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Assignment 2: The orientation of Cistercian abbey churches in Belgium

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I hereby declare that the materials contained in this essay are entirely the product of my own work, that sources used are fully documented and that the whole has not previously been submitted for any other purpose.

Chapter 1. Introduction

The objective of this essay is to verify through archaeoastronomical measurements and techniques, whether the conclusions related to the orientation of Cistercian abbey churches in Wales as proposed by Brady et al¹, can be extended to Cistercian abbey churches in Belgium.

The focus of the essay will be on the declination of the axis of the churches, and alignments with sunrise and sunset, in particular on the feast days of the Virgin Mary.

It has not been possible to visit all sites that have been part of the a priori selected research sample. The essay therefore includes archaeoastronomical measurements that have been performed through digital tools.

Field work *in situ* remains the key tool for the research included in this essay. On the other hand, it is very clear that digital tools are getting ever more sophisticated, and available, and that they can be a good addition in the tool set of the archaeoastronomer.

Chapter 2. Church orientation

McCluskey has written extensively on the principles underlying the orientation of Christian churches².

Since pre-Christian Rome the principle of praying and orienting temples towards sunrise has been well established. In the early Middle Ages, this principle became more precise, with an emphasis of church orientation towards the equinoctial east. With the emergence of Gothic architecture, this principle of orienting churches towards equinoctial east became even stronger, with William of St. Cloud documenting the principle in the fourteenth century³.

Another model for the orientation of churches considers the sunrise on the day of the patron saint to which the church is dedicated or the date of foundation⁴.

¹ Bernadette Brady, Darrelyn Gunzburg, and Fabio Silva, 'The Orientation of Cistercian Churches in Wales: A Cultural Astronomy Case Study', *Cîteaux – Commentarii cistercienses*, t. 67, fasc. 3-4, 2016

² Stephen C. McCluskey, 'Orientation of Christian Churches', *The Handbook of Archaeoastronomy and Ethnoastronomy*, 2015, Clive L. N. Ruggles, ed.

³ McCluskey, 'Orientation of Christian Churches'

⁴ McCluskey, 'Orientation of Christian Churches'

Chapter 3. Methodology

3.1. A priori selection of abbey sites in the data set

McCluskey gives guidelines for archaeoastronomical research in the area of church orientation, and in particular proposes large data sets in order to conclude on the intentionality of the orientations⁵.

The size of the dataset in this essay has been limited, but the guidelines for avoiding bias in the selection of sites towards a pre-set hypothesis have been applied.

Criterion 1. Geography

The first major criterion in the a priori selection of abbey sites is the definition of the geographical region.

Figure 1 shows that the selection in the research sample is limited to churches that were built in the area that was known as Lower Lorraine in the 10th century.

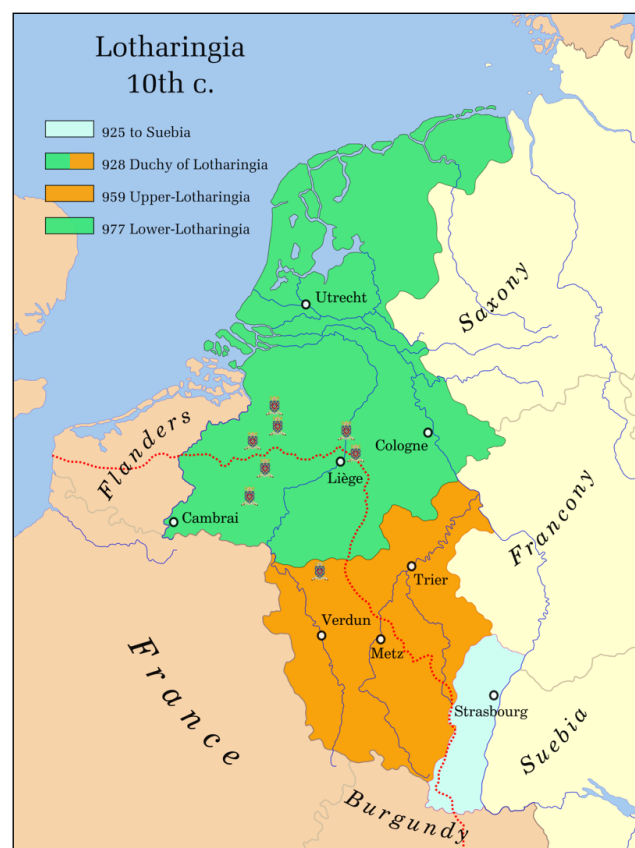


FIGURE 1. The 8 selected abbey sites in the map of Lotharingia in the 10th century

⁵ McCluskey, 'Orientation of Christian Churches'

In the period in which the abbeys were founded and the churches were built, this area was broken down into relatively small states, governed by local dukes, princes or bishops, but all belonging to the Holy Roman Empire at the start of the Hohenstaufen rule, as shown in Figure 2 and summarized in Table 1.

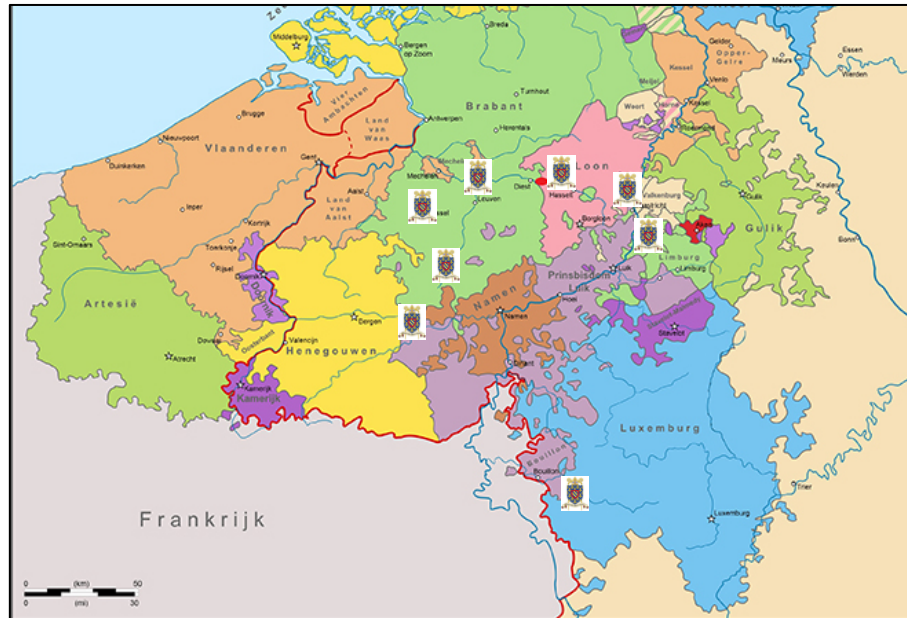


FIGURE 2. The 8 selected abbey sites in the map of the Holy Roman Empire 13th-14th century

TABLE 1. The 8 selected abbeys in the dataset with their geographical region at the time of foundation.

Abbey	Geographical region
Aulne	Prince-Bishopric of Liège
Herkenrode	County of Loon
Hocht	County of Loon
Orval	County of Chiny
Ter Kameren	Duchy of Brabant
Val-Dieu	Duchy of Limburg
Villers	Duchy of Brabant
Vrouwenpark	Duchy of Brabant

Criterion 2. Chronology

The second major criterion is chronology, as building techniques, including orientation practices, have been shown to evolve over time⁶.

⁶ McCluskey, 'Orientation of Christian Churches'

Table 2 shows that all abbeys and churches in the data set were founded, or included in the Cistercian order in the 12th and early 13th century, with the original church constructed before the end of the 13th century.

The 12th and early 13th century is indeed the period in which the Cistercian order grew fast under the impulse of St. Bernard of Clairvaux, and spread over large parts of Europe through a process of apostolic gestation, whereby members of large Cistercian abbeys (“mother-abbeys”) would establish new houses (“de novo”) or include existing monastic communities into the Cistercian order (“daughter-abbeys”)⁷.

TABLE 2. The 8 selected abbeys in the dataset with their foundation date, date of inclusion into the Cistercian order, and the construction date of the original church.

Abbey	Foundation date	Inclusion in Cistercian order	Original church construction date
Aulne	657	1147	1214-1244
Herkenrode	1192	1217	End 13 th century-1317
Hocht	1182	1182	unclear
Orval	1070	1132	End 11 th century-1124
Ter Kameren	1201	1201	Early 13 th century
Val-Dieu	1216	1216	1216-1225
Villers	1146	1146	1197-1266
Vrouwenpark	1215	1215	1250-1270

3.2. Field work methodology

Generic

The objective of the fieldwork is to determine the declination along both sides of the axis of the church, considering horizon altitude, in order to determine potential alignment of the church towards sunrise or sunset over the real horizon, on religiously significant dates, at the time of construction of the church.

For the sites in which *in situ* fieldwork was performed, *in situ* measurements are complemented by measurements done through Geographical Information Systems (GIS) in order to compare digital data acquisition with *in situ* measurements. Annex 1 includes a methodological analysis of the reliability of digital data acquisition.

Table 3 gives an overview of the applied methodology underpinning the declination measurements.

⁷ Constance Hoffman Berman, ‘The Cistercian Evolution. The Invention of a Religious Order in Twelfth-Century Europe’, University of Pennsylvania Press, Philadelphia, Pennsylvania, 2000

TABLE 3. The applied measurement methodology for the 8 selected abbeys in the dataset.

Abbey	Methodology
Aulne	<i>In situ</i> and digital
Herkenrode	<i>In situ</i> and digital
Hocht	Not possible
Orval	Digital
Ter Kameren	<i>In situ</i> and digital
Val-Dieu	<i>In situ</i> and digital
Villers	Digital
Vrouwenpark	<i>In situ</i>

It has not been possible to perform measurements, *in situ* or digital, for the church of Hocht Abbey, as there are not enough structural elements remaining to determine its orientation.

The latitude and longitude of the church site are measured *in situ* with the GPS Status & Toolbox app from MobiWIA Kft. on the iPhone 6 Plus.

The magnetic azimuth of the orientation of the axis of the church is measured by aligning a Suunto tandem/360PC/360R G compass to the structure of the church. Different techniques were used depending on the structure and the state of the church or church ruin. Specifics on these alignment measurements are included in the Annexes. The compass measurements were always performed in opposite directions, in order to take local magnetic anomalies into consideration. The measurements were only accepted if the compass measurements in opposite directions differ by 180° within 1° of accuracy.

The *in situ* compass measurements were always corrected for true north using the World Magnetic Model for the period 2014-2019 for magnetic declination, provided as an online tool by the NOAA National Centres for Environmental Information⁸, for the longitude and latitude of the site and the day of the measurement.

In order to determine the potential alignment of the church towards sunrise and sunset over the real horizon, rather than the theoretical horizon, the altitude of the horizon was measured along both sides of the east-west axis of the church with Suunto tandem/360PC/360R G clinometer. In none of the cases in the data set, it was possible to obtain a measurement of the horizon altitude due to buildings or trees preventing the view on the horizon. The horizon altitude measurement was determined through the Heywhatsthat on-line tool⁹. For the sites in which *in situ* measurements of longitude, latitude and azimuth were done, the horizon altitude determined through Heywhatsthat is considered to be *in situ* for the purpose of this essay.

⁸ <https://www.ngdc.noaa.gov/geomag-web/>

⁹ <https://www.heywhatsthat.com/>

Digital tools: Geographic Information Systems (GIS)

It has not been possible to visit the Villers and Orval Abbeys in the framework of this essay.

In order to include archaeoastronomical information for all sites in the pre-selected dataset, digital tools were used to determine the key parameters to calculate the declination of the axis of the church towards the real horizon: latitude, horizon altitude, and azimuth.

Two different tools were used to determine latitude and horizon altitude, i.e. Geopunt Vlaanderen¹⁰ for the abbeys in Flanders, and WalOnMap¹¹ for the abbeys in Wallonia.

For azimuth measurements, the ruler tool in Google Earth Pro and Set Compass¹² were used by aligning the central axis of the church structure, the centre beam of the roof when available, or ruined walls. The azimuth measurements from this method provide the orientation compared to true north, so no correction is needed for magnetic declination. It is important to note that consistently, azimuth measurements with Google Earth Pro and with Set Compass yield comparable results, probably because the underlying processes and calculation engine are the same (further research herein is not within the scope of this essay). It has been found to be more practical to align the Set Compass tool to structures than the Google Earth Pro ruler tool.

The azimuth of the abbey church and the horizon altitude could not be measured with digital tools for Vrouwenpark Abbey because the excavated north wall of the church, the only structural element remaining, is blocked from view on Google Earth Pro, on Set Compass, and on the GIS Geopunt Vlaanderen.

3.3. Measure of uncertainty

It is inherent to the nature of measurement that it always comes with a degree of uncertainty.

A detailed and in-depth estimation of the uncertainty related to the measurements included in this essay, is essential to infer assumptions on the intention and meaning of orientations of the abbey churches considered in this essay.

The objective is to estimate the overall uncertainty of the declination calculation resulting from the underlying measurements of latitude, azimuth and horizon altitude (Annex 2).

The resulting uncertainty for the declination is calculated with the skyscapeR app¹³ on the basis of the estimated uncertainty in azimuth and horizon altitude.

¹⁰ http://www.geopunt.be/kaart?viewer=Hoogtekaart_app/index.html

¹¹ <http://geoportail.wallonie.be/>

¹² <https://setcompass.com/>

¹³ <https://archaeofsilva.shinyapps.io/skyscapeR-legacy/>

The research in this essay studies alignment towards sunrise and sunset, and if this occurs on a distant horizon, a refraction uncertainty needs to be considered¹⁴. A refraction uncertainty of 0.50° is added to the declination uncertainty if the horizon altitude is smaller than 1.0°.

The last source of uncertainty in the determination of the declination of the abbey church orientation towards sunrise and sunset, is the size of the limb of the solar disc used by the builders, which has been estimated as half of the 0.5° diameter, or 0.25°¹⁵.

Table 4 shows the overall estimated uncertainty in declination towards the east and Table 5 towards the west.

TABLE 4. Overall estimated uncertainty in declination towards the east.

Abbey	Azimuth uncertainty [°]	Horizon altitude uncertainty [°]	Resulting declination uncertainty [°]	Refraction uncertainty [°]	Sun limb uncertainty [°]	Total declination uncertainty [°]
Aulne field	1.70	1.25	2.07		0.25	2.32
Aulne digi	2.25	1.00	2.20		0.25	2.45
Herkenrode field	1.70	1.25	2.26	0.50	0.25	3.01
Herkenrode digi	2.25	1.00	2.36	0.50	0.25	3.11
Orval digi	2.25	1.00	2.16		0.25	2.41
Ter Kameren field	1.70	1.00	1.90		0.25	2.15
Ter Kameren digi	2.25	1.00	2.22		0.25	2.47
Val-Dieu field	1.70	1.25	2.04		0.25	2.29
Val-Dieu digi	2.25	1.00	2.06		0.25	2.31
Villers digi	2.25	1.00	2.11		0.25	2.36
Vrouwenpark field	1.70	1.25	2.24	0.50	0.25	2.99

¹⁴ Bradley E. Schaefer, William Liller, 'Refraction Near the Horizon', in *Publications of the Astronomical Society of the Pacific*, p. 796-805, provided by the NASA Astrophysics Data System, July 1990

¹⁵ Bernadette Brady, 'The Dual Alignments of the Solstitial Churches in North Wales', in *Journal of Skyscape Archaeology*, Vol. 3, No. 1, 2017, Liz Henty, Fabio Silva ed.
(<https://doi.org/10.1558/jsa.30562>)

TABLE 5. Overall estimated uncertainty in declination towards the west.

Abbey	Azimuth uncertainty [°]	Horizon altitude uncertainty [°]	Resulting declination uncertainty [°]	Refraction uncertainty [°]	Sun limb uncertainty [°]	Total declination uncertainty [°]
Aulne field	1.70	1.00	1.85		0.25	2.10
Aulne digi	2.25	1.00	2.20		0.25	2.45
Herkenrode field	1.70	1.25	2.26	0.50	0.25	3.01
Herkenrode digi	2.25	1.00	2.36	0.50	0.25	3.11
Orval digi	2.25	1.00	2.09		0.25	2.34
Ter Kameren field	1.70	1.00	1.86		0.25	2.11
Ter Kameren digi	2.25	1.00	2.18		0.25	2.43
Val-Dieu field	1.70	1.00	1.74		0.25	1.99
Val-Dieu digi	2.25	1.00	1.97		0.25	2.22
Villers digi	2.25	1.00	2.19		0.25	2.44
Vrouwenpark field	1.70	1.25	2.27	0.50	0.25	3.02

3.4. Declination calculation

Using the latitude, horizon altitude and azimuth measurements as inputs, the declination along both sides of the axis of the church towards the real horizon was calculated with skyscapeR¹⁶.

For sites where declination results were determined through *in situ* measurements and through digital tools, the results were not averaged, but shown separately in order to quantify the differences between the two methodologies and the comparison with the uncertainty estimation.

Chapter 4. Results

Table 6 summarizes the results of the fieldwork and GIS digital analysis work, and the calculations with skyscapeR, i.e. latitude, longitude, true azimuth towards the east and towards the west, horizon altitude towards the east and the west, and calculated declinations towards the east and the west.

¹⁶ <https://archaeofsilva.shinyapps.io/skyscapeR-legacy/>

TABLE 6. Fieldwork and GIS digital analysis work, and skyscapeR calculation results.

Abbey	Lat [° N]	Long [° E]	True azimuth E/W [°]	Horizon alt E/W [°]	Declination E [°]	Declination W [°]
Aulne field	50.366	4.331	113.17/294.17	3.19/6.32	-12.17	20.04
Aulne digi	50.366	4.332	110.17/290.58	3.25/6.32	-10.31	17.81
Herkenrode field	50.957	5.280	82.43/262.43	0.14/0.09	4.45	-5.12
Herkenrode digi	50.956	5.280	80.40/260.13	0.04/0.06	5.62	-6.58
Orval digi	49.641	5.349	55.44/235.23	4.31/6.55	24.91	-16.36
Ter Kameren field	50.819	4.374	75.16/255.15	2.54/4.65	11.10	-5.79
Ter Kameren digi	50.819	4.375	72.24/252.38	2.54/4.65	12.88	-7.45
Val-Dieu field	50.698	5.806	50.60/229.60	2.72/6.60	25.78	-18.70
Val-Dieu digi	50.698	5.806	45.50/225.43	3.40/6.60	29.09	-20.76
Villers digi	50.591	4.530	113.32/294.22	10.85/4.88	-5.89	18.85
Vrouwenpark field	50.942	4.737	85.78/265.28	0.24/-0.02	2.44	-3.43

Figure 3 (eastern declinations) and Figure 4 (western declinations) shows the resulting declinations, with the estimated uncertainty margins, and the declinations for solstice (23.5°), major lunar extreme or standstill (28.6°), minor lunar extremes ($\pm 18.3^\circ$) and the peak of the declination distribution for the Spring Full Moon¹⁷ (-4°).

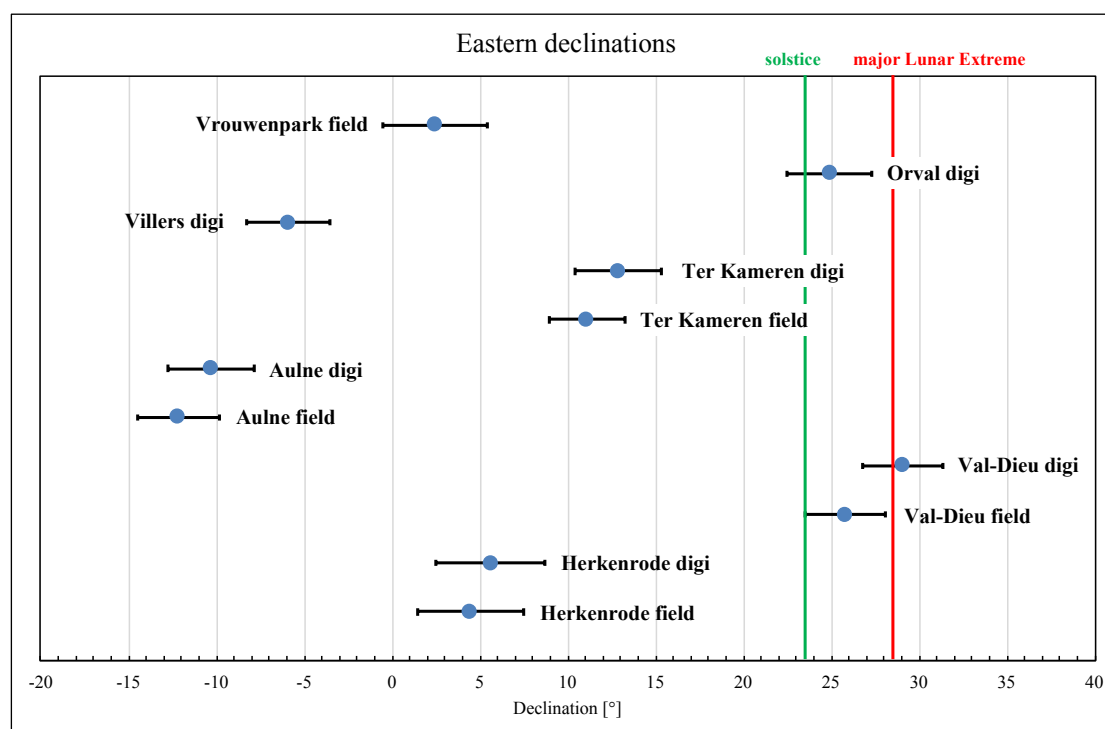


FIGURE 3. Resulting eastern declinations with estimated uncertainty margins

¹⁷ Fabio Silva, Fernando Pimenta, 'The Crossover of the Sun and the Moon', in *Journal for the History of Astronomy (JHA)*, xliii, 2012, Science History Publications Ltd., Provided by the NASA Astrophysics Data System

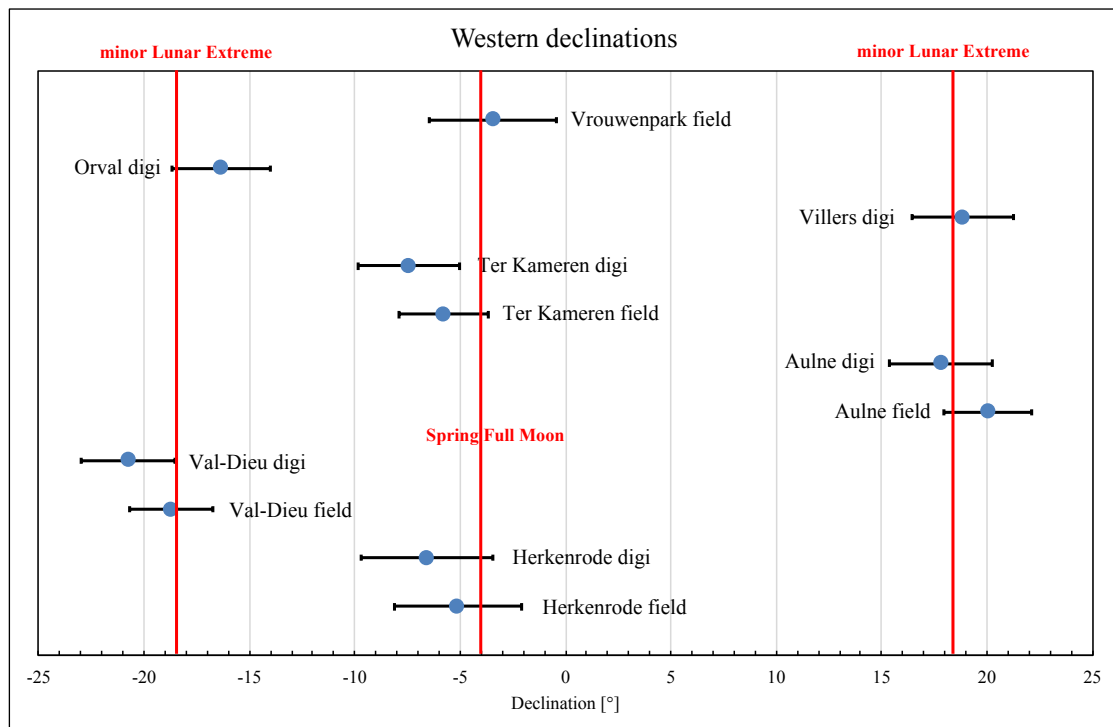


FIGURE 4. Resulting western declinations with estimated uncertainty margins

Table 6, Figure 3 and Figure 4 show that there are significant differences between the field results and the GIS digital results for the abbeys where both methods were applied. These differences are mainly a result of the significant differences in azimuth measurement between the two methods (see Table A1.1). The field results and digital results always overlap when taking into consideration the relevant uncertainty margins.

Chapter 5: Analysis and Interpretation

5.1. Cultural study

The oldest abbeys in the dataset have been founded (Villers¹⁸) or included in the Cistercian order (Aulne¹⁹ and Orval²⁰) under the direct authority of St. Bernard of Clairvaux, becoming very early daughter-abbeys of the Clairvaux abbey. Both Aulne

¹⁸ Thomas Coomans, 'L'abbaye de Villers-en-Brabant. Construction, configuration et signification d'une abbaye cistercienne gothique', Bruxelles, éd. Racine et Brecht, Cîteaux, *Commentarii Cistercienses (Collection Cîteaux studia et Documenta, XI)*, 2000

¹⁹ Gustave Boulmont, 'Les fastes de l'abbaye d'Aulne la riche de l'ordre de Cîteaux', Vanderpoorten et Delvaux, Gand et Namur, 1907

²⁰ Frans Doperé, 'Het middeleeuwse gebouwenbestand van de abdij van Orval (Villers-devant-Orval). Kritische reflecties voor een vernieuwend archeologisch-bouwhistorisch onderzoek', *Novi Monasterii*, Vol. 10, 2010, Marc Dewilde ed.

and Orval were founded as Benedictine monasteries before they were included into the Cistercian order.

The first Cistercian church building of Aulne and the church building of Villers were constructed in the same period and current research shows large architectural and architectonic commonality between both²¹, indicating strong cultural ties.

The two other male abbeys (Hocht and Val-Dieu) were founded after the death of St. Bernard, but were still closely related to Clairvaux Abbey. Hocht was founded in 1182 by monks from the Eberbach Abbey in Eltville am Rhein (Mainz, Germany), a daughter-abbey of Clairvaux²². The monks however left already in 1217, because of difficulties of economic exploitation, to found Val-Dieu, which in turn also became a daughter-abbey of Clairvaux²³. Hocht was subsequently turned into a female monastery, inhabited by Cistercian nuns from the Salvatorberg in Aachen.

There are three female abbeys in the dataset: Herkenrode, Ter Kameren and Vrouwenpark, all three founded or included in the Cistercian order end 12th century until beginning 13th century. Ter Kameren²⁴ and Vrouwenpark²⁵ were founded under the direct patronage of Henry I, Duke of Brabant, and remained under the direct spiritual authority of Villers. Herkenrode²⁶ was founded by a monk from Aulne.

Another cultural link between the abbeys of Villers, Orval and Herkenrode is the use of their churches as burial grounds for the local rulers that founded and supported them.

Table 7 shows the cultural diversity between the abbeys, allowing more detailed investigation into meaningful church orientation patterns within identified categories.

²¹ Frans Doperé, 'Selectieve aanwending en bewerking van natuursteen in de abdij Ten Duinen van de 13^{de} tot het begin van de 16^{de} eeuw. Een vergelijkend bouwtechnisch onderzoek tussen de dochterabdiën van Clairvaux op het huidige Belgische grondgebied', *Novi Monasterii*, Vol. 9, 2010, Harry Van Royen ed.

²² Agentschap Onroerend Erfgoed 2016: Cisterciënzerinnenabdij [online], <https://id.erfgoed.net/erfgoedobjecten/872> (consulted 21 July 2018)

²³ Doperé, 'Selectieve aanwending en bewerking van natuursteen in de abdij Ten Duinen van de 13^{de} tot het begin van de 16^{de} eeuw. Een vergelijkend bouwtechnisch onderzoek tussen de dochterabdiën van Clairvaux op het huidige Belgische grondgebied'

²⁴ Fernand Berthold de Ryckman de Betz, Georges Dansaert, Charles Terlinden, Maurice Marie Thibaut de Maisières, 'L'abbaye cistercienne de La Cambre: étude d'histoire et d'archéologie', Nederlandsche Boekhandel, Antwerp, 1948

²⁵ Bart Minnen, Ward Caes, Peter Hooft, 'Het archeologisch onderzoek van de kerk en het kerkhof van de cisterciënzerinnenabdij Vrouwenpark (Rotselaar, België)', in *Cîteaux. Commentarii cistercienses. Revue d'histoire cistercienne*, 2000

²⁶ Maarten Smeets, 'Een dame ontwaakt. Het archeologisch onderzoek in het cisterciënzerinnenklooster van Herkenrode in 2004', *Novi Monasterii*, Vol. 4, 2005

TABLE 7. The 8 selected abbeys with cultural specificities that could be studied for patterns of church orientation.

Abbey	Foundation	Cistercian lineage	Gender
Aulne	First Benedictine, then Cistercian	Clairvaux	Male
Herkenrode	De novo		Female
Hocht	De novo	Clairvaux	Male, then female
Orval	First Benedictine, then Cistercian	Clairvaux	Male
Ter Kameren	De novo		Female
Val-Dieu	De novo	Clairvaux	Male
Villers	De novo	Clairvaux	Male
Vrouwenpark	De novo		Female

5.2. Solar Alignments

A first analysis was performed by comparing the calculated declinations with a table of sun declinations from skyscapeR for the Epoch 1200, in order to determine the dates at which the church is aligned with sunset or sunrise of the real horizon.

The sun declination tables from skyscapeR are given in the proleptic Gregorian calendar, therefore the above dates need to be converted to the Julian calendar that was used at the time of the construction of the abbey churches²⁷ (Annex 3).

Figure 5 shows the calculated dates of alignment of the abbey churches towards sunrise (in black) and towards sunset (in grey), with a comparison to the most important feast days dedicated to the Virgin Mary in medieval times (in blue), i.e. Purification or Candlemas (2 February), Annunciation or Theological equinox (25 March), Assumption (15 August) and Nativity (8 September).

²⁷ Brady et al, ‘The Orientation of Cistercian Churches in Wales: A Cultural Astronomy Case Study’

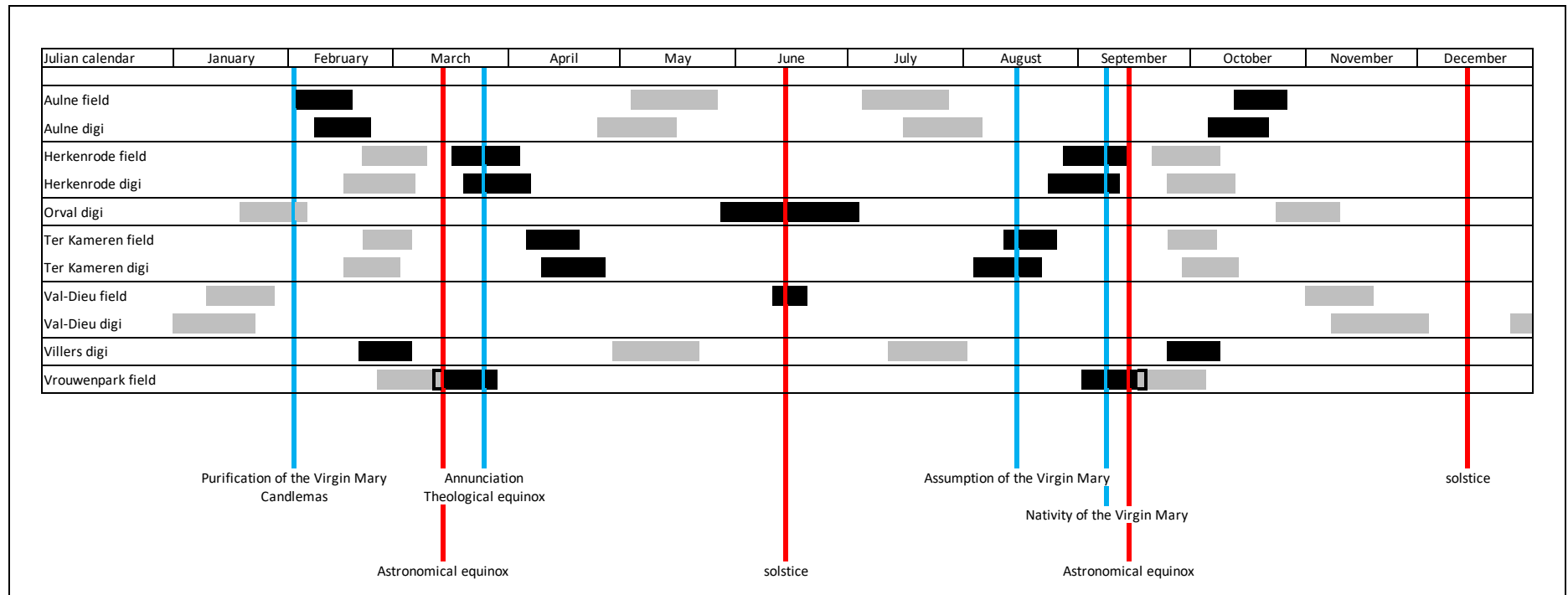


FIGURE 5. Dates of alignment towards sunrise (black) and sunset (grey)

For Aulne and Villers, there are no significant liturgical dates identified at which an alignment is found with sunrise or sunset.

Herkenrode church shows a clear alignment with sunrise on the Annunciation. Herkenrode was a female Cistercian abbey, and an important site of Mary pilgrimage, which reinforces the argument for an alignment with an important Mary feast day. The alignment with the Nativity of the Virgin Mary is within the uncertainty margins, but not as precise as the alignment with the Annunciation.

Figure 3 shows that the abbey church of Orval is aligned to sunrise at the solstice, in line with the symbolic significance of the solstice or “highest light”, symbolizing the magnificence of Christ.

Ter Kameren was a female Cistercian abbey, and the orientation of the abbey church shows a clear alignment to sunrise on the Assumption.

Val-Dieu has an eastern declination well beyond the solstice declination of 23.5° , so an alignment with solstice is rejected.

Vrouwenpark shows a clear alignment with sunrise on the Nativity of the Virgin Mary.

5.3. Lunar alignments

The eastern declination of Val-Dieu shows an alignment to the major lunar extreme or standstill for the digital results, but not for the fieldwork results, as shown in Figure 3. This alignment is therefore not convincing.

In contrast to the eastern declinations, Figure 4 shows a clear clustering of the western declinations in three groups. The western declinations of the female abbeys – Herkenrode, Ter Kameren, and Vrouwenpark – around 4° , i.e. the peak of the declination distribution for the Spring Full Moon. The western declinations of the male abbeys cluster around the minor lunar extremes or standstills, i.e. $\pm 18.3^{\circ}$.

The parallel construction and important architectural and architectonic commonalities between the first Cistercian church building of Aulne and the church building of Villers²⁸ could explain the clustering shown in Figure 4, which is more evident for the western declinations than for the eastern declinations.

Since early Christianity, there is a deep and spiritual symbolism linked to the moon, also reflected in Christian iconography and art. Benedictine churches have been found to be aligned to significant lunar events²⁹.

The full moon symbolizes the Virgin Mary, Full of Grace, so important to St. Bernard of Clairvaux and the Cistercians. This would reinforce the case for an alignment to the Spring Full Moon for female abbeys. The moon does not give light of its own, but, like the Virgin Mary, reflects the light of the true Sun, Jesus Christ, to enlighten the faithful.

²⁸ Doperé, ‘Selectieve aanwending en bewerking van natuursteen in de abdij Ten Duinen van de 13^{de} tot het begin van de 16^{de} eeuw. Een vergelijkend bouwtechnisch onderzoek tussen de dochterabdijen van Clairvaux op het huidige Belgische grondgebied’

²⁹ Eva Spinazzè, ‘The alignment of medieval churches in Northern-Central Italy and in the Alps and the Path of Light inside the church on the Patron Saint’s Day’, in *Mediterranean Archaeology and Archaeometry*, Vol. 16, No 4, 2016, pp. 455-463

The moon also symbolizes the Holy Church of Christ, illuminated by the true light of Christ, and reflecting his splendour to the faithful. This is an important concept in Christian theology, described by St. Ambrose, one of the most important Christian theologians and one of the four original Doctors of the Church, as “mysterium lunae”³⁰. It is noted that in his address to the Abbots and Abbesses of the Cistercian Order of Strict Observance in 2002, Pope John Paul II makes specific reference to this symbolism that “*Jesus is the radiant Sun of whom the Church must be the faithful reflection, in accord with the expression "mysterium lunae" (mystery of the moon), an expression that the Fathers cherished*”³¹.

Conclusion

The findings by Brady et al related to the orientation of Cistercian Abbeys in Wales could not all be extended to the studied Cistercian Abbeys in Belgium.

The three female Cistercian abbeys, i.e. Herkenrode, Ter Kameren, and Vrouwenpark, have abbey churches with a clear alignment to sunrise at major feast days of the Virgin Mary. The abbey church of Orval shows a clear alignment to the solstice, while for the other three male abbeys – Aulne, Val-Dieu, and Villers – no convincing orientation alignment could be demonstrated towards sunrise or sunset on significant liturgical dates.

A potential alignment towards lunar events was explored, based on the clustering of western declinations with lunar minor extremes, for the male Cistercian abbeys, and with the Spring Full Moon for the female abbeys. More research would be needed to confirm this alignment.

³⁰ Hugo Rahner, S.J., ‘Greek Myths and Christian Mystery’, Biblo and Tannen, New York, 1971

³¹ https://w2.vatican.va/content/john-paul-ii/en/speeches/2002/september/documents/hf_jp-ii_spe_20020919_trappisti.html

ANNEXES

ANNEX 1: Reliability of digital data acquisition

ANNEX 2: Uncertainty of measurements

ANNEX 3: Calendar conversion

ANNEX 4: Aulne Abbey

ANNEX 5: Herkenrode Abbey

ANNEX 6: Hocht Abbey

ANNEX 7: Orval Abbey

ANNEX 8: Ter Kameren (La Cambre) Abbey

ANNEX 9: Val-Dieu Abbey

ANNEX 10: Villers Abbey

ANNEX 11: Vrouwenpark Abbey