choppers, bifacial tools, hammerstones.

In my opinion, the ring diagrams for Buhlen nicely support the dwelling hypothesis of Fiedler & Hilbert (1987). The conclusion is that a tent was present, with a diameter of 4.5-5 m. Its main entrance was to the south, with possibly a second opening to the north. The hearth was located approximately in the middle of the tent. It is satisfying that the artefact density map (fig. 3) also suggests the presence of tent walls, thus corroborating the conclusions of the analysis by the ring method.

Accepting the existence of a tent at Buhlen, several further aspects can now be investigated:

1. Are there any differences between the various artefact groups, regarding the proportions in which they are located inside and outside the tent?

2. Is there is a demonstrable segmentation within the tent, in the sense that various artefact groups have different sector distributions?

As noted before (see 3.5), several artefact classes have very low frequencies. Therefore it is unavoidable to group them together. I have chosen to combine them into three groups:

A. borers, becs, burins, Pradnik sharpening flakes, backed knives; N = 16;

B. side-scrapers, scraper-like tools, plane-like tools; N = 63;

C. choppers, bifacial tools, hammerstones; N = 11.

In table 3, the numbers of these three artefact groups occurring inside (0-2.5 m) and outside the tent (2.5-4 m) are given. Each pair among the three groups is then compared, using the Fisher Exact Probability Test (Siegel, 1956). It can be noted that there are no significant differences.

We will now consider the interior of the tent, i.e. the area within 2.5 m from the hearth centre. This area is divided into two halves, in four different ways (table 4). Each pair among the three artefact groups is then compared with regard to their frequencies in the two halves, using the Fisher Test. Again, no significant differences can be demonstrated, suggesting that no functional segmentation existed within the tent of Buhlen.

One circumstance that could have created segmentation, is a sexual division of labour. If persons of both sexes occupied a dwelling, it is a reasonable expectation that one half would have been used especially by the woman or women, and the other half by the man or men (e.g. Faegre, 1979; Grøn, 1990). One conclusion of the above exercise could therefore be that at Buhlen only one of the sexes occupied the tent. At least, occupation by both sexes cannot be demonstrated.

It should be noted, however, that this conclusion is based on weak grounds in this case. In the first place, several different artefact classes were combined in the above analysis. In the second place, even after

Table 4. Buhlen, Lower Site, Layer 4, Tent ring. The interior of the tent, i.e. the area within 2.5 m from the hearth centre, is divided into two halves, in four different ways. The total number of artefact locations within this area is 56. In each case, these two halves are compared in terms of their artefact contents by the Fisher Exact Probability Test (Siegel, 1956). Artefact groups: A. Borers, becs, burins, Pradnik sharpening flakes and backed knives; B. Side-scrapers, scraper-like tools and plane-like tools; C. Choppers, bifacial tools and hammerstones.

Site-halves	Artefact groups A	B	C	Total
1. W (sectors 1,2,3,4)	5	16	2	23
E (5,6,7,8)	6	22	5	33
2. NW (2,3,4,5)	3	16	4	23
SE (1,6,7,8)	8	22	3	33
3. N (3,4,5,6)	5	17	3	25
S (1,2,7,8)	6	21	4	31
4. NE (4,5,6,7)	6	18	5	29
SW (1,2,3,8)	5	20	2	27

Pairs of artefact groups	p (Fisher Test)
1. A/B	0.55
A/C	0.42
B/C	0.41
2. A/B	0.30
A/C	0.22
B/C	0.37
3. A/B	0.62
A/C	0.65
B/C	0.63
4. A/B	0.47
A/C	0.42
B/C	0.23

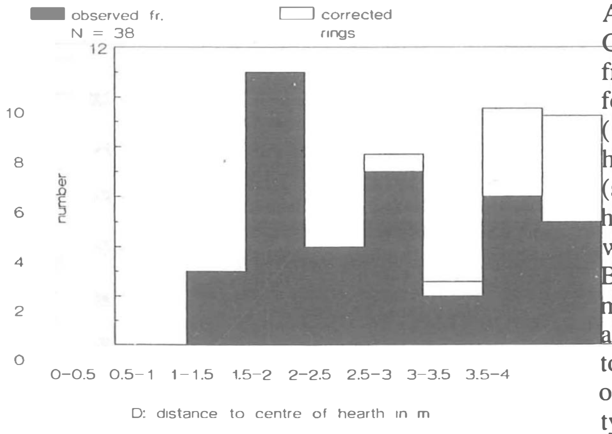

Fig. 14. Buhlen. Ring distribution for the northern half of the site (sectors 3, 4, 5, 6).

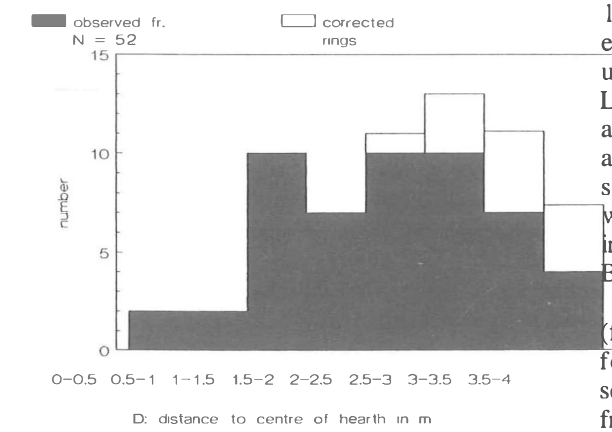

Fig. 15. Buhlen. Ring distribution for the southern half of the site (sectors 1, 2, 7, 8).

combining, numbers are quite low for two of the three groups created, which affects the value of any statistical test. Even if groups A and C are combined, however, and then compared with group B (scrapers), no significant patterning can be demonstrated.

In my opinion, an important reason for the absence of any segmentation within the tent of Buhlen could be the absence of a strong correlation between tool type and function in the Mousterian. For the Upper Palaeolithic it is known that for several tool types at least this correlation is quite strong. For example, backed bladelets seem to have been used almost exclusively as insets of 'projectiles', and scrapers predominantly for working hides (e.g. Cahen & Caspar, 1984; Juel Jensen, 1988; Moss, 1983). For the Middle Palaeolithic, however, several assemblages analysed by use-wear specialists, using the method of Keeley (1980), showed no clear correlations of this kind (e.g. Anderson-Gerfaud, 1981; Beyries, 1987; Gysels & Cahen, 1981). For example, 73 Mousterian side-scrapers from Corbiac and Pech de l'Azé showed traces of the following contact materials: wood (49), hide (7), plants (1), undetermined (16) (Anderson-Gerfaud, 1981). The high proportion of wood-working traces is interesting (see also Anderson-Gerfaud, 1990). Most of the handaxes from these sites were also used for wood-working. The same pattern was repeated in the work of Beyries (1987); wood-working was represented on most of the tools of all types. Thus, even if there existed a sexual division of labour, the poor correlation between tool type and function would preclude the possibility of observing it from the spatial distributions of formal types.

5. BELVÉDÈRE, SITE C, SOUTHERN CONCENTRATION

The ring distribution for this site is presented in figure 16 (the data can be found in table 5). This is a classical example of a unimodal distribution. It is very similar to unimodal distributions obtained for several Upper and Late Palaeolithic sites, such as Pincevent, Oldeholtwolde and Niederbieber (Stapert, 1989). For example, it is almost identical with the distribution of Niederbieber I, shown in figure 10:A. If this distribution is compared with that of Buhlen (fig. 11), it is evident that they are indeed very different. Ring distributions such as that of Belvédère are characteristic of hearths in the open air.

It is of interest to note that the artefact density map (fig. 7) for Belvédère is also very different from the one for Buhlen (fig. 3). Here we see no ring of richer squares, but a gradual decrease in density, going outwards from the central part of the concentration.

As noted in section 3.5, a distribution map of the cores is not available. Therefore we cannot study the

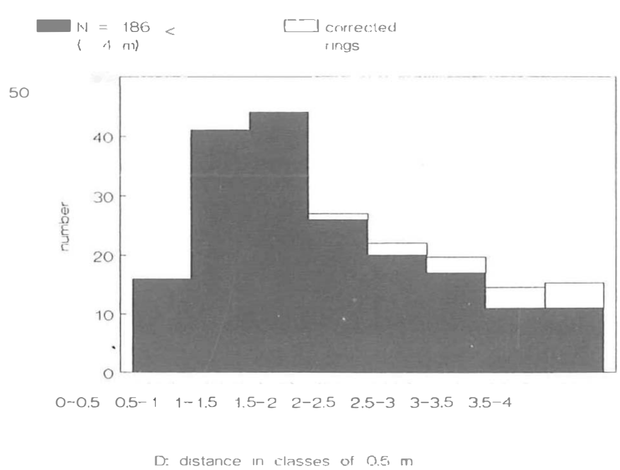

Fig. 16. Belvédère. Ring distribution for all artefacts larger than 2 cm, within 4 m from the centre of the presumed hearth.

Table 5. Belvédère, Site C, Southern Concentration. Artefact frequencies in rings of 0.5 m width around the centre of the presumed hearth. Note that rings farther than 1.5 m from the hearth centre are incomplete (fig. 6). Artefacts are divided into two size groups: 2-5 cm, and larger than 5 cm. Based on data in Roebroeks (1988).

Rings	2-5 cm	Larger than 5 cm	Total
0-0.5 m	12	4	16
0.5-1	39	2	41
1-1.5	38	6	44
1.5-2	22	4	26
2-2.5	20	0	20
2.5-3	14	3	17
3-3.5	10	1	11
3.5-4	8	3	11
Total	163	23	186

Table 6. Belvédère, Site C, Southern Concentration. Artefact frequencies in four sectors around the centre of the presumed hearth. Artefacts are divided into two size groups: 2-5 cm, and larger than 5 cm. For sector boundaries, see fig. 6. Based on data in Roebroeks (1988).

Sectors	2-5 cm	Larger than 5 cm	Total
A. All artefact locations within 4 m from the hearth centre			
1	51	6	57
2	22	9	31
3	46	3	49
4	44	5	49
Total	163	23	186
B. Artefact locations within 2 m from the hearth centre			
1	41	6	47
2	13	2	15
3	25	3	28
4	32	5	37
Total	111	16	127

centrifugal effect by comparing the ring distribution of flakes with that of cores. In this case, however, we can compare the artefacts of 2-5 cm with those larger than 5 cm. Within 4 m from the hearth centre, the average distance to the hearth centre of the first group is 1.62 m (Stand. Dev. 0.94), and that of the second group 1.80 m (Stand. Dev. 1.15). Thus, according to expectation, the larger artefacts are, on average, located somewhat farther from the hearth than the smaller ones, suggesting that the centrifugal effect was operative at Belvédère. However, the difference is slight, and not significant in a statistical sense. After combining the data into rings of 1 m width, a valid application of the chi-square two-sample test is possible: $0.5 < p$ (two-tailed) < 0.7. This means that this trend is rather weak.

In the case of Belvédère, only 4 sectors were used (fig. 6). The sector data can be found in table 6. As noted above, only in the area within 2 m from the hearth centre are the sectors approximately equally large (data in table 6 B). If the area within 2 m is divided into two halves, in such a way that the difference between numbers of artefacts in these halves is maximal, we find that the southern half has about twice as many artefacts as the northern half (66.1% and 33.9%, respectively). This difference between the two halves is significant in a statistical sense (according to the chi-square one-sample test: p (two-tailed) < 0.001). As sector 1 is richer than sector 4, the prevailing wind during at least one of the occupation phases can be reconstructed as roughly from the SSW. It can be concluded that flint-working was done near the hearth, and mainly to the SW and S of it.

Outside 2 m from the hearth centre, in sector 2 a marked concentration of eight large flakes is present. In this area also quite a lot of faunal remains were found. It can be suggested that at some distance from the hearth, to the NW of it, butchering work was done.

It would be interesting to repeat this type of analysis for other sites at Belvédère, preferably sites with substantial numbers of tools, such as Site K (Roebroeks et al., 1988).

6. RHEINDAHLEN, WESTWAND, *BEHAUSUNG* I

Above, it was concluded that the concentration at Buhlen was created inside a tent, while the hearth of Belvédère must have been located in the open air. Using these results as a background, we are now in a good position to evaluate the dwelling hypothesis of Thieme (1983) for the northern concentration at the *Westwand* site of Rheindahlen. In this case there was no hearth. The

Table 7. Rheindahlen, *Westwand*, *Behausung* I. Artefact frequencies in rings of 0.5 m width around the 'centre' of the dwelling structure postulated by Thieme (1983): see fig. 8. Note that rings farther than 2.5 m from the hearth centre are incomplete. Based on data in Bosinski (1966). Artefact groups: 1. Tools; 2. Blades; 3. Flakes larger than 3 cm; 4. Blocks; 5. Cores; 6. Nodule.

Rings	Artefact groups						Total
	1	2	3	4	5	6	
0-0.5 m	0	0	13	0	0	0	13
0.5-1	0	2	15	7	0	0	24
1-1.5	5	1	21	7	1	0	35
1.5-2	4	0	26	13	0	0	43
2-2.5	1	1	10	13	0	0	25
2.5-3	1	2	10	9	0	0	22
3-3.5	1	0	5	4	2	1	13
3.5-4	1	0	6	1	0	0	8
Total	13	6	106	54	3	1	183

Table 8. Rheindahlen, *Westwand, Behausung* I. Artefact frequencies in eight sectors around the 'centre' of the dwelling structure postulated by Thieme (1983). For sector boundaries, see fig. 8. Based on data in Bosinski (1966). Artefact groups: 1. Tools; 2. Blades; 3. Flakes larger than 3 cm; 4. Blocks; 5. Cores; 6. Nodule.

Sectors	Artefact groups						Total
	1	2	3	4	5	6	
A. All artefact locations within 4 m from the 'centre'							
1	2	2	18	10	1	0	33
2	0	0	6	1	1	0	8
3	1	0	5	4	0	0	10
4	2	0	5	1	0	0	8
5	4	1	23	7	0	0	35
6	1	1	15	12	0	0	29
7	2	0	12	10	1	0	25
8	1	2	22	9	0	1	35
Total	13	6	106	54	3	1	183
B. Artefact locations within 2.5 m from the 'centre'							
1	1	2	15	6	0	0	24
2	0	0	4	1	0	0	5
3	1	0	4	3	0	0	8
4	2	0	4	1	0	0	7
5	3	0	18	6	0	0	27
6	1	1	13	11	0	0	26
7	1	0	12	6	1	0	20
8	1	1	15	6	0	0	23
Total	10	4	85	40	1	0	140

geometrical centre of the ring and sector system is placed in the middle of the postulated dwelling; here an empty patch was interpreted as the location of a central tent pole (see 3.3). The ring and sector frequencies for Rheindahlen can be found in tables 7 and 8.

We will start by looking at the ring diagram for all 183 artefacts together: figure 17. The distribution is clearly unimodal, and in fact is very similar to the one for Belvédère (cf. fig. 16). The only difference is that the mode is one ring farther from the centre than in the case of Belvédère, but this is not essential. Thus, we may conclude that this concentration was created in the open air, not inside a dwelling as supposed by Thieme.

Again, it is not possible to study the ring distributions per sector, because the numbers are too small for that. However, as in the case of Buhlen, it is reasonable to study the ring distributions for two site-halves. The diagrams for the northern and southern site-halves are presented in figures 18 and 19. Both distributions are unimodal, and both have the mode in the 1.5-2 m ring. They are somewhat different, however, as in the case of the northern site-half artefact numbers drop sharply beyond 2 m, while in the southern site-half the distribution is more normal. I have no explanation for this difference, but I do not consider this phenomenon of much importance for the present discussion. The

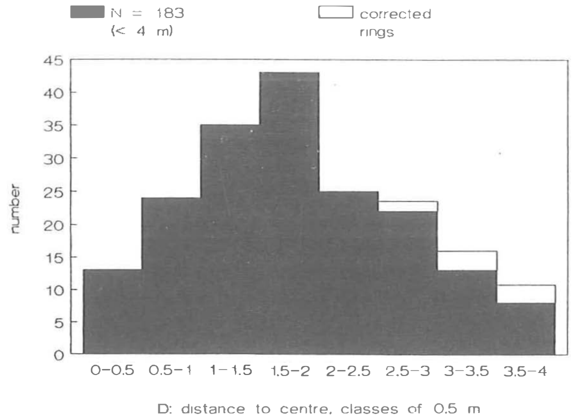

Fig. 17. Rheindahlen. Ring distribution for all artefacts larger than 3 cm, within 4 m from the centre of the dwelling No. 1 postulated by Thieme (1983).

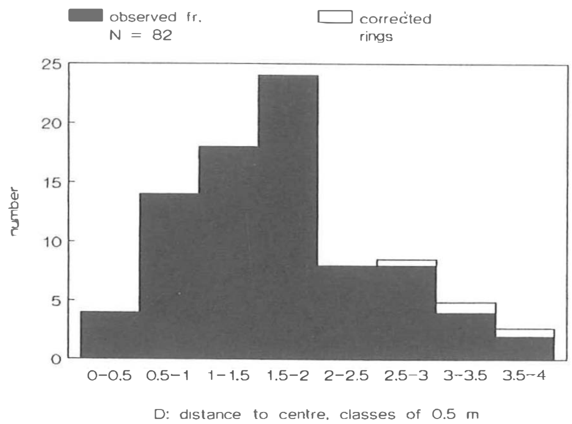

Fig. 18. Rheindahlen. Ring distribution for the northern half of the site (sectors 3, 4, 5, 6).

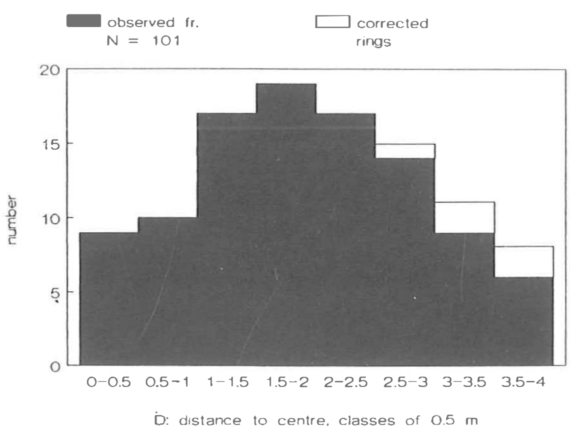

Fig. 19. Rheindahlen. Ring distribution for the southern half of the site (sectors 1, 2, 7, 8).

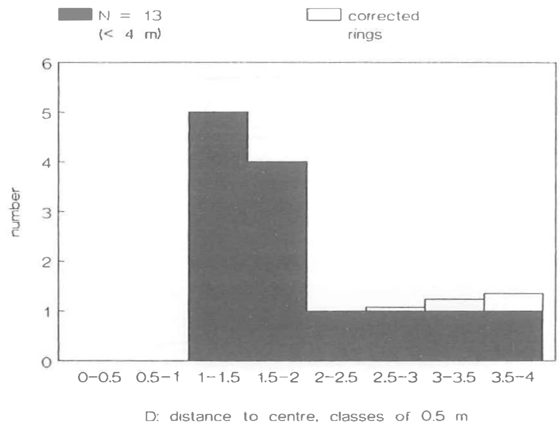

Fig. 20. Rheindahlen. Ring distribution of the tools.

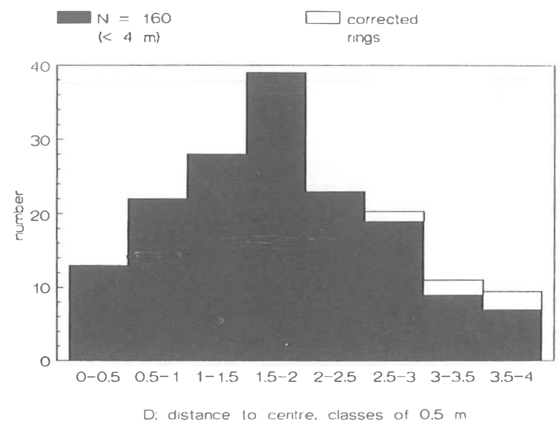

Fig. 21. Rheindahlen. Ring distribution of the flakes and blocks.

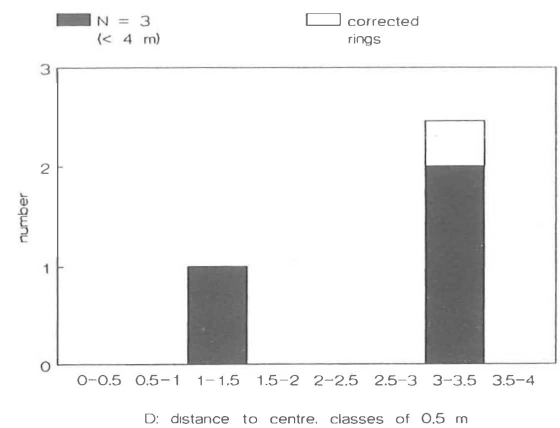

Fig. 22. Rheindahlen. Ring distribution of the cores.

conclusion must be that this concentration was created in the open air.

We will now look at the ring diagrams for three artefact groups separately: tools (fig. 20), flakes and blocks (fig. 21), and cores (fig. 22). The diagram for the tools is very clearly unimodal, and it is of interest to note that almost all tools are located within a relatively narrow zone around the 'centre': between 1 and 2 m. This must have been the distance from the 'centre' where people were mostly sitting. The diagram for the flakes and blocks shows a more normal distribution, and is also clearly unimodal. The number of cores is very small: a total of 3. This diagram is nevertheless included, because it indicates that at Rheindahlen the centrifugal effect must have been operative. If the three diagrams are compared, it can be seen that tools are, on average, located closest to the 'centre', flakes and blocks somewhat farther away, and cores still farther. This pattern, reflecting the centrifugal effect, is also found at many Upper and Late Palaeolithic sites (Stapert, 1989). The mean distance of the tools to the 'centre' is 2.02 m (Stand. Dev. 0.86), that of the cores 2.42 m. Also the only large unworked nodule was located far from the 'centre': at 3.08 m.

The artefact density map for Rheindahlen (fig. 9) is similar to the one for Belvédère, which also suggests that this concentration was produced in the open air.

As at many other sites (including Belvédère), a clear

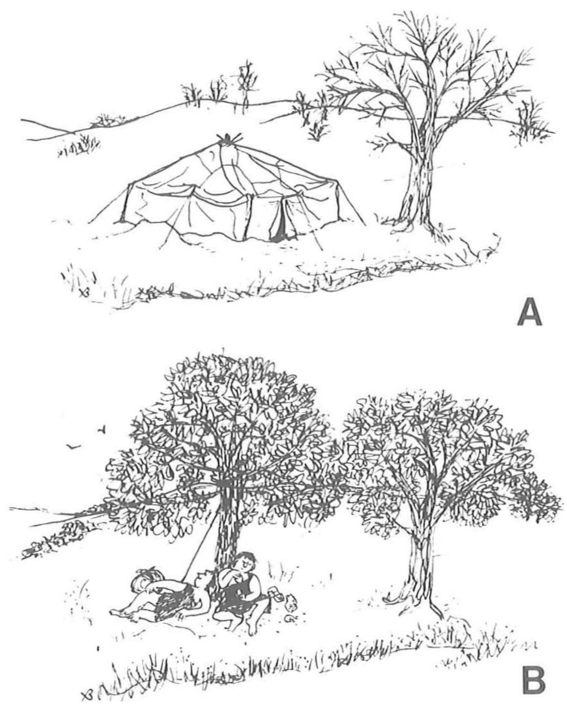

Fig. 23. Rheindahlen. Two contrasting site interpretations. A. according to Thieme (1983); B. according to the present author.

asymmetry in artefact density can be observed at Rheindahlen (see fig. 9). Within 2.5 m from the 'centre' (table 8 B), in the eastern site-half about twice as many artefacts are found as in the western half (68.6 and 31.4%, respectively). This difference is significant in a statistical sense (according to the chi-square one-sample test: p (two-tailed) < 0.001).

My conclusion is that this concentration was created in the open air. Is it possible to offer a hypothesis for the empty space in the middle of the concentration? My guess is that a tree stood here (fig. 23). This would explain why an area of about 0.5 m across remained empty. Of course, this idea cannot be proven. There are sites, however, where artefact concentrations near trees have been observed. A nice example is the ephemeral concentration at site no. 13 of Duvensee, described by Bokelmann (1986) as '*Rast unter Bäumen*'. If people were sitting under a tree at Rheindahlen, they might have used its trunk to lean against, as a windbreak (and its foliage as an umbrella). In that case the prevailing wind would have come from the west, because the eastern half of the site is the richest.

7. SOME CONCLUSIONS

Three Middle Palaeolithic sites were analysed by the ring and sector method. The main goal was to investigate whether or not dwellings were present. The background for this study is provided by the analysis of several Upper and Late Palaeolithic sites (Stapert, 1989), where it was found that ring distributions are of two types. Unimodal distributions are associated with hearths in the open air, while bimodal distributions seem to be characteristic of hearths inside dwellings.

At Buhlen (Lower Site, Layer 4) a tent ring was observed, consisting of a circle of large stones, with a hearth in the middle. It was found that the ring distribution is clearly bimodal, thus corroborating the dwelling hypothesis. No functional segmentation of the interior could be demonstrated, and it is suggested that this is caused by the absence of a strong correlation between tool type and function in the Mousterian.

At Belvédère (Site C, Southern Concentration) the presence of a central hearth is probable because of the clustered occurrence of burnt artefacts, though no charcoal was present. In this case a clearly unimodal ring distribution was obtained, indicating that the hearth was in the open air.

At Rheindahlen (*Westwand* site, '*Behausung* I') no hearth was present. In this case a dwelling structure was postulated by Thieme (1983). In the middle of the artefact concentration an empty space of about 0.5 m across was interpreted as the location of the central tent pole. This empty patch was used as the 'centre' for the ring and sector system. The obtained ring distributions, however, are clearly unimodal. Therefore, this concentration must have been created in the open air. It is suggested that the empty area in the middle was the location of a tree, under which people camped.

The density maps based on the principles outlined by Cziesla (1990) provided additional insight. It was found that in the case of Buhlen, a ring of somewhat richer squares accentuates the tent ring. In the cases of Belvédère and Rheindahlen, a gradual decrease in artefact numbers is visible, going outwards from the centre. Therefore, these density maps and the results of the ring and sector method are congruent, which is satisfying.

The results reported in this paper suggest that the ring and sector method is also useful for the analysis of Middle Palaeolithic sites. In fact, the ring diagrams presented in this paper are quite similar to the ones obtained for Upper and Late Palaeolithic or Mesolithic sites, whether unimodal or bimodal. The method seems to work well for all Stone Age periods, probably because the underlying processes (spatial behaviour in relation to a hearth, drop and toss zones, cleaning patterns) are basic, and do not vary very much between different cultural contexts.

8. ACKNOWLEDGEMENTS

Thanks are due to Miriam Weyns (B.A.I.) for drawing work. Xandra Bardet expertly corrected my English text, and made figure 23. A first draft of this paper was critically read by G.J. Boekschoten (Amsterdam), G. Bosinski (Neuwied), L. Fiedler (Marburg), W. Roebroeks (Leiden), M. Street (Neuwied), H. Thieme (Hannover) and H.T. Waterbolk (Groningen). I appreciated their comments very much, even when they heartily disagreed with me. Of course, all conclusions in this paper are my own responsibility.

9. NOTES

1. It is intriguing that, inside the structure and in its immediate surroundings, no more than 11 'tools' were present, as indicated on the map in Soffer (1989: fig. 34.9). This small number is all the more surprising because in the same area 46 cores are mapped. The mean distance between the tools and the geometrical centre of the structure is 2.21 m (Stand. Dev. 1.74); that of the cores is 3.59 m (Stand. Dev. 1.54). Therefore, the centrifugal effect seems to be strongly developed here, which at least points to an intensive occupation of the structure (see 3.2).
2. The following correction factors were applied for the ring diagrams in this paper.
   Buhlen. 2-2.5 m: 1.10, 2.5-3 m: 1.30, 3-3.5 m: 1.59, 3.5-4 m: 1.85.
   Belvédère. 1.5-2 m: 1.04, 2-2.5 m: 1.10, 2.5-3 m: 1.16, 3-3.5 m: 1.32, 3.5-4 m: 1.39.
   Rheindahlen. 2.5-3 m: 1.07, 3-3.5 m: 1.23, 3.5-4 m: 1.35.

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