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SPATIAL VARIATIONS IN THE PRESERVATION OF LATE NEOLITHIC AND BRONZE AGE BARROWS IN THE LOW COUNTRIES EXPLAINED BY DIFFERENCES IN SOIL FORMATION, DEGRADATION PROCESSES AND LAND USE HISTORY

Few elements in the present-day landscape of the Low Countries remind of late prehistory. Barrows are the most notable exception. A few thousand barrows in parts of Belgium and the Netherlands have survived until the present day (**fig. 1**; e.g. Lohof 1991; Theunissen 1999; De Reu 2012; Bourgeois 2013). They occur in small clusters or more diffuse patterns, sometimes spread over vast areas forming true »barrow landscapes«. These burial monuments, however, only represent a small percentage of those once present. Also, their preservation rate displays significant regional differences. In some parts large concentrations of barrows are known. This goes for the Campine region of northern Belgium and the southern Netherlands, as well as for parts of the central, eastern and northern Netherlands. In the sandy lowlands of northwestern Belgium (»Sandy Flanders«) and parts of northwestern France (Agache 1978) on the other hand, virtually all barrows have been erased from the landscape. In Sandy Flanders alone approx. 1100 levelled barrows were detected by aerial photography (De Reu 2012). That preservation conditions of barrows (and other site

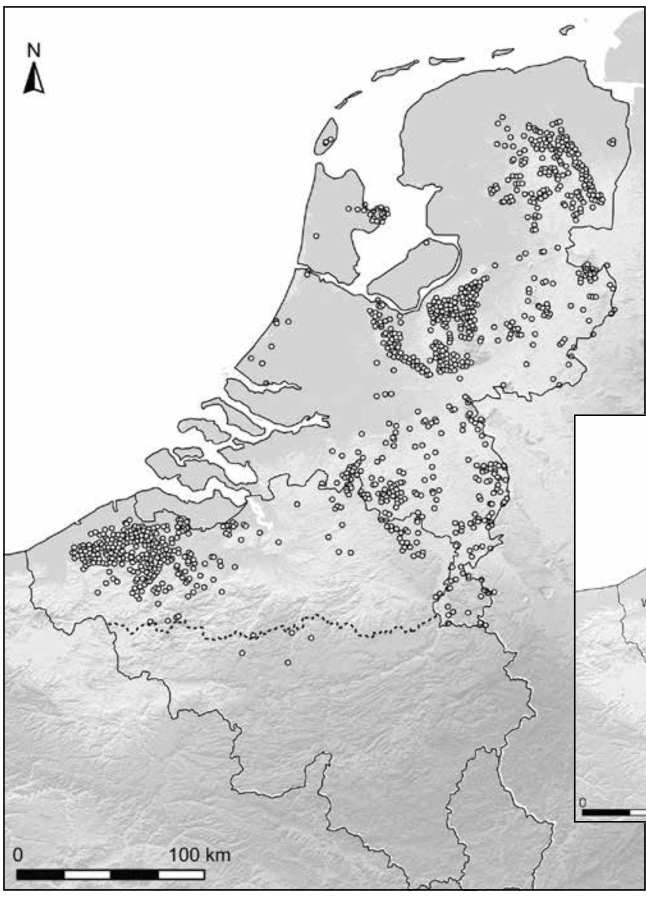

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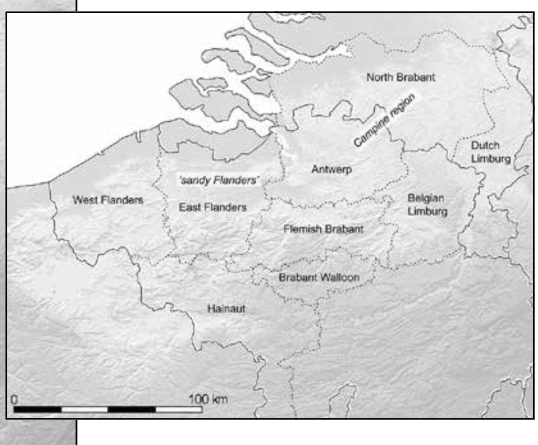
Fig. 1 **A** recorded barrows (○) dating between the Late Neolithic and the Middle Bronze Age in the Low Countries. Sites in Germany, France and the southern part of Belgium (below the dotted line, except for a few sites in northern Hainaut) are unmapped (distribution based on Bourgeois 2013, 6 fig. 1, 4; De Reu 2012; Vergauwe 2012). – **B** geographical position of the Dutch and Belgian provinces within the pilot area. The only province not fully incorporated in this study is Hainaut (just sites in the northern part of this province are discussed).



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types) are spatially different is a well-known fact in other parts of Europe (e. g. Denmark: Kristiansen 1985; England: Peters 1999). However, systematic in-depth studies on this topic – especially those addressing various spatial scales – are rare. This paper aims to determine which parameters influenced the preservation of barrows on a long-time scale and at multiple spatial scales, which regional differences are present and how these were caused.

As stressed in the key publication by M. Schiffer (1987), the archaeological record is influenced by many factors, both anthropogenic and natural, that worked on various scale levels. Research into formation processes of barrows in Northwestern Europe generally focuses on two separate scale levels: 1. the individual monument and 2. the barrow landscape. Examples of the former are more numerous and for example include studies seeking to explain the exceptional preservation conditions in a small number of Danish barrows (e. g. Holst/Breuning-Madsen/Rasmussen 2001). In the Low Countries, podzolisation in barrows has been an important research theme (e. g. van Giffen 1941; Scheys 1963; Waterbolk 1964). The formation history of barrow landscapes only gained attention in the last decades. These studies take into account processes like erosion and sedimentation, land use history, reclamation and urbanisation, and combine them with research factors (Denmark: Baudou 1985; Kristiansen 1985; Low Countries: Theunissen 1999, 49-54; Bourgeois 2013, 39-48). Even though processes affecting single monuments and barrow landscapes often are interrelated, they rarely are integrated in single studies. Multi-scale interdisciplinary geoarchaeological research has been gaining attention in the last decades (e. g. Kooistra/Kooistra 2003; Walkington 2010), but has not been applied to barrow datasets yet.

To answer our research questions we use archaeological, pedological and historical data obtained through a detailed literature survey. First the archaeological context is outlined and a general classification is given of processes that may have influenced barrow preservation in the Low Countries. Then we zoom in on the pilot area of our study: the central and northern part of Belgium and the southern part of the Netherlands. A series of excavated (and published) clusters of barrows is selected that shed light on soil formation processes and landscape evolution. At four additional locations small-scale prospective research (coring) was carried out. The selected monuments all originate from the period between the Late Neolithic and the Middle Bronze Age (c. 2900-1100 cal BC; dates for chronological phases in this paper are taken from Theunissen 1999, 54). Some sites have been used for burial in younger phases as well. For each location a distinction is made between three scale levels: 1. the individual barrow, 2. the site (often comprising a cluster of monuments) and 3. the microregional setting. Both site selection and definition of these scale levels are addressed in more detail below.

The analysis leads to the description of three regional clusters characterised by different trends in soil formation, degradation processes and land use history. The described trends in these regions should be seen as first »sketches«, that offer an explanation for the surprisingly large regional differences that are present. They do not allow an exact quantification of the importance of each process, or of the exact number of barrows that were once present in any given area. However, they may serve as starting points for future modelling in that direction. Also, the methodology used in this paper can be extrapolated to other regions.

BARROWS IN THE LOW COUNTRIES

The sandy landscapes of the northeastern, central and southern Netherlands and the northern part of Belgium were formed mainly as a result of the combined activity of wind, water and ice during the Saalian and Weichselian ice ages (**fig. 2**). In the south the cover sand landscape is bordered by an east-west oriented zone of sandy loams, roughly found in central Belgium, and further south by thicker loess deposits extending to northern France (e.g. Paepe/Vanhoorne 1967; Lebret/Lautridou 1991). In these sandy and loamy regions most late prehistoric barrows come to light. Far smaller numbers are known from regions covered by Holocene sediments, such as the central Dutch river area and the western coastal zones of the Netherlands and Belgium.

The research history of barrows in the Low Countries is regionally diverse. In most regions where burial monuments were still visible in the vast heathlands dominating the early modern landscape, they attracted attention from the 18th and 19th century onwards. This is the case for the Dutch sandy landscapes and parts of the Belgian provinces of Antwerp and Limburg. These regions witnessed a gradual professionalisation of barrow archaeology in the late 19th and early 20th century (e.g. Theunissen 1999, 42-46). After c. 1960 the intensity of Dutch barrow research decreased drastically. Most monuments became legally protected, and technical improvements (e.g. the dragline) opened new paths towards large-scale settlement excavations. Research into the burial mounds of West and East Flanders, on the other hand, only started three decades ago. Since the early 1980s more than 1100 circular monuments (Ampe et al. 1996; De Reu 2012, 68) were detected by intensive aerial photographic research. All of these have been levelled and are only recognisable by soil and crop marks left by their surrounding features, generally ring ditches (De Reu 2012). Various excavations have proven that these circular monuments represent the remains of prehistoric barrows.

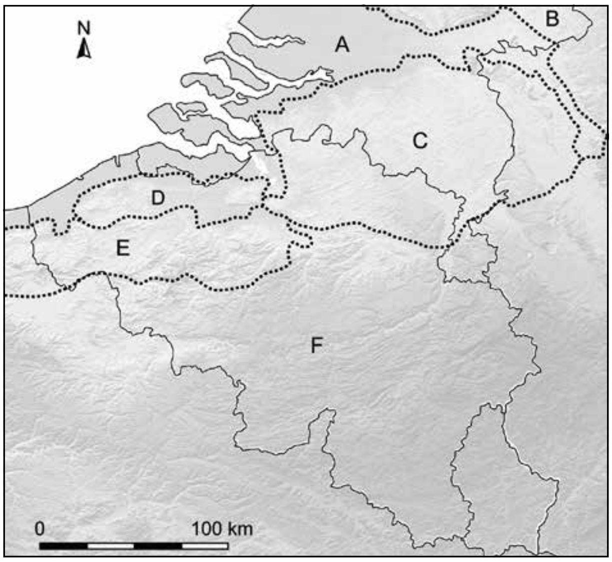


Fig. 2 Simplified map of the main physical geographical regions within and adjacent to the pilot area: **A** »Holocene« coastal regions of the western Netherlands and Belgium, and central Dutch river area. – **B** cover sand region of the central and eastern Netherlands. – **C** cover sand region of the southern Netherlands and northern Belgium. – **D** cover sand region of northwestern Belgium. – **E** loamy and silty »transitional zone« between cover sand and loess regions. – **F** loess region. – (After De Reu 2012, 28 fig. 1, 1; map »Landscapes of northwestern Europe« by the Rijksdienst voor het Cultureel Erfgoed [2011]).

The oldest burial mounds in the Low Countries date from the first part of the Late Neolithic (c. 2900-2450 cal BC) and are ascribed to the Single Grave culture (e.g. Bourgeois 2013, 31). Most are situated in the northern and central Netherlands. They are rare in the southern Netherlands and unknown in Belgium. Barrows dated to the second part of the Late Neolithic (c. 2450-2000 cal BC) have a wider distribution. Judging from ^{14}C dates the erection of burial mounds in West and East Flanders started approximately around 2300 cal BC (De Reu 2012, 205). In the Early (2000-1800 cal BC) and Middle Bronze Age (1800-1050 cal BC) barrows were erected throughout the Low Countries. Recent Dutch research has demonstrated that both the intensity of barrow erection and the reuse of existing barrows fluctuated significantly and was spatially diverse (Bourgeois 2013, 36-38). Therefore (and because of differential survival rates; see below) it is difficult to assess how many primary barrows were erected in each phase (but see Bourgeois 2013, 31 f. and De Reu 2012, 86-90 for some chronological trends).

In regions with favourable preservation conditions, barrows can be spread over vast areas. Within these »barrow landscapes« often small clusters of monuments occur. These are generally situated at elevations such as sandy ridges, and often display linear alignments of small numbers of mounds.

The appearance of barrows differs in time and place. A detailed discussion is beyond the scope of this paper, but some general trends can be outlined. Between the Late Neolithic and the Middle Bronze Age different types of barrow surrounding features occur. According to the most recent study for the Netherlands (Bourgeois 2013, 30-38), palisaded ditches and beehive graves (small burial chambers lined with wickerwork or palisaded walls) characterise Late Neolithic barrows. No »typical« peripheral structures can be ascribed to the Early Bronze Age. Primary barrows dated to that phase are very rare. In the Middle Bronze Age new types emerge, most notably barrows with banks, ditches and post circles. These types correspond well with Belgian finds, except for the provinces of West and East Flanders. Here a distinction is made between single, double and multiple ring ditches (Ampe et al. 1996, 65; De Reu 2012, 94-99). About 85 % of all monuments possess a single ring ditch. Double (10 %) and multiple ring ditches (5 %) are far less common. This uniform picture might be biased by the poor preservation conditions of barrows and the applied detection techniques. Ditched barrows are easier to spot from the air than palisaded or featureless ones. On the other hand, this regional Belgian typology displays striking similarities with the northern French Somme valley and the Kent region of southeast England (e. g. De Reu 2012, 204; Bourgeois/Talon 2009; Perkins 2010). Also, more than 40 excavations in West and East Flanders during which about 70 barrows were investigated (De Reu 2012, 73-85) have not altered the image fundamentally yet. The find of palisaded barrows at a small number of sites is the most notable exception (De Reu 2012).

SOIL FORMATION PROCESSES

From the moment they were erected barrows were subject to various post-depositional processes. The current preservation state of late prehistoric burial mounds is the result of processes spanning a period of between three and five millennia, depending on their age. In the next section an overview will be given of those factors that may have influenced the preservation of barrows in the Low Countries. A distinction is made between 1. turbation, 2. migration and accumulation and 3. erosion and sedimentation.

Turbation

The category of turbation includes all factors that lead to mechanical soil mixture. For this study bioturbation is the most important process. Other processes, such as cryoturbation (deformation by cyclical freezing and thawing), argilloturbation (deformation by swelling-shrinkage cycles caused by wet-dry cycles) and seismoturbation (mass movement by seismic activity) are not likely to have been of major impact on barrows. Bioturbation can be subdivided in faunaturbation, floraturbation and anthropogenic turbation (cf. Walkington 2010, 126-128). The effects of faunaturbation (disturbances caused by animal activity) are variable for each species (Hole 1981). Small burrowing mammals that spend part of their life underground cause the most damage (Gibson 1998, 22). These are foxes, badgers, rabbits and moles, and to a lesser extent (due to their size) rats, hamsters and voles. Badgers, for example, prefer to dig burrows in the slopes of loamy and well-drained hummocks (Dunwell/Trout 1999, 1-3). Worms also have a significant impact on soil formation. Over time their activity results in homogenisation of sediment and the formation of soil macropores, which in turn attract root growth (Canti 2003, 136). Floraturbation (the impact of vegetation on the soil) also occurs in various forms (Schaetzl et al. 1989), such as plant and tree rooting and windthrows or treefalls. The development of root systems depends on subsoil and vegetation type (van Breemen 1998). Treefalls can cause considerable damage. The sediment volumes affected by tree root disruption can amount to several cubic metres. In excavations these disturbances generally surface as ellipses or half circles with a length and width varying between 2-5 and 5-10 m. Their average depth varies from 0.8 to 1.5 m (Ulanova 2000, 161; Langohr 1993, 43). Anthropogenic turbation includes all forms of soil mixture and disturbances caused by direct human activity. Various examples can be given, such as sand extraction or reclamations for agricultural purposes.

Migration and accumulation

Migration and accumulation processes lead to (mainly vertical) transport of soil constituents. The mechanisms regulating this process are related to water flow in the soil system. Specific soil constituents dissolve in water and are moved. Others (colloids) disperse under specific conditions and can be transported as well. Both matter in solution and dispersed matter are leached from the topsoil, leaving an eluvial horizon, and accumulate in the subsoil, producing an illuvial horizon. As these processes take time, the occurrence of eluvial and illuvial horizons indicates more or less stable conditions for prolonged periods. Northwestern Europe witnessed a precipitation surplus during most of the Holocene (e. g. Bohncke 1991). Under these conditions three migration-accumulation processes are important: decalcification, clay migration and podzolisation.

Decalcification is the removal of calcium carbonates from the soil by dissolution processes. The Weichselian loess and cover sands in Northwestern Europe contained calcite when deposited, and are at present decalcified in the upper 2-5 m. Simulation studies show (Finke / Hutson 2008, 474) that around 3000 BC, decalcification was already deeper than 1.5 m in loess and even deeper in cover sand, under normal drainage conditions and in absence of erosion. It is therefore probable that topsoil material used to construct barrows was already decalcified and that the magnitude of decalcification cannot be used as an indicator of undisturbed conditions.

Clay migration is the process in which clay particles are transported from topsoil layers to subsoil layers. The resulting soil type is called Luvisol (IUSS Working Group WRB 2006). Near the (bare) soil surface, splash erosion detaches clay particles, making them available for transport (Jarvis / Villholth / Ulén 1999). In the topsoil, at low cation concentrations, clay can enter a dispersed state and be transported with flowing water. Deeper in the soil, where cation concentrations are higher, clay particles may leave the dispersed state and flocculate (Goldberg / Forster 1990) or be filtered out of the flowing soil water by smaller soil pores. As a consequence, clay accumulates. In loess, containing initially about 10 % clay, clay migration is likely to occur because the clay minerals are highly vulnerable to dispersion. Dispersion is less likely when loess is still calcareous or so strongly leached that it is very acidic and aluminium and iron cations dominate the soil solution (van Breemen / Buurman 2002). Simulations (Finke 2012) show that a well-developed Luvisol can form in a few millennia. In cover sand, the clay content is low and only thin bands of illuviated clay (*lamellae*) can develop. In loess, clay accumulation can be substantial, leading to thick accumulation horizons. It depends on the barrow construction material whether a Luvisol can develop in monuments in loess regions. In cases where construction material was collected from topsoils, its clay content would already be low at the construction time and later clay migration would be negligible. In that case it would not be possible to judge barrow stability by the clay migration process.

Podzolisation is one of the most important soil formation processes in the Low Countries. The term »podzol« refers to the presence of a greyish-white layer underneath the biologically active layer. Podzolisation is characterised by transport of organic matter, which occurs at very low concentrations of cations in the soil solution (e. g. Buurman / Jongmans 2005). This corresponds to a leached acid environment which develops in parent materials poor in weatherable minerals. Cover sands contain (after decalcification) mainly quartz and likely will produce podzols when the silt content is low. In soils containing soluble iron, podzolisation is conditional on the preceding leaching of iron. As a result, podzols only occur in sandy soils. In regions where loamy soils are predominant, they do not develop. Vegetation types that are typically associated with

Fig. 3 This cross section of the barrow »Partisaensberg« near Kasterlee (prov. Antwerpen/B), in the Campine region, displays clear podzol profiles both below and at the surface of the barrow, which is built up of heath sods. – (Photo R. Langohr, Vakgroep Geologie en Bodemwetenschappen, Universiteit Gent).

podzolisation are heather and coniferous forest (van Breemen/Buurman 2002). Heather vegetation develops as a result of deforestation, followed by prolonged grazing and sod cutting in the absence of fertilisation, and thus generally is caused by human activity. These activities induce a depleted soil with only shallow bioturbation as heather has a shallow rooting system. As a result, podzols develop more rapidly than under natural conditions (Spek 2004, 119-121). The eluvial horizon is vulnerable to wind erosion when the protective humus layer is lost as a result of sod cutting and overgrazing. The organic matter can illuviate below the biologically active zone and take the form of complexes of organic matter, aluminium and iron. In the accumulation horizon, two types of organic matter are often distinguishable: 1. soft black organic matter consisting of excretions of soil mesofauna, indicating biological activity, and 2. firm brownish organic matter consisting of illuviation coatings (De Coninck 1980). Although the exact speed is a subject of discussion and depends on local circumstances, a well-developed podzol takes centuries to millennia to form. Complete podzols developed in barrows (**fig. 3**) therefore indicate a relatively undisturbed environment. Podzolisation in barrows may occur faster and more pronouncedly when the brought-up material is already strongly leached (e. g. sods cut on heath fields).

In past research, podzolisation phenomena have been used as chronological proxies. A. E. van Giffen (1941) noticed that podzolisation effects are present in the old surface underneath some barrows, whereas they lack underneath others. He linked these differences to stages of landscape development, and especially deforestation followed by heath expansion. He dated barrows with podzol profiles to the Bronze Age, and monuments lacking these characteristics to the Late Neolithic. This model was nuanced by G. Scheys (1963), who studied the development of soil profiles underneath barrows in the Belgian Campine region. He argued that a gradual evolution in soil formation took place. As a result various transitional forms between »forest podzols« and »heath podzols« are encountered, influenced by sediment properties, subsoil, hydrology and human interference. Importantly, G. Scheys stated that soil profiles could change after the erection of a barrow (Scheys 1963, 226). H. T. Waterbolk rejected the stability of buried soils as well, noticing that pedological processes in mound bodies could affect their original character (Waterbolk 1964, 100). Complete mound bodies of Bronze Age barrows could become leached, leading to an enrichment and enhancement of the original soil. He called this process secondary podzolisation (*Sekundärpodzolierung*). Characteristic elements evidencing this process are greyish sods in the centre of the barrow and a pale E-horizon combined with a clearly defined B-horizon in the original soil profile. Podzolisation phenomena around postholes and burial pits (called »mini-podzols«) and the branching out of leaching horizons at the foot of a mound also result from secondary podzolisation (Waterbolk 1964, 98; cf. Modderman 1975, 15. 19).

Erosion and sedimentation

Erosion and sedimentation can be caused by natural factors, human activity or a combination of both. The intensity and scale of wind erosion or deflation are dependent on climate, geology and vegetation. In Belgium the volumes of wind eroded sediment currently vary between less than 1 and over 20 t per hectare per year (Verstraeten et al. 2006, 402). Mainly due to differences in land use, wind erosion has a far larger impact in the sandy regions of the southern Netherlands and northern Belgium than in the loamy regions of central Belgium, even though the latter in fact are more sensitive to erosion.

Whereas wind erosion predominantly occurs in sandy regions, water erosion mainly influences loamy and clayey soils (Langohr 1990, 211). The cover sand landscapes of the Low Countries hardly possess pronounced elevation differences and their sediments are less vulnerable to water transport than the finer silt and clay fractions found in loamy regions (Verstraeten et al. 2006, 389 f.). This difference is expressed in Belgian estimates of sediment volumes annually moved per hectare by water erosion. In the sandy landscapes of northern Belgium these vary between 0.1 and 0.4 t, whereas in the loamy landscapes of central Belgium they exceed 10 t (Gillijns et al. 2005, 19). Water erosion occurs in various forms, such as splash, sheet, rill and gully erosion (Hillel 1998, 435-437). Its character and intensity are influenced by geology, relief, vegetation and precipitation.

Numerous studies in regions across Europe demonstrate that human land use, erosion and sedimentation are interrelated, and that their effects were substantial from the Neolithic onwards (e. g. Vannière et al. 2003; Zolitschka / Behre / Schneider 2003; Dotterweich et al. 2012). Especially in areas with favourable habitation conditions, intensive deforestations took place. Woodland loss led to hydrological changes and soil degradation (e. g. Spek 2004, 116-119). This in turn caused erosion, especially in regions with large elevation differences. From the Late Medieval period onwards large drift sand areas developed in parts of the Low Countries (e. g. the central Dutch Veluwe region: Koster 1978). Sand drifts occurred in earlier phases as well, especially in intensively inhabited regions along rivers (e. g. van Beek 2009, 499-503).

Another important factor is modern land use (Van Oost et al. 2006). Tillage erosion results from agricultural activities such as ploughing. With the rise of mechanical agriculture since the 1950s large soil volumes can be worked. This can trigger or accelerate erosion, especially in sloping regions. Sediment loss is largely dependent on local topography and land use. Estimates for the Belgian loamy regions are between 8 and 9 t per hectare per year (Verstraeten et al. 2006, 400). A local form of erosion due to recreation activities occurs at footpaths and tracks, e. g. by the use of quad vehicles.

PILOT STUDY: CENTRAL AND NORTHERN BELGIUM AND THE SOUTHERN NETHERLANDS

The processes discussed above have not taken place in every barrow in the Low Countries. Each barrow has its own history of soil formation and degradation processes. This is not to say they occurred randomly. By analysing as many barrows as possible, it can be determined which processes were most current and which diachronological and spatial trends are present. The pilot area chosen to address these questions consists of the central and northern part of Belgium and the southern part of the Netherlands (**figs 1. 4**). It comprises the Dutch provinces of North Brabant and Limburg and the Belgian provinces of West and East Flanders, Antwerp, Limburg, Flemish and Walloon Brabant and the northern part of Hainaut. This pilot area is chosen because regional differences occur in the preservation of barrows and various excavation reports of (clusters of) monuments are available. Also, the main outlines of land use history are known or can be reconstructed by historical maps, especially with regard to the period from the Late Middle Ages onwards. Palynological data are outside the scope of this paper. Even though palynological analyses of barrows can shed light on land use history (e. g. Casparie / Groenman-van Waateringe 1980), they are only available for a very small and spatially biased number of monuments in the research area.

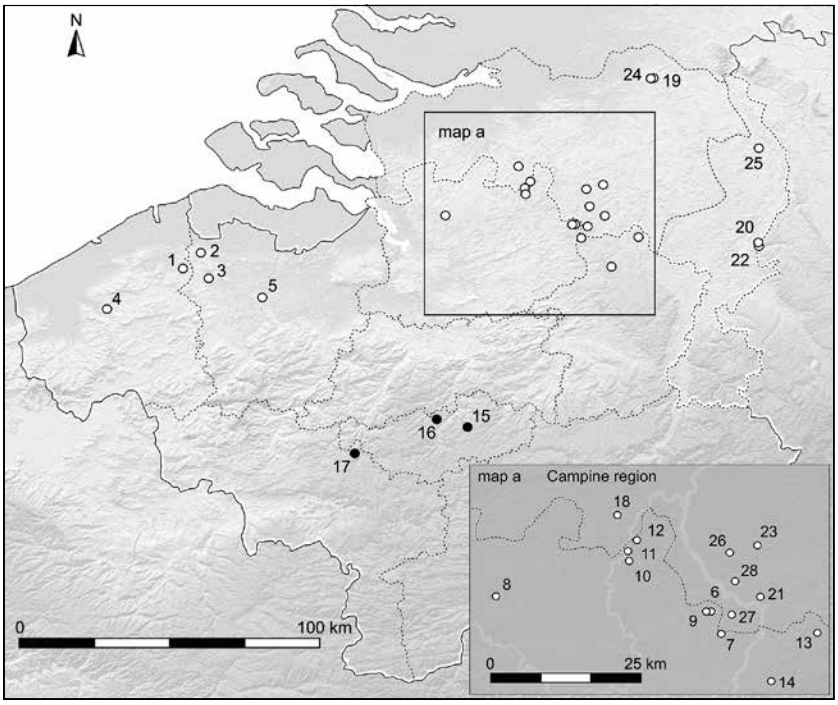


Fig. 4 Inventoried sites within the pilot area: ○ published sites with relevant information on formation processes; ● sites with small-scale prospections done by the current authors. – **1** Oedelem-Wulfsberge. – **2** Maldegem-Vliegplein. – **3** Ursel-Rozestraat. – **4** Kortemark-Koutermolenstraat. – **5** Gent-Hoge Weg. – **6** Mol-Grenspaal 194. – **7** Postel-Berg in 't Perk. – **8** Brecht-Hoge Heide. – **9** Postel-Bladelstukken. – **10** Weelde-Groenendaelsche Hoef. – **11** Weelde-Hogereindsche Bergen. – **12** Weelde-Vlasroot. – **13** Hamont-Haaterheide. – **14** Eksel-De Winner. – **15** Rixensart-Bois de Limal. – **16** Bonlez-Bois de Bonlez. – **17** Braine-le-Comte/Ronquières-Bois de la Houssières. – **18** Alphen-Kwaalburg. – **19** Oss-Zevenbergen. – **20** Swalmen-Hoogterras. – **21** Bergeijk-Hoge Berkt. – **22** Swalmen-Bosheide. – **23** Veldhoven-Toterfout-Halve Mijl. – **24** Oss-Vorstengrafdonk. – **25** Meerlo-Meerlose Postbaan. – **26** Hoogeloon-Smousenberg. – **27** Bergeijk-Witrijk. – **28** Bergeijk-Eerselse Dijk. – (Map R. Vergauwe / R. van Beek).

The currently known burial monuments mainly cluster in two large regions: West and East Flanders, where, as mentioned, no mound bodies have survived, and the Campine region of the southern Netherlands and northeastern Belgium (**figs 4. 7**). The distribution pattern is far less dense in other parts of the pilot area. There are no reasons to assume that these patterns reflect differences in late prehistoric habitation (e. g. the presence of different cultural groups). Excavation data are our most important information source. The selection of sites valuable to our study is determined by the quality and detail level of published barrow excavations. Publications are relatively numerous, but pedological descriptions are often undetailed or even lacking. An extensive literature survey and critical assessment have led to a selection of 24 sites (**fig. 4**), varying from single barrows to larger clusters of up to 30 monuments (Toterfout-Halve Mijl, prov. Noord-Brabant/NL; Glasbergen 1954a; 1954b). Additional prospective field research was done at four sites (see below). In total the 24 sites retrieved from literature comprise exactly 100 monuments providing relevant information. Obviously they represent only a small percentage of all barrows once present in this large region. Also, their distribution pattern is spatially biased. No less than 19 sites (in total 87 barrows) are situated in the Campine region. This dominance results from the region's long tradition of barrow research. The other five sites (13 barrows) are located in West and East Flanders and represent excavations of barrows discovered by aerial photography.

No high quality excavation data are available for the central part of Belgium. In order to be able to incorporate the central Belgian loess region in this study, the authors did prospective research by coring at three sites (7 barrows). These sites are situated in the northern part of the provinces of Walloon Brabant (Bonlez and Rixensart) and Hainaut (Ronquières). This allows a first preliminary comparison with other parts of the pilot area. Similar small-scale fieldwork was done at a single barrow in the Campine region (Brecht, prov. Antwerpen/B), which was under threat of future spatial planning. Concluding, our database consists of 108 barrows distributed over 28 sites. All locations date from the period between the Late Neolithic and the Middle Bronze Age (2900-1050 cal BC); for more precise dates for each site we refer to the primary excavation reports.

Tab. 1 Schematic overview of formation processes documented in individual barrows in the pilot area. Due to the levelling of all barrows in West and East Flanders, the exact importance of most processes cannot be established here (»no data«). On the other hand, the absence of evidence for certain processes in central Belgium (»not observed«) does not necessarily mean they did not occur.

Recognized processes in barrows			REGION: Campine region Belgium/Netherlands 20 sites, N = 88	Loess belt Central Belgium 3 sites, N = 7	West & East Flanders Northwest Belgium 5 sites, N = 13
SOIL FORMATION PROCESSES	**Turbation**	fauna	badgers (2) rabbits (10)	*not observed*	badgers (3)
		flora	rooting (5)	*not observed*	*no data*
		anthropogenic	'barrow diggers' (19) poachers (3) World War II (5) reclamation (7)	*not observed*	World War I (1) completely levelled (13)
	Migration/ accumulation	secondary podzolisation	(2)	*not observed*	*no data*
		'mini podzols'	(9)	*not observed*	*no data*
		'pseudo ring ditch effect'	(9)	*not observed*	*no data*
		redox reactions	Fe-precipitation (5)	Mn-precipitation (1)	*no data*
	Erosion/ sedimentation	processes under influence of water and gravity	sheet erosion/colluviation (5)	gully erosion (1) sheet erosion/colluviation (4)	*no data*
		aeolian processes	deflation (3) driftsand deposition (13)	driftsand deposition (1)	driftsand deposition (1)
		erosion caused by human activity	tillage erosion (33) collapse edges ring ditches (1)	*not observed*	*no data*
	Unknown cause	human origin (?)	'truncation' of mound body (7)	*not observed*	*no data*

The analysis focuses on three scale levels. The first level is the barrow. Here, the processes that affected individual monuments are analysed. The second level is the »site«. With this term we refer to the immediate environment of a barrow or cluster of barrows, within a distance of a few hundred metres. The third analytic level is the microregional setting. The studied microregions have a radius of roughly a few kilometres. It will be demonstrated below that the available archaeological data almost exclusively shed light on processes occurring in individual barrows. For the second and third level we are mainly dependent on physical geographical and historical geographical informations.

PROCESSES IN INDIVIDUAL BARROWS

The formation processes encountered in individual barrows are listed in **table 1**, which follows the categories described above. Three large regions are distinguished: the Campine region, West and East Flanders and the central Belgian provinces of Walloon Brabant and Hainaut. As discussed above, the former two are »sandy« regions and the latter is part of the loess belt (**figs 1-2. 7**). The division is based on the present-day distribution pattern of barrows and their research history, as well as the soil formation history of barrows. It will be maintained in the next sections.

Table 1 is biased by differences in research history and quality of documentation. As mentioned most information by far is available for the Campine region. The quality of the data varies considerably, both for sites and individual monuments. Information on individual barrows in other parts of the pilot area is limited. The destruction of all barrows in West and East Flanders (we will get back to the timing and character of that process below) means that no mound bodies are available for study, and formation processes working at that level cannot be recognised. The remains of these barrows do allow some relevant observations, however. The scarcity of information on barrows in central Belgium is caused by their small number and low research intensity.

Despite these limitations **table 1** shows informative general trends. Turbation processes are recognised in the Campine region and West and East Flanders. Badger burrows occur in both regions. No less than 3 out of 13 barrows in the latter area were damaged by these animals. Rabbit tunnels are documented in ten barrows in the Campine region. In some publications the effects of rooting and treefalls are described. Treefalls, documented in three barrows, are all found underneath these monuments, however. This means they are not post-depositional and predate the erection of these monuments. Both faunaturbation and floraturbation probably occur far more frequently than the present data suggest. These phenomena are often left undiscussed in reports and cannot always be derived from the excavation drawings. More information is available on anthropogenic turbation. In the Campine region at least 19 barrows were damaged by people digging for antiquities (»barrow diggers«), seven by (heath) reclamation, five by activities during World War II and three by poachers. We choose to classify the levelling of all barrows in West and East Flanders as a form of anthropogenic turbation as well, even though it actually concerns removal rather than mixture of sediment.

The documented processes of migration and accumulation consist of different forms of podzolisation. These are found in 23 barrows in the Campine region, more than a quarter of all inventoried monuments from this area. »Mini-podzols« have been documented in nine barrows. In two of these monuments and seven others a »pseudo ringditch« had developed. This term, introduced by J. N. Lanting and J. D. van der Waals (1974, 55) refers to an enhanced development of the B-horizon around a barrow, appearing as a circle. This phenomenon is related to organic material washing away from the mound body and accumulating at its foot. Specific forms of redox reactions, such as precipitation of iron hydroxides, have been recorded in five barrows. These phenomena are probably linked to podzolisation as well. Podzolisation did not occur in central Belgium, due to the high silt content of the parent material, whereas data for West and East Flanders are lacking.

The encountered erosion and sedimentation phenomena are mainly linked to aeolian activity. At 13 barrows in the Campine region and one in central Belgium drift sand sediments occur at the northeastern slope. Their position indicates the prevalence of southwestern winds. These sediments are not dated precisely. Most of them may date from the late or post-Medieval period, when sand drifts occurred frequently in the Low Countries. An older origin cannot be excluded. Three barrows in the Campine region show evidence of deflation. This process is equally difficult to date. Five out of seven barrows in central Belgium are affected by water erosion, whereas this did not occur in the Campine region. This regional variety originates from differences in soil texture (sandy versus loamy) and relief.

No less than 33 out of 88 barrows in the Campine region are affected by tillage erosion, mainly evidenced by the presence of plough soils. These phenomena indicate a large-scale impact of human land use. Seven monuments in this region are described as »truncated« barrows (e.g. Swalmen-Hoogterras, prov. Limburg/NL; Lanting/van der Waals 1974). The tops of these mounds are flattened and have lost their original soil profile. How this happened is yet unclear. Tillage seems an inadequate explanation, as only the tops of the monuments are affected.

PROCESSES ON A SITE LEVEL

Hardly any information is available on a site level, as most excavations and publications mainly focus on individual barrows. The genesis of barrow clusters in the Low Countries is only a relatively recent research topic, both with regard to use history and soil formation processes (e.g. Theunissen 1999, 49-54; De Reu 2012; Bourgeois 2013). A notable exception is the interdisciplinary analysis of a barrow cluster at the site of Oss-Zevenbergen (prov. Noord-Brabant/NL). Here, physical geographical research offered detailed insights into landscape processes such as erosion, drift sand deposition, podzolisation and human land use, as well as their effects on the archaeological remains (Fokkens/Jansen/van Wijk 2009, 35-52). At some sites information can be derived from comparing formation processes documented in different monuments within the same barrow cluster. Most monuments at the sites of Toterfout-Halve Mijl (Campine region), Oss-Zevenbergen and Swalmen-Bosheide (just north and east of the Campine region, respectively) have suffered from tillage erosion, suggesting that human land use affected these entire barrow clusters. Our own observations in Bonlez, Ronquières and Rixensart indicated the presence of clay illuviation horizons underneath all barrows, whereas most of the loess in their immediate vicinity was eroded and tertiary deposits were close to the surface. This probably points to accelerated erosion due to agriculture.

PROCESSES ON A MICROREGIONAL LEVEL

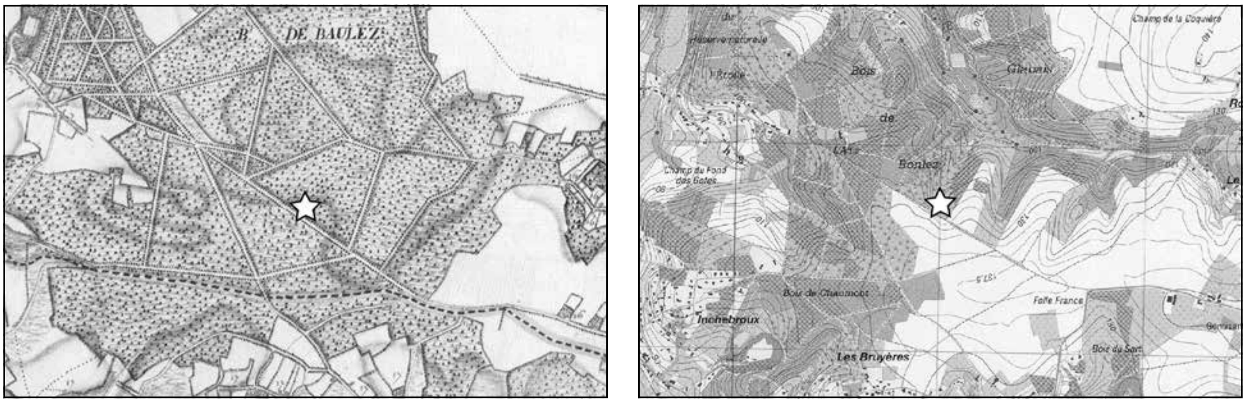
In excavation reports attention is given only rarely to landscape processes in the wider environment of sites. Nevertheless, this scale level is essential in reconstructing changes in land use history and their effect on the preservation of barrows. Therefore, the microregional landscape evolution of each site was reconstructed by means of series of historical maps. The oldest historical cartographical series covering Belgium integrally was drawn by Joseph de Ferraris between 1771 and 1778. In the southern Netherlands the oldest cadastral maps date from the early 19th century. For some microregions older cartographic documents are available, but to be able to compare sites the above-mentioned Ferraris maps were used as a starting point. These are compared to younger plans of the same areas. The recognised trends are interpreted by consulting additional literature. In this way a general image emerges of the landscape history during at least the last two centuries – and often longer back (Vergauwe 2012). The analysis results in three regional »scenarios« with regard to land use history, in which all sites can be placed. Spatially these regions again correspond to the tripartite regional division made above.

The heathlands in the cover sands of the Campine region

The environments of the sites in the Campine region, generally situated at sandy ridges, have all witnessed a roughly similar development in the last centuries. Typical are the vast heathlands that, according to the oldest maps, were still largely intact at the end of the 18th century. From that moment onwards a significant shift in land use and landscape organisation occurred. Large tracts of heathland vanished as a result of reclamation of wastelands into arable, meadows and forest. The introduction of mechanical agriculture since World War II significantly accelerated the transformation of these regions. The large majority of barrows that survived until the present day were located in heathlands at larger distances from settlements (cf. Bourgeois 2013, 44f.). These were reclaimed at a relatively late stage, from the late 19th century onwards, when archaeological interest in these monuments was established. The same trend has been documented in Denmark (Baudou 1985; Kristiansen 1985). Barrows situated in the infields of settlements probably disappeared at earlier stages, mainly from the Late Medieval period onwards when large agricultural complexes (open fields) developed in parts of the Campine region (see below).

The loess belt in central Belgium: »stable« environments in old forests

The small number of inventoried sites in central Belgium are found on silt loam soils, within forests that already existed in the late 18th century (**fig. 5**). In the last two centuries the morphology and use of these



a b

Fig. 5 The landscape in the vicinity of the central Belgian barrow site of Bonlez (prov. Brabant wallon/B), indicated with a star, as depicted on the Ferraris map of 1771-1778 (**a**) and a modern topographic map (**b**). The depicted area measures approx. 3 km × 2 km. – (After Ferraris map 1771-1778, map section 113, Jodoignes; Topographic Map of Belgium 1999, map section 40/1-2, Wavre-Chaumont-Gistoux).

a b

Fig. 6 The landscape in the vicinity of the western Belgian barrow site of Kortemark-Koutermolenstraat (prov. West-Vlaanderen/B), indicated with a star, as depicted on the Ferraris map of 1771-1778 (**a**) and a modern topographic map (**b**). The depicted area measures approx. 3 km × 2 km. The site location on the Ferraris map is an approximation, as this section of the map is difficult to georeference. – (After Ferraris map 1771-1778, map section 25, Oedelem; Topographic Map of Belgium 2004, map section 17/7-8, Knesselare-Zomergem).

forests do not appear to have changed very much, even though some of them became somewhat smaller as a result of reclamations. The forests indicated on the Ferraris map are well-developed, indicating that their origins predate the late 18th century. The position of the remaining barrows, within spatially low-dynamic forested environments, must have been key to their survival. This does not imply that no formation processes took place. Most sites in this region are situated near margins of plateaus (probably for visibility reasons) and their environments have suffered from erosion (see above). Strong correlations between late prehistoric and early historic land use, agricultural intensity, erosion and sedimentation have recently been documented in various other loess regions, for example in Germany (Kadereit/Kühn/Wagner 2010), Poland (Dotterweich et al. 2012) and the Czech Republic (Zádorová et al. 2013).

The fragmented cultural landscape of West and East Flanders

At the late 18th century the landscape of West and East Flanders had already been heavily modified and structured by man (**fig. 6**). The Ferraris map demonstrates that virtually all zones between hamlets, villages

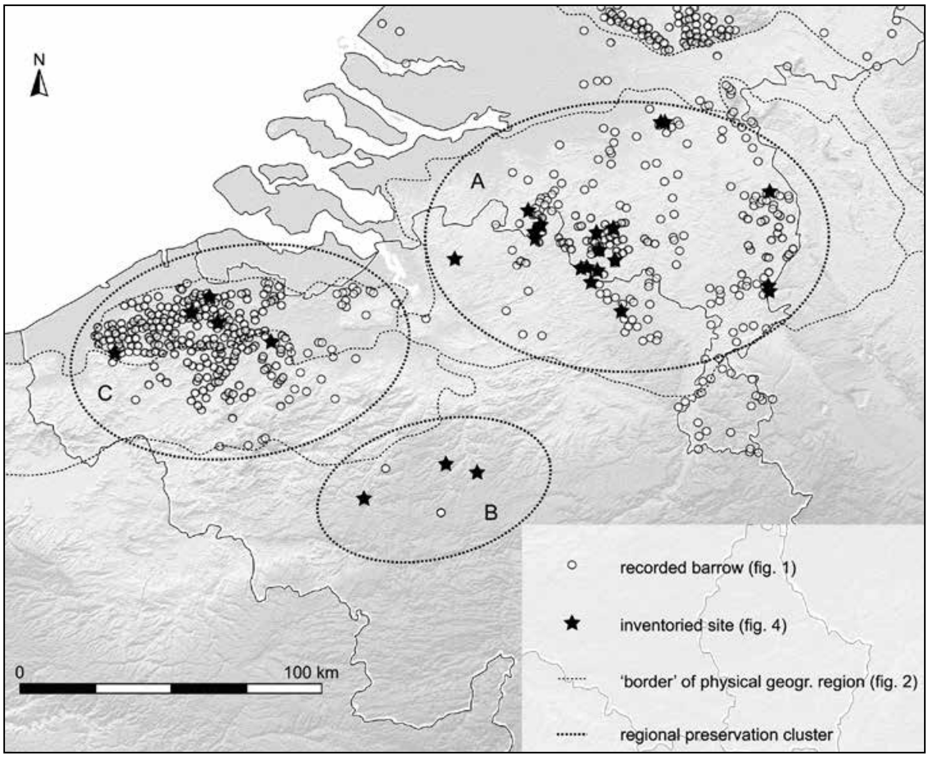


Fig. 7 Generalised regional clusters in barrow preservation, as based on observed formation processes on various scale levels, the physical geographical landscape structure and archaeological research history: **A** cover sand landscapes of the Campine region. – **B** loess belt in central Belgium. – **C** cover sand landscapes of West and East Flanders. – (Map R. Vergauwe / R. van Beek).

and cities had been parcelled and divided in arable land and meadows, leading to a closed bocage landscape. Various small forest relics, dissected by road systems, are present. All inventoried burial sites in this region are situated in areas that had been reclaimed before the late 18th century. These areas are fully parcelled and in use as arable land or pasture. Compared to other parts of the research area, the impact of man on the landscape was very severe at an early stage.

REGIONAL PRESERVATION »SKETCHES«

In the above inventory of soil formation processes three regional clusters have been distinguished. In the next section the signalled processes in each cluster (**fig. 7**) are summarised, placed in context and combined with some important general trends in land use history. This does not imply that the development of all barrows within these regions was exactly the same. Therefore, these descriptions should be seen as first »sketches« rather than strict, quantifiable models. Their main aim is to group the collected data into regional frameworks that can serve as preludes for future studies.

Sketch for the cover sands in the Campine region

In the Campine region hundreds of barrows have survived until the present day. Their intensive research history provides detailed information on the processes affecting them. The large-scale occurrence of podzolisation phenomena indicates soil formation changes that are mainly due to deforestations, and therefore to human land use. As discussed above, such transformations cannot be used as chronological proxies. Other processes influenced the morphology of mounds. These are generally destructive, as goes for bioturbation and erosion. On the other hand many barrows (see **tab. 1**) have partly been covered by drift sands. These deposits exclusively occur at their northeastern sections. As a result the centre of some barrows moved slightly through time. On some occasions (e.g. Bourgeois/Semey/Vanmoerkerke 1989) these shifted centres were used as central points when monuments were reused. From the 18th century onwards »barrow diggers« damaged various monuments.

In the 19th and early 20th century large tracts of heathland were transformed into arable land and, to a lesser extent, production forests. These transformations caused the destruction of many burial monuments. After World War II the introduction of agricultural machinery led to scale enlargement and intensification of land use. The majority of barrows that survived until the present day are situated in (former) heathlands. These escaped reclamation in the 19th and early 20th century as they lay outside the infields of contemporary settlements. The same pattern has been documented recently for parts of the southern and central Netherlands (Bourgeois 2013, 44f.). Some barrows and barrow clusters are still situated in heathland in small present-day nature reserves.

The transformation of heathland in early modern times was not the first reclamation phase influencing the barrow distribution pattern on a large scale. From the Late Medieval period onwards, open, communally used agricultural complexes, in Dutch called *essen*, developed on the large and fertile sandy ridges scattered over the Campine region (e.g. Spek 2004, 744-752). Both these open fields and smaller reclamations as a result of manuring became covered with thick so-called plaggen soils, burying archaeological sites and hindering their discovery. In some studies an explicit distinction is made between »heathland archaeology« and »*essen* archaeology« (e.g. Roymans/Kortlang 1999, 33), referring to differences in land use history and archaeological research strategies. Remains of levelled barrows are sometimes found at *essen* and underneath plaggen soils (Theunissen 1999, 49). Their exact number is very difficult to assess, as many *essen* have not been investigated yet. Also, levelled barrows do not necessarily leave archaeological traces. It is clear though that similar landscape units that have not been investigated form »blind spots« on barrow distribution maps (cf. Bourgeois 2013).

Sketch for the loess belt in central Belgium

Erosion is the most common soil formation process documented in the analysed barrows in the central Belgian loess belt. This process occurs in both other regions as well, but in this case the effects of slope processes are more significant. The erosion of monuments is influenced by precipitation, slope, geology and barrow construction material. Loess is very sensitive to both slope processes and deflation. The dense vegetation that developed in the Early Holocene originally will have offered protection against wind erosion. When this vegetation cover is removed, slope processes can be very destructive, as documented at Bonlez (barrow 2). The original soil profiles near this monument are covered by colluvium eroded from the mound. Erosion processes did not only affect barrows but their immediate environment as well, leading to a gradual levelling of the original topography. The dominant soil type in this region is the Luvisol, which has the characteristics of a clay illuvation horizon (Gysels 1993, 107). Horizons resulting from eluviation and illuviation of clay were observed at various barrows, indicating the level of the original soil surface. Podzolisation processes did not occur. The presence of Luvisols and absence of podzolisation result from the soil composition, that clearly differs from both »sandy« regions.

The studied sites are situated in relatively »stable« environments, at least from the late 18th century onwards. They are found in forests at current or former noble estates, which increased their chance of survival. Similar patterns, for example, are known from sites at Halle (prov. Vlaams-Brabant/B; Fourny/Van Assche 1993, 29f.) and Limal (prov. Brabant wallon/B; van Impe 1976, 7f.). In this part of the central Belgian loess belt, no barrows are known to have survived outside forests. This indicates that only those sites situated in low-dynamic environments have been preserved. This is supported by the fact that also the most developed soils are found in areas traditionally owned by the nobility and used for hunting and leisure, while the eroded soils are found in areas traditionally used for agriculture (e. g. Langohr / Sanders 1985). In this hilly region, the rise of mechanical agriculture triggered and accelerated erosion (Gysels 1993, 92; Verstraeten et al. 2006, 400). These processes may have led to erosion of barrows. The Ferraris map indicates that habitation density in early modern times in central Belgium was low compared to both other regions, and that human impact on the land was smaller. Nevertheless, large tracts of heathlands were reclaimed here as well from the 19th century onwards, which must have led to the disappearance of barrows.

Sketch for West and East Flanders

All barrows currently known in West and East Flanders have been detected by aerial surveys and excavations. These mound bodies were originally present can only be derived from circumstantial evidence, such as remains of badger burrows and rabbit holes – both animals dig in sloping surfaces – and the asymmetrical fill of ring ditches. Some monuments with different use phases indicate a shift of ring ditches in northeastern direction, probably pointing to a gradual »movement« of the centre of these barrows due to drift sand deposits (cf. Ampe et al. 1996, 78). Various barrow sites have been reused in younger periods, presumably indicating the presence of mounds that remained visible for centuries after their erection.

Despite the dominant position of barrows in the archaeology of Flanders since the 1980s, hardly any attention has been given to the factors that caused their large-scale destruction. The scale of this pattern indicates its origins have to be looked for in regional rather than local processes, and especially in land use history. Historical geographical research has demonstrated that Sandy Flanders witnessed a unique form of land use from the High Middle Ages onwards (Thoen 1997). As a result of population increase from the Carolingian period and especially from the 11th century onwards, an accelerated agricultural expansion took place. This resulted in a structured and intensively exploited cultural landscape, in which all available land was reclaimed and parcels were split up time and again. This situation would survive until the 19th century. The large differences in land use between the former County of Flanders and the Duchy of Brabant (in the Campine region) are clearly visible at the Ferraris map. The question how this development influenced the preservation of barrows is not difficult to answer. Sandy Flanders witnessed intensive tillage from the High and Late Middle Ages onwards, and the barrows once present in this region have all fallen prey to this intensive and prolonged form of land use.

DISCUSSION AND CONCLUSIONS

In this paper a first attempt was made to reconstruct the processes that influenced the preservation of barrows at a long time scale and at different spatial levels. As previous research on formation processes has mainly focused on either individual monuments and single processes (e. g. podzolisation) or on barrow distribution patterns, it is very rare to find information on all spatial levels in single studies. This pattern occurs throughout Northwestern Europe and is probably mainly caused by the history of barrow research. Most barrow excavations took place before the 1960s, when typological research questions prevailed. The rise of landscape archaeology since the 1990s has led to a shift from individual sites towards landscapes. Site location, land use history and the representativity of site distribution patterns have become important research topics. This study has demonstrated that these different scale levels and various types of data need to be integrated in order to carry out an in-depth, critical analysis. Also, it is of vital importance that future barrow excavations document evidence on soil formation processes in far more detail than has generally been done so far.

Archaeological evidence, soil data and information on historical land use can be used to identify spatial differences in formation processes of barrows and their environment. In this study, three regional »sketches« were developed. As the sample of well-documented sites is small, for now they chiefly describe regional variation in the relative importance of specific processes. These trends cannot be assumed simply valid for each barrow, or be extrapolated to neighbouring areas. Nevertheless, they do raise the awareness that multi-scale comparisons using empirical data are necessary in order to signal and explain spatially different trends. The mechanisms leading to the levelling of all barrows in West and East Flanders, for example, have never been addressed in detail.

On a more general note, detailed information on landscape evolution in the Low Countries between the Late Bronze Age and the Middle Ages is still rare. From our current data it is already clear that our pilot area witnessed significant transformations during this phase, such as deforestation and soil degradation of densely settled areas, erosion and sedimentation. The interplay between man and environment has been of fundamental influence on the formation of the barrow record. Deforestation and subsequent development of heathland were caused by man. In sandy regions these activities are reflected in podzolisation phenomena. Even though some barrows must have disappeared during these phases, for example as a result of erosion and early reclamations, far more were destructed from the Late Middle Ages onwards. This process is linked to increasing habitation density and various stages of agricultural intensification, reaching a peak in the early modern period.

The methodology developed in this paper can be applied to other regions. In this way the data collected in this research can be put in a wider northwest European context. Some basic general trends are clear already. The Campine region shows more similarities with (other) Dutch sandy landscapes than with the loess belt, for example. The large-scale disappearance of barrows in Sandy Flanders, on the other hand, is especially paralleled in parts of northwestern France (e. g. the Somme valley) and southeastern England (e. g. the Kent region). But even though the end results in the latter regions are largely the same, and land use intensity seems the key factor, the socio-economic factors behind these trends are different. Northwestern France, for example, was far less densely settled than Flanders, but land use was very intensive from the Carolingian period onwards (e. g. Fourquin 1975). In-depth regional studies are needed to analyse the mechanisms behind these processes.

The representativity of the current distribution pattern of barrows for the late prehistoric situation was not central to this research. That topic is probably best approached from a different angle, starting from overall distribution patterns rather than well-documented sites. Even then it is notoriously difficult to quantify the actual loss of barrows (cf. Theunissen 1999, 49; Bourgeois 2013, 40). However, our data allow some general preliminary observations. Despite the poor preservation circumstances, the currently known distribution pattern in West and East Flanders may be the most »complete«. From a thorough, GIS-based analysis J. De Reu concludes that the known sites probably form a roughly representative image (De Reu 2012, 116-128). The density of recorded barrows in the Campine region is slightly lower. Remains of some barrows are hidden underneath plaggen soils and many more have been destroyed during large-scale reclamations in early modern times. The latter are difficult to detect, as this region offers less favourable conditions for aerial photography. The original situation in central Belgium is even more difficult to assess. It is clear that barrows only survived in very specific circumstances here, and probably represent a fraction of all monuments once present. In this largely agricultural region erosion may have been a key factor.

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References

Agache 1978: R. Agache, La Somme pré-romaine et romaine d'après les prospections aériennes à basse altitude. Mémoires de la Société des Antiquaires de Picardie 24 (Amiens 1978).

Ampe et al. 1996: C. Ampe / J. Bourgeois / Ph. Crombé / L. Fockedey / R. Langohr / M. Meganck / J. Semey / M. Van Strydonck / K. Verlaeckt, The circular view. Aerial photography and the discovery of Bronze Age funerary monuments in East- and West-Flanders (Belgium). Germania 74, 1996, 45-94.

Baudou 1985: E. Baudou, Archaeological source criticism and the history of modern cultivation in Denmark. In: Kristiansen 1985, 63-80.

van Beek 2009: R. van Beek, Reliëf in Tijd en Ruimte. Interdisciplinair onderzoek naar bewoning en landschap van Oost-Nederland tussen vroege prehistorie en middeleeuwen [PhD thesis Univ. Wageningen] (Enschede 2009).

Bohncke 1991: S. J. P. Bohncke, Palaeohydrological changes in the Netherlands during the last 13.000 years [PhD thesis Vrije Univ. Amsterdam] (Amsterdam 1991).

Bourgeois/Talon 2009: J. Bourgeois / M. Talon, From Picardy to Flanders: Transmanche connections in the Bronze Age. In: P. Clark (ed.), Bronze Age Connections. Cultural Contact in Prehistoric Europe (Oxford 2009) 38-59.

Bourgeois/Semey/Vanmoerkerke 1989: J. Bourgeois / J. Semey / J. Vanmoerkerke, Ursel. Rapport provisoire des fouilles 1986-1987. Tombelle de l'Âge du Bronze et monuments avec nécropole de l'Âge du Fer. Scholae Archaeologicae 11, 1989, 3-48.

Bourgeois 2013: Q. Bourgeois, Monuments on the horizon. The formation of the barrow landscape throughout the 3rd and 2nd millennium BC [PhD thesis Univ. Leiden] (Leiden 2013).

van Breemen 1998: N. van Breemen (ed.), Plant-induced soil changes: processes and feedbacks. Developments in Biogeochemistry 42, 1998, 55-72.

van Breemen/Buurman 2002: N. van Breemen / P. Buurman, Soil Formation (Dordrecht [2]2002).

Buurman/Jongmans 2005: P. Buurman / A. G. Jongmans, Podzolisation and soil organic matter dynamics. Geoderma 125, 2005, 71-83.

Canti 2003: M. G. Canti, Earthworm Activity and Archaeological Stratigraphy: A Review of Products and Processes. Journal of Archaeological Science 30, 2003, 135-148.

Casparie/Groenman-van Waateringe 1980: W. A. Casparie / W. Groenman-van Waateringe, Palynological Analysis of Dutch Barrows. Palaeohistoria 22, 1980, 7-65.

De Coninck 1980: F. De Coninck, Major mechanisms in formation of spodic horizons. Geoderma 24, 1980, 101-128.

De Reu 2012: J. De Reu, Land of the Dead. A comprehensive study of the Bronze Age burial landscape in north-western Belgium [PhD thesis Univ. Ghent] (Ghent 2012).

Dotterweich et al. 2012: M. Dotterweich / J. Rodzik / W. Zgłobicki / A. Schmitt / G. Schmidtchen / H.-R. Bork, High resolution gully erosion and sedimentation processes, and land use changes since the Bronze Age and future trajectories in the Kazimierz Dolny area (Nałęczów Plateau, SE-Poland). Catena 95, 2012, 50-62.

Dunwell/Trout 1999: A. J. Dunwell / R. C. Trout, Burrowing animals and archaeology. Historic Scotland Technical Advice Notes 16 (Edinburgh 1999).

Finke 2012: P. A. Finke, Modeling the genesis of luvisols as a function of topographic position in loess parent material. Quaternary International 265, 2012, 3-17.

Finke/Hutson 2008: P. A. Finke / J. Hutson, Modelling soil genesis in calcareous loess. Geoderma 145, 2008, 462-479.

Fokkens/Jansen/van Wijk 2009: H. Fokkens / R. Jansen / I. M. van Wijk (eds), Oss-Zevenbergen. De langetermijn-eschiedenis van een prehistorisch grafveld. Archol Rapport 50 (Leiden 2009).

Fourny/Van Assche 1993: M. Fourny / M. Van Assche, Les tombelles protohistoriques de la Houssière (Braine-le-Comte, Hennuyères et Ronquières. Hainaut). Monuments classés. Amphora 71/72, 1993, 2-39.

Fourquin 1975: G. Fourquin, Le temps de la croissance. In: G. Duby (ed.), Histoire de la France rurale. 1: La formation des campagnes françaises des origins au XIVe siècle (Paris 1975) 377-552.

Gibson 1998: A. Gibson, The Walton Basin Project. In: H. Clevis / J. de Jong (eds), Archaeology and Landuse, three case studies. Prehistoric Links in Modern Europe (Zwolle 1998) 9-31.

van Giffen 1941: A. E. van Giffen, De tijd van vorming van heidepodzol-profielen aan de hand van archeologische waarnemingen. In: O. De Vries (ed.), Besprekingen over het heidepodzolprofiel. Gehouden op de bijeenkomst der sectie Nederland van de Internationale Bodemkundige Vereniging op 18 en 19 april 1941 (Arnhem 1941) 12-23.

Gillijns et al. 2005: K. Gillijns / G. Govers / J. Poesen / E. Mathijs / C. Bielders, Bodemerosie in België. Stand van Zaken. Koninklijk Instituut voor het Duurzame Beheer van de natuurlijke Rijkdommen en de Bevordering van Schone Technologie 10 (Brussel 2005).

Glasbergen 1954a: W. Glasbergen, Barrow Excavations in the Eight Beatitudes. The Bronze Age cemetery between Toterfout & Halve Mijl, North Brabant. I. The Excavations. Palaeohistoria 2, 1954, 1-134.

1954b: W. Glasbergen, Barrow Excavations in the Eight Beatitudes. The Bronze Age cemetery between Toterfout & Halve Mijl, North Brabant. II. The Implications. Palaeohistoria 3, 1954, 1-204.

Goldberg / Forster 1990: S. Goldberg / H. S. Forster, Flocculation of reference clays and arid-zone soil clays. Soil Science Society of America Journal 54, 1990, 714-718.

Gysels 1993: H. Gysels, De landschappen van Vlaanderen en Zuidelijk Nederland (Leuven 1993).

Hillel 1998: D. Hillel, Environmental Soil Physics. Fundamentals, Applications, and Environmental Considerations (San Diego 1998).

Hole 1981: F. D. Hole, Effects of animals on soil. Geoderma 25, 1981, 75-112.

Holst / Breuning-Madsen / Rasmussen 2001: M. K. Holst / H. Breuning-Madsen / M. Rasmussen, The South Scandinavian barrows with well-preserved oak-log coffins. Antiquity 75, 2001, 126-136.

van Impe 1976: L. van Impe, Ringwalheuvels in de Kempense bronstijd. Typologie en datering. Archaeologia Belgica 190 (Brussel 1976).

IUSS Working Group WRB 2006: International Union of Soil Sciences Working Group World Reference Base, World Reference Base for Soil Resources 2006. A framework for international classification, correlation and communication. World Soil Resources Reports 103 (Rome [2]2006).

Jarvis / Villholth / Ulén 1999: N. J. Jarvis / K. G. Villholth / B. Ulén, Modelling particle mobilization and leaching in macroporous soil. European Journal of Soil Science 50, 1999, 621-632.

Kadereit / Kühn / Wagner 2010: A. Kadereit / P. Kühn / A. G. Wagner, Holocene relief and soil changes in loess-covered areas of southwestern Germany: The pedosedimentary archives of Bretten-Bauerbach (Kraichgau). Quarternary International 222, 2010, 96-119.

Kooistra / Kooistra 2003: M. J. Kooistra / L. I. Kooistra, Integrated research in archaeology using soil micromorphology and palynology. Catena 54, 2003, 603-617.

Koster 1978: E. A. Koster, De stuifzanden van de Veluwe. Een fysisch-geografische studie. Publikaties van het Fysisch Geografisch en Bodemkundig Laboratorium van de Universiteit van Amsterdam 27 (Amsterdam 1978).

Kristiansen 1985: K. Kristiansen (ed.), Archaeological Formation Processes. The Representativity of archaeological remains from Danish Prehistory (Copenhagen 1985).

Langohr 1990: R. Langohr, L'homme et les processus d'érosion des sols limoneux de Belgique et du Nord-Ouest de la France. In: G. Leman-Delerive (ed.), Les Celtes en France du Nord et en Belgique, VI[e]-I[er] siècle avant J.-C. [exposition catalogue Valenciennes et al.] (Bruxelles 1990) 211-222.

1993: R. Langohr, Types of tree windthrow, their impact on the environment and their importance for the understanding of archaeological excavation data. Helinium 33/1, 1993, 36-49.

Langohr / Sanders 1985: R. Langohr / J. Sanders, The Belgian loess belt in the last 20000 years: evolution of soils and relief in the Zoniën Forest. In: J. Boardman (ed.), Soils and Quaternary Landscape Evolution (Chichester et al. 1985) 359-371.

Lanting / van der Waals 1974: J. N. Lanting / J. D. van der Waals, Oudheidkundig onderzoek bij Swalmen. I Praehistorie. Oudheidkundige Mededelingen uit het Rijksmuseum van Oudheden te Leiden 55, 1974, 1-111.

Lebret / Lautridou 1991: P. Lebret / J.-P. Lautridou, The Loess of West Europe. GeoJournal 24/2, 1991, 151-156.

Lohof 1991: E. Lohof, Grafritueel en sociale verandering in de bronstijd van Noordoost-Nederland [PhD thesis Univ. Amsterdam] (Amsterdam 1991).

Modderman 1975: P. J. R. Modderman, Bodemvorming in grafheuvels. Analecta Praehistorica Leidensia 8, 1975, 11-21.

Paepe / Vanhoorne 1967: R. Paepe / R. Vanhoorne, The stratigraphy and palaeobotany of the Late Pleistocene in Belgium. Mémoires pour servir à l'explication des cartes geologiques et minières de la Belgique 8 (Bruxelles 1967).

Perkins 2010: D. Perkins, The Distribution Patterns of Bronze Age Round Barrows in North-East Kent. Archaeologia Cantiana 130, 2010, 277-314.

Peters 1999: F. Peters, Bronze Age barrows: factors influencing their survival and destruction. Oxford Journal of Archaeology 18/3, 1999, 255-264.

Roymans / Kortlang 1999: N. Roymans / F. Kortlang, Urnfield symbolism, ancestors and the land in the Lower Rhine Region. In: F. Theuws / N. Roymans (eds), Land and ancestors. Cultural dynamics in the Urnfield Period and the Middle Ages in the southern Netherlands. Amsterdam Archaeological Studies 4 (Amsterdam 1999) 33-61.

Schaetzl et al. 1989: R. J. Schaetzl / D. L. Johnson / S. F. Burns / Th. W. Small, Tree uprooting: review of terminology, process, and environmental implications. Canadian Journal of Forest Research 19, 1989, 1-11.

Scheys 1963: G. Scheys, Podzolvorming belicht door archeologische waarnemingen. Pedologie 13/2, 1963, 216-230.

Schiffer 1987: M. B. Schiffer, Formation Processes of the Archaeological Record (Albuquerque 1987).

Spek 2004: Th. Spek, Het Drentse esdorpenlandschap. Een historisch-geografische studie (Utrecht 2004).

Theunissen 1999: E. M. Theunissen, Midden-bronstijdsamenlevingen in het zuiden van de Lage Landen. Een evaluatie van het begrip »Hilversum-cultuur« [PhD thesis Univ. Leiden] (Leiden 1999).

Thoen 1997: E. Thoen, The birth of »the Flemish husbandry«: agricultural technology in medieval Flanders. In: G. G. Astill / J. Langdon (eds), Medieval Farming and Technology. The Impact of Agricultural Change in Northwest Europe. Technology and Change in History 1 (Leiden, New York, Köln 1997) 69-88.

Ulanova 2000: N. G. Ulanova, The effects of windthrow on forests at different spatial scales: a review. Forest Ecology and Management 135, 2000, 155-167.

Van Oost et al. 2006: K. Van Oost / G. Govers / S. De Alba / T. A. Quine, Tillage erosion: a review of controlling factors and implications for soil quality. Progress in Physical Geography 30, 2006, 443-466.

Vannière et al. 2003: B. Vannière / G. Bossuet / A.-V. Walter-Simonnet / E. Gauthier / P. Barral / C. Petit / M. Buatier / A. Daubigney, Land use change, soil erosion and alluvial dynamic in the lower Doubs Valley over the 1[st] millennium AD (Neublans, Jura, France). Journal of Archaeological Science 30, 2003, 1283-1299.

Vergauwe 2012: R. Vergauwe, Studie omtrent bodemgenese en degradatieprocessen bij bronstijd grafheuvels in het zuiden van de Lage Landen [unpubl. M.A. thesis Univ. Ghent 2012].

Verstraeten et al. 2006: G. Verstraeten / J. Poesen / D. Goossens / K. Gillijns / C. Bielders / D. Gabriels / G. Ruysschaert / M. Van Den Eeckhaut / T. Vanwalleghem / G. Govers, Belgium. In: J. Boardman / J. Poesen (eds), Soil Erosion in Europe (Chichester 2006) 385-411.

Walkington 2010: H. Walkington, Soil science applications in archaeological contexts: A review of key challenges. Earth-Science Reviews 103, 2010, 122-134.

Waterbolk 1964: H. T. Waterbolk, Podsolierungserscheinungen bei Grabhügeln. Palaeohistoria 10, 1964, 87-102.

Zádorová et al. 2013: T. Zádorová / V. Penížek / L. Sefrna / O. Drábek / M. Mihaljevič / S. Volf / T. Chuman, Identification of Neolithic to Modern erosion-sedimentation phases using geochemical approach in a loess covered sub-catchment of South Moravia, Czech Republic. Geoderma 195-196, 2013, 56-69.

Zolitschka/Behre/Schneider 2003: B. Zolitschka / K.-E. Behre / J. Schneider, Human and climatic impact on the environment as derived from colluvial, fluvial and lacustrine archives – examples from the Bronze Age to the Migration period, Germany. Quaternary Science Reviews 22, 2003, 81-100.

Zusammenfassung / Summary / Résumé

Räumliche Unterschiede in der Erhaltung spätneolithischer und bronzezeitlicher Grabhügel in den Benelux-Ländern: Erklärungsmodelle anhand unterschiedlicher Bodenbildung, Abbauprozesse und historischer Landnutzung

Anhand eines mehrstufigen interdisziplinären Ansatzes werden in dieser Studie Prozesse zur Überlieferung von Grabhügeln im Gelände rekonstruiert. Die südlichen Niederlande und das nördliche bzw. zentrale Belgien sind hierbei das Pilotgebiet. Wir kommen zu drei regionalen »Skizzen«, die die wichtigsten Prozesse widerspiegeln, die dann weiter als Auftakt für eine Modellierung dienen können. Grabhügel in den Flugsandgebieten der niederländischen und belgischen Kempen (Skizze 1) sind hauptsächlich von Podsolierung, Bioturbation, Erosion und Landgewinnung betroffen. Erosion stellt den wichtigsten Prozess der Bodenbildung in dem zentralbelgischen Lößgürtel dar (Skizze 2); und schließlich hat die Sandzone im belgischen Flandern (Skizze 3) seit dem Mittelalter eine sehr intensive Bodenbearbeitung erfahren.

Spatial Variations in the Preservation of Late Neolithic and Bronze Age Barrows in the Low Countries Explained by Differences in Soil Formation, Degradation Processes and Land Use History

This study follows a multi-scalar interdisciplinary approach to reconstruct formation processes influencing the preservation of barrows. The southern Netherlands and northern/central Belgium were selected as pilot area. We arrive at three regional »sketches« signalling the most significant processes, which may serve as preludes for further modelling. Barrows in the cover sand areas of the Dutch and Belgian Campine region (sketch 1) are mainly affected by podzolisation, bioturbation, erosion and reclamations. Erosion is the most common soil formation process documented in the central Belgian loess belt (sketch 2). Finally, Belgian Sandy Flanders (sketch 3) witnessed very intense, prolonged tillage from the Middle Ages onwards, which led to the destruction of all barrows.

Variations spatiales dans la préservation de tumuli du Néolithique final et de l'âge du Bronze dans le Benelux expliqué par differences dans la formation du sol, processus de dégradation et l'histoire de l'utilisation des terres

Cette étude suit une approche interdisciplinaire multi-scalaire afin de reconstituer les processus de formation qui influent sur la préservation des tumuli. Le sud des Pays-Bas et la partie nord/centrale de la Belgique forment la zone d'étude. Nous arrivons à trois »esquisses« régionales de signalisation des processus les plus importants, qui peuvent servir de préludes pour modélisations plus détailées. Tumuli dans les zones sablonneuses de la Campine belge et néerlandaise (esquisse 1) sont principalement affectés par podzolisation, bioturbation, l'érosion et réclamations. L'érosion est le processus la plus courant documenté dans la ceinture du loess en Belgique centrale (esquisse 2). Finalement, la Flandre sablonneuse (esquisse 3) a été labouré très intensivement depuis le Moyen Âge, ce qui a résulté par la destruction de tous les tumuli.

Schlüsselwörter / Keywords / Mots clés

Belgien / Niederlande / Neolithikum / Bronzezeit / Landschaftsarchäologie / Erhaltung / Grabhügel
Belgium / the Netherlands / Neolithic / Bronze Age / landscape archaeology / preservation / barrow
Belgique / les Pays-Bas / Néolithique / âge du Bronze / archéogéographie / préservation / tumulus

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