

Ancient Roads and Fields in Northwestern Gaul – A GIS-Based Analysis

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Abstract

This paper is a summary of the methodology and the main results of a recent (1997-1999) geo-archaeological project concerning the ancient landscapes of parts of northwestern France and Belgium. The primary goal of this project was to reconstruct and interpret, the Roman road system and land organisation in this area, as well as other ancient (pre-medieval) linear features. To understand the structural organisation in this poorly preserved ancient landscape a full battery of techniques has been deployed: e.g. aerial photography, field survey, selective excavation, pedologic and palynological analysis, regressive examination of cartographic material, etc. All data gathered was digitised and integrated in a GIS, which allowed the spatial analysis of all cartographic and archaeological information and was very helpful in locating and explaining protohistoric and Roman roads and field patterns. Important methodological problems that needed to be solved concerned the use of oblique aerial photographs and cadastral map data when studying ancient patterns in a GIS-environment.

Key words: GIS, landscape analysis, ancient roads, field systems, aerial photography

1. The basic methodology

The methods and research results presented in this paper are part of a geo-archaeological project undertaken between 1997 and 1999 at Ghent University, with the support of the Fund of Scientific Research (Flanders). In general this study was concerned with the reconstruction of the landscapes in Western Belgium during the Roman occupation, essentially the first 4 centuries of our era. But as the Roman landscape cannot be isolated from earlier evolutions, it is the pre-medieval landscape as a whole that was looked at.

The primary goal of this project was to reconstruct and interpret the Roman road system and land organisation in this area, as well as other ancient (pre-medieval) linear features using a combined set of geographical and archaeological methods. This work should ultimately lead to some understanding of the human behaviour behind the landscape structure, in particular concerning the processes of the acculturation during the Roman period. Local answers to political, economic, technological and ideological stimuli should then be evaluated in relation to the Roman influence on autochthonous land organisation.

Another objective of the study was to explore the potential of new methods of palaeo-landscape analysis in a geographical area of Northern Gaul where, until recently, very little was known about the protohistoric and Roman landscape.

The study area is the *Civitas Menaporum* (figure 1). This former administrative unit of the Roman Empire covers the coastal plain, the flat sandy area and the loamy, hilly lowlands of Interior Flanders up to the river Scheldt. It stretches from north-western France to the south-eastern Netherlands. Even more interesting than its variety of natural landscape types is an unusually clear division during Roman times into a more romanized villa landscape with a classical urban centre Cassel in the south, and a more indigenous, less exploited rural area in the north (Vermeulen 1992).

At first sight, the chosen region appeared not to have known any pre-medieval landscape structures. The area is situated just south of the regions where large protohistoric field systems of the Celtic field type have been discovered. Also, the study area is a little too far to the north to expect any profound Roman influence on the land organisation. The well-structured and essentially military Roman road network only stretched as far as the southern fringes

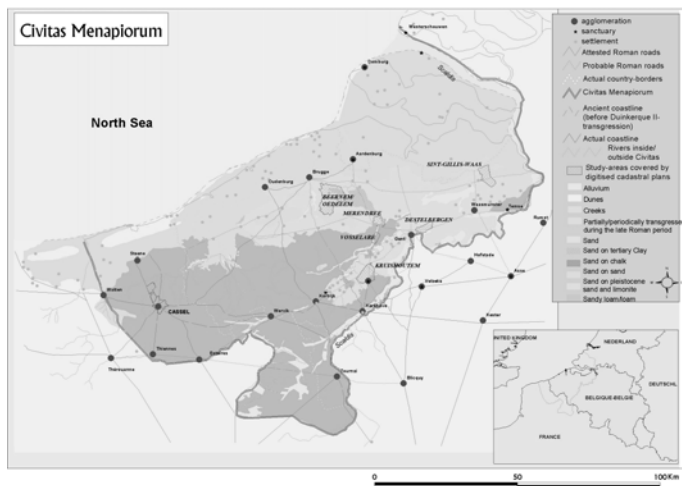


Figure 1: Localisation of the case studies and the main natural landscape types in the Civitas Menapiorum during Roman times.

of this region and only vague traces indicate a possible existence of an orthogonal Roman land division (centuriation).

Except in the surroundings of Roman capital Cassel (*Castellum Menapiorum*), most research was concentrated in the northern part of the *Civitas Menapiorum*, which is now called the Sandy Flanders landscape region. It is a sandy and lightly sandy-loamy, generally flat area situated between the river Scheldt and the coastal plain. The main reason for choosing this region as study area is the high level of objectivity and quality of the available archaeological information obtained through systematic aerial photography and numerous field observations carried out in the past 15 years.

Although the rural landscape in the study area is extremely varied and intensively used, the results of the systematic oblique photographic survey are impressive (Bourgeois et al. 1995). Currently, more than 50,000 aerial photographs, representing several thousands of settlement sites and burial places, have extended the archaeological database of the region in an almost “alarming” way for a detailed archaeological analysis (see figure 2a). Moreover, an intensification of flights since the late eighties, combined with a growing geographical approach, stimulated the discovery of many off-site features. Ancient roads, field-systems, wells, pools,

cult-places and other isolated traces in the landscape, most obviously of pre-medieval date, are some of the features that are now registered on a regular basis too. The discovery and interpretation of such phenomena offer an important additional resource to systematic archaeological research concerning the human landscape organisation of the periods concerned here.

Initially, the archaeological study consisted mainly in building a computer inventory of the “fossil” roads and fields based on the oblique aerial photographs of the Department of Archaeology of Ghent University (Vermeulen et al. in press). After charting all the relevant data, the central issue became to relate the detected linear patterns with archaeologically datable elements (see figure 2b). These fossil structures, which consisted of more than 2000 probable ancient roads and field boundaries, had to be differentiated from more recent and modern elements in the landscape and had to be interpreted and dated correctly. This meant historic-geographical and essential archaeological research at a detailed scale was necessary. The historic-geographical research involved classic regressive examination of cartographic and vertical photographic material, while the archaeological research demanded fieldwork (Vermeulen and Antrop in press).

This fieldwork included first a survey by field walking and auguring and second the excavation of selected sites. During the field campaign, several hundred selected ancient road traces and field systems were surveyed. Drillings with a simple Edelman-auger enabled us to make a detailed study of a selection of road-like features and a few supposed field ditches. Some 30 double line traces that were clearly visible on aerial photographs were verified systematically. This technique allowed us to draw some general conclusions regarding the nature of the traces, and more than once they confirmed our assumptions that these were indeed fossil roads. In general, it was fairly easy to retrace these ditches, to determine their location and to specify their dimensions (width, depth) and backfill. Sometimes a thin hardened stratum of soil constituting the original earthen road surface between the drainage ditches, was found. However, these drillings could provide only sporadic dating evidence.

Only by excavating the traces it is possible to determine their precise nature and date. Within the framework of this research, two methods were used. First a systematic and focussed study of some carefully selected traces by means of narrow sample trenches, and



Figure 2: (a) Ancient land divisions and Bronze Age burial monuments at the archaeological site of Aatrijke - Gemene Veld (prov. of West-Flanders). (b) Ancient field system at Koekelare “Bergbeek” (both aerial photographs: J. Semey, Ghent University).



Figure 3: General plan of the Roman traces (black) of roads, field ditches and farms found during the 1996-97 excavation campaign at Sint-Gillis-Waas.

second a large-scale excavation of entire systems in an open area, often as part of current rescue archaeology going on in the region.

The first method involved the digging of a series of limited sample trenches cutting across a number of fossil roads and field boundaries selected from the aerial photographs.

This type of fieldwork confirmed the existence of pre-medieval, mostly Roman, tracks and of some fields that were more or less simultaneously parcelled out. They are reassuring evidence of the fact that a considerable but as yet indeterminable part of the archaeological data consists of road and land division structures that were used in the Roman period and sometimes even before.

The second method, the open area excavation, was only applied within the scope of a number of large-scale rescue projects within the study area. Four excavations were the direct result of indications on aerial photographs, over these areas which were threatened with destruction. These *case studies* made a very important contribution to our research. They made it possible to excavate several hundred metres of Roman roads and in one particular case (Sint-Gillis-Waas) research could be done on the excavated parcel boundaries (figure 3).

Integrated with this fieldwork, colleagues from Ghent University were able to do quite a number of palaeobiological and pedological analyses. These pollen analyses, the study of macro-plant remains and detailed pedological observations, allowed us to reveal the environmental context of the line patterns detected with the help of the aerial photography, as well as the function and evolution of the various field structures.

2. GIS and spatial analysis

To be able to develop efficient methods of spatial analysis all collected data need to be integrated in a geographic information system or GIS, using a common cartographic reference base (Vermeulen 2000, Johnson et al. 1997, Jones 1997). In this study Arcview GIS 3.1 from ESRI formed the core for the integration

of data from different sources and the spatial analysis was mainly performed with Arcview's extensions Spatial Analyst 1.1 and 3D Analyst 1.0. For extraction and exploding geometrical data, procedures from ArcInfo 3.5.1. and AutoCad LT were used as well and also Microsoft Excel 97 offered interesting possibilities. Data management was achieved with Microsoft Access 97 and statistical analysis was performed with Microsoft Excel 97 and Statistica.

First, as many as possible relevant primary sources, such as maps and vertical aerial photographs were stored in this GIS, in vector or scanned versions. For the region considered this means that geographical information had to be derived from very different data sources provided by three countries: France, Belgium and the Netherlands. The integration of these data was not a simple task, as we had to deal with a multitude of sources with different data quality, scales and especially different projections. The following map-layers were integrated in the GIS: scanned topographic maps, digital orthophotographs, waterways, municipality-borders, geology, soils, a scanned version of an 18th century military map of the Low Countries and various vectored map-figures from archaeological literature. For some case study-areas we also digitised and georeferenced some 19th century cadastral plans. As the three-dimensional landform information is fundamental in all spatial analysis, we also extracted and transformed contour and height information from the scanned topographical map to build a digital elevation model (or DEM) of the same study micro-areas.

Secondly, the GIS comprised a database of all relevant archaeological information on the protohistoric and Roman periods in the *Civitas Menapiorum*. This not only includes the Roman settlement sites and other ancient findings known from earlier publications or recent fieldwork, but also all vectored excavation plans of relevant archaeological fieldwork in the area. Furthermore, the archaeological database includes all processed oblique aerial photographs, of which a majority is now scanned and stored on CD ROM. The main purpose is to store this archaeological information in a suitable way to examine vertical and horizontal relations between different archaeological sites and other elements of the landscape, like soil type, land form, geographical situation, terrain, rivers, etc. in time and space.

The oblique aerial photographs are an important data source. Several procedures had to be developed to optimise their manipulation and interpretation.

Each photograph is described in a relational database. The description contains, besides characteristics of the features, the metric co-ordinates of one point, which is clearly visible on the image and can be located easily on the topographical base-map. These reference points were entered in Arcview as a point theme that allows the creation of hot links between the GIS-maps and the photographic database. Thus, the oblique aerial photographs can be visualised easily by clicking on its map position. A first interpretation can be made by comparing the image directly with other thematic themes, such as known Roman settlements, roads and excavation-plans. Also, photographs can be selected from the database using map queries.

The photographic quality of the most interesting images was improved using imaging-software such as *Corel PhotoPaint*. Techniques such as contrast enhances, edge detection and filtering were used to improve the recognition of the marks.

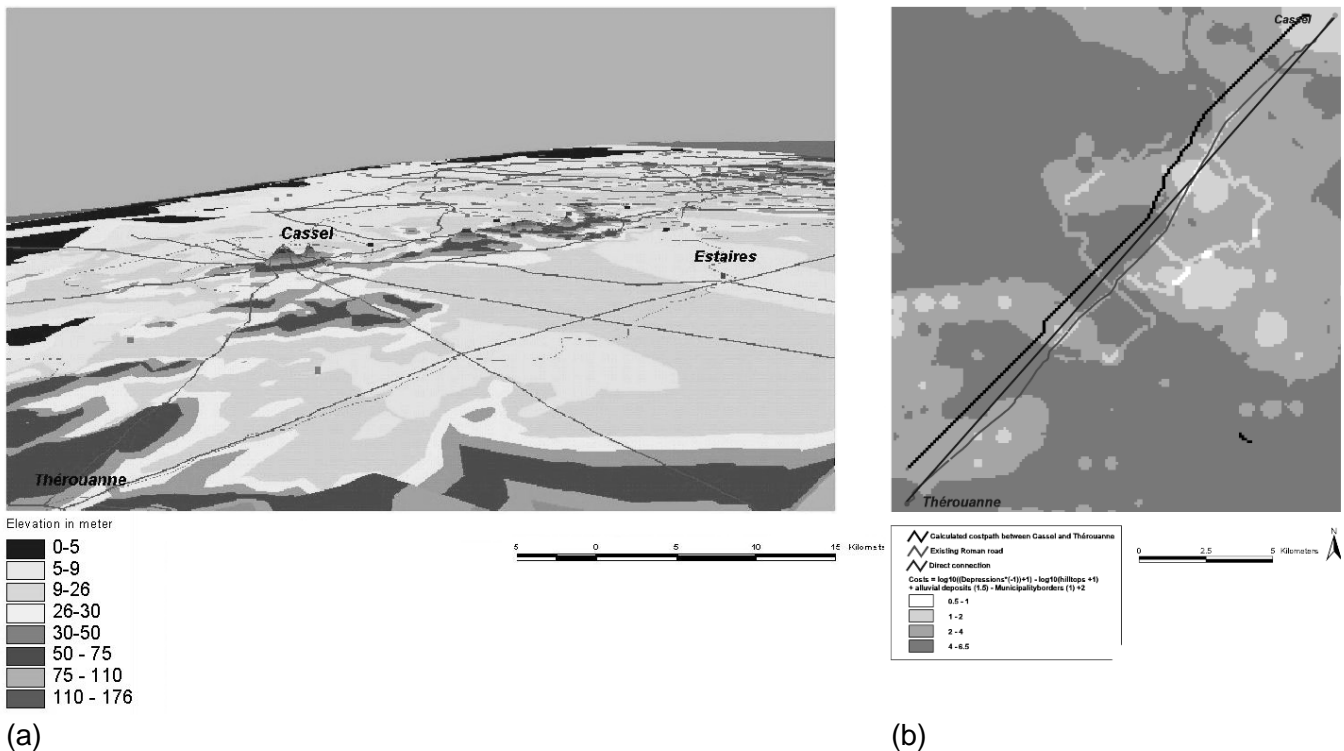


Figure 4: (a) 3D-visualisation looking from the SW to the NE, with known and supposed Roman roads and settlements overlaid of the area around Mount Cassel. (b) Cost-path analysis of the Roman road between Théroouanne and Cassel based upon the digital elevation model, the geological map and the viewshed analysis.

For the selected linear traces observed on oblique aerial photographs a method had to be developed for restitution and georeferencing these upon a common topographical base. This was achieved using the warping procedure in Arcview's Spatial Analyst. It applies a polynomial transformation of grid themes using control points (tic or tie points) that are common on the distorted image and the rectified topographical base, such as orthophotomaps. Useful tic points are the corners of the field that contains the marks.

So much for the basics of methodology. We now have a closer look at some of the analyses and results concerning the ancient roads and land divisions, which were studied. As space is limited here we will simply present a short overview of some of the most important approaches. A full publication of the results of this project is in preparation (Vermeulen and Antrop in press).

3. Ancient roads

An attempt has been made to examine the common characteristics of the limited number of well-attested and archaeologically known major Roman roads within the Civitas Menapiorum. The purpose is to derive a model to reconstruct possible connections between large Roman settlements where no exact road is known so far. The characteristics of archaeologically known Roman roads can be evaluated by map-overlapping, spatial analysis and statistical testing.

Cost surface analysis is one of the methods of spatial analysis available in GIS that was applied to study the Roman roads. It allows the modelling of route directions considering different features of the landscape and parameters of movement through the geographical environment. The connection between two places, a source and target place, is directed by the effort or "cost" to move through the landscape. The CostPath-algorithm in Arcview's Spa-

tial Analyst searches the route with the lowest accumulated "cost" between the source and target place. As many Roman roads have characteristic straight line connections, this method allows to evaluate the deviations between the theoretical and shortest straight line connection and the actual route. Deviations are compared to the local terrain conditions in order to explain them and understand the reasoning of the road builders. The results of this type of analysis can stimulate and help further research in areas where the major Roman roads are still hard to trace in the field.

This *cost path analysis* was applied on the Roman capital site of Cassel and its connection with the neighbouring major town of Théroouanne (ancient *Tarvenna*), located south of it. Roman Cassel was situated on a hilltop and became the core of a whole network of well-identified Roman roads. The connection between both cities follows the interfluvium between the alluvial lowlands of the river Aa basin in the north-west and the river Lys in the south-east (figure 4a).

The present road reflects in its major part an almost straight line connection between these two *Civitas* capitals and there is a lot of evidence that it corresponds partially to the original Roman road trace.

If we compare the Roman road with the straight line connection, several areas can be detected where the difference is more than 500 m. One of them is situated nearby Bavinchove where the reason for the choice for this particular trajectory might have been the existence of a little isolated hill, which allows better vision of the landscape. Visibility analysis using the same data in the GIS, confirmed that the visibility is much better from here than from the straight line connection (figure 4b).

The resulting cost-path, calculated from Cassel as source to Théroouanne as target, shows that the existing road fits quite well to known remnants of the Roman road. The model seems to indi-

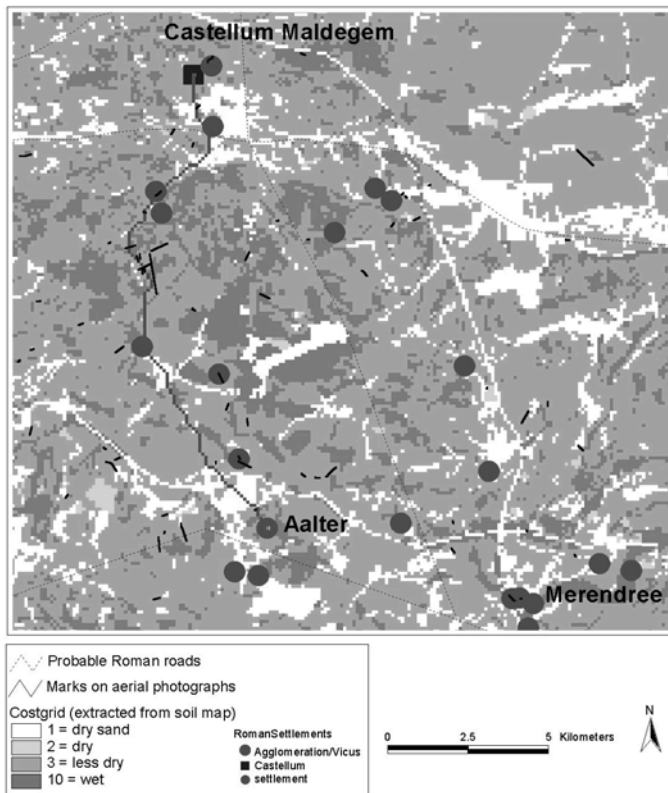


Figure 5: Cost path analysis between the Roman camp at Maldegem and the stone quarry area of Aalter in the north of Sandy Flanders.

cate that especially topographic depressions and the later developed municipality borders, often remnants of ancient roads in this region, are the main factors that explain the differences between straight line connection and the existing route.

A comparable model, based on similar parameters, was applied in the northern part of the study area where archaeological proof still lacks for the possible reconstruction of major Roman roads between the central settlements. This analysis met with some success. In some instances there seems to be a real connection between the hypothetical road trajectory and the location of recently discovered Roman sites and of fossil roads detected on aerial photographs. This kind of spatial analysis and GIS-modelling can be extremely helpful to detect corridors of high probability for major Roman road trajectories (see figure 5). It can become a valuable tool to define micro-regions where possible Roman roads have to be searched for in areas where archaeological and historical proof still lacks.

The application of these models needs detailed data with a high degree of certainty. This is difficult to obtain for the localisation of the large number of secondary and local roads. The irregularity of these roads, interconnecting minor settlements or leading from Roman or protohistoric farms towards their fields, is notorious. For the time being only a combination of systematic prospection with aerial photography and selected fieldwork can help to locate these.

Our excavation work in Sandy Flanders has shown that, although before the 18th century only earth roads and tracks seem to exist here, these minor connections can be investigated quite well. The fieldwork campaigns indicate so far that a large part of the double-linear features visible on aerial photographs can be dated in

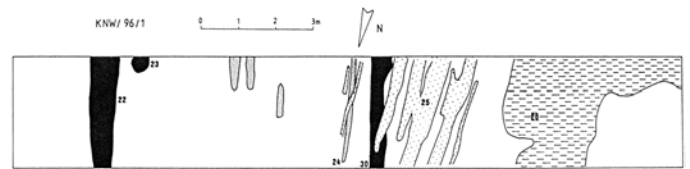


Figure 6: Knesselare: plan of the excavated pre-medieval road with ditches (22-30) and cart tracks (24) and of the cart tracks of a medieval road (25).

the Roman period, although precise dating is not easy, as the ditch fillings seldom contain numerous artefacts (figure 6). The excavated traces of these Roman roads may vary:

- Sometimes only the drainage ditches are preserved and the road surface has been completely eroded.
- When this road surface survives somehow, then a bundle or a couple of wagon tracks can be distinguished. Pedological processes such as iron precipitation often stress their presence.
- In other cases, the Roman road is succeeded by a medieval one, and a slight shift in location or orientation can be recognised.
- When the Roman road is excavated in an open area then its connection with adjoining and contemporary field-ditches could be noticed.

It is clear, however, that our selection of traces checked in the field by way of excavations is somewhat biased. Most of them already displayed surface indications, such as scatters of pottery, or the nearness of a known Roman settlement, pointing towards a possible Roman date. Therefore, it is also much too soon to draw statistically meaningful conclusions from these field checks.

There can be no doubt that many of the unexcavated road traces have a medieval or even a post-medieval date. A part of these can be isolated using techniques which analyse the relation of the old road traces seen from the air with cultural elements in the landscape. A buffering of municipality borders, which often coincide with medieval roads, is one of the possibilities. In figure 7a we see that the abandoned roads at the northern rim of the municipality of Aalter are very much related to the municipality border between Aalter and Ursel. A buffering zone of 200 m around this border allows a selection of those linear traces that are situated very close by. Several fragments of single and double lines with a mainly E-W orientation appear over a distance of some 2 km. The ditches are probably the remains of an early medieval (?) connection between Aalter and Ghent and are situated mainly on slightly elevated parts in the landscape.

However, not all traces of abandoned roads seen from the air are Roman or medieval. The use of different spatial analyses upon the GIS-database seems to indicate that some of the ancient roads and tracks might have a prehistoric date. A simple example from the northern edge of Sandy Flanders demonstrates this. A clearly visible lining of some 30 Bronze Age barrows has been discovered near the municipality border of Maldegem and Oedelem (Bourgeois et al. 1995). The barrows are spread over an area of more than 25 ha and they all are situated on dry to moderate wet sand. In the immediate vicinity of the barrows (figure 7b), a large number of field borders and a few fragments of ancient roads appear. The field borders do not show one main orientation, which may indi-

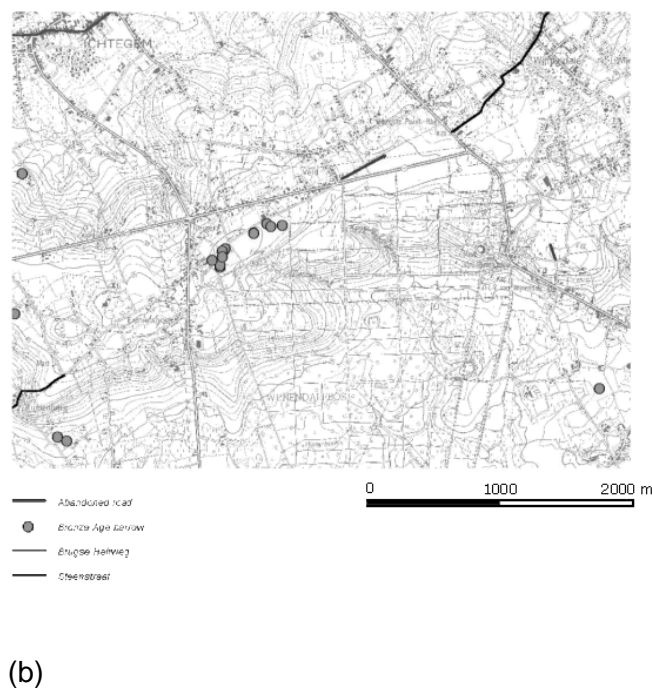
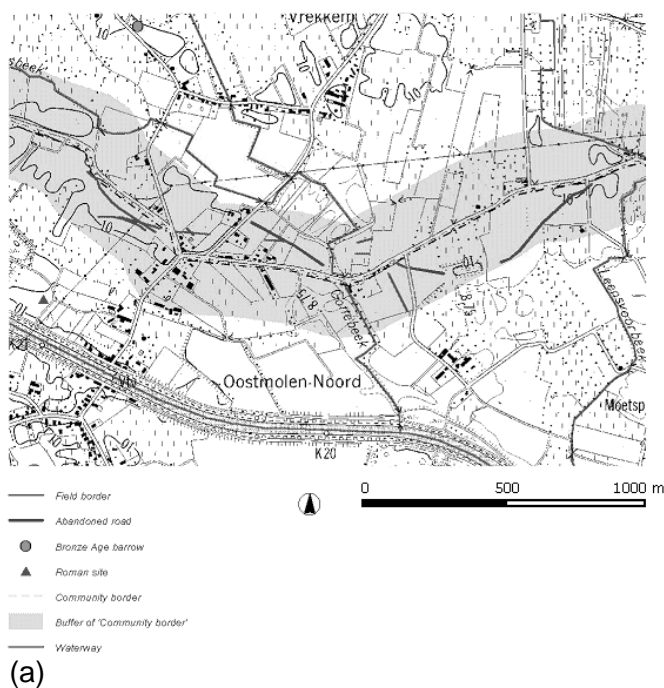


Figure 7: (a) The municipality borders between Aalter and Ursel and associated linear traces visible on aerial photographs. (b) Fragment of an ancient road connecting two parts of the “Roman” Steenstraat and other ancient features visible on aerial photographs.

cate their different chronology, but the orientation of the longest ancient road segment might suggest contemporaneity with the Bronze Age cemetery.

To conclude this section on the ancient roads, it must be clear now that the implementation of the results of aerial photography in the GIS environment, opens up a whole set of possibilities for studying so-called “fossil” roads, routes and tracks. The overlay of the archaeological traces with different thematic maps and geographical information and the use of spatial analysis in relation to physical and cultural aspects of the landscape offer great opportunities. Although confirmation in the field remains essential, firm hypotheses about the date and interrelation of a wide range of road traces can be constructed.

4. Field systems

Most of the detailed research concerning field systems was carried out in smaller micro-regions in which we had recent and reliable information. Six of these test areas lie within the Sandy Region, one in the south around the Roman urban centre of Cassel.

Different types of analyses were carried out, which will be summarised briefly here.

In the surroundings of the town of Cassel, spatial analysis in the GIS-environment was used to check the possible existence of a Roman normative land division (Antrop et al. in press). Several authors suggested recently that the rural landscape in a wide area to the south-southwest of Cassel and possibly even in other directions shows clear marks of Roman centuriation (Jacques 1987, Roumegoux and Termote 1993, Malvache and Pouchain 1994). In particular the hypothesis put forward by François Jacques, concerning “classic” 710 by 710 m module land divisions with orientations ranging from 31° NW (north of Cassel) to 35° NW (south of Cassel), has many followers. This work, mainly based

on the visual analysis of 19th and 20th century topographic maps, has never been tested in the field.

We checked the centuriation idea, not yet supported by field research, using digital overlays of different maps and by directional filtering the major landscape structures in the area. The analysis shows the classification of the orientation of field boundaries overlaid upon the presumed centuriation grid for the area around Cassel. The most significant concentrations of line segments are situated here in the intervals -25° to -35° and 55° to 65°, confirming a dominant north-west orientation of 31° (+/- 5°) as proposed by Jacques. Interesting to note is that some orientations agree rather well with the direction of the Roman roads, such as the ones towards the salt producing sectors on the edge of the former coastal area. However we must recognise that some orientations are also parallel to the drainage flow of the nearby Peene river, which could well have influenced the direction of field systems in Roman times.

In certain areas a more detailed observation of the cadastral field boundaries selected for directions between 26° and 36° shows much more “centuriation-oriented” field edges than published by F. Jacques in 1987. This illustrates well the potential of GIS based spatial querying on digitised ancient cadastral documents. It offers not only more detailed and flexible approaches for testing of centuriation hypotheses, but it also delivers basic maps for precise testing in the field.

After an inventory had been made of all ancient field systems on oblique aerial photographs in the region of Sandy Flanders, and the relevant traces were charted, the problem of interpreting and dating the structures became crucial. The surveyed micro-region is almost completely covered with sandy soils that facilitate agriculture, requiring less manual labour input. As these soils provide a good basis for agriculture, there is a high probability they have been used for longer periods during history. Light soils also reveal many features in aerial photography. However, these are seldom registered complete in one observation. Their visibility

strongly depends upon meteorological conditions, crop type and phenology of the vegetation. Hence, many observations in the most diverse conditions are necessary to obtain some coherent view. Also, all features, dating from different periods, are seen superposed, which makes their interpretation difficult.

The perceivable ditches might most probably also be a combination of multi-periodical land use (figure 8). Thus, it is impossible to assign a chronology to these features without excavating them.

It is even very difficult to establish a typology of the traces (Boissinot and Brochier 1997). In this study a purely morphological typology of the linear structures was attempted, for which it is still impossible to attach any chronological meaning.

Besides this purely morphological approach of linear ditches and field borders, the relationship of these features with surrounding elements is more significant in many cases (Chouquer 1997). These context elements can consist of environmental features, such as a river or a difference in elevation, or cultural features caused by human intervention, such as a road or other ancient structures.

In some cases both can offer good possibilities to collect some evidence about the chronology of the field structures. Two examples illustrate this.

- In the close vicinity of Ghent, several areas between 15 and 70 ha could be selected where the occurrence of traces could be associated clearly with environmental conditions. The traces indicated Bronze Age burial mounds and field ditches in close relation to slightly higher and drier sandy soils and could indicate of the nearness of the supposed settlement sites and surrounding fields. The zone shown here (figure 9a) is divided by the community border and consists of land sections which form a well preserved half-circle truncated by a brook. The total zone covers 70 ha, providing more than enough space for living and burying the death.
- The relation between the attested field borders and parallel traces or roads has also been examined. This example is situated in the municipality of Zingem where a regular arrangement of a field system was detected. The field borders, spreading over an area of about 13 ha are situated in the immediate vicinity of a recently discovered Roman settlement, cemetery and coin hoard. The ensemble consists of a framework of regular lines with a parallel or perpendicular orientation towards the presumed protohistoric and Roman road between the rivers Lys and Scheldt (figure 9b). The intermediate distance between the ditches is rather small, the estimated plot size varies between 0.6 and 1 ha. The field system is clearly the result of an organized construction, but the supposed Roman character still has to be proven by means of excavation.

Field excavation has been used in the more romanised landscape of the south of Sandy Flanders in a number of cases, such as with the field system discovered in Kruishoutem. Between two regional centres several field borders and a possible local road were found perpendicular to the Roman road. Like the major road they were dated in the 1st and 2nd centuries AD. Pedological and palaeo-botanical evidence suggest that the fields adjacent to the road system were mainly in use as meadows.

The discovery and precise dating of these systems gave us the opportunity to do some further GIS-analysis in the surroundings

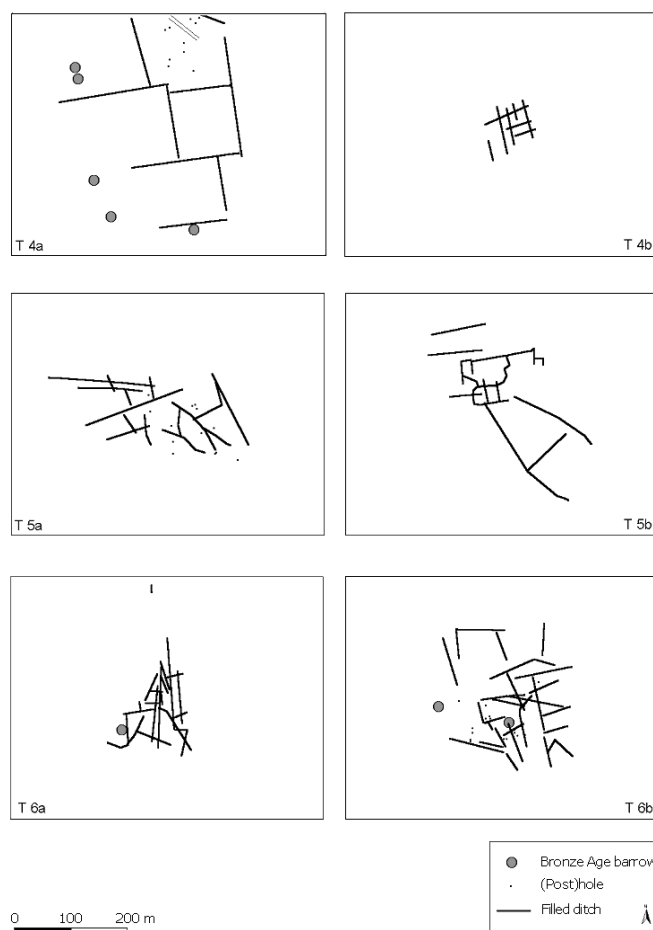
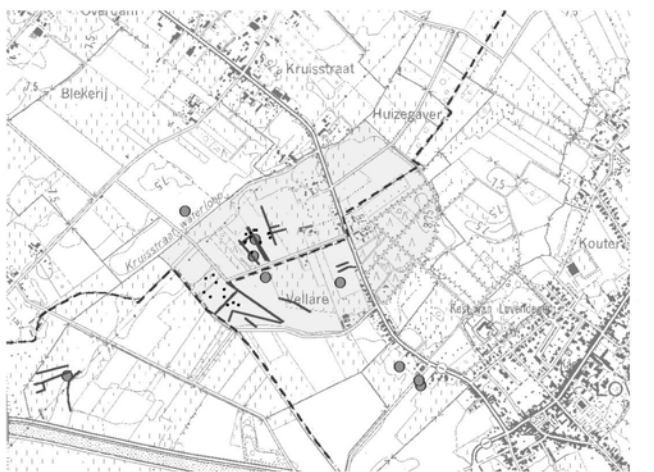


Figure 8: A selection of types of ancient field systems on aerial photographs in Sandy Flanders.

of these ancient features. The digitized cadastral plans of the beginning of the 19th century, allowed us to compare the orientation of the fields dated as Roman with the former land division of the whole municipality.

On the map representing the field border orientation four different concentrations of one dominant orientation can be recognised (figure 10a). These correspond to four different geomorphological land facets having different slope aspect, drainage conditions and soil types:

- The centre is situated on the most elevated zone of this study-area, with a flat terrain and where sandy soils dominate. The main orientation is north-east and the fields are quite large. The Ferraris map of 1770 shows that the landscape was characterised then by open arable land.
- In the Northwest on the valley slope of the river Lys, the same dominant northeastern orientation is found, which corresponds to the orientation of the waterways and the slopes, which can be up 5%. In the surroundings of the Gaverbeek where the terrain is flat, the field system is oriented perpendicular to this river, showing a main north-north-eastern orientation. This orientation is also found in small clusters in the immediate surroundings of the modern centre of the settlement of Kruishoutem, as well as close to the west of the Roman *vicus*.
- In the East sandy loamy soils dominate and the slope aspect is Northeast. The hydrography is oriented east-north-



(a)



(b)

Figure 9: (a) The possible burial zone on the communities of Zomergem and Lovendegem. (b) A possible framework of Roman field boundaries near Kruishoutem.

east and the major field borders have an orientation perpendicular to the waterways.

- In the South the field orientation is less concentrated than in the other parts of the study area. The dominant orientation is east-north-east, but disturbed by the second dominant north-eastern orientation.

Further analysis shows that the marks of the Roman cluster are correlated with a cluster of north-north-eastern and west-north-western oriented field systems of the 19th century cadaster map. Further research must confirm whether these might also be relics of the ancient field systems.

A comparable case study was achieved in the municipality of Sint-Gillis-Waas. Here the study area is situated far from known important Roman roads and settlements at the northern border of the *Civitas Menapiorum* where the romanisation of the settlements is rather low. No Roman roads or settlements were known here until very recently when two Roman field systems, some Roman houses and local roads were discovered by excavations. As the Roman road is not very straight and situated far from the main network of Roman roads in the Civitas, only the orientation of the ancient field systems has been examined here.

As the vectored cadastral map shows (figure 10b), the majority of fields are oriented between -30° (ENE) and 10° (N). This can be explained by the orientation of the drainage which is west-east oriented and most of the fields are perpendicular to the hydrography. In the south of the study area the orientation of the field system seems to be perpendicular to the main road (Reepstraat), which turns to the Southwest in the western part of the area and to the Southeast in the eastern part. The corresponding orientations of the field system range from -40° (NE) in the west to 10° (N) in the east.

In the centre and in the north, where sandy soils dominate, the main field orientation is northeast. Here, where the study area was covered by woods in 1770 as shown on the Ferraris map, the fields are much larger than in the rest of the study area.

The most complex cluster of marks is concordant with the 19th century cadastral divisions and absolutely parallel to the excavation plan of Roman fields near the Reepstraat. Because the marks complement the Roman fields very well we may suppose that the excavated Roman field system could once have been part of a much larger system of land division. However, no causal proof for this observed matching can be determined as many factors and chance might be implied.

A part of the study area is situated in the polders of the river Scheldt where a concentration of east-north-eastern oriented fields can be recognised.

Generally, the field systems are oriented perpendicular to the actual natural drainage system, which most likely had the same general direction during the Roman period.

5. Some conclusions

The greatest challenge in landscape analysis is the investigation of the *cultural landscape* (Vermeulen and De Dapper 2000). Certain aspects of the cultural landscape can be interpreted very easily, such as the location of cities, cemeteries and rural settlements. More complex archaeological and historical landscape features, such as segments of roads, networks of tracks and whole field systems, demand more effort and care to get integrated in a GIS and their spatial analysis and interpretation asks for sophisticated geographical skills. Typical problems concern the understanding of “black box” procedures available in a GIS, dealing with uncertainty and error propagation and the critical assessment of the historical meaning of ancient and actual landscape structures as revealed by aerial photographs and maps.

However, the project on the *Civitas Menapiorum* showed some convincing results of the application of GIS and spatial analysis for the efficient processing and integration of the most diverse data sources that are significant for study of the ancient land or-

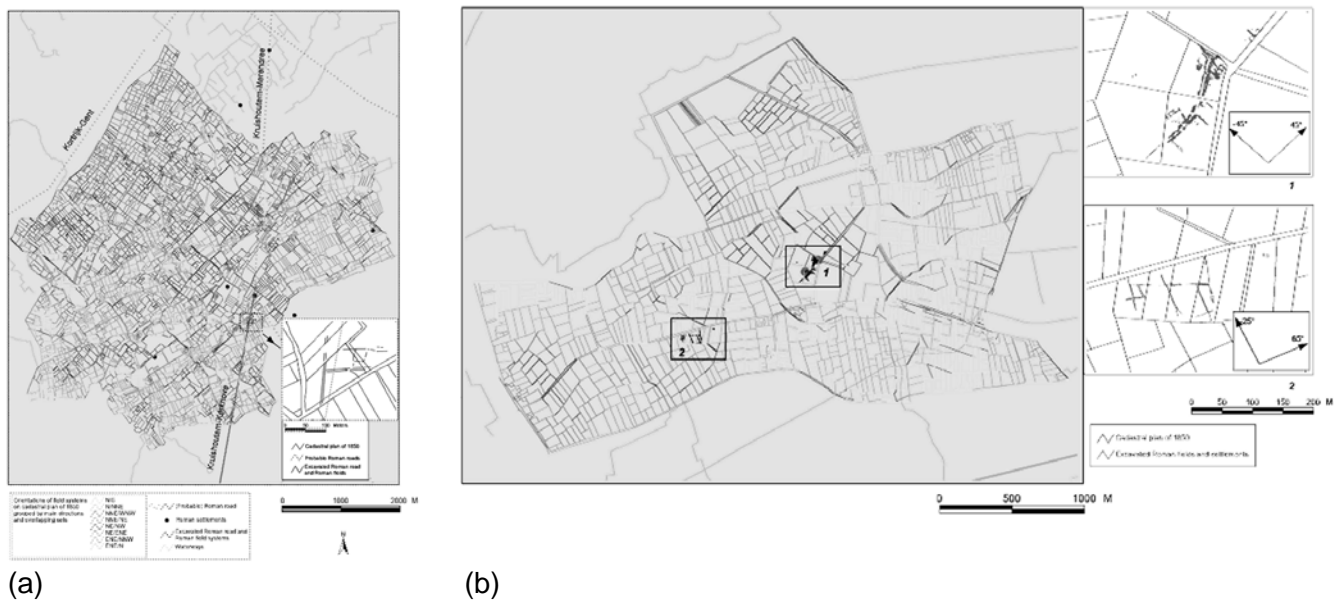


Figure 10: (a) Kruishoutem: cadastral plan of 1850 and excavation plan of a Roman road and possible Roman fields. GIS-filtering of the field boundaries according to the major orientations. (b) Sint-Gillis-Waas: GIS-filtered cadastral plan of 1850 and excavation plans of Roman field systems.

ganisation. The advantages are multiple and only some will be summarised here:

- data about the physical environment (topography, landform, soils) can be well integrated in a GIS-environment and spatial analysis can be shown to be a valuable tool for explaining Roman and other ancient roads and field patterns;
- a more complete use of oblique aerial photographs when studying such patterns is now possible;
- the cadastral map data, which are so important because of their historical dimension, can be used more efficiently for the spatial analysis of ancient field systems.

The examples shown here demonstrate, however, that detailed archaeological surveying and in particular stratigraphic excavations will remain essential to support even the best hypotheses. This is especially true when confronted with a type of archaeological features, *in fact just some lines in the landscape*, which present a whole range of problems concerning their historical interpretation.

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