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THE SUN'S LIGHT AT MICHAELMAS AND THE CISTERCIANS OF BRITAIN AND IRELAND

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This paper builds on research that was carried out between August 2014 and March 2016 when our team set out to investigate the sun's role in the churches of the eleven extant Cistercian Abbeys in Wales, all of which are now in ruins—Basingwerk, Margam, Cwmhir, Cymer, Neath, Strata Florida, Llanllugan, Valle Crucis, Aberconwy 1, Whitland, and Tintern. Previous work on English abbeys and churches focused on the eastern orientation of the structure. Our intention, however, was to understand the skylscapes of all extant Welsh Cistercian monastic sites where a skyscape was defined as the complex union of the monastery's unique relationship to the heavens in its landscape through its story written in architecture, stonework, and local topography. Thus rather than ignoring the landscape features, we treated each abbey as unique within its skyscape. To achieve this aim we used an interdisciplinary methodology drawing together the fields of anthropology (Bernadette Brady), archaeology (Fabio Silva), art history, and medieval history (Darrelyn Gunzburg). Additionally, all three of us are cultural astronomers. The results of Stage 1 left open the question as to whether the orientation of Welsh Cistercian abbey churches to Michaelmas and/or Saint David's Day was specific to Wales or was instead part of a wider story that involved Cistercian abbey churches in England, Scotland, and the island of Ireland.¹ This paper completes that research. It first recaps the methodology we used when measuring the Welsh Cistercian abbey churches which involved understanding how the sun moves in the sky across the year; outlining how we measured the orientation of the abbey churches; looking at how we considered them in their unique horizon views; and finally engaging with how they received the sun's light on key Julian calendar dates. We then present our findings from the second stage of our fieldwork in measuring the English and Scottish abbey churches, as well as those on the island of Ireland.

I. HOW THE SUN MOVES IN A LANDSCAPE

To understand how the sun can shine through a window or open door of an abbey church is to understand the sun's seasonal passage in the sky and its relationship to the landscape. By observing the position on the horizon of sunrise

¹ Bernadette BRADY, Darrelyn GUNZBURG, and Fabio SILVA, "The Orientation of Cistercian Churches in Wales: A Cultural Astronomy Case Study," *Cîteaux – Commentarii cistercienses* 67 (2016), p. 275-302.

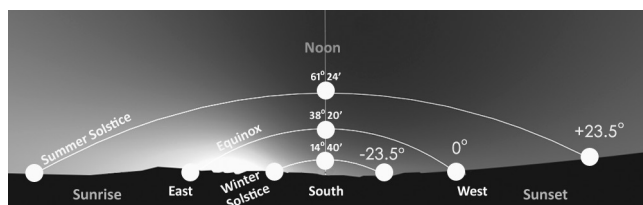


Fig. 1. The annual passage of the sun for latitude 52° north (mid Wales). The declination of the sun at the winter solstice is -23.5° , equinox 0° and the summer solstice $+23.5^\circ$.

every day for a period of a year one would see that it shifts like the swing of a pendulum. There are two extreme positions where the sun's pendular movement seems to come to a rest before changing direction. These are the two solstices, one of which occurs in the south-east in the winter and other in the north-east in the summer. There is also a mid-point in the east which is crossed twice where this movement is at its maximum speed. These are the two equinoxes. The same occurs on the western horizon for the position at sunset (Fig. 1). Additionally, the sun will gain its highest altitude each day at local noon, and this will also vary with the season. It rises highest in the sky at noon on the summer solstice, but has a much lower altitude at noon on the winter solstice. Between these extreme positions of the two solstices it will have an altitude that is midway between them at the equinoxes.

The sun's movement from one day to the next can be measured using declination, similar to latitude in that it is measured as degrees above or below the equator. The sun changes its declination every day, moving from $+23.5^\circ$ at the northern hemisphere summer solstice to -23.5° at the winter solstice. Halfway between these two times the sun will have a declination of 0° when it crosses the celestial equator, and this is the time of the equinoxes when the sun rises due east and sets due west. The sun's daily declination is directly linked to the calendar date and, using a table, the date can be translated into a solar declination and vice versa. Added to this, for a particular location and for any given date, the sun will always rise or set at the same point on the local horizon. In this way a particular date, the sun's declination, and the local landscape are all united, and a hill or valley on the horizon will always be influential upon and hence create a sunrise or sunset on the same date/solar declination. For example, in Figure 1, on the right, the summer solstice sunset ($+23.5^\circ$) will always occur at that place on the horizon. If an abbey church's west door is facing that point on the horizon, then it will receive the sun shining directly into the abbey at the summer solstice sunset. Hence by calculating the declination that an abbey church door or window is facing, it is possible to know the time of the year when the sun will rise or set aligned to the door or window. There are three components required to calculate the declination: the latitude of the location; the azimuth (compass bearing of the orientation); and the horizon elevation, whether, for example, there are any hills at that exact azimuth.

If there are hills around an abbey church and these are ignored and the researcher only measures the azimuth (compass bearing) of the church window or door, then the results will not give the dates when the sun will shine into the church. For example, in considering the twelfth century Cistercian Abbey of Corcomroe Abbey, County Clare, Ireland, the abbey is set in a broad valley which is steep to the north, but more open towards the south. The abbey church is orientated so that the east window points almost due east, azimuth 89° , but the east window faces some low hills with an altitude of 6.6° (Fig. 2 left). If these hills are ignored, then the researcher would conclude that the church is aligned due east to the equinox which, in the twelfth and thirteenth centuries, fell on the Julian date of 14 March. This would, however, only be the symbolic sunrise date. The actual sun rising over the hills and shining in the windows would occur on 25 March. For more details and other examples of our approach to the abbeys see the first part of this research published in 2016 and cited earlier.

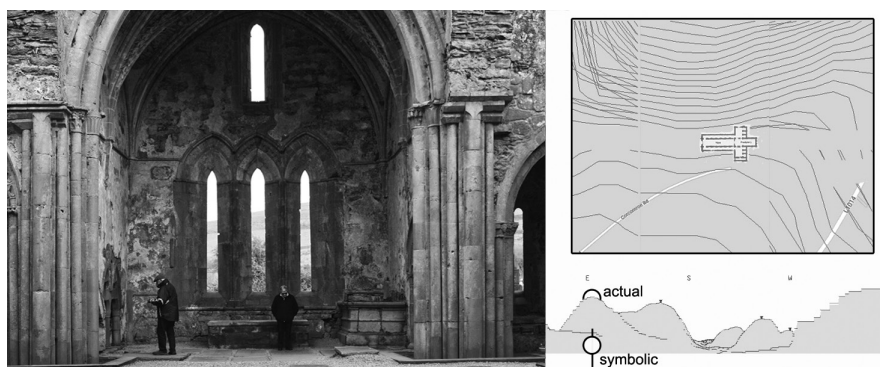


Fig. 2. Corcomroe Abbey, Co. Clare, Ireland. LEFT: the east window showing the hills. TOP RIGHT: a contour map of the abbey in its landscape. BOTTOM RIGHT: The horizon profile of the valley surrounding the abbey showing the sunrise position at the church's azimuth of 89° . If the hills were not there, the sun would be seen to rise on 14 March – symbolic sunrise. However, it is 11 days later, 25 March, before the sun rises over the hills and shines directly into the east windows.

II. FIXING AN ORIENTATION

Given that the monks of an abbey might want the church to receive direct sunlight through a west door or east window for a particular calendar date, the question arises as to how the builders would find this alignment in a hilly landscape. There are different ways that can be used to establish an orientation of a building. In towns or cities a church could take its orientation from either the street-grid or from an earlier structure, such as a Roman temple or even an earlier stone circle. The Cistercian abbeys, however, were built away from populated areas, so this method of mirroring another structure was probably not available or desirable, as

the Cistercians builders were generally not a part of the local community. In the absence of other structures, the next available option is to use the sun. By watching sunrises or sunsets over the course of several years it is possible to mark out the horizon for key dates. This could take quite a few years, however, as an overcast sky could delay an observation for another year, so observation of sunrises and sunsets is a method beset with difficulties, the least being the amount of time needed.

The easiest method was to work with the stars. For example, on the day of the astronomical equinox the sun crosses the celestial equator. Although today most people could not point out the line of the equator in the night sky, its location was monitored from antiquity.² An educated individual, particularly one who dealt with navigation or architecture, could trace the line of the celestial equator through the night sky using the stars and the key points and note where it cut the local horizon in the east or the west. Orientating the church to this point on the horizon would ensure that the sun shone through the door or window on that key date. The other key star lines are for the two solstices, sunrise or sunset (the Tropic of Cancer and Capricorn). Once these horizon points are established, an entire horizon calendar could be laid out and then observed over a year, thereby establishing the orientation for 25 March (Annunciation/Lady Day/New Year), 29 September (Michaelmas) or 15 August (Assumption), with potentially only small errors. Arranging the foundation of Corcomroe Abbey, Clare, Ireland, for example, to receive the light of the rising sun on the church equinox which was also the Feast of the Annunciation, would have been a straightforward procedure even with its hilly terrain.

III. METHODOLOGY

To measure the abbey churches, we used the following instruments: a Suunto KB-14 compass (with an advertised precision of 0.33°) for measuring azimuth, the point on the horizon that aligned with the doors or windows; a Suunto PM-5 clinometer (precision of 0.25°) to measure the altitude of the horizon, taking into account any hills visible through the doors or windows; and a handheld GPS, Garmin Etrex-10, for accurate positioning of longitude and latitude. Compass readings were corrected from magnetic azimuth to true azimuth using the World Magnetic Model.³ The azimuth and the altitude were then converted to declination using the formula for conversion of horizontal to equatorial coordinates which accounts for latitude (geographical location), true azimuth (orientation) and altitude of the horizon (local landscape). The Gregorian calendar dates provided by

² ARATUS, *Phaenomena*, trans. Aaron Poochigian, Baltimore 2010, lines 534-547 (p. 20).

³ National Centers for Environmental Information: <https://ngdc.noaa.gov/geomag/calculators/magcalc.shtml#declination>

a solar declination table were converted to the Julian calendar using the conversion factor appropriate to the century in which the monasteries were built. For the monasteries in question, this was an adjustment of seven days as, by c. 1200, the Julian calendar had drifted by seven days ahead of the correct solar calendar dates.

All of the abbey churches were also measured virtually by using Google Earth to check the fieldwork azimuths.⁴ Additionally, HeyWhatsThat was used to check the altitudes east and west.⁵ This was the method adopted by Brady when working with historical churches in Wales, where it was found that any deviation between live fieldwork and virtual fieldwork fell within the adopted measurement uncertainty (see below).⁶ Similar results had been found by other scholars who compared virtual measurements with live compass readings.⁷ With the Cistercian abbey churches we equally found that, where available, live and virtual fieldwork measurements agreed. Five of the Scottish abbey churches were measured only virtually (abbeys labelled VF in Table 2), as we were unable to travel to them. However, given the reliability of the virtual measurements shown in the case of all the other abbeys, we are confident in these measurements.

It is possible that historical and modern changes to the landscape, of a natural or cultural order, could have changed the horizon around these abbeys. However, we consider this effect to be negligible for two reasons. The first is that Cistercians built their abbeys in remote locations that to this day retain their isolated, and somewhat idyllic, settings often with no other structures around them. The second reason is that most abbeys have horizons that are far enough away that any changes to tree-cover would have made very little impact on visibility. To be fair, it is possible that this would impact some of the abbeys treated here, but their number should be small enough as not to introduce any systematic errors to our analysis.

Another important factor we had to take into account was to estimate the uncertainty in our measurements. Using the declination conversion equation, an uncertainty of 0.5° in the azimuthal measurements converts to an uncertainty of about 1° in declination. To this uncertainty we had to add two other components: uncertainty due to the size of the solar disc, and uncertainty due to atmospheric refraction near the horizon. As we had no way of knowing what limb of the sun's disc the builders may have used, whether the right, left, top or bottom sides of the sun, and given that this disc has a diameter of about 0.5° , we allowed for an added uncertainty of 0.25° to either side. Furthermore, because the sun's light is heavily

⁴ Google Earth Pro (V.7.1), <https://www.google.com/earth/download/gep/agree.html?hl=en-GB>.

⁵ Michael KOSOWSKY, <http://www.heywhatsthat.com> (accessed 20 June 2021).

⁶ Bernadette BRADY, "The Dual Alignments of the Solstitial Churches in North Wales," *Journal of Skyscape Archaeology* 3:1 (2017), p. 5-28 (p. 11).

⁷ Andrea RODRÍGUEZ-ANTÓN, A. César GONZÁLEZ-GARCÍA, and Juan Antonio BELMONTE, "Estimating the Reliability of Digital Data Acquisition in Cultural Astronomy: The Case of Roman North Africa," *Journal of Skyscape Archaeology* 3:2 (2018), p. 191-206: <https://doi.org/10.1558/jsa.34685> (accessed 30 January 2019).

refracted near the horizon, causing its colour to change to orange/red and its visual position to shift slightly, we increased the uncertainty for horizon events by 0.5° as suggested by Bradley Schaefer.⁸ In sum, our estimates of uncertainty for comparing our measurements to solar dates were 1.75° for horizon events (sun rise or set) and 1.25° for raised-horizon alignments (since refraction does not occur when the sun is rising or setting behind a hill).

A key issue within archaeoastronomy is the demonstration of intentionality, which allows scholars to argue whether an observed celestial alignment was intentionally built into the architecture or simply there by chance.⁹ One of the most widespread ways of tackling this is to rely on statistical reasoning, which means that if an identified alignment is unlikely to be due to chance (in statistical terms this is called statistical significance), then it is likely to be intentional.¹⁰ To address this issue, we applied the recent statistical significance test developed by Silva to our results.¹¹ This test looks at the frequency of orientations and explicitly compares them to what would be expected if the orientations were random. This comparison, which is done through numerical simulation, results in a p-value which is an indication of the probability of observing the measured orientations under the assumption of randomness. If this p-value is lower than 0.05, it means that it is unlikely that the measured orientations could be obtained by chance alone and therefore are likely to be intentional.¹² In addition to calculating this p-value, Silva's methodology also identifies the orientations that show intentionality.

For the present purposes we have implemented Silva's methodology using the measurements and uncertainties described above. The (null) hypothesis of randomness was simulated five thousand times. In the discussion below we include only figures that summarise the key findings, leaving a more complete statistical analysis for a subsequent publication.

IV. RECAP OF THE CISTERCIAN ABBEY CHURCHES IN WALES INVESTIGATION

Using the actual sunrises or sunset dates, our research with the Welsh Cistercian abbey churches indicated that the landscape in which the abbey churches sat was an important feature when it came to the orientations of the abbeys themselves. Table 1 shows the declination values obtained and Figure 3 is a visual representation of all the Welsh abbey churches showing their sunrise and sunset dates for the

⁸ Bradley SCHAEFER, "Refraction near the Horizon," *Astronomical Society of the Pacific* 102:653 (1990), p. 796-805.

⁹ Clive RUGGLES, *Astronomy in Prehistoric Britain and Ireland*, New Haven/ London 1999.

¹⁰ *Ibid.*, p. 42-43.

¹¹ Fabio SILVA, "A Probabilistic Framework and Significance Test for the Analysis of Structural Orientations in Skyscape Archaeology," *Journal of Archaeological Science* 118:105138 (2020): 108135.

¹² Ronald L. WASSERSTEIN and Nicole A. LAZAR, "The Asa's Statement on P-Values: Context, Process and Purpose," *The American Statistician* 70 (2016), p. 129-133.

Julian calendar. The length of the bars marking a particular sunrise or sunset for an abbey church reflects the level of uncertainty for the declination as discussed earlier. The abbey church of Strata Florida, for example, receives the setting sun directly through its west door in the first week of March and in late September to early October and sunrise through its eastern window in the second week of April and then again in the last week of August. For a full discussion on this data see our earlier publication.

Welsh Abbey	Mother House	Dec East	Dec West
Neath	Savigny, France	8.8°	-4.9°
Basingwerk	Buildwas	0.1°	2.8°
Tintern	L'Aumone, France	-1.1°	13.9°
Whitland	Clairvaux, France	8.5°	2.5°
Margam	Clairvaux, France	2.8°	0.4°
Strata Florida	Whitland	11.6°	-4.5°
Cwmhir	Whitland	9.4°	-1.9°
Aberconwy 1	Strata Florida	12.6°	-8.4°
Llanllugan	Strata Marcella	7.2°	-4.8°
Cymer	Cwmhir	13.7°	-1.1°
Valle Crucis	Strata Marcella	6.4°	13.6°

Table 1. The remaining Welsh Cistercian abbey churches with above-ground evidence of their original structure. They are listed along with their mother house and abbey church's eastern and western declination.

Figure 3 lays out our measured data graphically and this format is repeated for Scotland, the island of Ireland, and England. The top scale gives the Julian calendar dates (for 1200 CE) and each abbey church's horizontal bars therefore indicates the dates when the sun rises or sets in alignment with the church. The vertical lines are, from left to right, Saint David's Day (1 March), the astronomical equinox when the

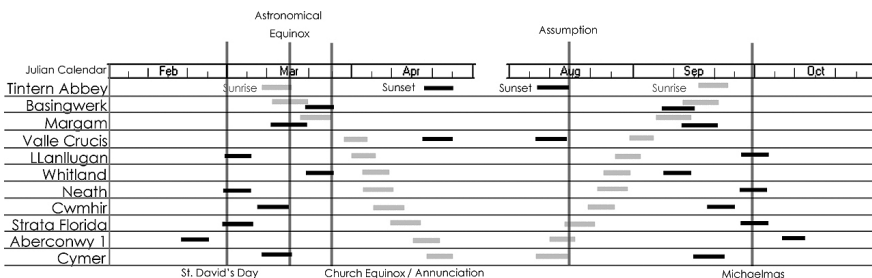


Fig. 3. The Welsh abbey churches' solar narratives. The eleven remaining Welsh Cistercian abbey churches and their alignments to Julian calendar sunrise and sunsets dates for 1200 CE. The abbey churches are arranged by order of their sunrise dates (eastern declination).

sun will rise and set due east/west (14 March), the Church equinox which is also the Feast of the Annunciation and the date of the New Year (25 March), the Feast of the Assumption (15 August), and, on the right, the Feast of Michaelmas (29 September).

At first, in our initial research we dismissed the orientation to Michaelmas (29 September in the Julian calendar) of Strata Florida, Neath, and Llanllugan abbey churches. While each church does align more closely with sunset on Michaelmas, as can be seen in Figure 3, this also corresponded with Saint David's Day on 1 March, and with Saint David being the patron saint of Wales, it seemed logical to conclude that these three Welsh abbey churches had captured this date in the orientation of their western doors. Nevertheless, we questioned the level of influence any local traditions might have had on a Cistercian abbey, a question that could only be answered if other, non-Welsh Cistercian abbeys were considered.

Additionally, we found two other dates. The first was 25 March, which at that time the church considered to be the equinox, as well as marking the Feast of the Annunciation, Lady Day, and New Year. This date had originally aligned with the actual equinox around the fourth century. However, by the twelfth century, the actual equinox occurred on the 14 March. This gave rise to two equinoxes:

- **Astronomical equinox** when the sun, on a flat horizon, rises due east, and which has a solar declination of 0° . This would have been 14-15 March in the Julian calendar.
- **Church equinox** on 25 March, which has a solar declination of $+3.5^\circ$ to $+4^\circ$.

In summary, we found that the Welsh abbey churches were generally orientated to receive the direct light of the sun on either the actual equinox, church equinox (the Annunciation), or Saint David's Day/Michaelmas. Repeatedly we found that these alignments were to sunsets (Fig. 3). Indeed, eight of the eleven abbey churches had key alignments with their western doors: Margam, Cwmhir, Cymer were aligned to the astronomical equinox; Llanllugan, Neath, and Strata Florida were aligned to Michaelmas; and Basingwerk and Whitland were aligned to the church equinox. Only Tintern Abbey in the south and Basingwerk in the north revealed orientations solely to the astronomical equinox to the east, while Valle Crucis, with its steep-sided valley, was missing from this list.

We concluded that these orientations were not a coincidence and that abbey churches were orientated to the sun's light on specific dates that were held to be important to the Cistercians. In that regard our research suggested that the orientation of the abbey's church was the prime generator of the orientation of the whole abbey complex and that the abbey church would then have dictated the orientation of the rest of the buildings in a particular location. Since the monks required sleeping and living cloisters, the abbey church may not have been built first, but our research suggested it was the first building to be laid out.

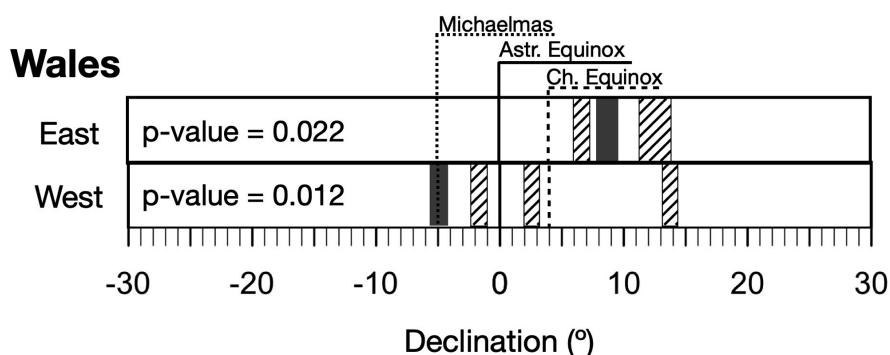


Fig. 4. Orientation of the Welsh abbey churches. Eastwards is indicated in the upper register and westwards in the lower register. The areas of shading indicate orientations, expressed as declinations, which were intentional. The darker shaded blocks show the highest statistical intentionality (p-value lower than 0.001), while the hatched blocks show less statistical significance. Michaelmas or Saint David's Day to the west is intentional and the eastern block, at dec +8° to +9° is, as shown in Figure 3, an artefact of this western orientation.

Applying Silva's test for intentionality to the set of eastern and western orientations of the Welsh abbey churches using the methodology described above, Figure 4 shows the p-value, which is below the 0.05 threshold, and indicates that the Welsh abbey churches are not orientated at random. In particular, two orientations are highlighted in the statistic for intentionality, the first being in the west with an orientation towards sunset on Michaelmas or Saint David's Day and the second in the east with a dec +8° to +9° which corresponds to a date in the first 10 days of April (see Fig. 3). However, Figure 3 reveals that the abbey churches that have the Michaelmas/ Saint David Day orientation in the west (sunset) have their opposite eastern sunrise orientation in this zone of dec +8° to +9°. Hence the intentionality shown in the east in Figure 4 is likely to be an artifact of the Michaelmas/Saint David's Day orientation to the west in that those abbey churches will also pick up sunlight shining into the abbey church on both those dates. Of note, this test reveals that the only orientation for Welsh Abbey churches with a strong statistical significance is that of a western orientation to either Michaelmas or its alternative solar date of Saint David's Day. Therefore, to resolve the question of whether our findings within the Welsh abbey churches were a feature of the Welsh culture—whether they were intentionally aligned to receive the light of the setting sun on Michaelmas (29 September) or Saint David's Day (1 March)—or whether these orientations belonged to a wider Cistercian narrative, from 2017–2021 Brady and Gunzburg measured the abbey churches of Scotland, England, and the island of Ireland.

V. THE SCOTTISH CISTERCIAN ABBEY CHURCHES

The Cistercians built fourteen abbeys in Scotland from 1136-1273. Seven of these abbeys still have sufficient above-ground evidence of their structures to allow accurate measuring. Table 2 is a list of these abbey churches and their east and west declinations.

Scottish Abbey	Mother House	Dec East	Dec West
Melrose, Scottish Borders (VF)	Rievaulx	3.1°	-0.5°
Dundrennan, Dumfries and Galloway	Rievaulx	-1.6°	10.9°
Glenluce, Dumfries and Galloway (VF)	Dundrennan	-12.9°	19.2°
Deer, Aberdeenshire (VF)	Kinloss	-4.9°	6.5°
Culross, Fife (VF)	Kinloss	2.3°	-1.7°
Balmerino, Fife (VF)	Melrose	3.4°	-1.5°
Sweetheart, Dumfries and Galloway	Dundrennan	-2.5°	4.5°

Table 2. The remaining Scottish Cistercian abbey churches with above-ground evidence of their original structure. They are listed with their mother house and abbey church’s eastern and western declination. VF indicates that the abbey churches were measured using virtual fieldwork discussed earlier.

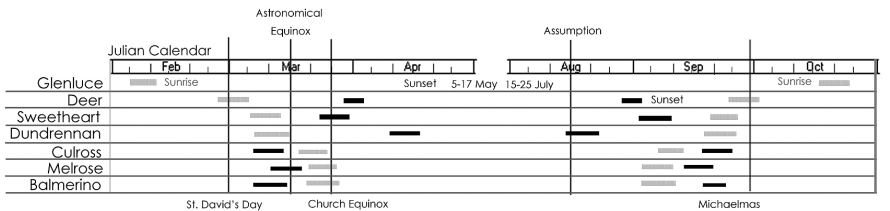


Fig. 5. The Scottish abbey churches’ solar narratives. The seven remaining Scottish Cistercian abbeys and their alignments to Julian calendar sunrise and sunsets dates for 1200 CE. The abbeys are arranged by order of their sunrise dates (eastern declination).

The orientation of these Scottish Cistercian abbey churches (Figs. 5 and 6) is more diverse than those reflected in Wales. Deer Abbey is the only abbey church which has a link to Michaelmas/Saint David’s Day and that orientation is to the east. Such a lone orientation is not statistically significant. The intentionality within the Scottish abbeys is to an orientation that either just misses the astronomical equinox in the west or just misses the church equinox in the east. This result may have been the result of compromise in order to embrace both equinoxes. Importantly with the Scottish abbey churches there is no emphasis on Michaelmas/Saint David’s Day.

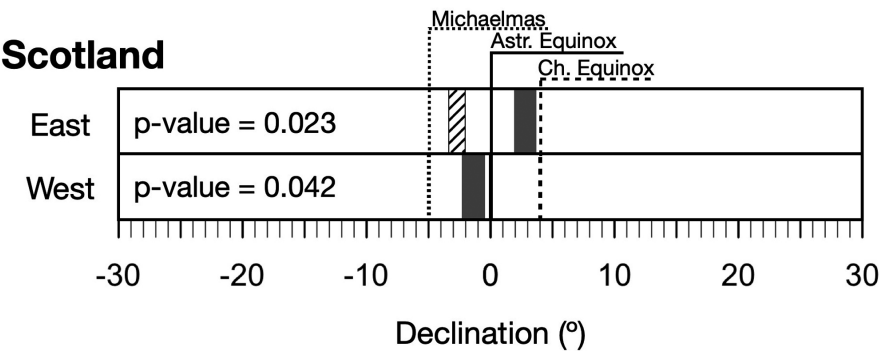


Fig. 6. Orientation of the Scottish abbey churches. Eastwards is indicated in the upper register and westwards in the lower register. The areas of shading indicate orientations, expressed as declinations, which were intentional. The darker shaded blocks show the highest statistical intentionality (p-value lower than 0.001), while the hatched blocks show less statistical significance. The only strong intentionally shown is that of in the west dec -2° to -3°, and in the east dec +2° to +3° dates which just misses the astronomical equinox (west) and church equinox (east).

VI. THE ISLAND OF IRELAND CISTERCIAN ABBEY CHURCHES

The Cistercians built twenty-seven abbeys on the island of Ireland from 1142-1272. Seventeen of these abbey churches still have above-ground evidence of their structures. Table 3 is a list of these abbey churches with their east and west declinations.

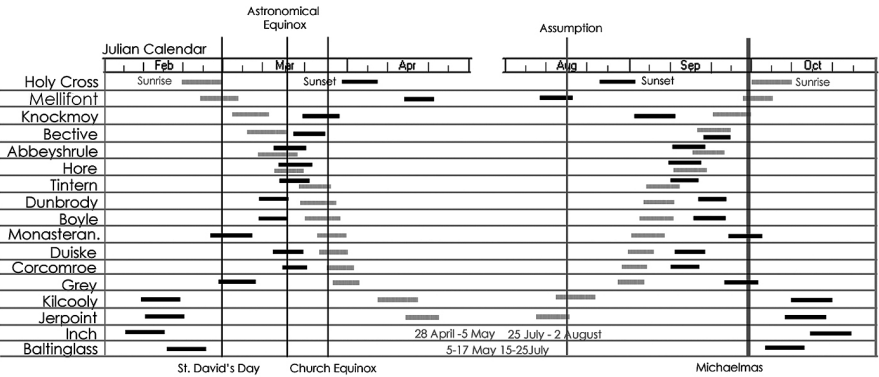


Fig. 7. The island of Ireland abbey churches' solar narratives. The seventeen Irish Cistercian abbey churches with remains that can be measured and their alignments to Julian calendar sunrise and sunsets dates for 1200 CE. The abbey churches are arranged by order of their sunrise dates (eastern declination).

Irish Abbey	Mother House	Dec East	Dec West
Mellifont, Louth	Clairvaux	-5.7°	12.6°
Bective, Meath	Mellifont	-1.6°	2.7°
Boyle, Roscommon	Mellifont	3.7°	-1.3°
Monasteranenagh, Limerick	Mellifont	4.7°	-4.3°
Baltinglass, Wicklow	Mellifont	19.2°	-8.3°
Jerpoint, Kilkenny	Baltinglass	13.3°	-10.9°
Holy Cross, Tipperary	Monasteranenagh	-6.9°	8.0°
Inch, Down	Furness, England	17.0°	-12.0°
Dunbrody, Wexford	St Mary's, Ireland	3.0°	-1.0°
Kilcooly, Tipperary	Jerpoint	11.4°	-10.6°
Abbeyknockmoy, Galway	Boyle	-2.9°	3.7°
Grey, Down	Holm, England	6.0°	-4.2°
Corcomroe, Clare	Inislounaght	5.9°	1.4°
Abbeyshrule, Longford	Mellifont	-0.9°	0.9°
Tintern de Voto, Wexford	Tintern, Wales	3.0°	1.4°
Duiske, Kilkenny	Stanley, England	5.3°	0.6°
Hore, Tipperary	Mellifont	0.8°	1.2°

Table 3. The remaining Irish Cistercian abbey churches with above-ground evidence of their original abbey structure. They are listed with their mother house and abbey church's eastern and western declination.

The dominant theme in the abbey churches of the island of Ireland (Figs. 7 and 8) is an intentional orientation to the west for the astronomical equinox, 14 March.

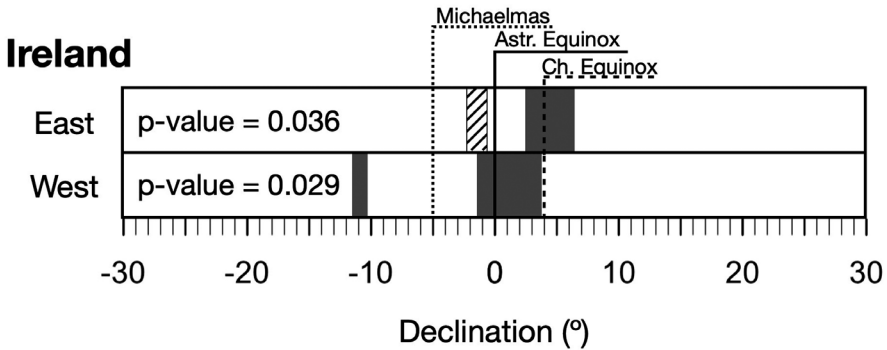


Fig. 8. Orientation of the Irish abbey churches. Eastwards is indicated in the upper register and westwards in the lower register. The areas of shading indicate orientations, expressed as declinations, which were intentional. The darker shaded blocks show the highest statistical intentionality (p-value lower than 0.001), while the hatched blocks show less statistical significance. There is a strong intentionality in the west to the astronomical equinox, while in the east the intentional orientation was to the church equinox, 25 March.

There is also intentionality to orientate the east towards the Church equinox date of 25 March. Compared with Wales, however, there is no emphasis on Michaelmas/Saint David's Day (29 September/1 March). The large block of grey in the west in Figure 8 overlapping with the shaded block in the east highlights the fact that some of the abbey churches, that of Tintern, Dunbrody, Boyle, Duiske and Corcomroe, manage to be orientated in such a way that they align with both equinoxes. This shows a similarity to the Scottish data where the abbey churches displayed an orientation that just missed the astronomical equinox in the west or just missed the church equinox in the east.

VII. THE ENGLISH CISTERCIAN ABBEY CHURCHES

The Cistercians in England built a total of sixty-six abbeys from 1124-1246, twenty of which still have above-ground evidence of their original abbey church structures. These abbeys are listed in Table 4 with their mother house, and the declination of their east windows and west doors.

English Abbey	Mother House	Dec East	Dec West
Furness, Cumbria	Savigny	19.7°	-7.7°
Waverley, Surrey	L'Aumône	-6.1°	10.3°
Rievaulx, North Yorkshire	Clairvaux	-24.9°	39.9°
Fountains, Yorkshire	Clairvaux	7.2°	-2.5°
Buildwas, Shropshire	Savigny	4.0°	-2.0°
Byland, Yorkshire	Savigny	3.9°	-0.7°
Bordesley, Worcestershire	L'Aumône /Garendon	6.9°	-5.2°
Calder, Cumbria	Furness, Cumbria	9.3°	-5.2°
Jervaulx, Yorkshire	Byland, Yorkshire	6.2°	-2.9°
Roche, South Yorkshire	Newminster	9.7°	-4.0°
Sawley, Lancaster	Newminster	8.1°	-0.8°
Dore, Herefordshire	Morimond	-20.0°	23.2°
Holmcultram, Cumbria	Melrose	6.9°	-6.5°
Kirkstall, West Yorkshire	Fountains, Yorkshire	-4.2°	8.5°
Croxden, Staffordshire	Aunay-sur-Odon	7.2°	-2.4°
Cleeve, Somerset	Revesby	-0.8°	10.1°
Beaulieu, Hampshire	Citeaux	6.8°	-4.3°
Netley, Hampshire	Beaulieu	6.1°	-5.7°
Hailes, Gloucestershire	Beaulieu	-4.9°	11.0°
Whalley, Lancashire	Combermere	-8.3°	11.6°

Table 4. The remaining English Cistercian abbeys with above-ground evidence of their original abbey church structure. They are listed with their mother house and abbey church's eastern and western declination.

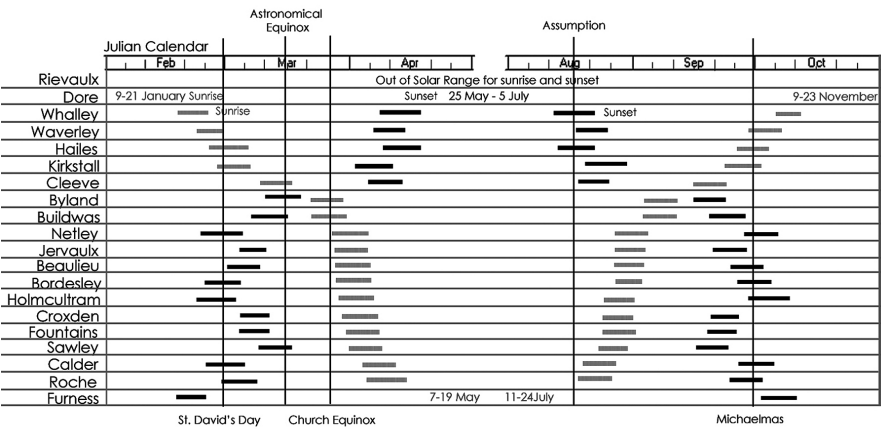


Fig. 9. The English abbey churches' solar narratives. The twenty remaining English Cistercian abbey churches and their alignments to Julian calendar sunrise and sunsets dates for 1200 CE. The abbeys are arranged by order of their sunrise dates (eastern declination).

There are two dates that are dominant for the English abbey churches (Figs. 9 and 10). The sunrise dates for the abbey churches from Byland to Roche (twelve of the twenty abbeys) all fall within the period 29 March-7 April. However, the significance of these dates is that, as shown in Figure 9, they are an artefact of the western orientation to Michaelmas/Saint David's Day which is significant. Being an artefact means that the abbey churches intentionally aligning with Michaelmas/Saint David's Day on the west will also unintentionally align with sunrise between 29 March and 7 April, the actual date for the alignment depending on their eastern

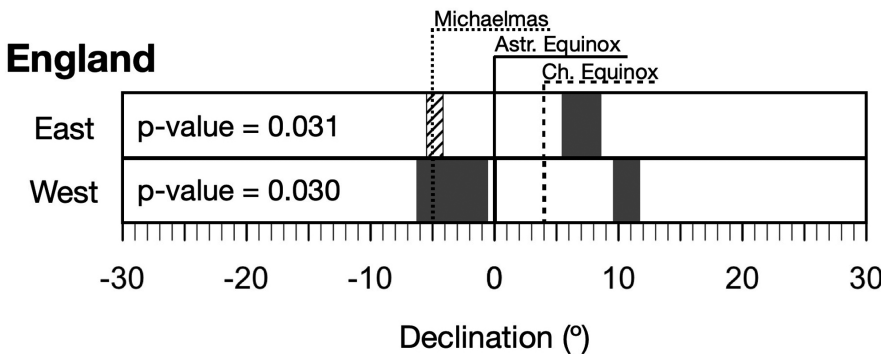


Fig. 10. The English abbey churches' orientations. Eastwards is indicated in the upper register and westwards in the lower register. The areas of shading indicate orientations, expressed as declinations, which were intentional. The darker shaded blocks show the highest statistical intentionality (p-value lower than 0.001), while the hatched blocks show less statistical significance. Michaelmas/Saint David's Day to the west spread across 6° declination is intentional, and that to the east, less so. According to this statistical method, the church equinox and astronomical equinox are not intentional.

horizon. Three abbeys are orientated to the east at these dates (Waverley, Hailes, and Kirkstall), while six are orientated to the west for these dates (Netley, Beaulieu, Bordesley, Holmcultram, Calder, and Roche). This represents a larger proportion of abbey churches with their western doors orientated to Michaelmas or Saint David's Day than was found with the Welsh abbey churches and answers the initial research question concerning whether this alignment in the Welsh abbey churches was to Saint David's Day or to Michaelmas, a result which indicates that the latter is correct. Figure 10 shows the result of applying Silva's statistical method and it shows that, as with the Welsh abbey churches, the western orientation to Michaelmas/Saint David's Day is the key statistical orientation. Notably, the church equinox and astronomical equinox do not show up as intentional orientations.

VIII. DISCUSSION

Our aim was to resolve the question of whether our findings within the Welsh abbey churches of an intentional alignment to receive the light of the setting sun on Michaelmas (29 September), which was also a mirror of Saint David's Day (1 March), belonged to a wider Cistercian narrative. Having measured the abbey churches of Scotland, England, and the island of Ireland, we found that the English abbey churches have an even greater appetite for this alignment to Michaelmas/Saint David's Day than Wales. The logical conclusion from this finding is that it is highly unlikely that the English Cistercians would be celebrating the patron saint of Wales. Therefore, we can only conclude that the privileged alignment for them was to Michaelmas, and that in the cases of Strata Florida, Neath, and Llanllugan, a local case can be made for these Welsh Cistercians who wanted to honour the light of Saint David's Day. However, in each of the regions examined no other patron saints were found to have been privileged in the alignment of their abbey churches. If they had taken this perspective, then the data would have revealed alignments to Saint Andrew for Scotland (30 November; translation 9 May), Saint Patrick for Ireland (17 March; translation 10 June), and Saint George for England (23 April). The question arises then as to why the Cistercians chose to honour Saint Michael.

Without engaging in an extensive analysis of medieval angelology as authors such as David Keck and Serge-Thomas Bonino have done, we have drawn a short overview of how Saint Michael may have fitted into Cistercian thinking.¹³ First, then, as a general statement, across a wide range of medieval texts, such as saints' lives, the Rule of Saint Benedict (c. 480-c. 548), the tract of reforming Benedictine Peter Damian (c. 988-c. 1072), and the sermons of Bernard of Clairvaux (c. 1090-1153), angels infused, saturated, and pervaded the thinking, feeling, and sensory landscapes of the medieval West and formed an integrated network around medi-

¹³ David KECK, *Angels and Angelology in the Middle Ages*, New York/Oxford 1998; Serge-Thomas BONINO, *Angels and Demons, a Catholic Introduction*, ed. Matthew LEVERING and Thomas Joseph WHITE, trans. Michael J. Miller, Thomistic Ressourcement Series 6, Washington DC 2016.

eval life. Bernard was, as Leclercq noted, a ‘continuator of the patristic era’ and his title, ‘the last of the Fathers’, as Keck pointed out, referred to the fact that he was ‘the last major theologian not to use the dialectical method.’¹⁴ Instead, the *Rule of St Benedict*, to which Cistercians rigorously paid attention, explicitly advocated against disputation. Hence Bernard’s account of angels in *On Consideration* 5.4.7 reads like a creed:

And first let us remember that the citizens of that country [the heavenly Jerusalem] are spirits, mighty, glorious, blessed, separate personalities, of graduated rank, from the beginning standing in their own order, perfect of their kind, having ethereal bodies, endowed with immortality, passionless; not so created, but so made—that is, through grace, not by nature; beings of pure of mind, benignant affections, religious and devout; of unblemished morality; inseparably one in heart and mind, blessed with unbroken peace, God’s building, dedicated to the divine praises and service.¹⁵

Bernard understood that being a monk made a man more like an angel than other men and that pursuing the religious life offered the template for living this angelic life on earth within a particular structure, the abbey.¹⁶ In the New Testament, the importance of angels came through the role they played in the drama of salvation and, as Bonino reflected, the world of the New Testament was a world conflicted: the choice was either to be under the protection of God or enslaved to the tyranny of the devil.¹⁷ This choice was faced by everyone, whether monk, mendicant, or layman, and in the secluded world of the monastery.

Michael emerged as the pre-eminent angel of the Middle Ages offering protection against demons and evil.¹⁸ He was first cited in the Old Testament in *The Book of Daniel* (10:13, 10:21) written, according to Richard Freeman Johnson, around 164 BCE, as a guardian angel of the Jews, the one who, at the end of time, would raise from the dead all those who had been inscribed in the book (12:1).¹⁹ Michael was also frequently portrayed as the *psychostasis*, the one who supervised the weighing of the souls at death and at the Final Judgement.²⁰ In *Jude* (9) he battled the devil for the body of Moses, an action which Johnson argued ‘sanctioned the belief that Michael could defend men at the moment of death from the attack of the devil.’²¹ It was, however, in *Revelation* (12:7-9) that Michael become known as the warrior-angel who led the army of God in the war in heaven and overcame the dragon by hurling it to earth. In this portrayal Michael became the saint representative of the Church militant.

¹⁴ JEAN LECLERCQ, “General Introduction to the Works of Saint Bernard (III),” *Cistercian Studies Quarterly* 40:4 (2005), p. 392; KECK, *Angels and Angelology*, p. 76-77.

¹⁵ SAINT BERNARD, “On Consideration,” in *Saint Bernard of Clairvaux Collection: 9 Books*, Oxford 1908, E-Book 5.4.7, p. 1300.

¹⁶ JEAN LECLERCQ, *The Love of Learning and the Desire for God: A Study of Monastic Culture*, New York 1982, p. 57-58.

¹⁷ BONINO, *Angels and Demons*, p. 29.

¹⁸ KECK, *Angels and Angelology in the Middle Ages*, p. 168.

¹⁹ RICHARD F. JOHNSON, *Saint Michael the Archangel in Medieval English Legend*, Woodbridge 2005, p. 14, n. 21.

²⁰ *Ibid.*, p. 87.

²¹ *Ibid.*, p. 87.

Michael was never martyred, like other saints and as 'an asomatic being who does not participate in the earthly and temporal reality of humans', Johnson commented, without the material relics that were so essential to the cults of other saints, his influence came from the legends that grew around him connected with the role he played at the moment of death and at the end of time.²² Major shrines were raised at Mount Gargano in southern Italy, the oldest shrine in Western Europe dedicated to the archangel following his appearance in an apparition to Bishop of Sipontum for three nights in a row, the final night being 29 September, 493, and at Le-Mont-Saint-Michel in Normandy, where an apparition appeared to Bishop Aubert of Avranches in 708. A plethora of churches were dedicated to him and cathedrals such as Salisbury Cathedral built altars to him.²³ Furthermore, in Assumption texts that first began circulating in the fourth century, such as Gregory of Tours (c.538-594) *Libri miraculorum* I, *De gloria beatorum martyrum* IV [PL LXXI, 708]), Christ entrusted the Virgin Mary's soul to Michael as she crossed into heaven.²⁴ As the cult of Mary developed in importance in the eleventh to thirteenth centuries, so Michael's role changed. In medieval imagery, Michael and the Virgin were often depicted together at the scene of a recently deceased, Michael gripping the scales of judgement and the Virgin interceding on behalf of the dead person's soul.

We may not know exactly why the Cistercians aligned some of their abbey churches to receive the light of the setting sun on the Feast of Saint Michael. Keck maintained that an annual Feast on 29 September recognising the triumph of good over evil through Michael's capacity to protect men against demons gave the medieval world 'a concrete focus for thanking and venerating the service of the angels.'²⁵ As noted earlier, an abbey church alignment that allowed the light of the setting sun on the Feast of Saint Michael to fall inside the church meant that this annual celebration could be held within the walled community of the abbey. In our previous paper we also noted that 29 September coincided with the beginning of autumn and entry into the dark part of the year. Taking all of this into account, what we can rely on with certainty is that the evidence of our current fieldwork presents a new piece of primary evidence that has been built into the footprint of these abbey churches. In this paper we have offered a suggestion as to why this might have been an attractive option to the Cistercians. It is now open to researchers versed in archival retrieval to add to our empirical evidence.

IX. CONCLUSION

The aim of our research was to address the question that arose from our first investigation of the Welsh Cistercian abbey churches. This showed a tendency to have the orientation of the western doors to Saint David's Day (1 March) or

²² *Ibid.*, p.4.

²³ KECK, *Angels and Angelology*, p. 4, 170, 180.

²⁴ JOHNSON, *Saint Michael the Archangel*, p. 28.

²⁵ KECK, *Angels and Angelology*, p. 168.

Michaelmas (29 Sep). As these two dates both have the same solar declination and Saint David is the patron saint of Wales, the only way to decide on the possible intention of the builders was to explore the other Cistercian abbey churches in Scotland, the island of Ireland, and England.

All the Cistercian abbey churches in these regions which had visible remains were measured. Using Silva's statistical significance test allowed us to identify which orientations in each region were more likely to have been intentional. This not only provided an objective and quantitative way of demonstrating that these churches were not orientated randomly, but it also gave focus to our interpretations and confidence in addressing the question of Michaelmas. Our results revealed that this orientation to Michaelmas/Saint David's Day was in fact a distinct English feature as it was substantially represented in the English abbeys than in any of the other regions. In the light of this evidence and given that it would be unlikely that the English Cistercians would honour Saint David with their western doorways, we concluded that it was the sunlight of Michaelmas that was being welcomed into the churches. Additionally, this was supported with the Cistercian devotion to the Virgin Mary and her associations with Saint Michael and the west.

With such a strong emphasis on Michaelmas in the English Cistercian abbey churches, we hypothesised that this English Cistercian feature may have drifted west into Wales and may have been deemed acceptable due to the coincidence of also aligning to Saint David's Day. However, what challenges this hypothesis is that no other patron saint, either in Scotland (Saint Andrew) or on the island of Ireland (Saint Patrick) were so honoured by the Cistercians. In contrast, the Cistercians on the island of Ireland and in Scotland appeared to ignore, reject or be unaware of the English Cistercian model and if anything, in the case of Ireland, they maintained faithfulness to the equinoxes, church or astronomical. Of the four regions researched, the desire to receive the sunlight of the setting sun at Michaelmas into their abbey churches appears to be a distinctly English Cistercian feature.

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La lumière du soleil à la Saint-Michel et les cisterciens de Grande-Bretagne et d'Irlande

Cet article s'appuie sur des recherches antérieures concernant le rôle du soleil dans les églises des abbayes cisterciennes du Pays de Galles. Les résultats de ce projet ont laissé ouverte la question de savoir si leur orientation vers le coucher du soleil à la Saint-Michel (29 septembre) et à la Saint-David (1er mars) était spécifique au Pays de Galles ou faisait plutôt partie d'un contexte cistercien plus large. Cette étude porte sur les abbayes cisterciennes d'Angleterre, d'Écosse et de l'île d'Irlande, et se sert d'une recherche sur le terrain, directe et virtuelle, autant que de l'interprétation des données. Nos résultats indiquent que les églises abbatiales anglaises ont un intérêt encore plus grand pour cet alignement sur la Saint-Michel/Saint David qu'au Pays de Galles, alors qu'il est absent en Écosse et en Irlande. La conclusion logique est qu'il est très peu probable que les cisterciens célébraient le saint patron du Pays de Galles, mais plutôt saint Michel.

The Sun's light at Michaelmas and the Cistercians of Britain and Ireland

This paper builds on previous research about the sun's role in the churches of Cistercian abbeys in Wales. The results of that project left open the question of whether the focus of their orientation to sunset on Michaelmas (September 29) and Saint David's Day (March 1) was specific to Wales or was instead part of a wider Cistercian narrative. This study looks at Cistercian abbey churches in England, Scotland, and the island of Ireland, and uses a combination of live and virtual fieldwork as well as significance testing. Our findings indicate that the English abbey churches have an even greater appetite for this alignment to Michaelmas/Saint David's Day than Wales, whereas it is absent from Scotland and Ireland. The logical conclusion from this is that it is highly unlikely that the Cistercians would be celebrating the patron saint of Wales, but rather Saint Michael.

Das Sonnenlicht am Michaelstag und die Zisterzienser Großbritannien und Irlands

Dieser Artikel baut auf einer vorausgegangenen Forschung zur Bedeutung der Sonne in den Kirchen der Zisterzienserabteien in Wales auf. Die Forschungsergebnisse dieses Projekts ließen die Frage unbeantwortet, ob der Fokus bei der Ausrichtung der Kirchen auf den Sonnenuntergang am Michaelstag (29. September) und am Sankt Davidstag (1. März) spezifisch für Wales oder vielmehr Teil einer umfänglicheren, zisterziensischen Überlieferung war. Diese Studie untersucht zisterziensische Abteikirchen in England, Schottland sowie Irland und verwendet eine Kombination von Feldforschung vor Ort und virtueller Feldforschung sowie Signifikanzprüfungen. Unsere Ergebnisse deuten darauf hin, dass die englischen Abteikirchen sogar eine noch größere Neigung zu einer Ausrichtung in Abhängigkeit vom Michaelstag bzw. St. Davidstag haben als diejenigen in Wales, während eine solche in Schottland und Irland fehlt. Die logische Schlussfolgerung daraus ist, dass es höchst unwahrscheinlich ist, dass die Zisterzienser den Schutzpatron von Wales feierten, sondern dass es vielmehr der heilige Michael war.

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