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*JAN TRACHET, SAMUËL DELEFORTRIE, KRISTOF DOMBRECHT, JAN DUMOLYN, WARD LELOUP, ERIK THOEN, MARC VAN MEIRVENNE, WIM DE CLERCQ**

Turning Back the Tide : The Zwin debate in perspective. A historiographical review of the medieval port system northeast of Bruges

1. INTRODUCTION

> *And so, having enjoyed favourable winds, they crossed the sea and touched at a landing site not far from the castle of Bruges. The […] town is inhabited by Flemish settlers, and enjoys very great fame for the number of its merchants and for its affluence in all things upon which mankind places the greatest value*[1].

As the 11th-century *Encomium Emmae Reginae* describes, Bruges became a leading European cultural and economic centre during the Middle Ages. The specific position it held within transcontinental and maritime trade route networks played a crucial role in this development. Lying inland, a navigable connection to the sea was not self-evident for Bruges. In order to attain and retain such connections, natural creeks were connected with man-made canals, dams and sluices, creating a port system that was named *totum pro parte* after its main waterway : the *Zwin*[2]. At the borders of the main creek, a series of Zwin cities developed, including *Damme*, *Monnikerede*, *Hoeke*, *Mude* and *Sluis*. These cities functioned as a network of outports, which shaped the region into a linear suburban extension of Bruges. The land that was cut across by this port system simultaneously evolved from natural mudflats and saltmarshes into an embanked agricultural landscape. To make these wetlands arable and liveable, a vast network of dikes and ditches were constructed, which resulted in seemingly opposed interests : on the one hand, searching a navigable way to the sea, and, on the other, protecting the land against flooding. Both incentives stimulated innovative hydrological engineering and had a far-reaching impact on the coastal landscape.

In spite of this hydraulic *tour de force*, the silting up of creeks and canals turned out to be geomorphologically inevitable, and ultimately Bruges lost its vital connection to the sea[3]. The subsequent commercial downturn of the port functions of Bruges in the 16th century proved that outports, such as *Monnikerede* and *Hoeke*, were not viable without the port network in which they were founded[4], which

*. — Jan Trachet, Historical Archaeology Research Group, Department of Archaeology, Ghent University, Sint-Pietersnieuwstraat 35, B-9000 Ghent, Belgium ; This review is conducted as part of the Research Foundation Flanders (FWO)-funded project, Medieval Bruges and its outer ports. A landscape-archaeological contribution to the Zwin debate (3G004013). We thank drs. Russel Palmer for his valuable comments and linguistic corrections ; Samuël Delefortrie, Research Group Soil Spatial Inventory Techniques, Department of Soil Management, Ghent University, Coupure links 653, B-9000 Ghent, Belgium ; Kristof Dombrecht, Research unit Economy, Ecology and Demography, Department of History, Ghent University, Sint-Pietersnieuwstraat 35, B-9000 Ghent, Belgium ; Jan Dumolyn, Henri Pirenne Institute for Medieval Studies, Department of History, Ghent University, Sint-Pietersnieuwstraat 35, B-9000 Ghent, Belgium ; Ward Leloup, Henri Pirenne Institute for Medieval Studies, Department of History, Ghent University, Sint-Pietersnieuwstraat 35, B-9000 Ghent, Belgium ; Erik Thoen, Research unit Economy, Ecology and Demography, Department of History, Ghent University, Sint-Pietersnieuwstraat 35, B-9000 Ghent, Belgium ; Marc Van Meirvenne, Research Group Soil Spatial Inventory Techniques, Department of Soil Management, Ghent University, Coupure links 653, B-9000 Ghent, Belgium ; Wim De Clercq, Historical Archaeology Research Group, Department of Archaeology, Ghent University, Sint-Pietersnieuwstraat 35, B-9000 Ghent, Belgium.

1. — Campbell, Keynes 1998, p. 46-47.

2. — *Zwin* is in its broadest sense generally used to denominate the large tidal area that functioned as the gateway for medieval Bruges. What we denominate as *Zwin inlet* refers to the largest tidal branch that was dammed in *Damme*.

3. — Ryckaert 1982.

4. — Sosson 1993.

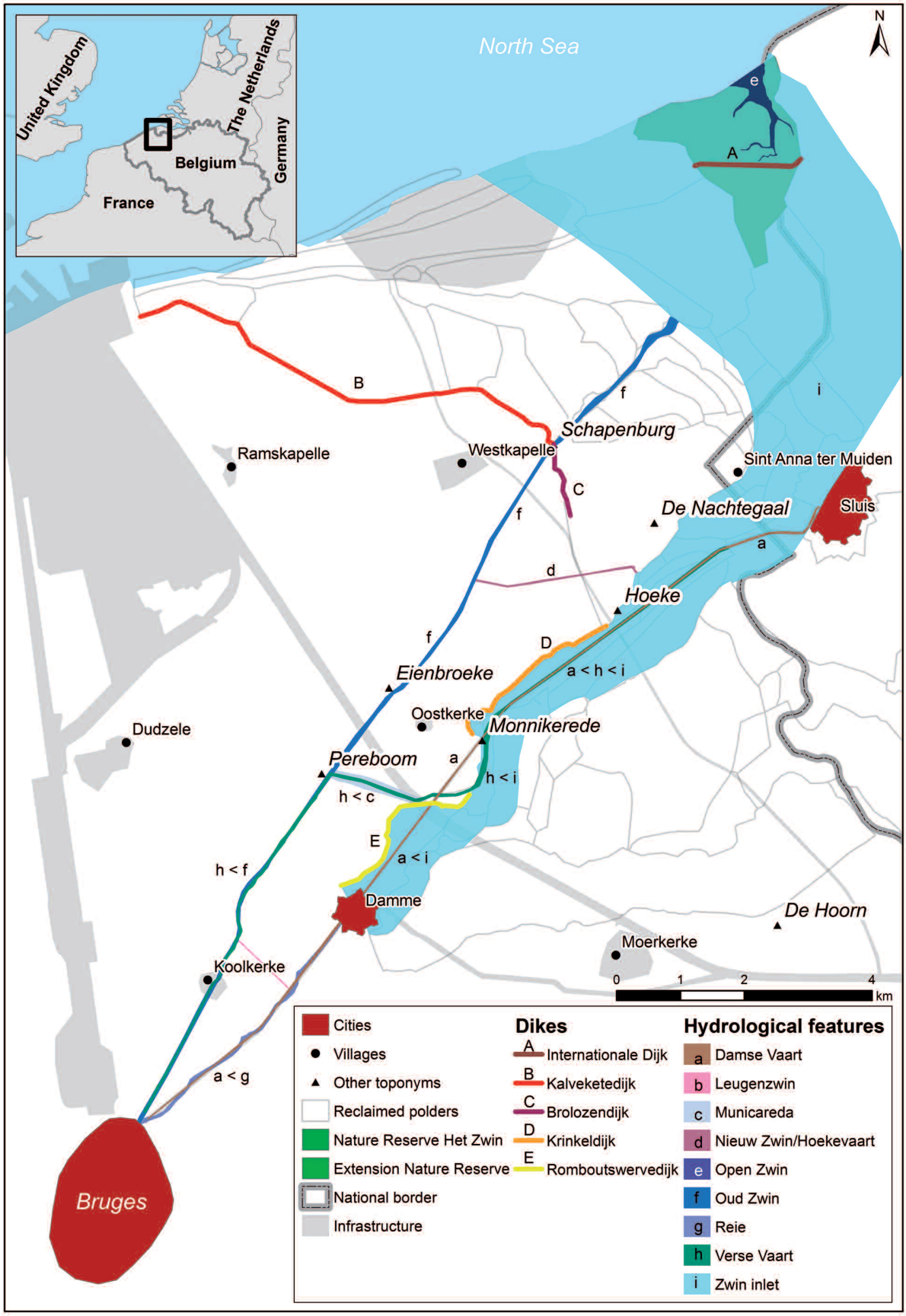

FIG. 1. — *Abstract map of the Zwin region with indication of the dikes (A-E), hydrological features (a-i), and toponyms : (A)* Internationale Dijk, *(B)* Kalveketedijk, *(C)* Brolozendijk, *(D)* Krinkeldijk, *(E)* Romboutswervedijk *; (a)* Damse Vaart, *(b)* Leugenzwin, *(c)* Municareda, *(d)* Nieuw Zwin/Hoekevaart, *(e)* Open Zwin, *(f)* Oud Zwin, *(g)* Reie, *(h)* Verse Vaart, *(i)* Zwin inlet. *As the course of some waterways is overlapping, their mutual relation is explained by the symbol '<'. For example 'h<f' means that the younger* Verse Vaart *(h) is dug into the former bed of the older* Oud Zwin *(f).*

resulted in their eventual desertion. Although multiple economic stimuli were the driving force behind landscape transformations in the medieval period, it would be post-medieval military policies that marked the landscape in the subsequent centuries. Today, the large-scale inundation resulting from intentionally breaching dikes during the Eighty Years' War, the line of defensive works built by Louis XIV and the Napoleonic canal between Bruges and *Sluis* remain the most visible landscape features.

Conflicting views and intense discussions over the development of the medieval port system has resulted in a controversy which we denominate as the *Zwin debate*. For more than a century (1871-2014), this controversy was chiefly pursued by historians and soil scientists, who used written sources, historic maps and soil maps. Apart from traditional prospection research[5], archaeological input was virtually non-existent. However, the last decade has seen spectacular advancements in landscape archaeology with the development and application of innovative, non-invasive prospection techniques, such as aerial photography, LiDAR and geophysics. Moreover, recent research in areas surrounding the Zwin have revolutionized the understanding of the morphology and evolution of such transformed wetlands[6]. These studies have also insisted on reinvigorated parallel research on a regional scale, although the application and integration of new techniques and studies have not yet been fully established with respect to the Zwin debate. An integration of traditional and innovative interdisciplinary research will not only grant more insight into the geomorphology of the eastern corner of the Belgian coastal plain, but also clarify early medieval commercial expansion of the region. In addition, such an approach has potential for detecting the exact location, layout and quality of preservation of deserted Zwin cities. This valuable information may also provide a solid basis for further use in heritage management, environmental planning and public archaeology initiatives.

The aim of this paper is to critically review previous attempts to characterize and understand the Zwin area; focussing on influential published works that have centred round and shaped the Zwin debate. It will offer a platform for renewed research into one of Europe's leading yet little-known medieval port networks. In the first section, we will offer an overview of nearly 150 years of research, divided into four characteristic phases. The second section focusses on two landscape components, which, in our opinion, are crucial for a relative dating and geomorphology of the area: the *Oud Zwin* and the *Krinkeldijk*. The topography of these linear features will guide us through this unique historical land- and seascape. Finally we will show how the integration of new data and techniques will contribute to a better understanding of the Zwin area (fig. 1).

2. THE ZWIN DEBATE: TRENDS IN RESEARCH

Louis Gilliodts-Van Severen indirectly opened the Zwin debate in 1871 by studying and publishing the inventories of Bruges' archive. In the same year, the occlusion of the tidal Zwin inlet was finalized with the construction of the *Internationale Dijk*[7], reclaiming the new *Willem-Leopoldpolder* on its landward side and leaving an area of mudflats and saltmarshes at its seaward side. This untouched mouth of the *Zwin* has been protected as a nature reserve since 1952[8]. Due to progressive silting of the tidal inlet, the ZTAR LIFE + project has been launched in order enlarge the tidal area and give the water, mudflats and wildfowl more space[9], which, in 2014, coincides with the start of the current study.

Historiographically, the 142 years of research between 1871 and 2014 created a debate that pits historians against soil scientists, academics against amateurs, urban versus rural approaches, and regional versus international perspectives. Moreover, geomorphologically, after a millennium of embanking, the tide has turned with this first « unembankment » in the Zwin area.

2.1. The Zwin debate begins (1871-1945)

In addition to archival work, Gilliodts-Van Severen was the first to study Bruges' connection to the sea[10]. Although he focussed on the 16th-century situation rather than including earlier phases, his work resulted in the opening up of archives and set the tone for subsequent research. Unfortunately, due to some geographical misinterpretations, his work also caused long-lasting confusion concerning the names of some canals. A second contributor worth mentioning is the priest and local historian Opdedrinck. He studied the archives of *Damme*, inspiring future local historians and laying down the foundations for amateur histori-

5. — Hillewaert 1984.
6. — Soens 2009; Thoen, Borger 2013a.
7. — The name of the dike translates into *International dike*, which refers to the fact that it intersects the Belgian-Dutch border.
8. — Burggraeve, Decleer 1991, p. 41.
9. — ZTAR: Zwin Tidal Area Restoration. See http://www.natuurenbos.be/nl-BE/over-ons/projecten/Ztar.
10. — Gilliodts-Van Severen 1895.

ography of the Zwin region[11]. The first author venturing into the origins of the Flemish coast was Edouard Jonckheere[12]. Although his descriptions of the geomorphology of the Zwin inlet are vague, one of his reconstruction maps clearly suggests a large coastal inlet reaching Bruges in the 4th century[13]. A few years later, Jonckheere also made an attempt to describe the pattern of dikes and waterways[14]. Raoul Blanchard's study of the Flemish coastal plain and the evolution of the Zwin area built on Gilliodts-Van Severen's data[15]. Hence, Blanchard did not manage to correctly situate the canals in time or place either, which is clear from his reconstruction maps. More importantly, was his general view on the geomorphology of the coastal plain. He considered the Zwin as a large 5th-century inlet which reached Bruges and gradually silted up, without any natural catastrophes. Next, Rudolf Häpke paid more attention to historical geopolitical and economic questions, leaving geomorphology aside[16].

After these rather general contributions and the interruption of WWI, it was not until the 1930s that the brothers Antoine and Jos De Smet thoroughly studied the history of the Zwin and its ports. Antoine De Smet, who is regarded as one of Belgium's founders of historical cartography, was the first to relate written evidence to cartographic sources and pre-cadastral documents[17]. As a consequence, he was able to offer a more structured and detailed topographical description of the waterways, whereas his predecessors remained rather vague and unsure[18]. He also succeeded in unravelling the confusion about hydronyms, such as the *Verse Vaart, Oud Zwin* and *Nieuw Zwin*[19]. As for the geomorphology of the region, he used Blanchard's model of the silted-up inlet, but adjusted it by arguing that, during the process of sedimentation, not one – the proper *Zwin* – but several waterways remained open in between accreted islands. In particular, the *Oud Zwin* was now attributed more importance. For the first time it was regarded as a proper, navigable and natural waterway[20]. Apart from this influential contribution, both Antoine and Jos De Smet frequently published more popular papers, through which an interest in the history of the *Zwin* became more widespread amongst a less specialised audience.

The last two contributions to this first phase of the Zwin-related research conformed to Blanchard's point of view, but approached the subject from a more regional(istic) perspective[21]. Both authors started with a geological introduction but diverged later, with Maurits Waterschoot focussing on dikes, embankments and water boards, and Jozef De Langhe concentrating on the evolution of the eastern coastal plain. In fact, these two works did not present new information but were aimed at synthesizing the existing data and translating it into a comprehensible narrative for a broad and Dutch-speaking public. As non-professional historians they are forerunners of a trend that would return after the dust of World War II had settled.

All in all, in its initial phase, the Zwin debate was opened by the dissolution of historical and geological data. It was overall assumed that a large inlet gradually silted up during the Middle Ages. This was considered to be a natural process in which no drastic changes occurred and in which human actions had little or no influence.

2.2. Stepping up the academic input : two colloquia (1945-1978)

In the decade following WWII, a new and crucial research phase arose through close academic cooperation between historians and soil scientists. The historian-soil scientist duo, Jan Dhondt and René Tavernier, converged on their growing interests in the genesis of the coastal plain. Dhondt's interest developed from his studies of the County of Flanders[22], while Tavernier analysed the quaternary deposits of the coastal plain and revolutionized perceptions of its development. In summary, he adopted the interpretation of the *Asise de Dunqerque* being a transgression deposit[23] and subdivided it into a series of individual transgressions[24]. In doing so he ruled out Blanchard's model of a gradually reducing inlet and replaced it with a model in which three successive phases of marine transgression radically reshaped the landscape.

Through the mediations of both men, the ideas of another, younger, duo – historical geographer Adriaan

11. — Theerens 1996.
12. — Jonckheere 1903.
13. — Jonckheere 1903, p. 55.
14. — Jonckheere 1912.
15. — Blanchard 1906, p. 191-200.
16. — Häpke 1908.
17. — These documents are known as *ommelopers* and give a geographical overview of set of land parcels in order to collect specific taxes to finance local water management.
18. — De Smet 1933 ; De Smet 1934.
19. — De Smet 1933, p. 1024-1025.
20. — De Smet 1933, p. 1030-1059.
21. — Waterschoot 1939 ; De Langhe 1939.
22. — Dhondt 1948, p. 344.
23. — Briquet 1930.
24. — Tavernier 1948.

FIG. 2. — *Claeissens' copy of Pourbus' geographically accurate map of the Franc of Bruges (1571), depicting the 16th-century landscape northeast of Bruges*. © Musea Brugge, Groeningenmuseum. Lukas-Art Flanders VZW.

Verhulst and soil scientist Jean Ameryckx – were brought together in a 1958 colloquium[25]. At that time, Verhulst was preparing a study of the formation of water boards[26] in the coastal plain. Ameryckx was working in the national subsoil programme, focussing on the coastal area and was supervised by Tavernier. In the programme of soil mapping, Tavernier's tripartite division was applied, albeit sometimes reluctantly[27]. The 1958 colloquium was thus aimed at integrating new pedological and geomorphological insights with historical sources, and eventually resulted in the construction of the Dunkerque Transgression Model. This model had a profound and lasting influence on the general interpretation of human-landscape interactions throughout time in the coastal plains of the Low Countries[28]. In this first multidisciplinary model, three subsequent marine strata of clay were correlated to both an oscillating sea-level and the presence or absence of archaeological finds, toponyms and historical records. As a con-

25. — AMERYCKX, VERHULST 1958.
26. — Soens explains water boards as « local organisations that since the 13th century were responsible for the construction and maintainance of dikes, waterways and discharge sluices in the Flemish coastal plain. » (SOENS 2006, p. 35.)
27. — AMERYCKX 1953 ; MOORMANN, AMERYCKX 1950.
28. — ERVYNCK, BAETEMAN 1999.

sequence, it was argued that the transgressive periods introduced uninhabitable environmental conditions, and were interrupted by periods of marine regression in which the coastal plain was again occupied. On three out of the four items addressed by the colloquium, a tentative agreement was reached. The fourth item, the connection of Bruges with the sea between the 9th and the 11th centuries remained unsettled[29].

One of the most notable contributions to the Zwin debate resulting from the intensified research was pinpointing the creation of the tidal Zwin inlet to AD 1134, and relating it to transgression III-B. Verhulst attributed the cause of this marine transgression to a single storm surge, and in doing so unwarily laid the foundations of the next colloquium, which occurred some 20 years later[30]. In subsequent years, both Verhulst and Ameryckx wrote many papers detailing their new findings, successfully synthesising the results into a new paradigm. First and foremost, Verhulst substantiated the transgressions and regressions with historical data[31]. Furthermore, he reconstructed the reclamation and embankment of the Zwin area from the 13th century onwards[32]. Ameryckx integrated this supportive historical data into the geomorphological transgression model of the Belgian coastal plain[33]. Through their combined output, the comprehensible Dunkerque Transgression Model became established quickly and was accepted easily.

The model served as a practical steppingstone for further research. From the 1960s onwards, local historical societies increased in popularity and became involved in the debates surrounding the genesis of the Zwin region. Examples include *Sint-Guthago*, founded by self-trained amateur historian, René De Keyser. In reaction to and in dialogue with Verhulst, De Keyser wrote several articles discussing the hydrological network northeast of Bruges[34]. Although his writings were not considered to be of a high academic standard, he introduced several new elements that were incorporated into the debate and still hold. Two of his major contributions were the subdivision of the *Oud Zwin* into several parts with different chronologies[35], and suggesting that the *Budansflit* was a possible predecessor of the tidal Zwin inlet of 1134[36]. Another prolific writer based in *Sint-Guthago* was Maurits Coornaert, whose most notable contribution to the debate was his well-structured summary of both De Keyser's often chaotic theories and Astaes' research on the waterways north of Bruges[37].

Academic contributions initially came from research promoted by Verhulst. Nicole Pannier, for example, studied both the network of dikes north of Bruges and the Dunkerque III-B transgression[38]. Remarkably, she sided with De Keyser's dating of the *Krinkeldijk* and location of the *Budansflit*, whilst questioning the arguments of Verhulst. Moreover, just like Elisabeth Gottschalk in that period[39], she started focusing on the frequency of storm surges, which demonstrated a first incongruence with the transgression-based paradigm. In addition, Cornelis Dekker's historical-geographical research in South-Beveland put even more pressure on the Dunkerque model[40]. The rigid framework of transgressions and regressions was further contradicted by new Roman and medieval archaeological research in the Belgian coastal plain[41]. In order to efficiently confront these new data, Verhulst and Gottschalk organized a further colloquium[42] during which the Dunkerque Transgression Model was disentangled as a model that was both constructed by circular reasoning and theoretically invalid. From a pedological point of view, the transgressions turned out to be indistinguishable from one another[43], and historical and climatological data now suggested storm surges as the motor of landscape transformation. However, the geomorphological concept of flooding and retreating water volumes remained[44]. As a consequence, the more straightforward transgression model continued to be applied in both academic and popular literature, providing a convenient shorthand for explaining apparent gaps in knowledge regarding (pre-)historic human occupation of the coastal plain.

In short, the second phase of the Zwin debate was marked by two important colloquia in which interdisciplinary cooperation between historians, soil scientists, geographers, climatologists, toponymists and archaeologists led to new understandings of how the Belgian coastal plain developed. The driving force of

29. — Ameryckx, Verhulst 1958, p. 22-23.
30. — Verhulst 1959a, p. 29.
31. — Verhulst 1959a.
32. — Verhulst 1959b.
33. — Ameryckx 1959; Ameryckx 1960.
34. — De Keyser 1960b; De Keyser 1962; De Keyser 1963; De Keyser 1964.
35. — De Keyser 1964, p. 139-140.
36. — De Keyser 1959, p. 2; De Keyser 1964, p. 122.
37. — Astaes 1964; Coornaert 1968.
38. — Pannier 1970a; Pannier 1970b.
39. — Gottschalk 1971.
40. — Dekker 1971.
41. — Thoen 1978; Verhaeghe 1977.
42. — Gottschalk, Verhulst 1980.
43. — Mostaert 1980, p. 72.
44. — Baeteman 2013, p. 15.

the geomorphological processes was first attributed to an alternation of transgressions and regressions, but was later correlated with a more irregular pattern of storm surges. Not only was there a rapprochement of academics from different domains, but amateur researchers also joined the debate.

2.3. The slow death of the Dunkerque model (1978-2010)

However much the first colloquium had induced an immediate intensification of research, the second colloquium did not. The old Dunkerque Transgression Model was only half-heartedly abolished, leaving both historians and soil scientists rather empty-handed[45]. It took several years before a new generation of researchers would gather enough data to reopen the debate. Marc Ryckaert – another pupil of Verhulst – did so from a historical-geographical point of view, which he had already begun at the colloquium by thoroughly synthesising preceding historical-geographical research on the Belgian coastal plain[46]. He critically applied the colloquium's outcomes to the genesis of the tidal inlet[47], and clearly analysed the silting up of the Zwin in the late medieval period[48]. Jean-Pierre Sosson and Brigitte Fossion offered more economic-historical approaches, employing urban network theory in their analyses of the Zwin region's urban network[49]. From a geological stance, new extensive research into the Holocene evolution of the coastal plain was conducted after nearly 30 years of inactivity. A study of the western coastal plain by Cecile Baeteman[50] was followed by a study of the eastern coastal plain by Frank Mostaert[51]. Based on new field data, both geologists further disproved the rigid transgression and regression model, and gradually constructed a new geomorphological framework. At the time, Belgian archaeologists were influenced by the new trend of *Landesaufnahme*, which resulted in extensive field-walking combined with archival research[52]. The first thorough archaeological prospection in the Zwin region using this approach was conducted by Bieke Hillewaert[53]. In addition to university-based non-invasive research, first rescue and later preventive archaeology increasingly provided new insights from large infrastructure projects north of Bruges[54]. Although these datasets were gradually redefining Holocene development of the coastal plain, they were not adopted into popular and much-read historical literature. Furthermore, the sequence of well-known transgressions and regressions continued to be used as a reference[55]. The comprehensibility of the Dunkerque model and the lack of easy alternatives hampered the integration of new datasets and the forging of new paradigms.

Interdisciplinary projects in the central Belgian coastal plain attempted once more to deconstruct the Dunkerque model by successfully integrating environmental and landscape data[56]. A new comprehensive geomorphological model for the genesis of the coastal plain in the Low Countries was finally proposed by both Peter Vos and Robert Van Heeringen[57], and Baeteman[58]. Briefly, this new paradigm refuted the view that environmental conditions synchronically changed throughout the entire coastal plain over the last 2,000 years. Any type of coastal landscape (e.g. dunes, mudflats, salt marshes, tidal streams, peat bogs) could be present simultaneously, and at relatively close proximities. The mechanism of coastal transformations cannot simply be attributed to sea-level fluctuations driving transgressions and regressions, rather it is the interplay between palaeotopography, a decelerating relative sea-level (RSL) rise, sediment supply, tidal channels and accommodation space that generally forms the coastal landscape[59]. Furthermore, historical research has exposed the anthropogenic agency in this process, particularly with regard to accommodation space[60]. Reclaiming wetlands and building dikes limited the available space for tidal channels in between the dikes, while draining polders and extracting peat made the land behind the dikes subside and therefore vulnerable to flooding[61].

The third phase of the debate can be characterized by an older generation's persistence of the Dunkerque model on the one hand, and a younger generation working across traditional disciplinary boundaries to integrate new datasets on the other. The new generation of geologists, historians and archaeologists,

45. — Thoen, Borger 2013b, p. 3.
46. — Ryckaert 1980.
47. — Ryckaert 1985.
48. — Ryckaert 1989 ; Ryckaert, Vandewalle 1982.
49. — Sosson 1993 ; Sosson 1998. ; Fossion 1992.
50. — Baeteman 1981.
51. — Mostaert 1985.
52. — Nenquin, Van Moerkerke 1990.
53. — Hillewaert 1984.
54. — Hollevoet, Hillewaert 1989 ; In 't Ven and De Clercq 2005.
55. — Examples are Coornaert 1991 and Verhulst 1995.
56. — Ervynck, Baeteman 1999 ; Tys 2001.
57. — Vos, Van Heeringen 1997.
58. — Baeteman 2005 ; Baeteman 2007.
59. — Baeteman 2013, p. 24.
60. — Augustyn 1991 ; De Kraker 1997 ; Soens 2009 ; Tys 2003.
61. — For a good summary see Thoen 2013.

working from ideas established at the 1978 colloquium, finally ruled out the transgression and regression model, and gradually replaced it with a new paradigm.

2.4. 2010-2014 : a new model, new questions and new research

In order to invigorate and perpetuate this new paradigm, a third colloquium, « Landscapes or Seascapes ? The history of the coastal environment on the North Sea area reconsidered », was organized in 2010 and published in 2013[62]. Having a more international scope, it reproduced not only an overview of the work in the Belgian coastal plain[63], but also included contributions which engaged with the surrounding North Sea area. Notably, the evolution of embankments in adjoining coastal areas[64] seems to differ from the model still applied in the Zwin area[65] and suggests the need for re-evaluation. The last paragraph of Erik Thoen's epilogue argued that « regional differences still deserve to be underpinned with more in-depth research. […] Therefore, much real inter and trans disciplinary research is still very necessary »[66], and served as one of the incentives to initiate the Zwin Project.

Recent research into the Zwin region has proved productive. *Raakvlak*, the intermunicipal service of Bruges and its surroundings, has published the seminal work, *On the Interface of two Landscapes*[67], which foregrounds state of the art archaeological, landscape and historical-geographical research of the region for the period prior to AD 1127. Recent historical research has resulted in equally ground-breaking works concerning the origins of the Zwin cities *Damme* and *Sluis*[68], and the forthcoming monograph *Bruges, a Medieval Metropolis, c. 850 - c 1580*[69].

Local archaeologists and geographers have also contributed by integrating new insights into more popular articles of the region's genesis[70]. Moreover, local historical societies, such as *'t Zwin Rechteroever* and *Sint-Guthago*, have again joined the debate by resuming cartographic and historical studies[71], and publishing archaeological chance finds[72].

Recent archaeological excavations in the adjoining coastal plains continue to provide more proof of a continuous, permanent and varied human occupation, and demonstrate how differing coastal landscapes were inhabited in both Roman and medieval periods[73]. In the Zwin region, on-going archaeological research has revealed new prehistoric and Roman sites[74].

A rather incongruous tailpiece to this overview is the two articles published by geologist Roger Charlier[75]. Rather than furthering the debate, his work potentially serves to undo many recent advances. First and foremost, Charlier consistently refers to outdated research. He incorrectly situates the breakthrough of the Zwin inlet in the 13th century and persistently makes use of the now-disproved transgression and regression model[76]. Furthermore, he relies on an inaccurate, and unreferenced, reconstruction map taken from a popular account of the Zwin area[77], and subsequently uses it to describe the 13th-century hydrography, thereby regarding the *Oud Zwin* as one of five coexisting tidal branches without further specification[78]. However much progress has been made in coastal research during the last decades, the articles of Charlier confirm that the Zwin debate is in need of modernization and deserves re-examination. Moreover, recent integrated and interdisciplinary approaches on the genesis and occupation of the broader North Sea area, and specifically Bruges and its surroundings, demonstrate the necessity of revitalizing and innovating somewhat obsolete research in the Zwin area.

3. TO THE TEST : LINEAR LANDSCAPE COMPONENTS AS A GUIDELINE

In order to demonstrate the above constructed historiographical analysis, it seems appropriate to elaborate on some more specific topographical features[79]

62. — Thoen, Borger 2013a.
63. — See papers of Baetemen, Tys and Soens.
64. — See papers of Meier and Rippon.
65. — Verhulst 1995.
66. — Thoen 2013, p. 423.
67. — Hillewaert, Hollevoet 2011.
68. — Leloup, Vannieuwenhuyze 2013.
69. — Dumolyn, Brown forthcoming.
70. — Termote 2012 ; Wintein 2002 ; Wintein 2006 ; Wintein 2009 ; Wintein 2010.
71. — Terryn 2013a ; Terryn 2013b.
72. — Tilleman 2013 ; Tilleman 2014.
73. — Demey, Vanhoutte 2013 ; Pieters, Baeteman 2013 ; Deckers, Ervynck 2013 ; Dijkstra and Zuidhoff 2011 ; Sier, Van Dinter 2003 ; De Clercq 2011.
74. — Personal communication from Dieter Vewerft, a publication is forthcoming.
75. — Charlier 2005 ; Charlier 2011.
76. — Charlier 2005, p. 425, 432 ; Charlier 2011, p. 746, 748.
77. — The current study has found that the map was taken from Chastelain 1957.
78. — Charlier 2005, p. 425-426 ; Charlier 2011, p. 747-748.
79. — Throughout the Zwin debate, various topo- and hydronyms were used to denote the same place. In order to not unnecessarily complicate the following chapters, we have chosen to consequently use one term and refer to its equivalents if necessary.

that are closely related to the region's geomorphology. The landscape stretching between Bruges' city walls and the present-day nature reserve (fig. 1) is cut diagonally by two features: the *Oud Zwin* and the *Krinkeldijk*. Both features link up the hydrological phenomena of the coastal landscape and the anthropogenic adaptation to it. They represent the seemingly opposing human objectives of maintaining a navigable way to the sea and protecting arable and inhabitable land from that same sea. Digging the canal (*Oud Zwin*) and dike (*Krinkedijk*) were conditional for Bruges to become the main commercial metropolis of the medieval North Sea area. Moreover, as both axes transect the study area, they incorporate crucial information on the relative chronology and geomorphology of the Zwin region, and are therefore worth a closer look (fig. 3).

3.1. The Oud Zwin

The *Oud Zwin*[80] is a waterway that ran from Bruges northeast to the coast (fig. 1f and fig. 3f). Initial studies gave barely any attention to the existence, let alone the function, of the *Oud Zwin*. Gilliodts-Van Severen argued that the digging of the *Verse Vaart*[81] – which he mistook for the connection between Bruges and *Damme* – decreased the use of the *Oud Zwin*[82]. However much Blanchard does not mention the *Oud Zwin*, the course of the *Verse Vaart* on his 13th-century reconstruction map and the course of the *Nieuw Gedelf* on his 16th-century reconstruction map both show an analogy with the most south-western part of the *Oud Zwin*[83], thus creating confusion concerning these different canals[84]. Jonckheere recognized the *Oud Zwin* as a canal between Bruges and *Schapenburg*[85], but also got tangled in the renaming and re-digging of the different tidal branches and canals. Nevertheless, based on its rectilinear dikes as well as on the different geomorphological zones it intersects, he was the first to argue that the *Oud Zwin* was an artificial canal[86]. Whereas Jonckheere was mainly confining himself to a descriptive analysis of cartographical sources, De Smet successfully integrated historical cartography with written sources. Furthermore, he challenged Jonckheere's hypothesis of the *Oud Zwin* being a human-made canal, and reasoned for it to be a natural waterway[87]. The first to focus specifically on the *Oud Zwin* itself was De Langhe[88]. He specifically considered the short section of this waterway, flowing northeast from the sluice at *Schapenburg*, following the successive embankments from the 13th-century onwards (see fig. 2f and 3f). At first he categorically argues that the longer and older part of the waterway, stretching between Bruges and *Schapenburg*, was a manmade canalisation of a tidal branch[89]. However, the existence of this preceding natural creek is a hypothesis he is less convinced of in his more general overview of the Flemish coastal plain[90]. Ameryckx resolutely stated that his soil cores affirmed the artificial origins of the *Oud Zwin*, however, he was unable to substantiate the argument with new data. Instead, he resorted to adopting Jonckheere's arguments; that the canals have a rectilinear course and that they intersect multiple landscapes (fig. 3f and fig. 4)[91]. Within the framework of the transgression and regression model, he dated the construction of the canal as subsequent to the construction of the dike belt[92]. Consequently, its primary function would have been the drainage of the « protected » land[93]. Verhulst at first concurred[94], but later adopted a middle course by considering the *Oud Zwin* as an artificial chain of natural creeks. Moreover, he dated canalisation prior to the construction of the dike belt and the alleged storm surge of 1134[95].

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80. — Also *Oud(e) Zwijn* or *Oude Zwijne Vaert*
81. — Also *Varsche Vaart* or *Zoete vaart*. This canal was dug in different phases between 1557 and 1566 in order to replace the silted and unnavigable remnant of the Zwin inlet (fig. 1h) (Ryckaert, Vandewalle 1982, p. 61-62.).
82. — Gilliodts-Van Severen, Gailliard 1871, p. 470.
83. — Blanchard 1906, p. 192-198.
84. — Just like the *Verse Vaart*, the hydronym *Nieuw Gedelf* was probably re-used for whenever a new canal was dug. In this case, we can identify it as the *Verse Vaart*. Further, it was also used to denominate a canal that bypassed *Damme* in the 14th century or the *Kanaal van Oostburg* from the early 16th century (Ryckaert, Vandewalle 1982, p. 58-59.).
85. — This toponym is generally referred to as the place where the Oud Zwin discharched its water through a sluice in the dike belt. The sluice itself is sometimes referred to as *Kwintenssluis*. Beyond the dike belt, the discharched watercourse was named *Reigaartsvliet*. Whereas we will use *Schapenburg* to locate the end of the Oud Zwin, also *Reigaartsvliet* and *Kwintenssluis* can be found throughout literature to situate to same point.
86. — Jonckheere 1912, p. 18-25.
87. — De Smet 1933, p. 1027-1028.
88. — De Langhe 1935a; De Langhe 1935b.
89. — De Langhe 1935a, p. 121.
90. — De Langhe 1939, p. 110.
91. — Further reading on this particular discussion in De Smet 1933, p. 1033 and Ameryckx 1954a, p. 84.
92. — We use « dike belt » to denote a series of dikes that are often referred to as *Evendijk (B)*. Adopting a certain terminology, however, includes in this case the adoption of a related morphogenesis. Since this morphogenesis is still a matter of discussion, we use general term « dike belt » to refer to the series of dikes, running from Heist over Schapenburg to *Damme*. However, different sections of this belt have different names. Between Heist and Schapenburg, we consider the *Kalveketedijk* (fig. 1B). Between Schapenburg and *Hoeke* we consider the *Bloe(d)loze* or *Brolozendijk* (fig. 1C), between *Hoeke* and *Monnikerede* we consider the *Krinkeldijk* (fig. 1D), and between the Verbrand Fort and *Damme* we consider the *Romboutswervedijk* (fig. 1E). For the spatial reconstruction of the dikes, we've primarily used Verhulst 1995 and the Anon 2003.
93. — Ameryckx 1953, p. 106-107; Ameryckx 1954a, p. 85-86.
94. — Ameryckx, Verhulst 1958, p. 8.
95. — Verhulst 1959a, p. 27-28.

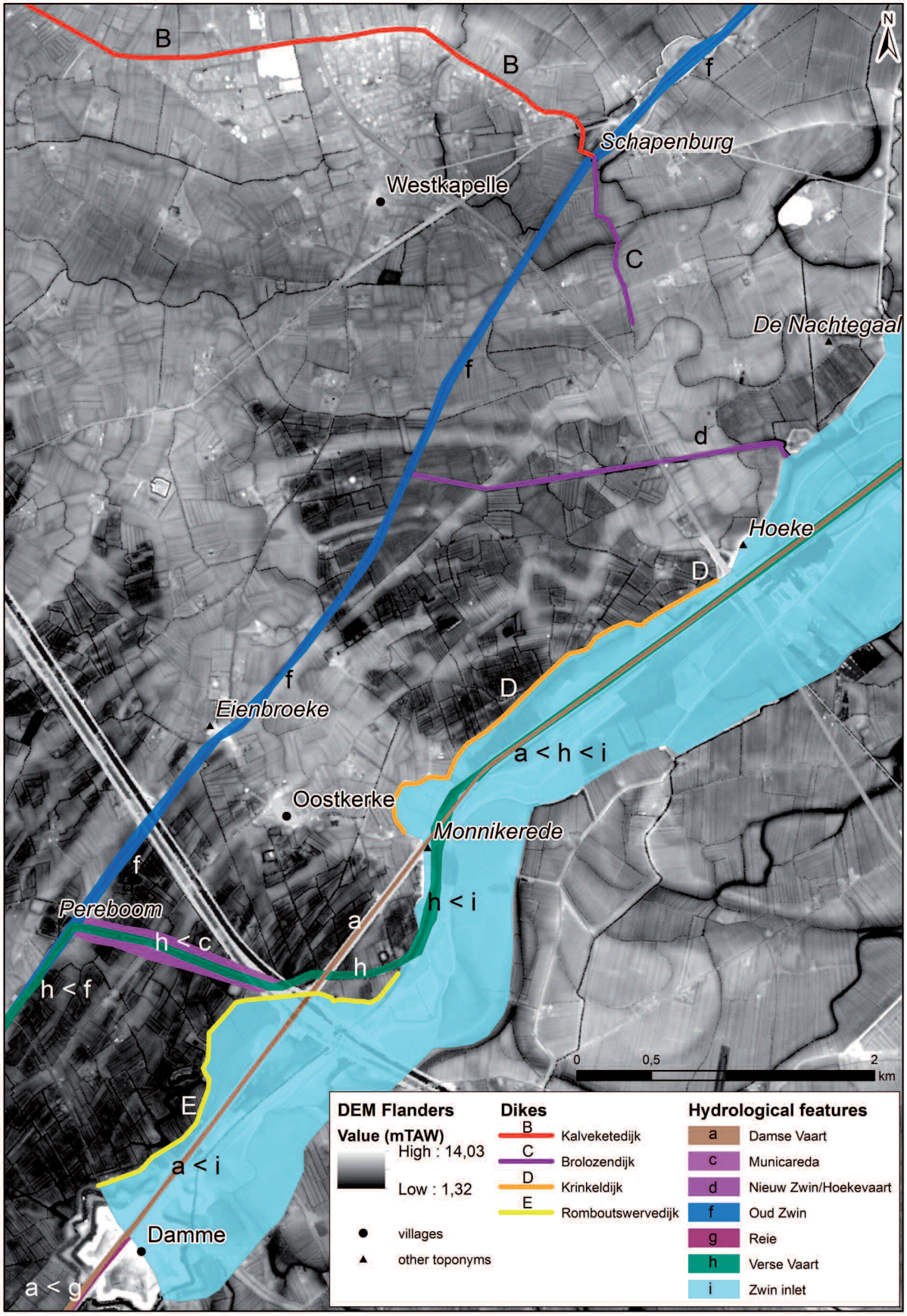

FIG. 3. — *Central part of the research area on the DEM Flanders. For legend details see figure 1.*

FIG. 4. — *Detail of the* Oud Zwin *cutting through older landscape elements on an orthogonal aerial photograph from 2009 (b) and on the DEM Flanders (c).*
© AGIV, Orthofoto's, middenschalig, kleur (2009), provincie West-Vlaanderen.

Notwithstanding the disagreement concerning its date and function, the *Oud Zwin* was at that moment generally accepted to be a bipartite waterway. The first part stretched from Bruges, over *Koolkerke* and *Eienbroeke* to its sluice at *Schapenburg*. From here the second part was prolonged/left open in the subsequent embankments as far as the *Graafjansdijk*. De Keyser challenged this interpretation by subdividing the first part of the *Oud Zwin* in a series of canalisations. He initially distinguished two subsections[96] and concluded that five different phases of construction had occurred[97]. The argument that was decisive for his further discourse was the localisation of the *Pylyserdam* near *Pereboom*[98], whereas De Smet and Ameryckx considered the *Pylyserdam* to be located near the sluice at *Schapenburg*[99]. De Keyser suggested that the initial course of the *Oud Zwin* turned east-southeast at *Pereboom*, after which it followed the course of the *Municareda*[100] (fig. 1c and fig. 3c) that discharged into the *Budansflit* (infra)[101]. The part of the *Oud Zwin* between *Pereboom* and the dike belt would have been dug in two subsequent phases[102]. In a reply to these and other propositions put forward by De Keyser, Verhulst fiercely refuted his arguments and stated that a course running over *Municareda-Budansflit* was totally unfounded[103]. After this first intervention, Verhulst did not reply to De Keyser's adapted hypotheses, nor did he touch upon it in his later articles[104]. Coornaert appreciated De Keyser's idea of a phased construction and managed to phrase his argument more coherently[105]. Hillewaert supported De Keyser's idea of a compartmentalized *Oud Zwin* too, and provided new evidence that supported parts of his thesis. Based on the soil map and oblique aerial photographs, Hillewaert argued that the *Oud Zwin* between *Eienbroeke* and *Schapenbrug* cuts a systematic pattern of reclaimed peat bog (see fig. 4). Consequently, the canal postdates these structures, which probably date to the second half of the 12th century[106].

Ryckaert seemed to concur with Verhulst. Without discussing the issue in depth, he generally considered the *Oud Zwin* as a navigable drainage canal that stretched from Bruges to the dike belt[107]. However, in *Landscape and Agriculture in Medieval Flanders*[108], Verhulst suddenly endorses the idea that the *Oud Zwin* initially discharged its water near *Monnikerede*, into a predecessor of the Zwin inlet[109]. Remarkably, he does not mention the *Oud Zwin* in his subsequent and last articles on the Zwin area[110] and the coast[111]. Historical-geographer Willy Wintein, relied on

96. — DE KEYSER 1960a ; DE KEYSER 1960b.
97. — DE KEYSER 1964.
98. — DE KEYSER 1960b, p. 11.
99. — AMERYCKX 1953, p. 107 ; DE SMET 1933, p. 1053.
100. — Or *Monniker-ede,* which could be translated as « waterway of the monks ».
101. — DE KEYSER 1960a, p. 7.
102. — DE KEYSER 1962, p. 50-54.
103. — VERHULST 1962.
104. — VERHULST 1966.
105. — COORNAERT 1968.
106. — HILLEWAERT 1984, p. 444-445, 511-514.
107. — RYCKAERT 1982, p. 21 ; RYCKAERT 1985, p. 24 ; RYCKAERT 2002, p. 66.
108. — This was in fact a revision of VERHULST 1966.
109. — VERHULST 1995, p. 30.
110. — VERHULST 2000b. A second remarkable fact is that he often refers to Coornaert (1968), whereas he could and should refer to his own work.
111. — VERHULST 2000a.

Verhulst's last insights to describe the course of the *Oud Zwin* but focused on the fact that the first step towards an north-eastern connection of Bruges with a tidal creek was to cut through a sandy ridge near *Koolkerke*[112]. He dates the canalisation of the *Oud Zwin* to between 9th and 11th centuries[113]. A view which was confirmed by Hillewaert[114].

3.2. Krinkeldijk-Romboutswervedijk

The *Krinkeldijk* and *Romboutswervedijk* are two dike segments that once bordered the left bank of the Zwin inlet (fig. 1D-E and fig. 3D-E). Initial authors paid little attention to the different dike segments or their chronologies, and considered them as a continuous and simultaneously built dike belt, protecting Bruges' northeastern foreshore. As a consequence, the dike segment between *Damme* and *Hoeke* was only discussed when it was integrated within the relative chronology of the Dunkerque Transgression Model. Ameryckx argued that the complete dike belt was built in reaction to the IIIA-transgression (10th century), in the relative calm regressive period before transgression IIIB (11th-12th century). His soil samples proved that presumed IIIB-deposits stopped at the seaward side of this dike belt[115]. In the 1958 colloquium, historians tried to put a more exact date on the transgressions and started to relate the dikes and sediment deposition with historical sources. Although Ameryckx's argumentation remained the same, the construction of the dike complex was now correlated with the start of, and therefore built in reaction to, transgression IIIB, which was now dated at 1100[116]. One year later, Verhulst tried to deliver a new synthesis and substantiated the debate with more historical data. He introduced several new ideas regarding the different parts of the dike belt. Firstly, he argued that the dike segment between *Heist* and *Hoeke*, which might have had some fragmentary predecessors, was most likely enclosed immediately at the offset of the IIIB-transgression[117]. In the perpendicular turn at *Hoeke* he finds evidence to postulate that the segment between *Hoeke* and *Damme* was only erected after the more powerful IIIB-transgression had broken through[118]. His second argument revolves around the meandering course, and name, of this dike segment (fig. 5)[119].

De Keyser argued that the dike between *Hoeke* and *Damme* was already erected at the time the IIIB-floods began. Drawing upon the process of relief inversion that made land between *Hoeke*, *Damme* and *Dudzele* settle, he argues that the land was all the more vulnerable to flooding. Moreover, he assumed that the large tidal creek in the direction of *Damme* had a predecessor in the aforementioned *Budansflit*[120]. This argument could be used to explain the winding course of the *Krinkel-* and *Romboutswervedijk*, and agreed with his deviating hypothesis of the *Oud Zwin*. Pannier adopted De Keyser's view in her *licentiaat* (Master's) dissertation, which was supervised by Verhulst and Ameryckx. Moreover, she added that in the absence of the preceding *Budansflit*, the dike builders would not have turned at *Hoeke*, but would just as well have continued heading southeast towards higher ground such as *De Hoorn* (fig. 1)[121]. Parallel with the discussion on the *Oud Zwin*, Verhulst in 1995 reluctantly agreed that the *Krinkel-* and *Romboutswervedijk* bordered a small tidal inlet which preceded the 1134 enlargement. In the same paragraph however, he inconsistently holds on to a course of the *Brolozendijk* that in 1100 stopped near *Hoeke*[122]. Verhulst only cursorily touches upon this topic in his subsequent articles[123]. Wintein again supported De Keyser and proposed the presence of a continuous ringdike reaching further southwest than *Damme* that was raised before 1100[124]. Later, Wintein made a sudden reversal by suggesting the dike segment coming from *Westkapelle* did not turn southwest near *Hoeke* but continued its path further east-northeast. The storm surge of 1134 subsequently made the dike burst and created the inlet towards *Damme*, whereupon the *Krinkel-* and *Romboutswervedijk* were erected[125]. The reason why and the sources upon which he relied to make this U-turn are not clear, since such a hypothesis

112. — Wintein 2002, p. 28-29.
113. — Wintein 2006, p. 20.
114. — Hillewaert 2011.
115. — Ameryckx 1953, p. 102-103; Ameryckx 1954b, p. 112.
116. — Ameryckx and Verhulst 1958, p. 5.
117. — Verhulst 1959a, p. 22.
118. — In this article, Verhulst also pin-points the breakthrough of the large tidal creek in the direction of *Damme* at AD 1134 and relates it to a storm surge that was described by several contemporary sources. An article focused on this particular aspect of the Zwin debate is forthcoming.
119. — Verhulst 1959a, p. 23-25.
120. — De Keyser 1960a, p. 6-8.
121. — Pannier 1970a, p. 165-170.
122. — Verhulst 1995, p. 41-42. In his discription of this dike segment, Verhulst obviously relies on Ameryckx 1953, p. 103. However, whereas Verhulst lets the Brolozendijk stop at *De Nachtegaal*, Ameryckx had no such thing in mind and thought of a simultaneous connection with the Krinkeldijk.
123. — Verhulst 2000a; Verhulst 2000b.
124. — Wintein 2006, p. 21.
125. — Wintein 2010, p. 9-10.

FIG. 5. — *The remaining part of the* Krinkeldijk *between* Hoeke *and* Monnikerede *on an oblique aerial picture*.
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was not previously suggested. Finally, Hillewaert proposed a compromise between both Verhulst and De Keyser, in which small local dikes were united to form a continuous defensive dike that protected the hinterland. The remaining tidal channels were later boarded with lengthy dikes. The example given for this second phase comprises the *Krinkel-* and *Romboutswervedijk* that possibly boarded the *Budansflit*, which is once more suggested as the possible predecessor of the Zwin inlet[126].

4. CONCLUSIONS

Over nearly 150 years the processes and actors involved in the creation, commercial heyday and silting of the Zwin region have been extensively discussed in what we denote as the Zwin debate. The multiple perspectives offered by a variety of trained amateurs and scholars have been at times conflicting. Since 1871, the mind-sets, methodologies and approaches applied to the Zwin region have dramatically changed, and the availability of new kinds of data has had significant impact on the outcomes of research. Based on these parameters, we have distinguished four trends in the Zwin debate.

In the first phase (1871-1945), the research was based on historical and geological data. As information on the earliest phases of the inlet was non-existent, research primarily focused on the later stages of silting. The overall assumption was that there was a large inlet that gradually silted up due to natural processes. The second phase (1945-1978), saw the rapprochement between scholars of different scholarly domains, who met at two influential colloquia. The post-war recording of the Belgian soil map brought new insights concerning the evolution of the coastal plain and intensified the Zwin debate. The alternation of transgressions and regressions was seen as the driving force of geomorphological processes until the irregular pattern of storm surges was attributed more importance. Only since the third phase

126. — HILLEWAERT 2011, p. 115.

(1978-2010), was human agency recognized in the geomorphology of the Zwin. The Dunkerque model was slowly replaced by a new paradigm based on the integration of new pedological and archaeological data. Since 2010 intensified research interest can be observed in the broader North Sea area and the Belgian coastal plain.

To demonstrate how these trends in research dealt with specific landscape components, we discussed two linear features that stretch through the Zwin area : the *Oud Zwin* and the *Krinkeldijk*. This detailed study of both the *Oud Zwin* and the *Krinkeldijk* has shown that research in the Zwin area is outdated and has not kept up with trends in the surrounding regions. For both features, the debate has become preoccupied with reinterpreting the same limited set of historical maps, texts and pedological data. Although the outdated geomorphological framework in which these topographical features are interpreted has been disregarded, received notions of these features, and by extension the broader eastern Belgian coastal plain, still persist. This is problematic as the landscape is being primarily interpreted through the same limited set of historical sources rather than taking advantage of potential new data sources.

Landscape-archaeological research has recently demonstrated the potential gain from non-invasive prospection techniques. Although available for many years, traditional remote sensing techniques, such as the analysis of oblique, orthogonal and historical aerial photographs or LiDAR-data, has been so far underused. The added value of these techniques is particularly to be found in macro-scale analysis, providing insight into the overall landscape geomorphology (fig. 3 and fig. 4). The application of techniques such as geophysical survey, DGPS-mapped fieldwalking and UAV-mounted-3D-photogrammetry, can deliver new and highly detailed datasets, which when incorporated within a site-based strategy can provide high-definition images on a micro-scale. The interdisciplinary integration and confrontation of traditional and new techniques will deliver much-needed multiscaled datasets, resulting in a better understanding of the evolution of the Zwin area.

Keywords : Geomorphology, Archaeological Prospection, Bruges, Medieval Port, Zwin, Coastal landscape.

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