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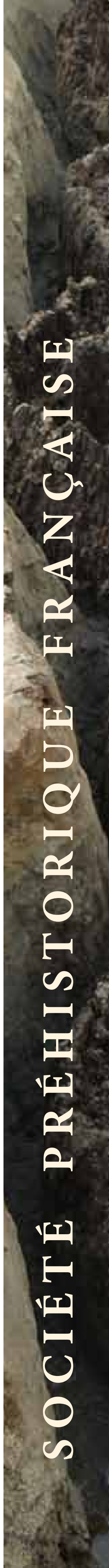

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CREUSER AU MÉSOLITHIQUE

DIGGING IN THE MESOLITHIC

ACTES DE LA SÉANCE
DE LA SOCIÉTÉ PRÉHISTORIQUE
FRANÇAISE

CHÂLONS-EN-CHAMPAGNE

29-30 MARS 2016

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Nathalie Achard-Corompt,
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Siège social : 22, rue Saint-Ambroise, 75011 Paris
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Mesolithic Pit Hearths in the Northern Netherlands

Function, Time-Depth and Behavioural Context

Hans Peeters and Marcel J. L. T. Niekus

Abstract: Pit hearth features are omnipresent on the coversand area in the Netherlands and bordering regions, especially the northern part of the Netherlands. They occur throughout the Mesolithic, between c. 9200 and 5000 cal. BC, and also in later periods, although in much smaller numbers. In this paper we briefly discuss different aspects of these features, such as shape and size, infill and contents, as well as spatio-temporal patterning, on a (sub-) regional scale and at site-level. In general, pit hearth features are filled with little more than charcoal and sand; flint and other lithics are rare, as is (charred) bone. The spatio-temporal distribution of pit hearth features is not homogeneous at a landscape level; shifting patterns can be observed over the long-term at the regional level but also on the level of the individual site. In addition, on the basis of ^{14}C dates there exist spatial configurations of statistically ‘contemporaneous’ pit hearth features. A number of possible functions, including pits for roasting, cooking and smoking food, the heating of flint and other stone, and in particular the production of tar are discussed in more detail. It is clear, however, that there is a lot to be said about ‘pit hearths’ and that, despite the vast body of data, there is still no consensus on their function or functions.

Keywords : Mesolithic, pit hearths, spatio-temporal patterning, function, behavioural context.

Les foyers en fosse mésolithiques dans le Nord des Pays-Bas : fonction, datation et approche comportementale

Résumé : Des structures creusées interprétées comme foyers-en-fosse sont omniprésentes dans les régions sableuses des Pays-Bas et régions avoisinantes, et en particulier dans le Nord des Pays-Bas. Elles sont présentes à travers quasiment tout le Mésolithique, entre 9200 et 5000 cal. BC, ainsi que pendant les périodes plus récentes pendant lesquelles elles sont cependant moins fréquentes. Dans cette contribution nous décrivons plusieurs aspects de ces structures, comme leur morphologie et dimensions, le remplissage et le contenu, ainsi que la distribution spatiale et chronologique à l’échelle régional et à l’échelle du site. Le remplissage des fosses se compose généralement de charbon et de sable ; des objets en silex ou d’autres roches sont rares, tout comme des restes osseux (brulées). La distribution spatiale et chronologique dans le paysage n’est pas homogène ; l’image est différenciée à l’échelle régionale à long terme. L’occurrence chronologique de ces structures est en outre variable. En plus, nous pouvons identifier des configurations spatiales de fosses « contemporaines » d’un point de vue statistique de datations ^{14}C. Nous discutons en plus grand détail plusieurs hypothèses concernant la fonction des foyers-en-fosse, comme la préparation de nourriture (rôtissage, cuisson, fumé), le chauffage de silex et autres roches, ainsi que la production de goudron végétal. Il est claire que beaucoup reste à dire sur les « foyers en fosse » et que, malgré le grand nombre de données, nous savons toujours peu de leur fonction ou fonctions.

Mots clés : Mésolithique, foyer en fosse, distribution spatiotemporelle, fonction, contexte comportemental.

Besides lithics, hearth features represent the most common phenomenon in the Mesolithic of the Netherlands, as well as adjacent regions within the Northwest-European plain (fig. 1). In general terms, two categories are distinguished: surface hearths, and pit hearths. Depending on the preservation conditions, surface hearths are usually associated with fragments of charred hazelnut shell, lithics (both burnt and unburnt) and fragments of bone (charred and uncharred). The second category, pit hearths which were dug into the subsoil, usually have an infill of charred plant remains (charcoal, parenchymous material) and sand. If at all present

Fig. 1 – Site locations mentioned in the text. 1: Oirschot; 2: Rotterdam-Beverwaard; 3: Hattemerbroek; 4: Dronten-N23; 5: Nieuwe-Pekela/Stadskanaal; 6: Mariënberg; 7: Epse; 8: Hoge Vaart; 9: Hardinxveld-Giessendam; 10: Oldenburg-Eversten (Germany); 11: Verrebroek (Belgium). A: Meuse; B: Rhine; C: Hunnepe Palaeoriver; D: Peat Colonies.

***Fig. 1** – Localisation des sites mentionnés dans le texte. 1 : Oirschot ; 2 : Rotterdam-Beverwaard ; 3 : Hattemerbroek ; 4 : Dronten-N23 ; 5 : Nieuwe-Pekela/Stadskanaal ; 6 : Mariënberg ; 7 : Epse ; 8 : Hoge Vaart ; 9 : Hardinxveld-Giessendam ; 10 : Oldenburg-Eversten (Allemagne) ; 11 : Verrebroek (Belgique). A : Meuse ; B : Rhin ; C : Hunnepe Palaeoriver ; D : Peat Colonies.*

there are generally few lithics or hazelnut fragments. Apart from the above few other generalisations can be made. Pit hearths do not form a homogeneous category in terms of size and content, neither are they evenly distributed geographically. Although they do occur throughout the Mesolithic, very little is known about their use, and the behavioural context within which these functioned.

In this paper we will focus on these pit hearths, and discuss in more detail the aspects of function, geographical and chronological patterning and behavioural context. We will first outline in more detail the characteristics of each of the two hearth categories, in order to define the extent of their differences. Next, we discuss various aspects concerning the pit hearths in particular: their shape, infill and contents, spatial arrangements ('configurations'), and geographical and chronological occurrence. Finally we will discuss the potential function of these features, and expand on the behavioural context. Recently, P. Crombé and coauthors (Crombé et al., 2015; see also Crombé, 2015) have questioned the anthropogenic character of 'pit hearths', and have suggested a natural origin (burnt ant nests). Although we do agree with the authors that multiple natural processes may explain the occurrence of pit (hearth) like features on (Mesolithic) sites, we feel it is not warranted to explain away all pit hearths as natural phenomena for a number of reasons. This issue will not be discussed as part of this review but addressed elsewhere.

SURFACE HEARTHS AND PIT HEARTHS (9200–5000 cal. BC)

The terminology already points to a distinction between the two hearth categories on the basis of the setting: the one refers to a fire at or near the surface, while the other refers to a fire in a dug pit. However, there are other differences which need to be addressed.

Surface hearths

Surface hearths are features where an open fire burned directly at the surface or in shallow pits or depressions (< 10 cm deep). As there was continuous oxygen supply, high temperatures (> 650°C) were easily reached. Wood from a broad range of species served as fuel, and consisted of branches and to a lesser extent tree logs; both dead and live wood were used (Van Rijn and Kooistra, 2001).

Various craft activities (e.g. flint tool production and maintenance, working of hides, bones and wood) were conducted in the direct vicinity of these hearths, as well as the consumption of food. Surface hearths probably functioned as a direct source of heat and light, and played an important role in the context of food preparation and consumption, as well as in the production and maintenance of tools, and certainly had social and likely symbolic meaning (Lavrillier, 2011).

The archaeological manifestation of these hearths consists of a rather dense concentration of charred plant material, mixed with burnt lithics and (mostly burnt) bone fragments (fig. 2). Bone remains are, however, not always found; absence of bone can be the result of bad preservation conditions, or on the other hand the lack of activity involving bone or leading to the burning of the bone. Charcoal is not always found either, probably due to post-depositional decay or possibly wind action removing charcoal particles, in which case only a cluster of burnt lithics can point to a hearth place (Sergant et al., 2006). Sometimes a zone of reddish sand is visible underneath a concentration of charred/burnt material, which results from in situ oxidation of iron due to heating (Hamburg et al., 2001; Opbroek and Hamburg, 2012).

Pit hearths

These features are related to 'closed' heating in pits, with a maximum diameter only rarely exceeding 1.5 m, and a maximum depth less than 1 m. Although high temperatures can be reached (850–900°C in experimental research; Groenendijk and Smit, 1990), it is likely that temperatures were between 200 and 500°C (Kubiak-Martens et al., 2011 and 2012). Wood served as fuel, and anthracological analysis indicates the use of a restricted number of tree species. Logs and thick branches, of both dead and live wood, were used (Van Rijn and Kooistra, 2001; Kooistra, 2011 and 2012). There are hardly any indications of craft activities such as flint working and/or food consumption in association with these features. Pit hearths might have functioned in the context of food preparation, such as the cooking of plant food or meat. Since there is evidence for the extraction of some kind of 'matter', these features might have been used for the production of charcoal or tar. Flint artefacts (often burnt) can be present within the feature, but generally in low quantities. The same holds for charred fragments of hazelnut shell and small fragments of burnt bone. In a few instances, such as at Oirschot (Arts and Hoogland, 1987) and Rotterdam-Beverwaard (Niekus et al., 2016), cremated human remains were found in or associated with features similar in appearance to pit hearths. There are a few documented cases where the infill of pit hearths contained (fragments) of perforated mace-heads or *Geröllkeulen* (Drenth and Niekus, 2009a and 2009b), in one instance associated with cremated human remains (Rotterdam-Beverwaard; Niekus et al., 2016). Other stone items, such as fragments of heated cobbles often referred to as 'cooking stones' or 'potboilers', are rare (e.g. Beuker, 1989; Devriendt, 2015).

The archaeological manifestation of this category of hearths consists of a U or bowl-shaped feature with almost exclusively rounded base. The diameter of the original pit is not always easy to determine; micromorphological analysis has shown that pits may have been wider than suggested by macroscopic assessment (Exaltus, 2001). High concentrations of charcoal are usually present in the lower part of the feature. Charcoal can be present in the form of

Fig. 2 – Cross section through a surface hearth at Hoge Vaart. The orange-brownish zone results from oxidized iron coatings due to heating. The white particles just above this zone are fragments of calcined bone and burnt flint.

***Fig. 2** – Section verticale d'un foyer de surface à Hoge Vaart. La zone orange-brunâtre est le résultat d'une oxydation du fer due à l'échauffement. Les particules blanches au-dessus de cette zone sont des fragments d'os calcinés et des silex brulés.*

large lumps of charred tree logs/branches at the bottom of the pit, and/or as smaller angular chunks mixed with sand in the basal part of the infill (fig. 3). Frequently, only a grey to blackish 'shade' without stratification is visible due to charcoal dust present in between the sand grains. Often, pit hearths only become visible at this charcoal-rich level during excavation meaning that the upper fill is often missing. Indications for in situ oxidation of iron due to heating are sporadic; micromorphological analysis has, however, revealed the presence of quartz grains cracked due to thermal shock (Exaltus, 2001).

IN SEARCH OF FUNCTION

Although pit hearths are a common feature in the Mesolithic of the Netherlands, and the northern Netherlands in particular (Groenendijk, 1987; Peeters and Niekus, 2005; Niekus, 2006), little is known about their function. Based on ethnographic information, it has been suggested that these pits were used in the preparation of food (Groenendijk, 1987), e.g. roasting of nuts (hazelnuts) and seeds (acorn), cooking of plant food (e.g. starch-rich tubers and roots) or quantities of meat, and smoking of meat or fish. Other suggested functions are the drying of hides or other non-food items, the intentional heating of flint (thermopreparation), the heating of boiling or cooking stones (Groenendijk and Smit, 1990), and the production of tar (Jansen and Peeters, 2001; Kubiak-Martens et al. 2011 and 2012). From an archaeological perspective, these possible functions appear difficult to identify. We will briefly discuss some of these issues below.

Roasting of nuts and/or seeds

As mentioned, charred fragments of hazelnut shell are occasionally found in the infill of pit hearths. In the majority of cases it concerns only a small number of fragments (< 20); frequencies above 100 fragments are exceptional (Fens, 2012; Kubiak-Martens et al., 2012). Radiocarbon dating of fragments of hazelnut shell and charcoal sampled from the very same pit tend to return diverging results, but radiocarbon dates which, from a statistical point of view, can be considered 'contemporaneous' do sometimes occur (Crombé et al., 1999; Fens, 2012; Opbroek and Hamburg, 2012). In the case of widely diverging results, hazelnut shell fragments turn out to be older than the charcoal. As the dates obtained fit dates of charred hazelnut shell sampled from earlier surface hearths at the same sites, it is likely that hazelnut shells in pit hearths are intrusive, and do not relate to the

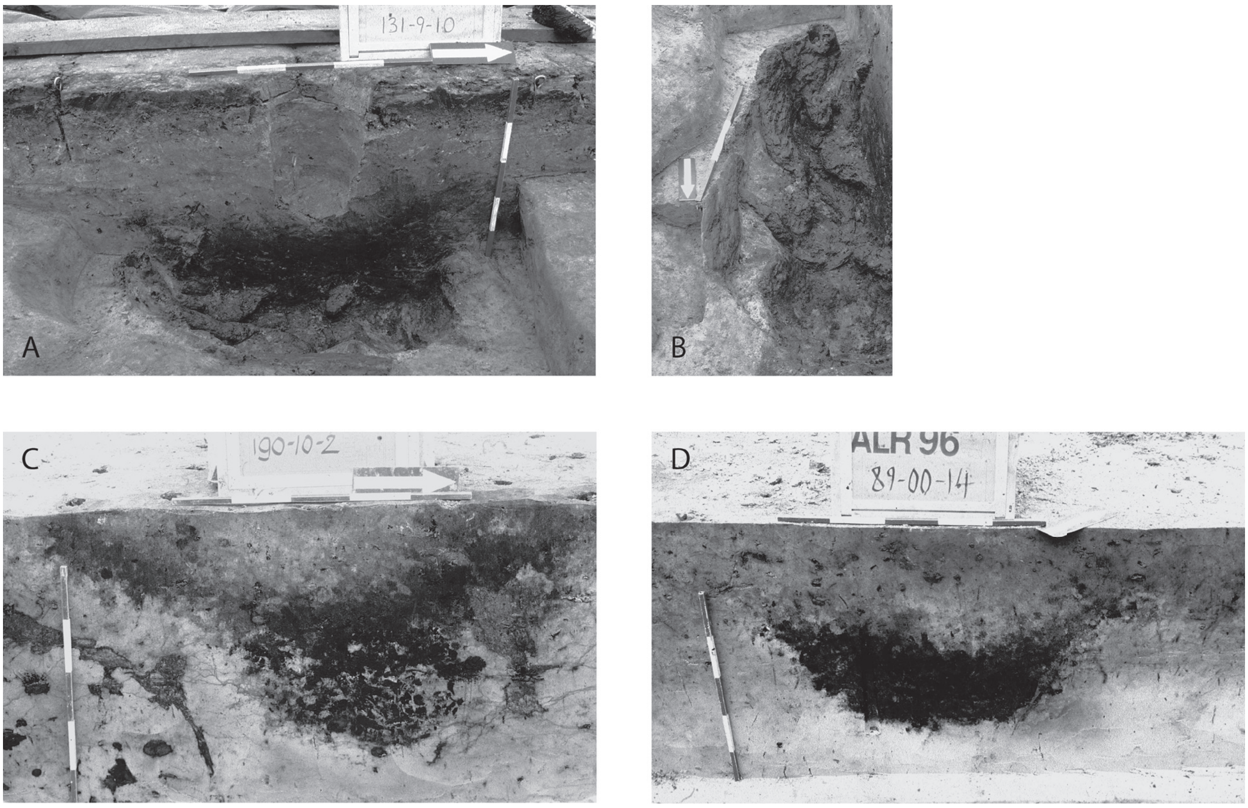

Fig. 3 – Examples of pit hearths from Hoge Vaart. A: wide and deep pit hearth with charred logs on the bottom; B: detail of the in situ charred logs; C: pit hearth with a mixture of angular charcoal and sand in the bottom part; D: pit hearth with a cluttered charcoal infill and some admixture with sand in the bottom part.

***Fig. 3** – Exemples de foyers en fosse à Hoge Vaart. A : foyer large et profond avec des bûches carbonisées au fond ; B : détail des bûches carbonisées in situ ; C : foyer avec un mélange de charbons anguleux et de sable au fond ; D : foyer avec un remplissage désordonné avec du charbon et un peu de sable au fond.*

function of these features (cf. Crombé et al., 1999; Van Strydonck and Crombé, 2005; Opbroek and Hamburg, 2012). Even if the dates are similar, a functional relation between the hazelnut shell and the pit is difficult to confirm, as a difference in age of just several years to a few decades cannot be excluded; fragments of hazelnut shell can still be intrusive.

Apart from the chronological aspect, the roasting hypothesis itself bears an intrinsic problem: the act of roasting is meant to prepare a foodstuff for delayed consumption, which requires extraction out of the pit and subsequent storage. Hence, the evidence one would hope to find would already have been removed by Mesolithic hunter-gatherers. However, some occasional finds of pits with large amounts of hazelnuts (e.g. Howick, Verrebroek) are suggested to provide evidence for roasting and/or small-scale storage (Cotton, 2007; Cunningham, 2011). Also, the regular occurrence of charred hazelnut shell fragments at Mesolithic sites demonstrates that this foodstuff was an important dietary element in the Mesolithic.

Cooking of plant food and/or meat

As is the case with the roasting hypothesis, the possibility of pit hearths having functioned as cooking pits for plant food or meat also lacks substantial archaeological evidence as support. Again, the envisaged result, cooked food, will have been removed from the pit. However, one can hope for the presence of unintended 'by-products' such as overheated (charred) food remains left in the pit, or leftovers of consumed food thrown into the pit where charring occurred. Microscopic analysis of charred vegetative (parenchymous) remains from pit hearths in the northern Netherlands has delivered some evidence for edible plants, notably horsetail *(Equisetum)*, rush *(Scirpus)*, reed mace *(Typha)* and male fern *(Dryopteris filix-mas)*, all of which possess edible roots (Perry, 1997, 1999 and 2002). Elsewhere, charred remains of goosefoot *(Chenopodium album)*, mare's-tail *(Hippuris vulgaris)*, and water lily *(Nymphaea alba)* have been identified (Visser et al., 2001; Bastiaens et al., 2005). Of course, we have to consider the possibility that these plants ended up in the pits, not as food, but as a part of the heating technology, for instance to provide a covering layer for the purpose of heat control. There is also the chance that these were collected unintentionally during the gathering of the firewood. In view of the mixed association of species from aquatic, marsh and dryland environments, these latter hypotheses do not seem very likely.

With regard to the cooking of meat, any evidence is lacking or is at best extremely sparse. Bone remains are virtually absent, and again, if meat was cooked in pit hearths it would have been removed once done. Geochemical analysis of soil and charcoal samples from one pit at Hoge Vaart returned rather high values of phosphate (P), calcium (C) and strontium (Sr), which might point to the former presence of animal matter (Jansen and Peeters, 2001). However, the interpretation of such geochemical data remains notoriously difficult.

Smoking and heating

The potential use of pit hearths for the purpose of smoking hides and/or fish is certainly one to consider, but is once again difficult to test from an archaeological perspective. The pit hearth would have functioned as a smoking device, whilst the hide or fishes were fixed on racks, which leave hardly any archaeological trace. One would need excellent preservation conditions to find evidence for this. The heating of rocks, however, would have better chances of leaving archaeological evidence.

Thermopreparation of flint, for instance, would be expected to leave occasional 'accidental' debitage due to overheating. However, in the case of the Netherlands and bordering parts of Germany and Belgium, there exists no definitive proof for thermopreparation during the Mesolithic, making this a highly improbable option (Peeters, 2001). Heating of unmodified cobbles to serve as boiling stones or potboilers is, however, not to be excluded. Fragments of cobbles of (quarzitic) sandstone broken as a result of thermal shock occur at sites where flint is also found in considerable quantities (e.g. Beuker, 1989; Devriendt, 2015). The question remains as to whether or not heating of such stones required the use of pit hearths. The scarcity of fragments in the pit hearths themselves indicates that thermal shock did not, or only rarely occur in the pits. Fragments of heat-cracked cobbles are furthermore found at sites where pit hearth features are actually absent. Interestingly, there are three known examples of perforated maceheads which showed thermal shock, and were also related to pit hearths (Drenth and Niekus, 2009a and 2009b).

Production of tar

The use of tar produced from wood (pine) and bark (birch) in the Mesolithic is evidenced by hafted lithics and lithics with tar residue (e.g. Larsson, 1983; Bokelmann, 1994), as well as through chewed lumps of tar (Aveling and Heron, 1999). This shows that tar was produced in the context of complex (i.e. composite) tool manufacture, and maybe also served medicinal purposes (Aveling and Heron, 1999; Baumgartner et al., 2012). Until recently, little was known about the production of tar without containers, such as ceramic pots or bowls. However, among the charred vegetative remains from pit hearths, 'glassy matter' and tar-like globules appeared to be frequently present, and were suggested to result from tar production (Jansen and Peeters, 2001). The possibility of tar distillation in pit hearths has been investigated further by means of SEM physicochemical analysis at several sites such as Hattemerboek (Kubiak-Martens et al., 2011) and Dronten-N23 (Kubiak-Martens et al., 2012). The glassy, highly reflective, graphite-rich and porous substance was shown to be attached to charcoal or bark, and was the result of a process of liquefaction starting in wood cells/pores (Kubiak-Martens et al., 2012). Gas Chromatography-Mass Spectrometry and Infrared Spectroscopy of samples furthermore provided evidence for phenanthrene as a biomarker for thermal degradation of pine wood through distillation (pyrolysis), and found that the carbonised tar-like substance was produced from wood/bark under relatively high temperatures (c. 400°C) and oxygen-free conditions (Kubiak-Martens et al., 2011 and 2012). If pit hearths were indeed used for tar production, which requires temperatures between 340 and 400°C, then the glassy matter is a by-product (overheated wood; temperatures between 450 and 600°C), whilst the tar globules must be considered 'leftovers', and the charcoal as remaining fuel (Kubiak-Martens et al., 2011 and 2012). However, we have to consider the possibility of unintended formation of tar under favourable conditions, e.g. during the cooking of quantities of meat. Another possibility is that tar was not the desired product, but charcoal. However, in the absence of any ethnographic evidence of charcoal production among hunter-gatherers we do not find this very likely in a Mesolithic context.

PIT HEARTHS IN SPACE AND TIME

Now that we have briefly discussed the archaeological manifestations of pit hearths in terms of the characteristics of infill and general morphology, and have explored the potential use(s) of these features, we want to address some other aspects. These concern their geographical and chronological distribution within the Netherlands on the one hand, and spatial configurations and chronology at the site level on the other.

Geographical distribution and landscape

The great majority of pit hearth features in the Netherlands are found north of the Rhine. A rough estimate is that at present approximately 3,500 have been recorded from around 175 different sites in the study area. The geographical distribution continues into adjacent parts of Germany, and whilst also present in the southern Netherlands and adjacent parts of NW Belgium (i.e. Sandy Flanders), their occurrence is less frequent here (Fries et al., 2013, fig. 7; Crombé et al., 2015, fig. 1). The question posed is whether their overwhelming presence north of the Rhine has any cultural significance. For a start, their 'absence' in the western part of the Netherlands is due to the fact that most of the Mesolithic 'landscape' is buried under meters of peat and clay. Occasional observations, such as in Rotterdam (Niekus et al., 2016), suggest that pit hearths were in fact present in this part of the country as well. Observations in the Central Netherlands' Rhine-Meuse valley are almost entirely restricted to rather small-scale excavations on aeolian river dunes; here, no pit hearths have to our knowledge been identified thus far. In the coversand region of the southern Netherlands, isolated pit hearths occur but not in clusters, as is often the case north of the Rhine.

It should be stated that this picture of pit hearth distributions is biased by research traditions, and the specific attention paid by some researchers (including the authors of this paper) to pit hearth occurrences in the northern Netherlands. As noted above, pit hearths are often only recognised when the charcoal concentrations at a deeper level in the sandy subsoil become visible. Large-scale machine stripping to detect these features seems to have been done more often in the northern Netherlands than in the south. Furthermore, large-scale landscape management projects in parts of the northern Netherlands, such as in the 'Peat Colonies' in the province of Groningen, received attention from archaeologists interested in the Mesolithic (Groenendijk, 1997), which led to the discovery of many sites and the development of a special interest in pit hearths (Groenendijk, 1987; Groenendijk and Smit, 1990) including ample radiocarbon dates.

As far as we can see from the available data, pit hearths seem to be restricted to the sandy parts of the landscape, which generally consist of an undulating Late Glacial coversand plain and aeolian river dunes within and alongside river plains. These river dunes have mainly formed during the Late Dryas, but there is mounting evidence from the Rhine-Meuse valley that river dune formation continued well into the Early Holocene (Cohen and Hijma, 2008; Hijma et al., 2009). This observation implies that the Early Holocene landscape was more dynamic at a sub-regional to local scale than has been assumed. Hence, there is a possibility that the Mesolithic use of river dunes, including the digging of pit hearths and other features, started later in some parts of the country than in others (Peeters et al., 2015). In this respect it is noteworthy to mention that pit hearths are a common feature on river dunes investigated by archaeologists in the Flevoland Polders (Peeters, 2007), whilst they seem to be rare on river dunes in the Rhine-Meuse valley. On the other hand, this by no means implies that there were no people active on the dunes in the latter area; on the contrary, lithics attest to the presence of Mesolithic hunter-gatherers in this region (Peeters et al., 2015).

The absence of pit hearths in the loess area in the south-eastern part of the Netherlands does not necessarily mean that these structures were not used. It may very well be a result of taphonomy: the Early Holocene surface of the loess landscape has suffered severe erosion. In addition, micromorphological investigations have shown that charcoal in loess deposits in this region decays under certain circumstances (Huisman et al., 2012). As a consequence, pit hearths can be invisible to the naked eye and will thus also be strongly underrepresented in radiocarbon dates. Indeed, the recent discoveries in Northern France (see papers in this volume), where loess deposits with different geochemical conditions occur, clearly demonstrate the presence of features which can be labelled as 'pit hearths'.

Long-term and (sub-) regional chronological patterning

Pit hearths occur throughout the Mesolithic in the Netherlands. The earliest radiocarbon dates (roughly between c. 9200 and 8700 cal. BC) fall within the Late Preboreal. At the Middle to Late Atlantic boundary, c. 5000 cal. BC, pit hearths more or less disappear from the archaeological record; Neolithic and Bronze Age examples are very rare. This date also corresponds with the Mesolithic- Neolithic transition, and the appearance of the earliest Swifterbant pottery in the wetlands of the western half of the Netherlands.

About 750 radiocarbon dates on charcoal sampled from pit hearths are available. When considering each date to reflect a single activity event, the frequency of events through time reveals a remarkable pattern (fig. 4). We observe a steady rise in the number of dates in the Boreal (c. 8200–7000 cal. BC) towards the Early Atlantic (c. 7000–6000 cal. BC), followed by an equally rapid decrease during the Early Atlantic. From the second half of the Early Atlantic into the first half of the Middle Atlantic the number of dates decreases further, but less dramatically compared to the previous decline. The second half of the Middle Atlantic shows a new rise in the number of dates, again followed by a decline at the Middle to Late Atlantic boundary, c. 5000 cal. BC.

This pattern of fluctuation in the numbers of dates, used here as a proxy for activity events, has been the subject of discussion for several decades. H. Waterbolk (Waterbolk, 1985 and 1999) suggested that this pattern reflects demographic shifts due to changes in vegetation: the densification of forests in the Atlantic led to a decrease of game on the higher grounds, which triggered movement of

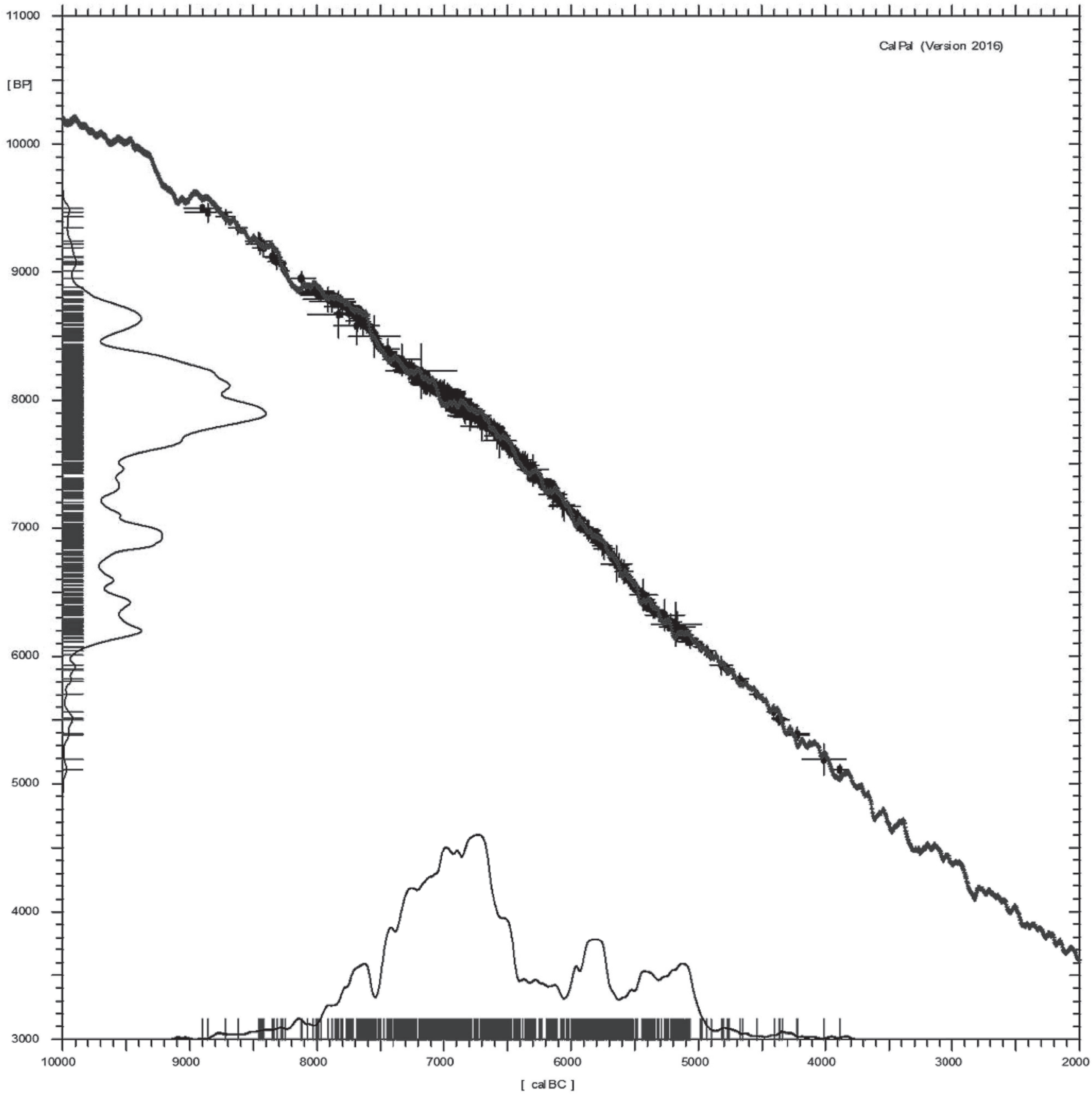

Fig. 4 – Sum probability plot (CalPal version 2016) of 756 radiocarbon dated pit hearths from the Netherlands. The dates were calibrated using the calibration curve IntCal13 (Reimer et al., 2013).

***Fig. 4** – Diagramme de la somme des probabilités (CalPal version 2016) de 756 foyers en fosse des Pays-Bas datés par [14]C. Les datations sont calibrées à l'aide de la courbe de calibration IntCal13 (Reimer* et al.*, 2013)..*

hunter-gatherer populations towards the lower grounds, characterised by more open wetland environments. However, although the dates reflect hunter-gatherer presence, one cannot equate this presence with population density (Peeters, 2007). Rather the dated 'events' correspond to particular activities (Peeters, 2009).

It is nonetheless possible that climatic factors are involved: the drop in the number of dates coincides with the 8.2 Ka Event (Peeters, 2007 and 2009; Crombé, 2015), triggered by the catastrophic drainage of Lake Agassiz (Canada). This drainage event is known to have triggered a sea-level jump of 1.5–2 m in the southern North Sea (Hijma and Cohen, 2010), on top of structural relative sea-level rise in the order of 2 m a century. In addition, at about the same time, the Storegga tsunami impacted upon the coasts of the southern North Sea (Weninger et al., 2008), to variable degrees (Hijma and Cohen, 2011). Typically, the archaeological record from the Central Netherlands' Rhine-Meuse valley shows a gap of c. 200 years around this series of events when considering the published radiocarbon dates (Peeters et al., 2015).

How, and to what extent environmental factors might have influenced aspects of hunter-gatherer behaviour in connection to pit hearths, is still an open question. Lumping all radiocarbon dates into a single explanatory framework is without doubt too simplistic. For a start, it may be instructive to break down the dataset according to smaller (geographical) units (see e.g. Peeters and Niekus, 2005, fig. 20), preferably defined by drainage systems. Sea-level rise, climate and differences in sub- regional conditions will have resulted in variable landscape dynamics, which in turn might have led to variable and changing patterns of behaviour at that scale.

As an example, the archaeological record from the upper 'Hunnepe drainage system' (a prehistoric system which no longer exists) demonstrates hunter-gatherer activity which involves manufacture and use of flint tools during the Preboreal and Boreal, i.e. Early and Middle Mesolithic. The use of pit hearths starts at the Boreal to Early Atlantic boundary and continues to the Middle to Late Atlantic boundary. Hence, pit hearths are of Late Mesolithic age, but hardly any lithics from this period are known from the upper part of the Hunnepe system (Hermsen et al., 2015; here: fig. 5). In contrast, Late Mesolithic flint is well represented in the lower part of the system, as well as pit hearths. The radiocarbon dates show a trend where the earlier dates are found in the upper part of the Hunnepe system, and the younger ones in the lower part of the system (Peeters et al., in prep.).

The 'Peat Colonies', which are for the most part situated in the province of Groningen, may serve as a second example of a regional perspective on hunter-gatherer behaviour. From this vast coversand area, which is characterised by a rather uniform geomorphology, hundreds of pit hearths have been excavated over the years and dozens were radiocarbon dated (Groenendijk, 1987 and 2004; Niekus, 2006). As with the upper 'Hunnepe drainage system' mentioned above, there is ample evidence in dated pit hearths as well as lithic scatters and surface hearths for Early and Middle Mesolithic activity, but there is hardly any evidence for the presence of Late Mesolithic hunter-gatherers. The earliest pit hearths date to the late Preboreal and the use of this type of hearth in this region continues until halfway through the early Atlantic, c. 6500 cal. BC, after which there is a clear decline in the number of dates. So far there are no pit hearths dated after c. 6200 cal. BC from the area, but only from the stream valleys along the edges of the Peat Colonies. The same goes for Late Mesolithic flint artefacts. Hence, spatial and chronological patterns of differentiation occur at a (sub-) regional scale. More systematic analysis of the data from a regional perspective may provide further insight into the interpretation of patterns discussed above.

Intra-site spatial and chronological patterning

Sites with pit hearths show considerable variation, not only in respect of the number of features and the temporal patterning, but also in the intra-site spatial distribution of the pits. The number of features per site ranges from only one specimen to extensive distributions consisting of hundreds of pit hearths (fig. 6). Well-known examples of these extensive site-complexes are Nieuwe Pekela 3 (Groenendijk, 2004), Mariënberg (Verlinde and Newell, 2006), the earlier mentioned sites Hattemerbroek and Dronten-N23, and further to the east the German site of Oldenburg-Eversten (Fries et al., 2013). As discussed in more detail elsewhere (Niekus, 2006, section 7 and fig. 35) there is considerable variation in the temporal distribution of radiocarbon dates. Some sites show a wide range of dates (Early-Late Mesolithic), without any marked temporal clustering, while others are clustered within in a relatively short time span, often during the Late Mesolithic. Even within sites there might exist a spatio-temporal dimension. For example, at the site Stadskanaal 1, which is situated on the western part of the same coversand ridge as Nieuwe Pekela 3, pit hearth dates are on average older than those from Nieuwe Pekela 3 suggesting a spatial shift in the use of pit hearths. At the site Epse differences in temporal patterning between the northern and southern part of a coversand ridge have also been observed (Hermsen and Van der Wal, 2015).

Features are not distributed uniformly over these sites and considerable differences in pit hearth density have been observed. Based on a study of excavation-plans in combination with extensive radiocarbon dating, several types of recurring spatial arrangements ('configurations') of pit hearths were identified (fig. 7). The following configurations were observed (Niekus, 2011 and in prep.): isolated pits, pairs/double pits, triangular arrangements, quadrangular and polygonal arrangements, (curvi-)linear configurations, and clusters (small and large). Radiocarbon dating suggests that a temporal dimension is present. Some types of configurations occur throughout the Mesolithic while others, especially relatively dense clusters, only occur in the archaeological record from the Late Boreal/

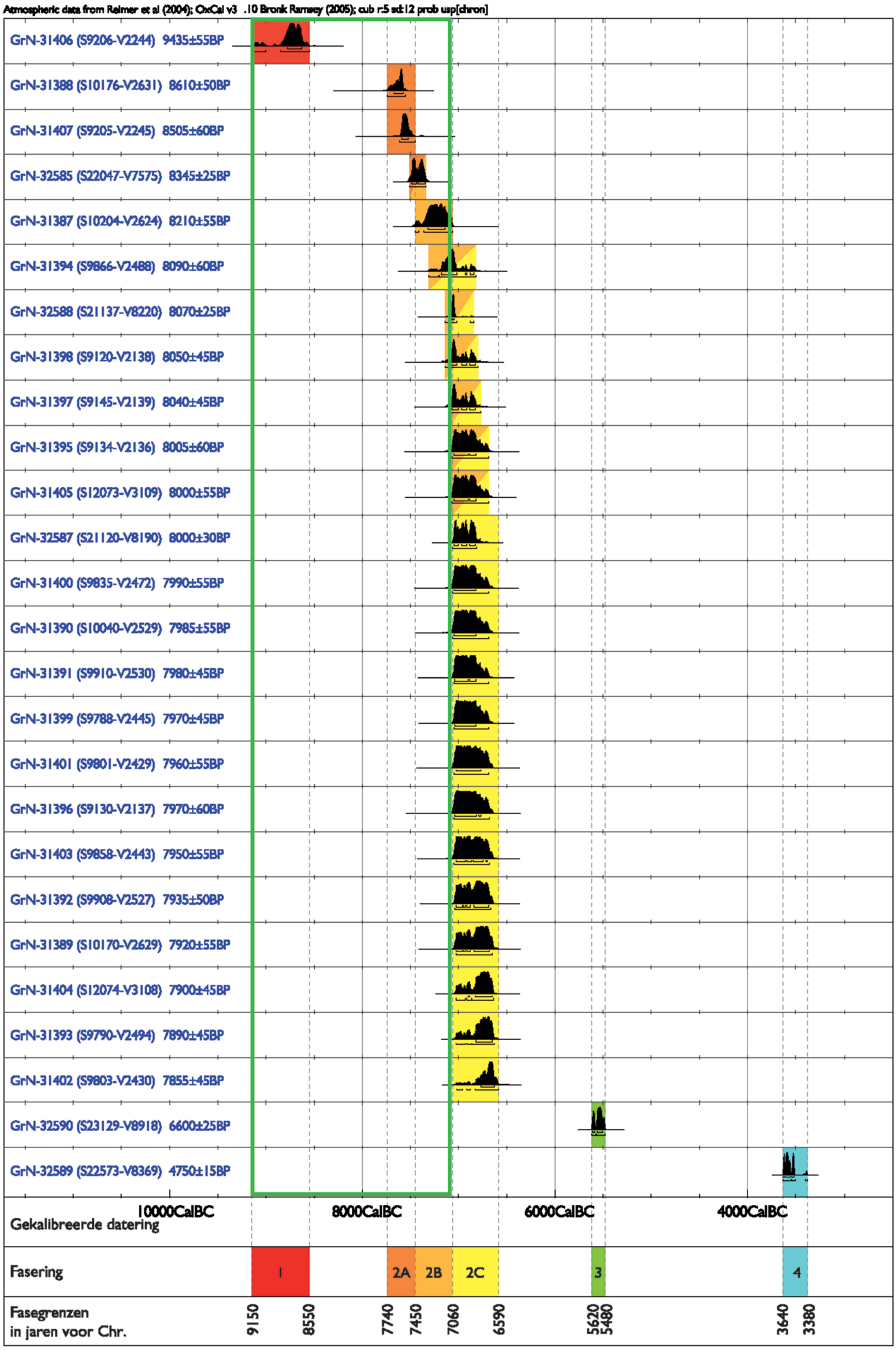

Fig. 5 – Calibrated dates of pit hearths from the site of Epse. Based on typological and technological characteristics, the Mesolithic lithic assemblages (indicated by the green frame) from this site principally predate the 2C pit hearth phase (adapted from Hermsen et al., 2015).

***Fig. 5** – Datations calibrées de foyers en fosse du site d'Epse. À partir des caractéristiques typo- et technologiques, il est possible de dater les industries lithiques mésolithiques (indiqué par le cadre vert) du site avant la phase 2C des foyers en fosse (modifié d'après Hermsen et al., 2015).*

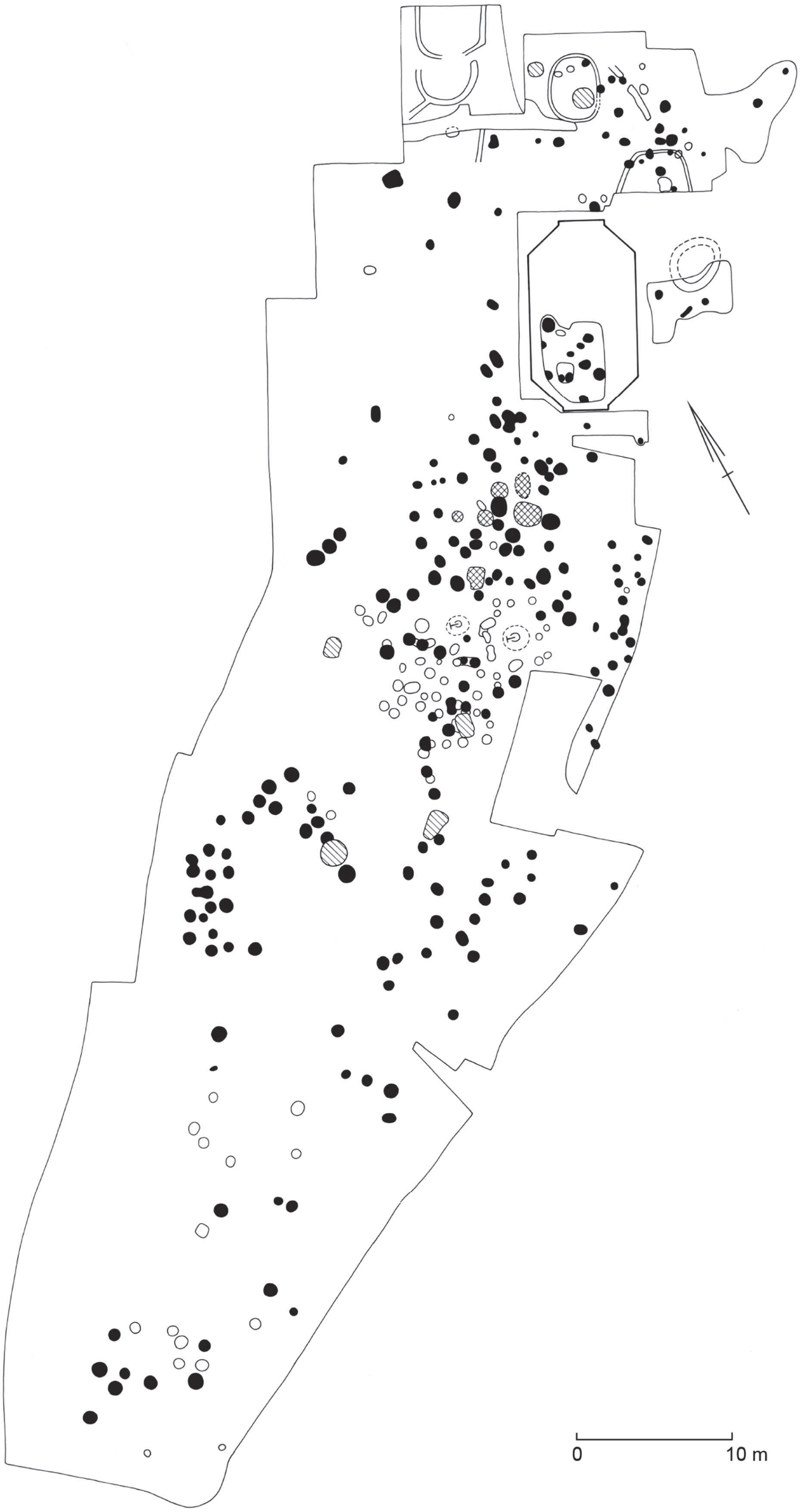

Fig. 6 – The Mariënberg-Schaapskooi site, example of a site with hundreds of pit hearth features and several Late Mesolithic graves. Black: Mesolithic pit hearths; cross-hatched: Mesolithic grave pits; hatched: Neolithic graves; open: post-Mesolithic features, scale 1:400 (after Verlinde and Newell, 2006).

Fig. 6 – *Le site de Mariënberg-Schaapskooi, exemple d'un site avec des centaines de foyers en fosse et quelques fosses de sépulture du Mésolithique Final. En noir : foyer en fosse mésolithique ; hachures : fosse de sépulture mésolithique ; hachures croisées : fosse de sépulture néolithique ; pointillé : trace post-mésolithique, échelle 1/400 (d'après Verlinde et Newell, 2006).*

Early Atlantic onwards, i.e. the later part of the Middle Mesolithic and the beginning of the Late Mesolithic.

PIT HEARTHS AND CERAMICS

As pointed out above, pit hearths seem to 'disappear' from the archaeological record around the Mesolithic-Neolithic boundary, which for the Netherlands is set at 5000/4900 cal. BC by convention (Louwe Kooijmans et al., 2005). Whilst the LBK arrived several centuries earlier in the south-eastern part of the Netherlands, the earliest pottery (assigned to the Swifterbant Culture) appeared at this time in the western part of the country, where the landscape was dominated by wetland environments. This Early Swifterbant pottery is known from sites like Hardinxveld-Giessendam 'Polderweg' and Hardinxveld-Giessendam 'De Bruin' in the Rhine-Meuse valley (Louwe Kooijmans, 2001a, 2001b and 2010), and Hoge Vaart in the Flevoland Polders (Peeters, 2007 and 2010). In connection to the disappearance of pit hearths, the latter site provides some interesting information.

Prior to 5000 cal. BC, Mesolithic activity at this location (a coversand ridge stretching into an extended back-barrier swamp) involved the use of pit hearths. Due to structural sea-level rise, the area became increasingly wet. Between 5000 and 4900 cal. BC the site was temporarily inundated due to increased dynamics in an adjacent freshwater tidal gully, which led to some erosion. Shortly after this 'event', people returned to this place where they undertook activities in a completely different behavioural context. These people were still hunter-gatherers, but pit hearths were no longer used; instead we see the use of surface hearths in association with flint tool manufacture and use, as well as food consumption. In consideration of the narrow range of flint tools (trapeze-shaped points; scrapers used for the working of fresh hides; simple blades used for plant processing), it seems likely that visits were of relatively short duration. Activities also involved the use of T-shaped perforated antler adzes, and on the spot production (and subsequent abandonment) of ceramic vessels, among others. According to the radiocarbon dates, these kinds of activities continued for over 300 calendar years, and came to an end by 4550 cal. BC when paludification of the sand ridge was complete.

The relatively abrupt change of the Mesolithic and Neolithic phases of activity at Hoge Vaart came with the disappearance of pit hearths, and the appearance of ceramic vessels. The thick-walled vessels made at this location were generally of poor fabric; rare thin-walled vessels were of better fabric and possibly produced elsewhere instead of locally (Peeters, 2010). The evidence for pottery production on this very location is quite strong: lumps of knead clay, crushed quartz for tempering, and imprints of reed mats which probably served as working floors (Peeters, 2007, 2010). Vessels fired at low temperatures collapsed on the spot after abandonment. Apparently, pottery production was aimed at short-term use, perhaps for the cooking of foodstuffs. Some other observations suggest they were containers for tar, especially the presence of 'glassy matter' (see section 3.4) on the inner wall of some pottery sherds (Jansen and Peeters, 2001).

FINAL CONSIDERATIONS AND CONCLUSIONS

This consideration of pit hearths in the Mesolithic of the Netherlands maybe raises more questions than it answers. Indeed, there are still many unknowns, despite the fact that these features, of which there are thousands, have been studied by archaeologists for decades. The unknowns are the most obvious when it comes to the functional interpretation of pit hearths. Indeed, there exist multiple possibilities, most of which cannot be excluded based on archaeological observations. Neither can we rule out the possibility that the function of pit hearths changes through time. The question of whether there is any direct relationship between the disappearance of pit hearths and appearance of ceramics at the Mesolithic to Neolithic boundary is equally difficult to answer. Nonetheless, it cannot be ruled out, and leaves us room for at least two hypotheses.

In a first scenario, food preparation stands central: the shift from the use of pit hearths to the use of pottery connects to a rather abrupt change of cooking tradition. If this has been the case, does this mean that changes occurred in, for instance the social role of cooking? In a second scenario, tar production is at the forefront: the shift from the use of pit hearths to the use of pottery connects to a rather abrupt change of technology. In this case, it can be hypothesised that a decrease of primary resources (e.g. pine wood) for tar distillation has led to technological innovation. Such innovation may have invoked other ways of tar production, or the replacement of tar for particular purposes with another raw material. Any of the scenarios, and possibly there are more, connects the use of pit hearths and ceramic vessels to a shared objective, notably the transformation of one or more materials into a new material: wood and bark into tar, clay and temper into pottery, plant material and/or meat into cooked food. Hence, from such a perspective, pit hearths and ceramics fit into a technology of transformation.

Of course, as always, a word of caution is needed. It is certainly not necessary that pottery is functionally equivalent to pit hearths. Indeed, we have pointed out that within the broad category of 'pit hearths' variability exists in terms of size and contents. Further analysis is needed to define this variability in more detail, as to provide a basis for functional interpretation. And indeed, there is no reason to assume that early ceramic vessels all were produced for the same purpose. In-depth isotopic and lipid analysis of crusts attached to pottery sherds will help to shed light on this topic (compare Raemaekers et al. 2013).

To conclude, we hope to have shown that the phenomenon of pit hearths in the Mesolithic is open to a

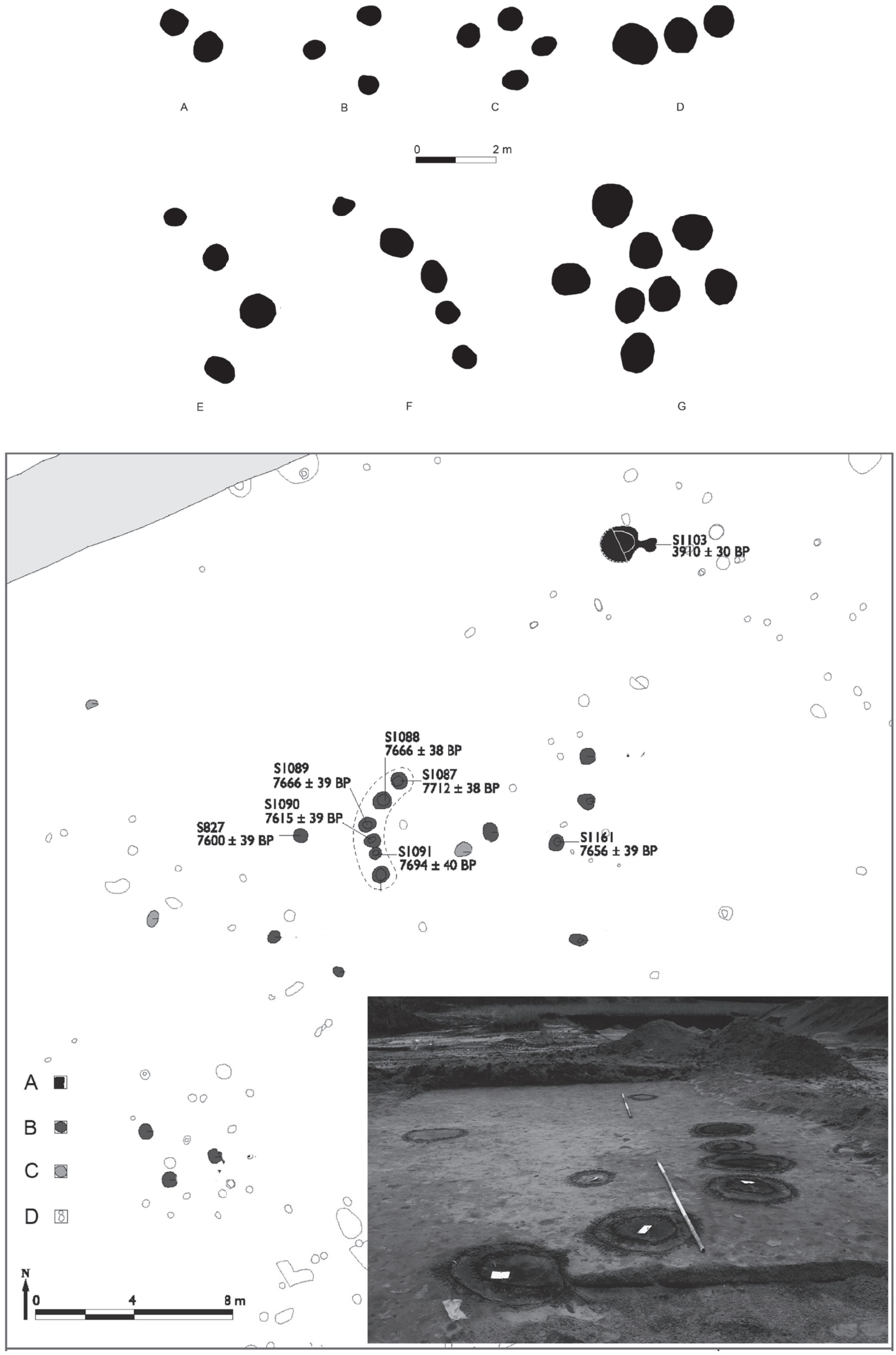

Fig. 7 – Top: Example of pit hearth configurations from the northern Netherlands. A: double pits/pair; B: triangular configuration; C: quadrangular configuration; D: (short) linear configuration; E-F: (curvi)linear configurations; G: small cluster (≤ 10 pits). Drawing E. Bolhuis, RUG/GIA, from Niekus 2011 and, in prep. Bottom: A curvilinear pit hearth configuration with corresponding ^{14}C dates at Epse. A: Late Neolithic pit hearth; B: Mesolithic pit hearth; C: possible Mesolithic pit hearth; D: other feature (after Hermsen et al., 2015).

***Fig.** 7 – En haut : exemples de configurations de foyers en fosse du Nord des Pays-Bas. A : double foyer ; B : configuration triangulaire ; C : configuration quadrangulaire ; D : (courte) configuration linéaire ; E-F : configurations curvilinéaires ; G : petit groupement (≤ 10 foyers). Dessin E. Bolhuis (RUG/GIA), d'après Niekus, 2001 et en prép. En bas : Une configuration curvilinéaire avec des datations radiocarbone à Epse. A : foyer en fosse néolithique ; B : foyer en fosse mésolithique ; C : éventuel foyer en fosse mésolithique ; D : autres structures (d'après Hermsen et al., 2015).*

broad range of research questions that are worth pursuing, as the answers provide important insights into particular aspects of hunter-gatherer behaviour. Detailed analysis of charred plant remains from pit hearths informs us about potential function, but also about environment.

Geochemical, micromorphological and physicochemical analysis also provide information about possible functions. And systematic radiocarbon dating allows analysis of spatial and chronological patterns, at intra-site level and at the scale of the landscape. Although we have already built a substantive record for the Netherlands, there is still a lot to learn.

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Hans Peeters
Groningen Institute of Archaeology
Poststraat 6, NL-9712 ER Groningen
j.h.m.peeters@rug.nl

Marcel J. L. T. Niekus
Stichting STONE / Foundation for Stone Age research in the Netherlands
c/o Lopendediep 28, NL-9712 NW Groningen
marcelniekus@gmail.com