FACING COMPLEXITY

An interdisciplinary study of an early medieval Dark Earth witnessing pasture and crop cultivation from the centre of Aalst (Belgium)

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ABSTRACT
The ubiquitous urban Dark Earths compose a main challenge for urban archaeologists. Due to their homogeneous character they cannot be readily understood based on field data alone. Geoarchaeology (field study and micromorphology) has shown to be particularly well suited to tackle these layers, and to reveal their complex formation histories and the human activities and natural events involved. During the excavations of the site of Sint-Jozefs-college in the centre of Aalst (Belgium) a thick dark earth was discovered underneath the remains of the rampart of the 11th century town wall. An interdisciplinary study, involving archaeology, geoarchaeology and phytolith analysis has been performed. It demonstrates that the Dark Earth layer has a long formation history involving pasture and crop growing, intimately mixed with soil processes such as bioturbation and colluviation. The identified activities confirm the rather rural character of the area until the 11th century AD.

KEYWORDS
urban geoarchaeology, soil micromorphology, phytoliths

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1. Introduction

The understanding of the formation and build-up of urban deposits is an important issue in urban archaeology. Beyond being the container for artefacts and ecofacts, soils and sediments can provide detailed information on the context in which human activities took place locally, and on the wider environment. Although many layers can readily be identified during fieldwork, part of the urban stratigraphy remains difficult to understand based on field data alone (see for instance Devos et al., in press). This is especially true for the urban Dark Earths. These are thick, dark coloured, humic, homogeneous units covering large surfaces that are often rich in anthropogenic remains (charcoal, ceramic, brick, bone, mortar, coprolites, slag, etc.) (Nicosia et al., 2017; Devos, 2019). Geoarchaeological studies, and especially micromorphology, have shown to be particularly well adapted to study these layers and reveal their secrets (see for instance Macphail, 1994; Cammas et al., 1995; Devos et al., 2011; Nicosia et al., 2013; Nicosia and Devos, 2014; Borderie et al., 2015; Wouters et al., 2017; Nicosia, 2018; Devos, 2019). The numerous studies performed in European towns demonstrated the often complex and unique formation histories of the urban Dark Earth. This implies that each Dark Earth should be investigated on an individual basis. It is only by doing so that the site stratigraphy can be understood and the succession of human activities and natural events can successfully be deciphered.

During the excavation on the site of Sint-Jozefscollege in Aalst, a Dark Earth composed of two thick, dark, humic and macroscopically stratigraphically undifferentiated units, whose origin, formation and archaeological significance were unclear, were identified and sampled.

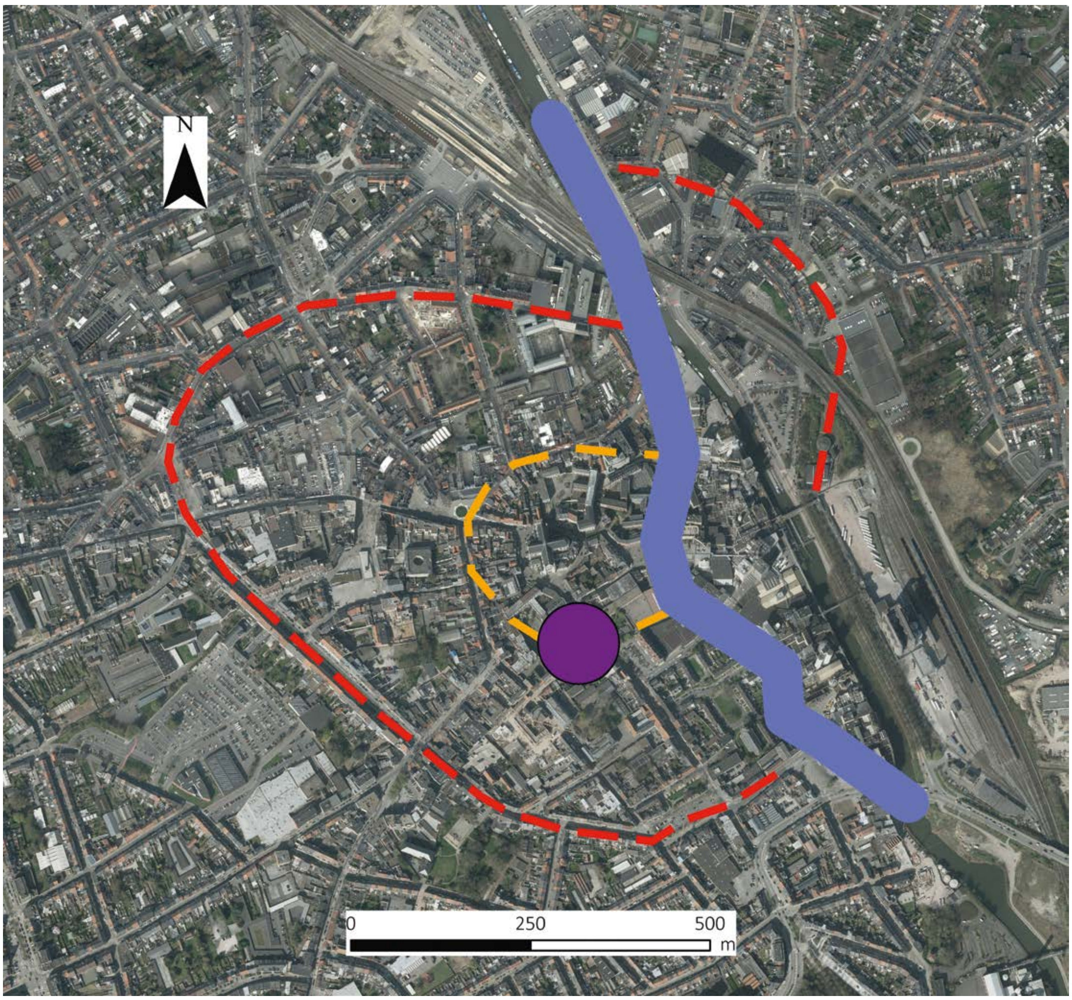

Figure 1. Map showing the location of the site of Sint-Jozefscollege and the two stone town ramparts (orange: first town wall; red: second town wall; blue: the medieval course of the Dender river; purple dot: site of Sint-Jozefscollege). Digitale versie van de Orthofoto's, middenschalig, kleur (Informatie Vlaanderen, 2017).

The aim of the present study is to verify field hypotheses and to evaluate the potential of integrated archaeological, geoarchaeological and phytolith studies to understand these Dark Earth units.

Figure 2. View from the east on the excavation trench.

2. The archaeological site and its historical meaning

The site of Sint-Jozefscollege is situated at the edge of the historic centre of Aalst, on the left bank of the Dender river (Fig. 1). On the Belgian soil map the area is located at the margins of the loess deposits. The site is marked as 'built area' (OB) (Louis, 1961), which implies that no detailed information on local soil development is available. The elevation of the site is ca. 13m above sea level. The excavations of 2009 (Fig. 2) revealed among others the presence of the remains of the ditch and earthen rampart of the first town wall (De Groote and Moens 1995; De Groote et al. 2010a; De Groote et al. 2010b) (Fig. 3). Underneath this earthen defence wall, which remnants functioned as a protective bell, a thick Dark Earth was observed (Fig.s 3, 4). As the Dark Earth covered some Merovingian remains (*infra*), this 30 to 40 cm thick layer can be generally dated between the 6th and the middle of the 11th century. It is divided into an older, about 10 cm thick, light coloured homogenic unit (Fig. 4a: unit 2; Fig. 4b: unit 24) and a younger 20 to 30 cm thick darker unit (Fig. 4a: units 7, 8a and 8b; Fig. 4b: unit 25). During the excavation the oldest unit, which contained some Merovingian pottery sherds, was interpreted as remains of a meadow. The younger thick unit, containing some pottery dating from the 8th until the early 11th century, was interpreted as the remnants of arable land.

The medieval town of Aalst has its roots in the Early Medieval period (5th-9th c.), when a Merovingian settlement developed into a Carolingian manor, first mentioned as the *locus Aalst* in the property lists of the abbey of Lobbes, made around 868-869 (De Groote, 2010; De Groote, 2013). A *polyptycum* lists the properties of the abbey by *pagus*, mentioning *Alosta* in the *pagus Bracbattensis*. Besides that, a *discriptio villarum* is preserved, in which many details about this property are mentioned. This phrase makes it clear that it was a bipartite manor, composed of a court with demesnes, which was cultivated directly for the owner of the domain, and of farmsteads (*mansi*) with tenements or tenures, which the farmers or tenants cultivated for themselves in exchange for services

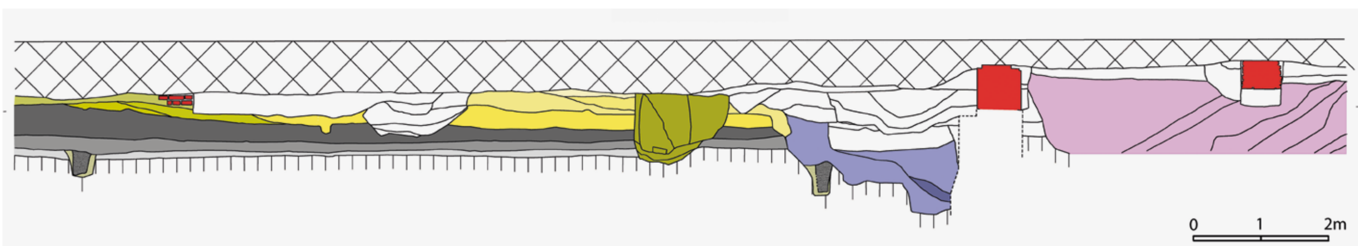

Figure 3. Northwest profile of Trench 1 (light and dark grey: Dark Earth layers covering two Merovingian postholes; yellow: remains of 11th c. earthen rampart; blue: 12th c. extraction pit; green: late medieval pit; purple: post-medieval debris pit; red: brick foundations).

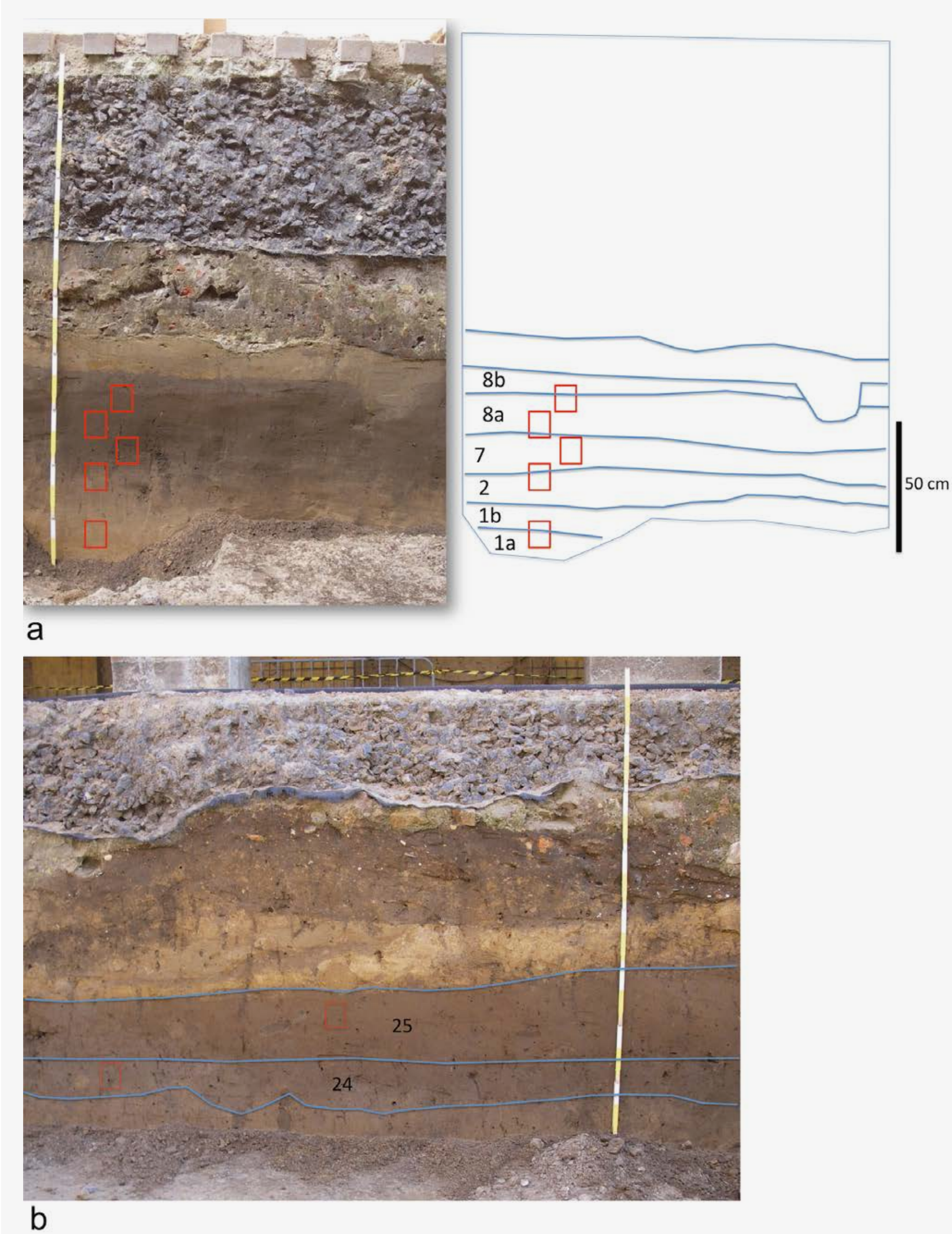

Figure 4. Analysed sections with indication of the stratigraphical units/horizons and the location of the block samples for micromorphology (a: NW profile; b: SO profile).

and payments (for military service) and goods (Callebaut, 1983). The exact location of this Carolingian settlement or its outlay is still unknown, but has to be situated in the direct neighbourhood of the St. Martins church, of which archaeological remains point at a pre-10th century origin, probably first serving as a proprietary church (De Groote, 2010; De Groote, 2013).

The excavations of 2009 revealed, for the first time, traces of a Merovingian settlement, which were preserved underneath the remains of the 11th century earthen defence wall, including a series of postholes belonging to at least one main building (De Groote et al. 2010a; De Groote et al. 2010b). All four radiocarbon analyses on charcoal from the postholes situate this occupation in the period of the 5th to the first half of the 6th century. Ceramic finds, collected from the postholes and from the lower 10 cm of the thick covering layer of Dark Earth, confirm this chronology. After the abandonment of this occupation, the area seemed to have been (re-)incorporated in the agricultural area, as could be derived from the thick humiferous layers of Dark Earth covering it. The aim of the study of these layers of Dark Earth was to unravel the occupation history between the Merovingian habitation and the construction of the first town wall.

3. Material and methods

3.1. FIELD OBSERVATIONS AND SAMPLING

Field descriptions were made according to the 'Comprehensive Field Data Bases' (Langohr, 1994) and the 'Guidelines for Soil Profile Description' (FAO, 2006). Adapted checklists were applied to describe associated features (Fechner et al., 2004). Additionally, mole galleries were counted on horizonal sections at 10 cm intervals starting from the top of the Dark Earth (Fig. 5). Undisturbed and oriented block samples were taken from the studied vertical sections for the realisation of soil thin sections (Fig. 4).

3.2 SOIL MICROMORPHOLOGY

Thin sections were prepared from the air-dried blocks in the laboratory (Beckmann, 1997). The thin sections are 8 cm long and 6 cm large. Their thickness is ca. 30 µm. Observations were made with a petrological microscope under plain polarised light (PPL), under crossed polarizers (XPL), and oblique incident light (OIL) at magnifications of 25x, 100x, 200x, 400x and 500x. The thin sections were also scanned under (UV and blue) fluorescence at 400x magnification (Van Vliet-Lanoë, 1991; Stoops, 2017). The thin sections were described following the international nomenclature of the 'Guidelines for analysis and description of soil and regolith thin sections' (Stoops, 2003). Semi-numerical counting was performed according to Macphail and Cruise (2001) and Borderie (2011).

3.3. PHYTOLITH STUDY ON THIN SECTIONS

The phytolith analysis was carried out according to Vrydaghs and Devos (2019, in press) and Vrydaghs et al. (2016a; 2017). Besides specific cases (coprolites, plant fragments, etc.), a series of squares of 5 by 5 mm were selected, based on the results of the micromorphological study. These target the phytolith content of the soil matrix thereby avoiding compiling phytoliths with other depositional histories (e.g. phytoliths within coprolites, ash remains, etc.). Within these selected areas, four fields of 0.2 mm^2 were systematically scanned. The phytolith analysis consisted of a four-step approach:

1. systematic recording of the distribution patterns of the phytoliths;
2. inventory of the phytoliths within each distribution pattern. The naming of the phytoliths follows the nomenclature of ICPN2.0 (ICPT, in press);
3. counting of the phytoliths within each distribution pattern;
4. description of visibility, preservation and colour of the individual phytoliths following Vrydaghs and Devos (in press).

Table 1 Field descriptions of the stratigraphic units of the studied sections

Profile	Unit	Description	
1		Recent pavement	
		Gravel layer	
		Heterogeneous levelling layer	
		Heterogeneous, loam, pale yellow to very pale brown, abrupt smooth lower boundary	Earthen rampart
	8b	Homogeneous, sandy loam, reddish gray, iron pan at lower boundary, abrupt smooth to wavy lower boundary	Dark Earth
	8a	Homogeneous, sandy loam, dark gray, clear wavy lower boundary	Dark Earth
	7	Homogeneous, sandy loam, gray, clear to gradual wavy lower boundary	Dark Earth
	2	Sandy loam, light gray, clear wavy to irregular lower boundary	Bbi
	1b	Sandy loam, pale yellow, abrupt, wavy lower boundary	E
	1a	Sandy clay loam, very pale brown	Bt
2		Gravel layer	
		Heterogeneous levelling layer	
		Heterogeneous, loam, pale yellow to very pale brown, abrupt wavy lower boundary	Earthen rampart
	25	Homogeneous, sandy loam, reddish gray, clear wavy lower boundary	Dark Earth
	24	Homogeneous, sandy loam, gray to dark gray, gradual wavy to irregular lower boundary	Dark Earth
		Sandy loam, gray to light gray	Bbi

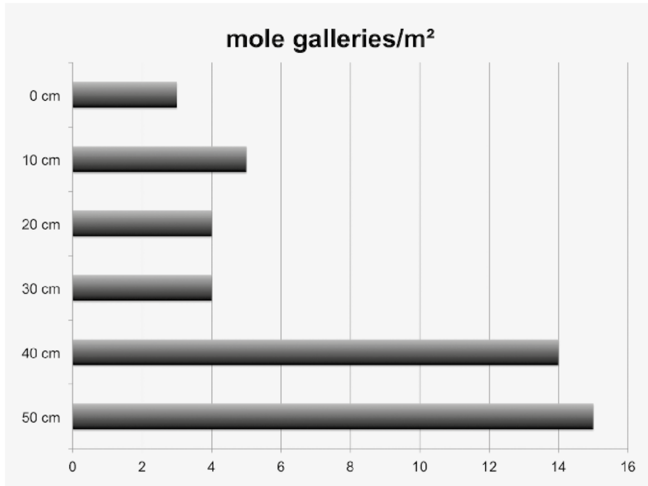

Figure 5. Counting of the mole galleries. Mole galleries have been counted each 10 cm starting from the top of the dark earth (= 0 cm) down to the base (= 50 cm). The oldest phase, corresponding to unit 2 (=40 and 50 cm) shows the highest concentration of galleries.

4. Results and discussion

Field data are summarised in table 1. The counting of the mole galleries is reported in figure 5. Micromorphological data are presented in table 2 and phytolith data in figure 6.

4.1. POST-DEPOSITIONAL PROCESSES

To understand the site history, one also needs to take into account post-depositional processes, as these can strongly affect the sedimentary matrix (Mallol and Bertran, 2010; Karkanas and Goldberg, 2019). Therefore, these will be discussed first.

The construction of the earthen rampart of the first city wall in the 11^{th} century AD had a double effect on the preservation of the Dark Earth underneath. On the one

Table 2 Overview of the most relevant micromorphological observations and interpretations per stratigraphic unit

Unit	Main characteristics	Interpretation
1a	Moderately developed subangular blocky microstructure; chito-enaulic to porphyric; dominated by unsorted silt to medium sand sized quartz; additional minerals: feldspar, glauconite and mica; abundant limpid clay coatings	Bt
1b	Massive to poorly developed subangular blocky microstructure; chito-enaulic to coarse monic; dominated by unsorted silt to medium sand sized quartz; additional minerals: feldspar, glauconite and mica; few limpid, layered and few dusty clay coatings, common earthworm and root galleries	E, affected by biological activity
2	Welded granules to poorly developed subangular blocky microstructure; chito-enaulic to coarse monic; dominated by unsorted silt to medium sand sized quartz; additional minerals: feldspar, glauconite and mica; abundant earthworm and root galleries and excremental organo-mineral aggregates; typic iron nodules	Pasture land
7, 8a, 24 & 25	Welded granules; chito-enaulic; dominated by unsorted silt to medium sand sized quartz; additional minerals: feldspar, glauconite and mica; humic, common randomly and unoriented anthropic remains (charcoal, bone, ceramics, rounded soil fragments, ashes, including vitrified phytoliths, coprolites); abundant earthworm and root galleries; dusty clay coatings, short wavy lenses of dusty fine material, phosphatic nodules	Crop cultivation
8b	See previous, iron crust at lower boundary	Crop cultivation + compaction

hand, this cover originally composing of several meters of sediment sealed off the Dark Earth units below, thus protecting them from any posterior activity and almost all natural impact (bioturbation, etc.). This is for instance witnessed by the very sharp boundary between the top of the Dark Earth and the sediments of the earthen rampart. As such, the Dark Earth possesses a high potential to identify human activities taking place before the construction of the rampart and to estimate their impact on the environment.

On the other hand, this massive dump of material caused the compaction of the upper part of the sequence and the subsequent redistribution of iron as witnessed by a lower porosity and the presence of an iron crust.

4.2. THE PARENT MATERIAL

The basal part of the studied sequence is mainly composed of silt to medium sand sized quartz, with some glauconite, which is rather typical for Aeolian deposits in Middle Belgium (Van Ranst et al., 1982). Micromorphological observations showed that anthropogenic materials were rare and probably intrusive. The observed limpid clay coatings are associated with natural processes and stable surfaces (Fedoroff and Goldberg, 1982; Macphail et al., 1987; Mikkelsen and Langohr, 1996). Being decalcified, this parent material has – without amendments – a very limited chemical fertility (see for instance Langohr, 2001).

4.3. FORMATION OF DARK EARTH

The formation of the Dark Earth on the site of Sint-Jozefscollege is the result of a complex interplay of a series of natural events and human actions, both involving a series of processes. These processes will be outlined first.

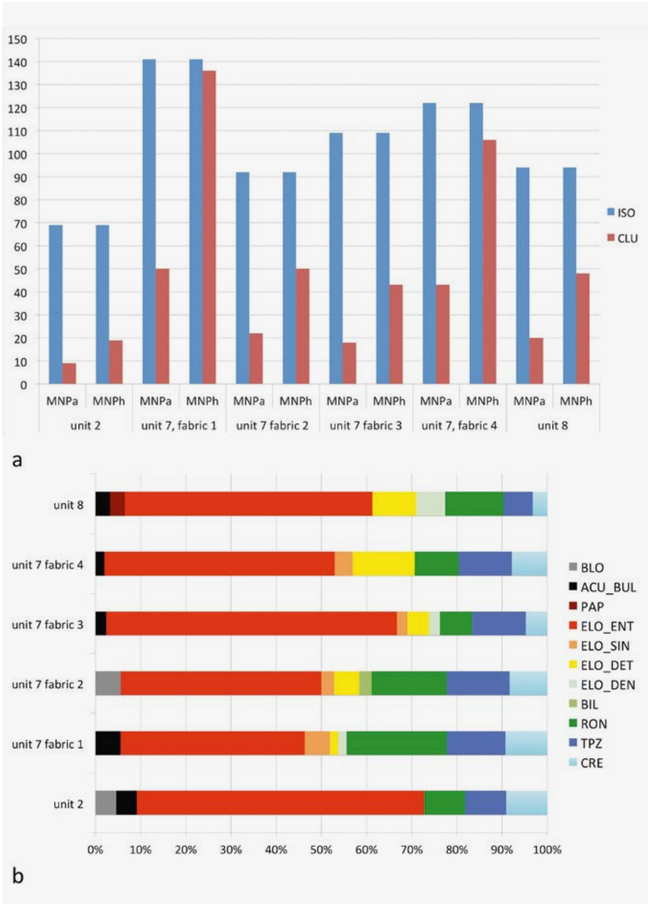

Figure 6. Results of the phytolith analysis:

a. Minimal Number of Distribution patterns (MNPa) and Minimal Number of Phytoliths (MNPh) per distribution pattern. ISO : Isolate ; CLU : Cluster.

b. Frequencies (in %) of the various phytolith types. BLO : Blocky ; ACU_BUL : Acute bulbosus ; PAP : Papillate ; ELO_ENT : Elongate entire ; ELO_SIN : Elongate sinuate ; ELO_DET : Elongate dentate ; ELO_DEN : Elongate dendritic ; BIL : Bilobate ; RON : Rondel ; TPZ : Trapezoid ; CRE : Crenate.

4.3.1. Processes

A first process that has been observed is the accumulation of material resulting in a thickening of the Dark Earth. Main components are the input of colluvial material, household (kitchen) waste, excremental waste (coprolitic material) and construction waste (earthen-based construction materials). The household waste is identified based on the combined presence of charcoal, bone (Fig. 7a), burned bone (Fig. 7b), ceramics (Fig. 7c) and vitrified silica (Fig. 7d). The latter results from the melting of phytoliths (see for instance Gebhardt and Langohr, 1999; Vrydaghs et al., 2017). Coprolitic material, often in combination with phosphatic nodules (Fig. 7e) and fungal sclerotia, reveals the addition of excremental waste. The construction waste is mainly composed of dense rounded aggregates (Fig. 7f). These

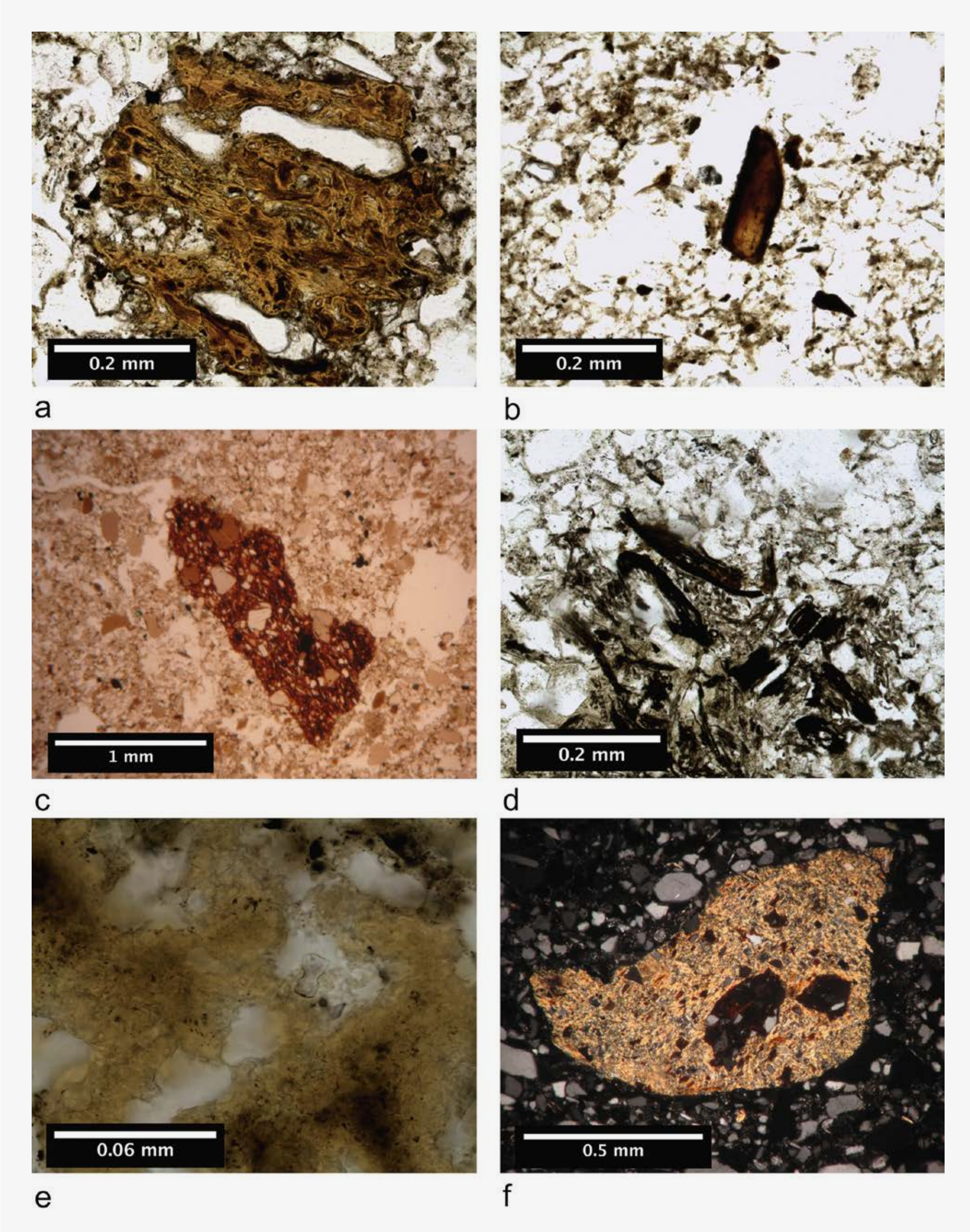

Figure 7. Photo micrographs:

a. weathered bone fragment (unit 8, PPL)
b. burned bone fragment (unit 8, PPL)
c. ceramic/brick fragment (unit 8, PPL);
d. charred plant remains including phytoliths (unit 8, PPL)
e. detail omnivore coprolite containing phytoliths (unit 24, PPL)
f. earthen based construction material (unit 8, PPL)

are microscopic fragments of earthen-based construction materials (daub, clay-floors, etc.) (Devos et al., 2013a).

The anomalous thickness of the horizon composed of one similar, unsorted, mineral fraction, containing anorthic iron oxide nodules further suggests the input of colluvium (Mücher et al. 2018).

A second process, the eradication of the original stratification and/or horizonation is mainly due to human reworking (digging) and bioturbation (mainly moles (Fig. 5), earthworms and roots). The fully mature character of the Dark Earth indicates that the degree of homogenisation outreaches the sedimentation/accumulation rate.

We further observed the degradation of earthen-based construction materials, resulting in their fragmentation and the release of sedimentary particles (particularly of coarse silt and very fine sand) (Macphail, 2003). The well-aerated soil, in combination with a high biological activity, favours a rapid humification of organic remains (plant fragments, excrements, etc.,). Therefore only small quantities of more resistant seeds and fruits will be preserved.

Further pedogenic processes are clay translocation and oxidoreduction (see *infra*).

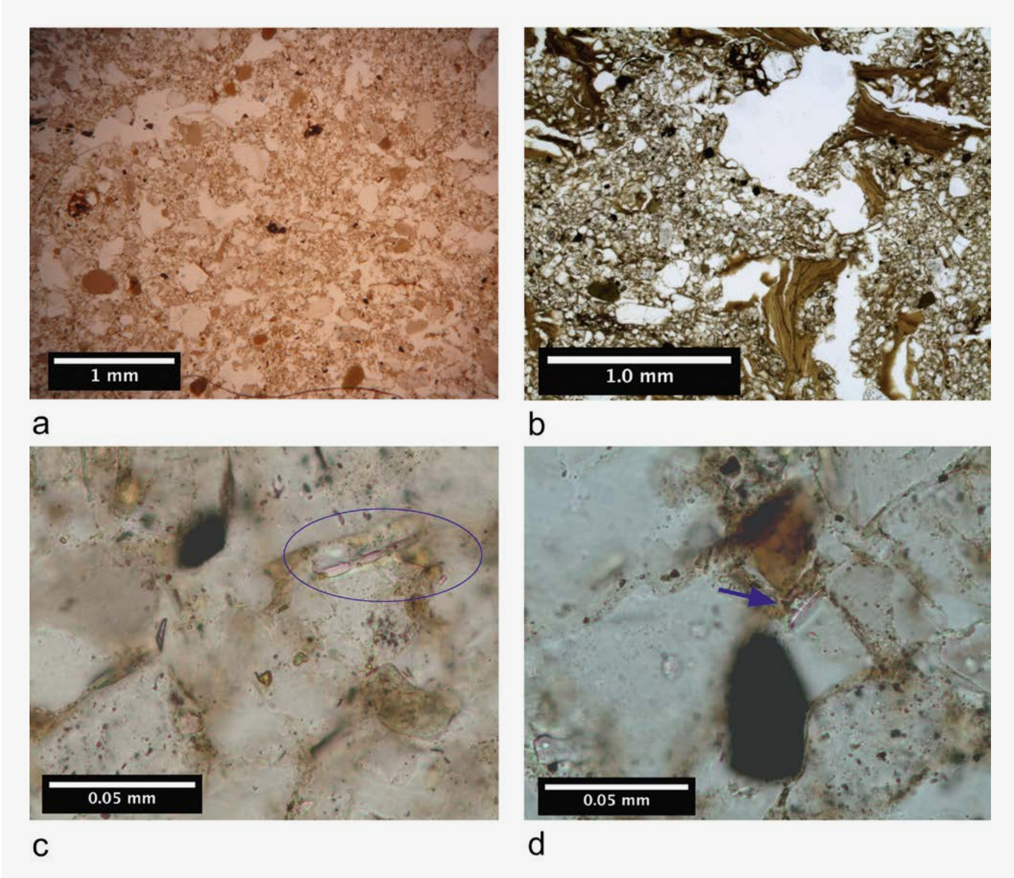

Figure 8. Photo micrographs:

a. organo-mineral excremental aggregates (unit 2, PPL)
b. limpid clay coating (unit 1, PPL)
c. isolated CRENATE (outer periclinal surface) observed within the soil matrix of the pasture land (unit 2, PPL)
d. isolated RONDEL observed within the soil matrix of the pasture land (unit 2, PPL)

4.3.2. Human activities

Pasture land

Unit 2 witnesses the presence of pasture land.
This unit has similar mineral composition and texture to the underlying parent material, thus indicating that this unit is the result of pedogenic processes rather than the addition of new sediments. The horizon is strongly affected by bioturbation. This is evidenced by the high quantity of mole galleries (Fig. 5), abundant organo-mineral excremental aggregates (Fig. 8a) and (root) galleries. In combination with its humic character, this indicates an ancient (near) topsoil horizon (Gerasimova and Lebedeva-Verba, 2010). The presence of abundant limpid clay coatings (Fig. 8b) further evokes a permanent soil cover. This unit shows the lowest amount of phytoliths, mostly isolated. The phytolith assemblage, composed of redundant and typical types such as CRENATE (Fig. 8c), RONDEL (Fig. 8d) and TRAPEZOID phytoliths is consistent with the identification of a grassland cover (see also Devos et al., 2013a).

Some phosphatic remains and fungal sclerotia have been noted, suggesting the presence of animals. Moreover, we observed multiple redoximorphic traces suggesting local muddy conditions, often found in association with animal trampling (Mikkelsen and Langohr, 1996; Goldberg and Macphail, 2006). Grazing can also explain the anomalous high bioturbation by common earthworms and moles (Langohr et al., 2015).

Crop fields

Traces of the presence of a crop field have been observed within units 7, 8a, 8b, 24 and 25 (Fig. 4).
The humic character, in combination with the presence of mesofaunal activity and root galleries, implies that we are again dealing with an ancient (near) topsoil horizon (Gerasimova and Lebedeva-Verba, 2010). The high mineral and textural similarity with the underlying unit indicates that they share the same sedimentary matrix (see for instance Devos et al., 2009; 2013a). The ubiquitous presence of textural pedofeatures, including dusty clay and clay-silt coatings along pores (Fig. 9a) and short wavy lenses of dusty (humus/soot rich) fine material, clearly point to the mixing of the ancient topsoil as a consequence of agricultural activities (Courty et al., 1989; French, 2003; Lewis, 2012). Complementary evidence of the physical workings of the soil are the strong fragmentation and random distribution of anthropogenic elements such as charcoal, bone and ceramics (Devos et al., 2009; 2013a; 2013b; 2017). Within the charcoal fraction for instance, we observe a clear dominance of the finer fractions (Fig. 9b), pointing to the

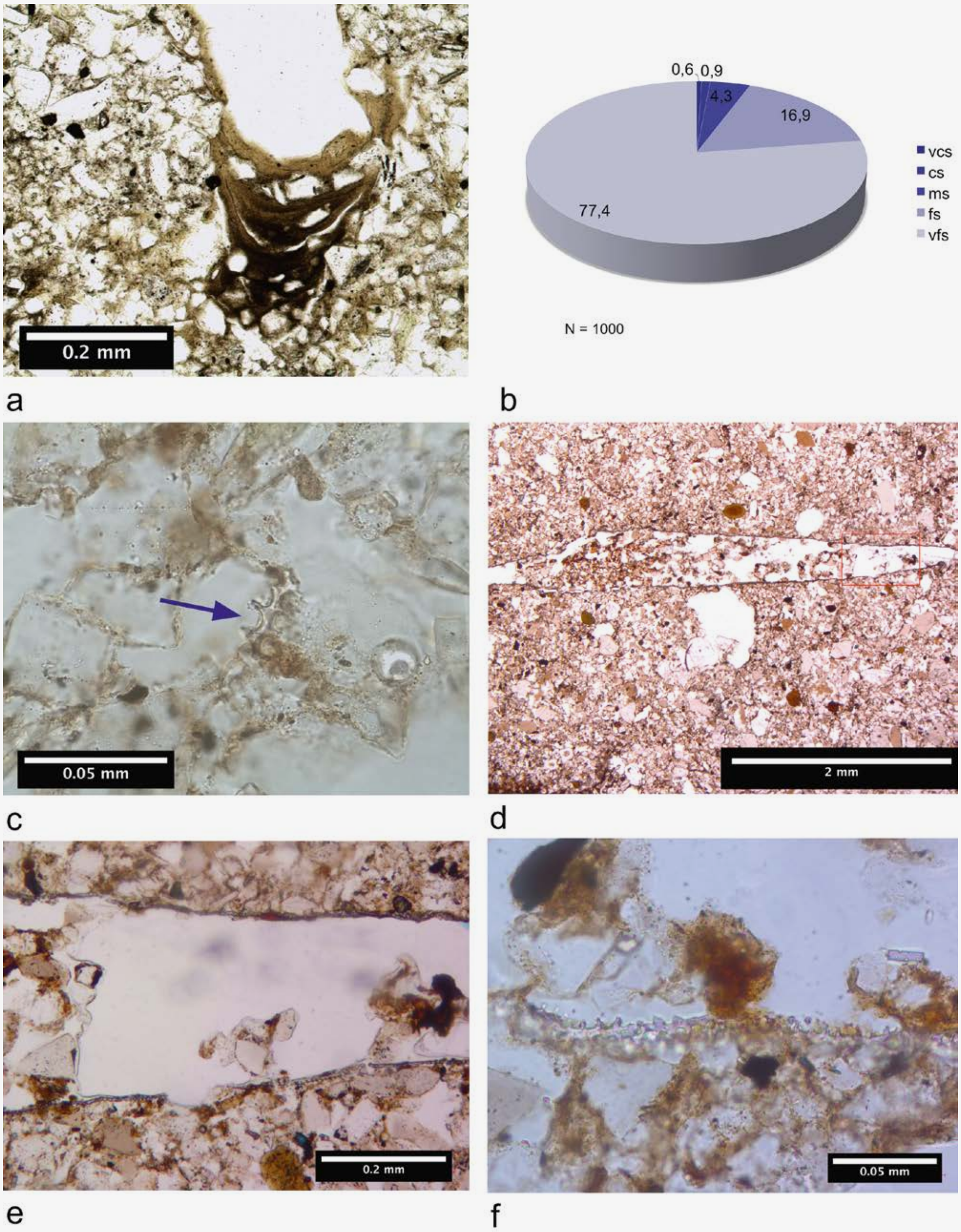

Figure 9. a. dusty clay coating (PPL)
b. graph showing the importance of the different charcoal fractions within units 2, 7 and 8; a clear dominance of the finer fractions can be noted
c. broken isolated Elongated dendritic observed within the soil matrix of the cropland (unit 7, PPL)
d. articulated Elongated dendritics (unit 25, PPL)
e. details of d
f. details of d

physical destruction of the charcoal. Furthermore, the presence of isolated and clustered phytoliths also points to physical disturbance of the soil horizon (Devos et al., 2013a; Vrydaghs et al., 2016b).

The addition of manure is evidenced by the combined presence of kitchen waste, coprolitic remains and phosphatic nodules. The anomalous thickness of the plough layer (> 10 cm) does not only result from the addition of manure, but is probably also due to the steady input of colluvium. This anomalous thickness, combined with the high degree of homogenisation further indicates the long-lasting character of the agricultural activity. The very high degree of biological activity observed in unit 7 might indicate some episodes of pasture and/or fallow.

The phytolith spectrum of the soil matrix shows the appearance of Elongate dentritics (Fig. 9c), indicating the presence of cereals. As these phytoliths can have multiple origins, a further taphonomical study was performed to confirm whether or not these phytoliths originate from locally cultivated crops. The ones that are observed within coprolites or associated with excremental remains can be related to manure. Those that show traces of heating or that are associated with charred remains indicate processing and food preparation. Clustered and isolated ones are typical for disturbed contexts (see Vrydaghs and Devos, in press) and are as such not a reliable source of information for the identification of *in situ* cultivated cereals. It is only the articulated Elongate dentritics observed within the soil matrix that indicate *in situ* decomposition of cereal remains, thus suggesting a local origin (see for instance Devos and Vrydaghs, 2009; Devos et al., 2013a; 2017) (Figs. 9d, 9e, 9f).

As the articulated systems that have been observed are not oriented in the right way, their botanical identification based on morphometric criteria was not possible (see for instance Vrydaghs et al., 2016; Wouters et al., 2019).

5. Archaeological and historical significance

Several places within the late medieval town wall hold proof of the agricultural exploitation of this area from prehistoric times until the early 13th century (De Groote 2013; De Groote 2018; De Groote and De Mulder 2018). This micromorphological study on a Dark Earth, found underneath the first town rampart and covering the early Merovingian settlement, was a unique opportunity to analyse the agricultural activities in the medieval pre-urban period of Aalst. The oldest activities, immediately following the Merovingian habitation, point in the direction of grasslands, and possibly pasture. The traces are partly erased by later agricultural activities, dating from the Carolingian period until the middle of the 11th century. Remains of an ancient field have been documented, in particular, traces of soil working, crop growing and the application of fertilizers. The micromorphological study also suggests an intensification of anthropic impact during this period. The presence of cereal pollen (including rye) and cornflower in 11th-century parcel ditches on the same site (De Groote and Moens 1995, 137), proves the existence of crop fields in the immediate vicinity.

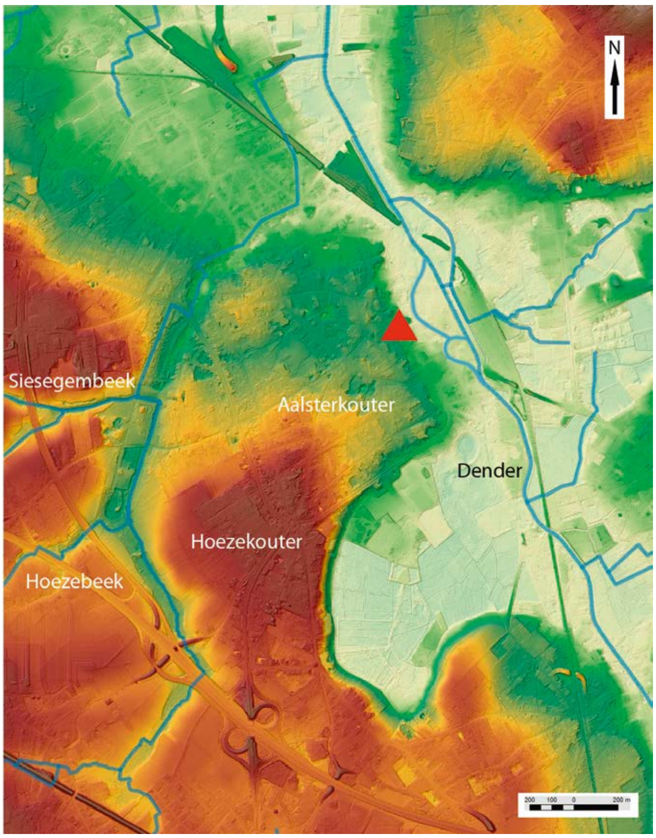

Fig. 10 Location of the “Aalsterkouter” on the digital terrain model (DTM) of Aalst (© Agiv/NGI). The oldest town centre is indicated by a red triangle.

All these data point to how these areas were already in use as arable land in the early middle ages and before. The micromorphological study shows that the use of the area as crop field was well established from the Carolingian period on. Due to its location, it is likely that this area was part of the central field of the domain of the Carolingian *Villa Alost*. In general, as known from the historical record in Flanders, the evolution from a central field, separated from small, individual fields, to a large, joined field complex occurred in the following ages (10th-12th century) (Verhulst 1995). During this period emerged the name ‘kouter’ (Lat: *cultura*), mostly with the place name as a prefix. For this reason, it seems very likely that this field complex was part of the agricultural exploitation belonging to the domain farm as its *cultura*, and of which a part was known as the *cultura de Alost* in the late medieval period (De Groote 2013) (Fig. 10).

6. Conclusions

The integrated archaeological, geoarchaeological and phytolith studies conducted on the Dark Earth of the site of ‘Sint-Jozefscollege’ permitted the identification of the main processes behind the formation of the Dark Earth on this site. It demonstrates that its formation does not result in one single anthropic activity with slowly growing horizon thickness of the Dark Earth, but rather from a succession of different activity phases, combined with colluviation and intense bioturbation. Within the Dark Earth a succession of different human activities is identified: pasture followed by crop growing. The latter involved the addition of important quantities of fertilizer, mainly manure and household waste, to improve the fertility of the initially poor soil. The identified activities confirm the rather rural character of the area until the construction of the town wall in the 11th century.

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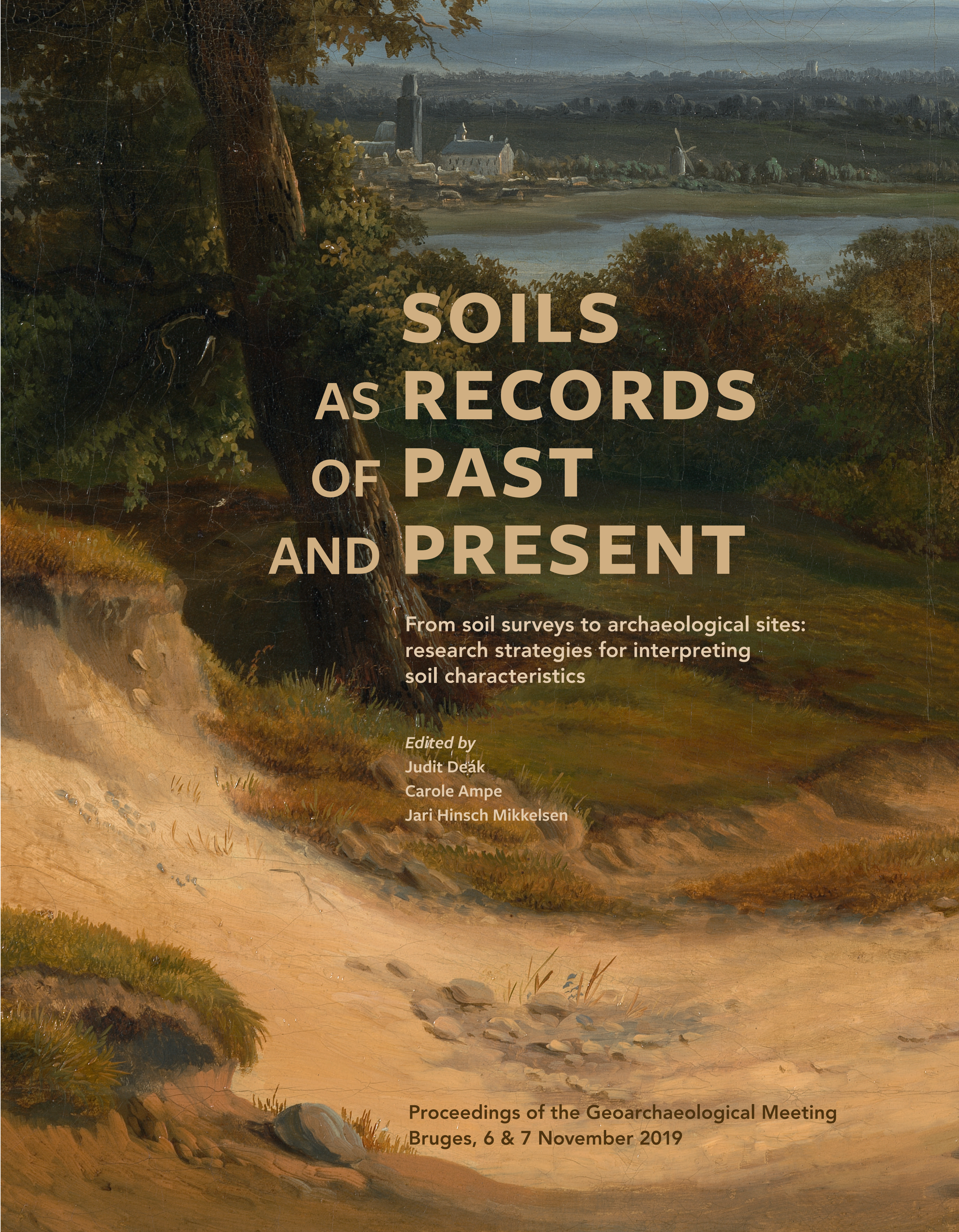

SOILS AS RECORDS OF PAST AND PRESENT

From soil surveys to archaeological sites: research strategies for interpreting soil characteristics

Edited by
Judit Deák
Carole Ampe
Jari Hinsch Mikkelsen

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TABLE OF CONTENT

3. Archaeology and soil science, unravelling the complexity

4. Past climates and environments

5. Present and future use of soil data