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ORIENTATION OF THE CHURCHES IN THE HISPANIC MEDIEVAL CASTLES

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ABSTRACT

It is a well-known fact that the pre-Romanesque and Romanesque churches are usually oriented to positions compatible with the sunrise on some day of the year. This supposes an annual variability that allows a precise calculation of the stakeout day, making possible to analyse the reasons for choosing that specific day. However, in the churches of medieval fortifications there are functional conditions that can alter this general criterion. In this case there are strong defensive conditions that can prevail over the symbolic conditions of the sunrise orientation. This is not the general rule and there are numerous examples of churches forced by orientation to very unfavourable positions in the territory. Therefore, this study may be of interest and provide a new point of view when concerning to churches with functional conditions very different from the normal ones. Due to the scarcity of specific studies on the orientation of the churches of fortified ensembles, the authors propose to analyse the orientations measured in a group of 43 Spanish and Portuguese churches linked to medieval fortifications built between the 9th and 13th centuries. Only churches that may be directly related to fortification have been selected, excluding doubtful cases. It is not included the numerous castles in which it is not possible to identify the church or chapel. Finally, some interesting atypical cases will be analysed, which are very notable in this type of churches.

KEYWORDS: Romanesque fortifications, Church orientation, Solar movements, Orientation measure, Spanish castles, Portuguese castles

1. INTRODUCTION

As other previous beliefs, Christianity considered the adoption of guidelines of orientation of its sacred important spaces, although not at the beginning. The first churches were developed in a clandestine situation, so the main intention was to go unnoticed. They are private houses "domus ecclesiae" and later the "tituli". In these cases there are no defined guidelines for orientation.

However, Christians had got the habit of praying towards the east. It is collected by numerous testimonies (Tertuliano, 2001), (Eusebio de Cesarea, 1973). Christians have freedom of worship from the reign of Constantine, so the first buildings built specifically for Christian worship, some of them are oriented to the east and others to the west because of liturgical reasons. In both cases the priest directs the pray to the east, specifically towards the sunrise, as Eusebius of Caesarea quotes. The relative position of the priest and the faithful was changed, as Vogel and others points out (Vogel, 1962; McCluskey, 2015).

This trend continues during the following centuries. The most of the churches are oriented to the east quite precisely, which is a widely known and studied fact (Nissen, 1906; Cave, 1950; Pérez-Valcárcel, 1998; Kräuchi, 2020). There were some exceptions in some periods such as the pre-Romanesque and Asturian times (8th to 10th centuries) in which there was a notable incidence of orientations towards the northeast in directions that are outside the possible locations of the sunrise as it is indicated by several authors (Gonzalez-Garcia et al. 2010). The reasons for this deviation are unknown. In some cases they are easily explained by the topographic conditions of the place, but in other cases it is not possible a reasonable justification. However, the most of the churches, even in these periods, have orientations compatible with the sunrise. They are the so-called canonical orientations.

From the beginning of the Romanesque period, the orientations are mostly canonical. From the measurement of 906 Romanesque churches, Pérez Valcárcel and Pérez Palmero have shown that in the Iberian Peninsula only 3.99% have no canonical orientations (Pérez-Valcárcel & Pérez Palmero, 2020). About these, 3.95% are orientations located further north than the summer solstice and 0.2% are orientations further south than the winter solstice. There is also a very small number of churches oriented to the west, 0.2%.

Interesting studies have recently been published analysing the interactions between various aspects of construction and astronomy. A widely analysed topic is the possible symbolic relationship between the orientation and the feast of the patron saint of the church (Hinton, 2006; Kräuchi, K, 2020). Also the light effects linked to orientation (Incerti, 2015). Likewise, the interesting study by Lluis i Ginovart on the orientation and staking system in churches of the Arán valley can be cited (Lluis i Ginovart, 2021, 1-2). But the most of the studies carried out have focused on the analysis of churches in a certain area or a specific historical period (Ali & Cunich, 2001; Liritzis and Vassiliou, 2002, 2006; Hinton, 2006; González-García & Belmonte, 2015; Dallas, T.G. 2015, 2018; Hannah, 2015; Sassin, 2016; Spinazzé, 2016; Hannah, Magli and Orlando, 2016; González–García and García Quintela, 2018; Motta and Gaspani, 2018). Studies referring to the function for which the churches were destined are less frequent. Pérez Valcárcel and Pérez Palmero have analysed the Romanesque churches of the Iberian Peninsula based on their use as parish, monastic churches of religious or military orders, hermitages, etc (Pérez-Valcárcel & Pérez Palmero, 2020). Hoare has also published recently a study of English parish churches (Hoare, 2015).

There are numerous examples of churches in the Romanesque period, especially monastic, in which the orientation to the sunrise is imposed on functional needs. It seems as if it was an essential conditioner that justifies very doubtful, complicated or even not very correct constructive solutions (Pérez-Valcárcel, 2018). This is observed in churches of all types, but in those of the fortified sites it seems to be an adjustment between defensive needs and orientation. This is the subject of this study which, according to the authors' knowledge, has not been previously analysed.

A series of fortified Romanesque or Romanesque groups from the Iberian Peninsula will be studied to analyse this question. Many of them have been the subject of subsequent interventions that may have seriously altered the morphology of the castle. However, it is possible to determine with reasonable certainty the orientations of the Romanesque or pre-Romanesque churches are part of these groups in the cases that will be seen, although they have been modified in later centuries.

2. CHARACTERISTICS OF MEDIEVAL FORTIFICATIONS IN THE IBERIAN PENINSULA

The medieval fortifications of Ancient Hispania, currently Spain and Portugal, have specific characteristics, in many ways different from those common in Europe. These characteristics affect the defensive systems and the precariousness of the living spaces, so the construction of the worship space is usually different from that of other places. For this reason, it is convenient to make a brief introduction of the characteristics of these fortified enclosures. The study focuses on Hispania between the 8th and 13th centuries,

which corresponds to the pre-Romanesque and Romanesque periods. Muslim fortifications are obviously excluded, except for those cases in which they were reused and churches were built on them.

It must be taken into account that the circumstances of medieval Hispania largely determine the fortification solutions. There is a period of intermittent war practically from the Muslim invasion to the capture of Granada, with a few battles, but with constant incursions. Clashes took place both between Christians and Muslims, as between Christian kingdoms and Muslim taifas[1] each other. In this context, it is necessary to create small but hard-to-challenge fortifications that allow the territory to be consolidated, since several small fortifications were more useful for this purpose than a big one. In fact, most of them were abandoned when they were no longer needed. And these castles were in remote places of little agricultural value, which has allowed the conservation of a huge number of them at the present.

Many of these castles are small, although there are some of large dimensions. In many cases they use their own situation on rocks that are difficult to access and that improve their defence. Christian castles usually have circular-shaped castellated cubes and a homage tower, generally rectangular, much greater height. Contrary to European castles, the towers do not have a sloping roof, but a plane roof that allows rainwater to be collected and sent to the cistern. On many occasions the fortification is reduced to the tower, the only thing preserved. It is possible there was an external defence built with soil, adobe, mud wall or wood, which has been lost due to being elements of little durability. In any case, the tower is the really fortified element, which in many castles has at least three separate levels with timber floors. The lower was usually dedicated to the guardhouse and warehouses, in the second floor there was usually a large hall where the chapel could be attached and the upper usually contained the bedrooms. Its construction is made with stone masonry from the area without plastering. Brick is also used in later dates. Moreover, to the main defence line formed by the tower and the first enclosure, successive fortified enclosures are added in many cases, either concentric as in Turégano (Segovia) or attached as in Ansiães (Portugal). When the castle is located on the plain, it often has a dry moat.

Muslim castles were usually simpler, especially during the caliphate of Cordoba. They were normally made up of a perimeter wall with cubes with a square plan and lack a homage tower. Many of them have albarrana towers a defensive system of Arab origin and characteristic of Spanish castles, since it was widely copied by the Christians[2]. An exceptional example is Calatrava la Vieja (Ciudad Real) with formidable defences and even with four corachas[3] with water wheels to drive water from the river that could be derived to the moat in case of siege. Several churches were built in this type of castles, once taken by the Christians, which will be also the object of study.

There is a rare circumstance in Europe in the Hispanic castles of the Romanesque and earlier times. The castles were usually spoils of war and therefore belong to the king, who entrusts his defence to a vassal in reward for his services and may withdraw it, if he did not comply properly. The castle of Calatrava la Vieja is an interesting case. After the conquest of Toledo, the Muslim warden surrendered the castle to Alfonso VI, who entrusted his defence to the order of the Temple. After a period of occupation, the Templars considered it impossible to defend, so the king entrusted it to the abbot of Fitero, who founded the Calatrava order for that function. Unlike in Europe, where many castles were owned by a feudal nobleman, in Hispania most castles are royal property. This situation will be gradually change and the most of the castles from the 14th century going to be donated by the monarchs for noble families in exchange for their support.

However, an interesting and little studied aspect is the orientations of churches that are part of fortified complexes. It is evident that in the Hispanic Middle Ages it was inconceivable to build a fortification without a sacred place to ask for divine help, greatly needed, even if it was small or included in the general set. However, in a large number of castles it is actually difficult to identify the chapel. The wall is usually preserved and also the towers. The set of buildings, usually made of wood and attached to the interior of the wall, has almost always been lost. In these buildings there were warehouses, houses, forges and other dependencies, among which there would be surely a chapel. It would be probably a very functional place, with few concessions to decoration. In the new building in the Ponferrada Templar castle, the chapel is under the armoury room, since the old fortress apparently does not have a place of worship. In some of the most spectacular castles in Spain and Portugal such as those of Arnoia and Algoso (Portugal) or that of Zafra

[1] The taifas were small Muslim kingdoms into which the Caliphate of Córdoba was divided after its abolition in 1031.
[2] An albarrana tower is a tower separated from the wall and connected to it by a bridge that can be knocked down if the enemy takes it.
[3] A "coracha" is a single wall that protects the communication between a fortress and an external point, usually a water supply. It only exists in the Iberian Peninsula, so it has no translation.

(Guadalajara, Spain), a distinctive chapel cannot be identified either. One of the best preserved chapels, Sta. María de Valverde in the Loarre castle has got a small size and highly austere. It is the old chapel of the castle, before building the extension for the Augustinian congregation, for which was built the great church of San Pedro.

Even in big castles is difficult to find out the chapel sometimes. Thus, in castles such as Torrelobatón or Montealegre de Campos, no chapel appears that has been identified with certainty. It is possible that the worship was held in a nearby church as Atienza (Guadalajara). But in castles located in very rugged areas such as Peñafiel (Valladolid) or Doiras (Lugo) this option would involve difficult and unsafe movements. It is not probably these castles lacked a chapel, so it is possible that it was one of the dependencies that have not been preserved.

When a church exists in the fortified enclosure, its size is not always in accordance with the importance of the building. We can find castles of great importance with a small church, as in Pambre. On the contrary the church can be disproportionately size until the point occupying a big part of the enclosure as in Turégano. There are also cases with churches proportionate to the size and importance of the castle, such as in Loarre, Montearagón, Artajona or Montemor-o-Velho. However, what this article tries to analyse is if the orientation of such churches was subordinated or not to military needs.

3. ORIENTATION MEASUREMENT AND FACTORS CONSIDERED

The position of the solar ortho that could be observed by the builders of the church occurs at point P, which corresponds to a certain height of the horizon. The position of the temple is defined by point C, which marks the measured orientation, but the real day on which the stakeout was made would correspond to a sunrise on a flat horizon at point D, which is what is has defined as position of the "true ortho" (figure 1).

The necessary data are the orientation and the height of the horizon, which considerably affects the position of the true ortho. The orientation is measured with a compass by the angle it makes with the north direction and the height of the horizon is measured with a clinometer. It is also necessary to know the latitude of the place, since the solar trajectories depend on it. In addition, minor factors intervene in the problem, such as the eccentricity of the apparent orbit of the Sun or the precession or nutation movements of the Earth. The eccentricity of the orbit only has a very slight influence on them. The calculation model takes this into account, despite of its low incidence. Another factor involved in the problem is the effect of solar radius and atmospheric refraction. The solar radius is 16 'and 34' must be added due to atmospheric refraction. This assumes that when the sunrise is observed it is actually 34 'lower than the horizon. This difference has not been taken into account, but it is applied to the general error admitted, since the possible alignments would undoubtedly have a higher error.

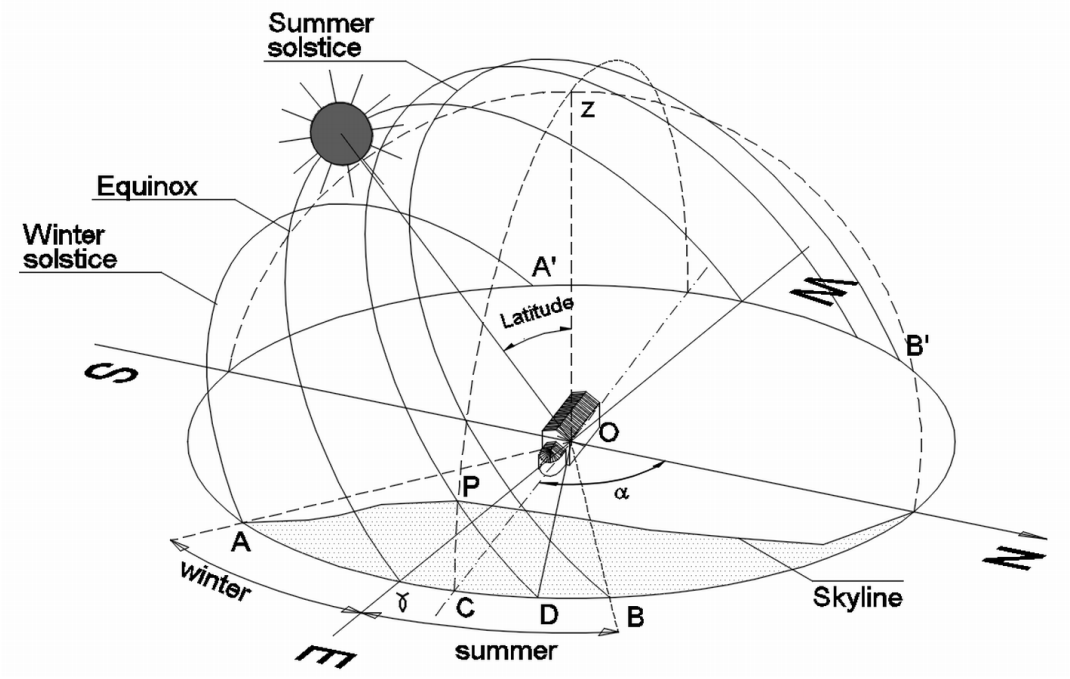

Figure 1.- Measurement of the orientation of a church

Orientation measurements were taken by the authors using a Suunto KB-14/360R G precision compass. The axis orientations of the apse and, where appropriate, of the church nave have been taken in all the cases in which they have been accessible. When it is not possible to access the interior, the orientations can be taken from the outside at various points, of which we consider the most significant sides of the apse. The compass used gives a precision of 0.25º. However, the irregularities of the building and the lack of fixed references, it is advisable to estimate in the calculations a possible error of ± 1º with respect to the measured value. In all cases the orientation has been verified with aerial photos, using the Iberpix application of the National Geographic Institute of Spain. The compass measurements can be altered by local magnetic distortions or metallic elements, which have not been observed in these particular churches, although they have been observed in other measurements previously.

In order to calculate the position of the solar ortho, it is essential to measure the altitude of the horizon. We have used a Leica brand laser meter; model DISTOTM D8 with a digital clinometer with a precision of 0.05º. But this measure is not always possible, as there may be subsequent buildings or obstacles that prevent it. In these cases, the Iberpix viewer, already mentioned, has been used, which provides the distance to the element that defines the horizon and the difference in level between said element and the church. With this, the tangent of the vertical angle is obtained that allows correcting the real position of the solar ortho.

4. THE LOCATION OF THE CHURCH IN THE CASTLE

At the contrary to what it might seem, in many occasions the situation of the church or chapel was not especially important. An example can be very revealing. Gaillard Castle, which was ordered to be built by Richard the Lionheart in 1197 as a strong point of the Duchy of Normandy, had a church located in a corner of the courtyard. It did not belong to the original design, but it was built by John Lackland and certainly with little sense, because its windows allowed the French assault in 1204. The figure 2 shows the engraving of Viollet-le-Duc, that indicates the situation of the chapel with the letter H (Viollet-le-Duc, 1967). The orientation of the church is not canonical, but is fixed by the wall which it is attached.

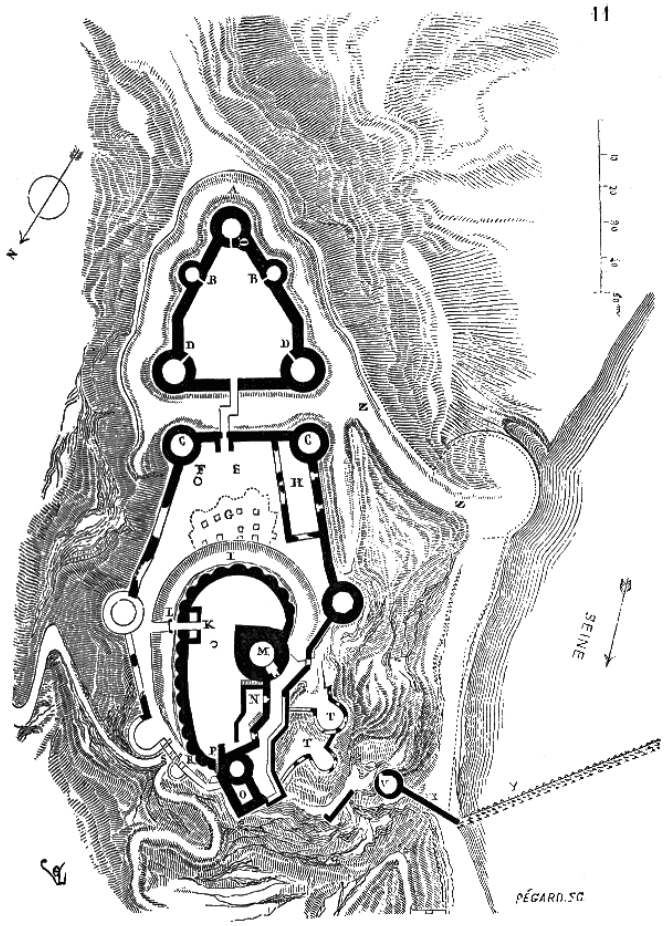

Figure 2. Gaillard Castle. Normandy.

For the purposes of this study, it is convenient to distinguish various types of church locations in relation to the castle. The church may be located within the enclosure defined by the rampart as another building, to be a part of the fortification, or even to be outside. Constructive constraints are very different. Based on this situation, we are going to distinguish four groups: churches built against the wall or other elements of fortification, such as the towers, churches located inside the castle and those located outside. The fourth group corresponds to churches that have been built reusing Muslim defensive elements, in which case their orientation is forced, but present interesting aspects.

Churches located within the limits of a walled town have been excluded from this study, except if the church has a strong relationship with the fortification. A church in a city may be influenced by the previous design of the streets, but it is probably not related to the polychoretic.

The analysed database is made up of the following churches. They are ordered by their geographic longitude from west to east. The actual measured orientation, the position of the solar sunrise considering the altitude of the horizon and the days that it could be staked, towards the solar sunrise or towards sunset are indicated. These days have been calculated with the Orient 3.1 program developed by the authors, which allows defining these dates with accuracy about 2 days at the equinoxes and about 12 days at the solstices. The dates correspond to the Julian calendar, the current one is that time.

Table 1. Orientation of the churches of the fortifications in the Iberian Peninsula

Church	Site	Province	Orient.	True Ortho	Altitude horizon	Type	Day East	Day West
Ntra. Señora	A Lanzada	Pontevedra	89.2	86.5	3.00	Interior	19-mar	09-sep
Santiago	Oeste	Pontevedra	69.8	66.6	3.20	Attached	01-may	31-jul
S. Martín	Manhente	Portugal	77.80	77.80	0.00	Exterior	06-apr	24-aug
Sta. María	Soutomaior	Pontevedra	155.4	155.4	8.50	Attached		
Cristo	Tomar	Portugal	91.88	90.92	1.15	Interior	11-mar	18-sep
S. Miguel	Guimaraes	Portugal	66.2	63.5	2.85	Exterior	10-may	18-jul
S. Pedro	Pambre	Lugo	83.90	82.49	1.50	Interior	29-mar	04-sep
Sta. María	Monterrei	Orense	83.78	83.31	0.50	Attached	25-mar	02-sep
S. Salvador	Ansiaes	Portugal	81.0	81.0	0.05	Exterior	01-apr	29-aug
Sta. María	Ansiaes	Portugal	91.7	91.6	0.05	Exterior	09-mar	18-sep
S. Juan	Ansiaes	Portugal	85.5	84.7	0.90	Exterior	23-mar	05-sep
Sta. María	Bragança	Portugal	98.6	98.6	0.00	Interior	24-feb	01-oct
S. Juan	Támara	Palencia	61.5	61.5	0.00	Interior	17-may	14-jul
Sta. María	Barromán	Ávila	62.7	62.7	0.00	Attached	16-may	16-jul
S. Salvador	Ávila	Ávila	87.5	86.3	1.35	Attached	21-mar	09-sep
Santiago	Turégano.	Segovia	82.8	82.8	0.00	Attached	27-mar	01-sep
S. Martín	Fuentidueña.	Segovia	103.2	101.4	1.96	Interior	19-feb	08-oct
Sta. María[4]	New Calatrava	Ciudad Real	73.2	73.2	0.00	Attached	17-apr	11-aug
Sta. María[5]	Old Calatrava	Ciudad Real	81.3	81.3	0.00	Attached	30-mar	29-aug
Sta. María	Old Calatrava	Ciudad Real	44.0	44.0	0.00	Attached		
Sta. María	Pedraza	Segovia	124.1	124.1	0.00	Exterior		
Sta. María	Maderuelo	Segovia	79.3	79.3	0.00	Interior	03-apr	26-aug
S. Vicente	Frías	Burgos	107.8	103.7	4.20	Attached	15-feb	13-oct
S. Miguel	Beleña de Sorbe	Guadalajara	65.44	62.48	3.10	Exterior	15-may	15-may
S. Juan	Almería	Almería	109.7	109.7	0.00	Reused		
Sta. María	Estella.	Navarra	71.7	64.7	7.12	Interior	05-may	24-jul
S. Saturnino	Artajona	Navarra	87.3	85.9	1.45	Interior	20-mar	07-sep
Sta. María	Ujué	Navarra	94.6	94.6	0.00	Attached	05-mar	24-sep
S. Gil.	Luna	Zaragoza	101.4	100.2	1.35	Exterior	22-feb	05-oct
S. Pedro	Loarre	Huesca	83.3	79.6	4.05	Attached	03-apr	27-aug

[4] Templar church
[5] Calatrava church

Sta. María	Loarre	Huesca	88.3	84.6	4.05	Attached	24-mar	06-sep
Desconocido	Loarre	Huesca	69.3	61.5	8.00	Exterior	17-may	16-jul
Sala Dña. Petronila	Huesca	Huesca	110.8	110.0	0.90	Reused		
Jesús Nazaret	Montearagón	Huesca	90.0	89.9	0.15	Attached	14-mar	15-sep
Sta. María	Muro de Roda	Huesca	34.9	34.9	0.00	Attached		
S. Emeterio y Celedonio	Samitier	Huesca	121.05	119.1	1.80	Attached	08-jan	22-nov
Sta. María	Alquézar	Huesca	93.61	91.76	2.03	Interior	08-mar	18-sep
S. Martín	Buil	Huesca	57.38	52.51	4.50	Exterior		
Sta. María	Aler	Huesca	97.4	91.7	6.30	Attached	10-mar	19-sep
Sta. María	S. Martí Sarroca	Barcelona	72.7	72.7	0.00	Attached	17-apr	12-aug
S. Vicente	Cardona	Barcelona	85.75	84.31	1.59	Interior	24-mar	06-sep
S. Miguel	Olérdola	Barcelona	93.7	93.7	0.00	Interior	07-mar	27-sep
S. Miguel	Olérdola	Barcelona	96.5	96.5	0.00	Interior	02-mar	30-sep

The first group correspond to churches that are built attached to the defence elements taking advantage of them. It is a fully functional approach. To build a strong defensive wall was complicated and expensive. It is logical to build the wall serving two enclosures simultaneously. In some cases, the church is simply attached to wall, as in Torres del Oeste, Soutomaior, Calatrava la Vieja, Frías, Ujué, the two churches within the Loarre castle or Montearagón. In other cases, the church itself becomes a defensive bastion, such as Monterrey, Barromán, the Ávila cathedral, Turégano, Frías, Calatrava la Nueva, Muro de Roda, Samitier, Aler, Llimiana or Sant Martí Sarroca. The apse is inside a cube of the wall in the cathedral of Ávila, Aler or Barromán. The apses can be part of the fortification protecting access in Calatrava la Nueva, Muro de Roda or Monterrey. Other churches may be on a steep rock that constitutes a sufficient natural fortification as Llimiana, Sant Martí Sarroca or Frías. On occasions such as Ujué or Turégano the fortification develops concentrically to the church that seems to have been the starting point of the complex. Finally, the church itself is a first line of defence in Samitier.

These churches are strongly conditioned by their defensive function, so orientation might seem to become a secondary aspect. However, most of them have canonical orientations, except Muro de Roda, the church of the order of Calatrava in Calatrava la Vieja and Soutomaior. The last one is very late and there is no evidence that it was located in the same position in the much smaller Romanesque first fortification. In the case of Samitier, the most atypical of all, its orientation could be canonical, but it will be seen that the topographical determining factor is decisive.

A second group is formed by the churches located inside the main fortified compound, but which are exempt or at least not part of the defensive system. In the most of cases their orientation does not present any defensive conditioning factors, so it is reasonable to think that the orientation criterion should have been similar to that used in other contemporary churches. There are great differences between them. There are small churches with an evident use of chapel only for residents of the castle, such as in Pambre, large churches such as San Saturnino de Artajona or even cathedrals such as Cardona. The church is usually located in a central position in large fortifications such as the Convent of Christ in Tomar. Generally, no special conditioning factors are observed in its orientation, which is canonical in all cases. A singular case is Maderuelo in which the church of Sta. María is deviated 34º from the layout of the streets to give it a canonical orientation, which implies a clear intentionality.

The third group is formed by churches located outside the fortified enclosure. Only churches with a closer relationship to the fortification have been considered in the specific database. It may be because of its proximity, because it is a nexus between the castle and the town or because the town did not have a sufficient entity by itself. Sometimes, they are located outside the main enclosure such as in the churches of S. Salvador and Sta. María de Ansiães, but inside the second ring of defence. But the most of cases their situation is on the slope between the fortified compound and the population that is in the flat area. It seems as if these types of churches did not have got the defensive concerns of the first Romanesque. They are usually in areas relatively far of Muslim danger at the time of construction. It could be considered that in a possible confrontation between Christians, no one would dare destroy a church, but in any case it is a hypothesis without possible confirmation. They are very frequent and it is not always easy to determine if their initial use was linked to the fortification or to the town. In some cases such as Guimarães or Gormaz, its

relationship with the castle is evident, but in many others such as Pedraza, San Esteban de Gormaz or Buil, there is an appreciable distance that makes one doubt. In all cases, the orientation is not conditioned by military reasons, so the general criteria may be applied.

Finally, two very different churches and two very distant periods are cited as an example of the reuse of different Muslim military precincts to mosques. This circumstance obviously excludes any hypothesis of predetermined orientation.

There are numerous examples of reusing Muslim mosques as churches. In some cases, the church was attached to the side of the mosque, as in the Cristo de la Luz in Toledo. At the most frequent cases it was built on the mosque turning the church 90º like the old cathedral of Badajoz or the cathedral of Huesca. On others, it was oriented to the north as the safe case of S. Sebastián de Toledo or the probable case of Hérmedes de Cerrato (Pérez-Valcárcel & Pérez-Palmero, 2018). New churches were normally built in the fortified complexes, although taking advantage of pre-existing walls. This is the case of the castle of Calatrava la Vieja, where the primitive Templar church and the later one of the Order of Calatrava are superimposed. Both are attached at the southeast wall of the castle, but with different orientations. The Templar church has an orientation of 81º17'that corresponds approximately to the civil equinox (not the astronomical one) in the year of its construction[6]. In this case the horizon is closed by the outer wall, so it had to be calculated carefully and fairly accurately. On the contrary, the Calatrava church was built over the previous one that remained as a crypt and was simply attached to the same wall, which has got an orientation of 44º. It is an orientation that does not correspond to any possible position of the sunrise. It seems that the intention would have been to orient the church towards the east without forcing its situation in the fortress. The function in this case has passed over the symbolism. In contrast, in Calatrava la Nueva, the same Order built the church with a canonical orientation. Of course, attached to the wall forming a strong bastion, that defends the access gate.

Two interesting cases of reuse are the Sala de Doña Petronila and the chapel of Sta. Catalina in the castle of Jaén. They are not related to each other, but they are two examples of two ways of orientation in a reuse that was not intended for it.

The Sala de Doña Petronila occupies the upper part of the hexagonal tower of the old Arab fortress, converted into the Palace of the Kings of Aragon in Huesca. It is a reused space where a magnificent chapel was built, that tradition supposes is the place of the wedding of this queen. The room had an orientation of 110º 48', which is a winter orientation, quite atypical, but in any case canonical. The intention of this orientation is evident because the access to this room is uncomfortable.

At the contrary, the chapel of Sta. Catalina is located in an albarrana tower of the Jaén castle, built by the Muslims on a hill that has been fortified since pre-Roman times. According to tradition, the chapel was ordered to be built by the Castilian king Fernando III after the conquest and it is located inside the tower, which is practically oriented north (11º15 '). It is evident that it is a strictly functional solution without any symbolic intent. An interesting fact about this chapel is its small size. This suggests that if in this occasion such a small enclosure was fitted out, despite having plenty of space; it was because the king himself seemed sufficient. Therefore, it is possible to think that it was what they were used to seeing.

The churches attached to the fortification represent 37.04% of the total database; the interiors to the enclosure 35.19% and the exteriors 27.78%. The three groups are quite similar so the statistics are comparable.

Making a statistic of the measured cases, the results are as follows.

Table 2. Orientations in churches in medieval fortified enclosures

	Number of churches oriented according to the angle												
Orient. inº	<57	57-63	63-69	69-75	75-81	81-87	87-93	93-99	99-105	105-111	111-117	117-123	>123
Attached	2	3	2	2	1	4	2	1	1	0	0	2	0
Inside	1	1	1	0	2	6	2	2	2	2	0	0	0
Outside	1	2	1	0	3	2	2	1	1	0	1	0	1
Total	4	6	4	2	6	12	6	4	4	2	1	2	1

[6] For medieval builders the equinox occurred on the Julian date of March 21. There are even Mozarabic calendars that indicate March 25 as "equinocti verni: mundi dies primus". According to the calendar used there would be between 7 and 11 days of difference with the astronomical equinox.

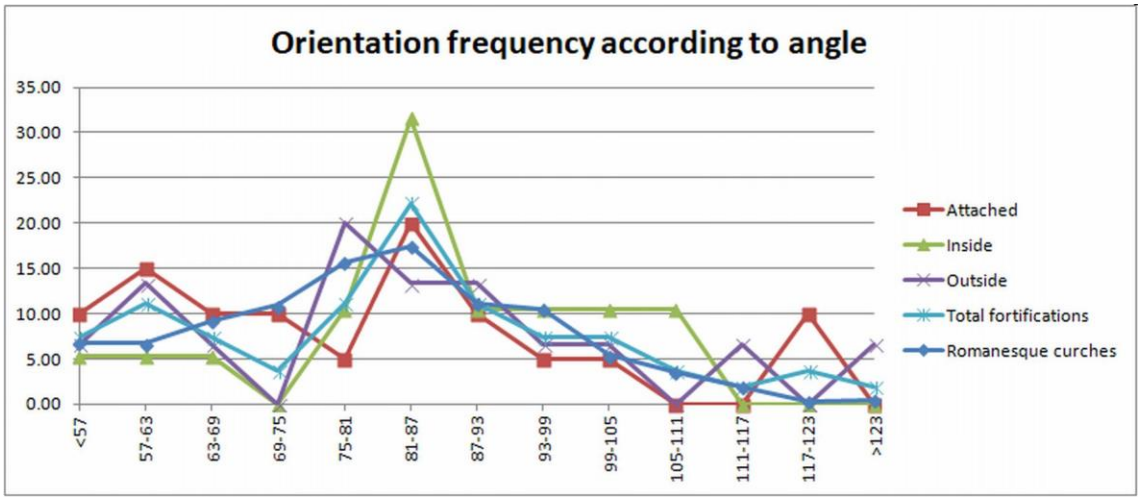

Figure 3. Statistics of the orientations in churches in medieval fortified enclosures.

It is observed that in all cases there is a higher frequency in the band between 81º and 87º that corresponds to the equinox orientation on the Julian dates of construction. However, there is also a greater dispersion among the churches that were part of the fortification (figure 3). To evaluate these graphs they are going to be compared with the statistic with the general of the Romanesque churches (Pérez-Valcárcel & Pérez Palmero, 2020).

Table 3. Statistical parameters of the measured orientations

		Average of orientations	Average of true orthos	Standard deviation
Churches in fortifications	Attached	82.93	80.78	26.15
	Inside	87.17	84.44	17.23
	Outside	86.00	83.59	20.06
Romanesque churches		84.26	80.40	18.43

Comparing the statistical data of the different cases, it is observed that the churches linked to the medieval fortifications in Hispania have orientations with mean values similar to those of the general statistics of the Hispanic Romanesque. In the case of the churches located inside the enclosure, the statistical deviations are similar to the general 17.23%. Those located abroad have a greater deviation of 20.06% and those attached to the fortification have a much higher deviation of 26.15%. The number of churches studied is certainly much lower than the general statistic, but it is reasonable to assume that these values indicate a trend. Especially in the case of the churches attached to the fortification, it seems evident that the functional conditions of defence have a significant importance that in many cases has forced non-canonical orientations.

5. SOME EXAMPLES

At the following, some representative examples of churches linked to medieval fortifications will be studied. The cases of Ansiães and Artajona will be analysed as churches located inside the fortified enclosure. Ansiães is not used as a defensive element while Artajona collaborates indirectly with the defence. Next, several cases in which the church participates in various ways in the defence of the complex will be analysed, such as Torres del Oeste, Loarre and Muro de Roda. Finally, we will see the special case of Samitier in which the church is the defensive system by itself.

5.1. Castle of Carrazeda de Ansiães. Bragança. Portugal

Ansiães Castle is built on a pre-Roman fortified hill, which was a posterior Muslim fortress (Fernandes, 2001). It was taken by Fernando I of Castile and the first Portuguese king Afonso Henriques conferred the first Portuguese Carta Foral in 1160. It is a very representative example of the churches located outside the main enclosure. This occupies the upper part of a low-rise hill with an access door to the southeast defended by two towers and a keep at the opposite end on the steepest area. There is no evidence that a chapel existed in the main compound (figure 4).

The church of San Salvador was built at the end of the 12th century within a second walled enclosure and in front of the entrance (figure 5). It has got one of the most notable Portuguese Romanesque doorways, and it is located parallel to the slope and has an

orientation of 81 ° with a practically zero horizon altitude. Possible stakeout dates are April 1 and August 29. This church seems to have performed the double function of serving the garrison of the castle and the population of the walled enclosure. There is evidence of a stable settlement and it was also common for populations to take refuge in the castle in case of danger. In this case and its date of construction, the danger was not Muslim but it had to come from the kingdom of León. This may justify a poor defence of the church. No Christian army of the time would dare to carry out an attack that was considered sacrilegious and whose consequences could be very serious.

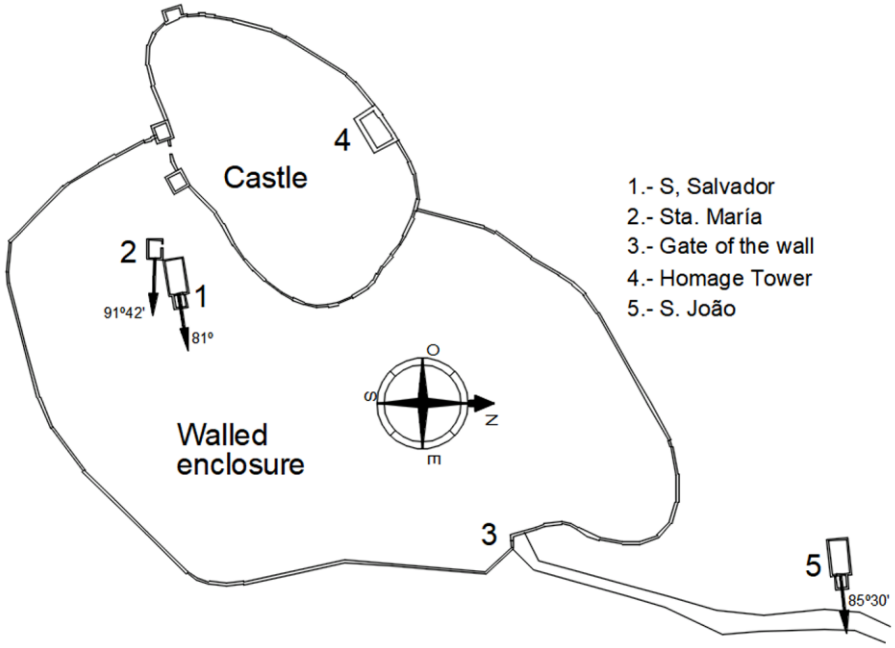

Figure 4. Fortified enclosures in the Castle of Ansiães.

Figure 5. Church of S. Salvador de Ansiães and castle.

In a very unusual position, the Gothic chapel of Santa María was built in the 14th century attached to the southeast corner of the church of San Salvador, as a funeral chapel for the Sampaio family. Its orientation is 91.7°, rotated more than 10° with respect to the previous one. Possible stakeout dates are March 9 and September 18. The orientation has been clearly deliberate, since the rigging of the union between the two churches is correctly executed and there are not topographical reasons to justify the turn.

There is a third church, already outside the fortified area, which is that of San João. It is a very ruined

church that belonged to the Hospital Order and it has got an orientation of 85.5° and an altitude of the horizon of 0.90°, which corresponds to March 23 or September 5. As can be seen, the three churches have different orientations but they are always canonical. It seems evident that each of them has been oriented in the way that its builders considered correct, without taking into account the others. This situation occurs in all the cases analysed of churches located inside the enclosure, in which it seems that defensive conditions have not been considered.

5.2. *Cerco de Artajona. Artajona. Navarra. Spain.*

El Cerco de Artajona is one of the most important medieval fortifications in the kingdom of Navarra. It is a large walled enclosure with seventeen towers, which are currently of the bestorre type, although ten of them are preserved at the present[7]. The church of S. Saturnino began to be built in 1085 and finished in 1109. It was a small Romanesque church, occupying the same position as the current great 13th century Gothic church. The remains of the ancient Romanesque apse with a square plan and with the same orientation have been found in excavations (Cañada Palacio et al., 2005; Sesma Sesma et al., 2011). It has an orientation of 87.3º with a horizon Altitude horizon of 1.45º, which corresponds to March 20 or September 7. It is a canonical orientation near to the spring equinox. The church is located in an exempt position and is not part of the fortified enclosure, therefore has not conditioned the orientation.

In this case the church contributes significantly to the defence, not because of its position, but because of its function. The hill lacks springs and the only water available comes from the rain. The church has got a roof over the Gothic vaults that leads the water to their lower parts (figure 6). At that point, they are channelled towards stone downspouts that lead the water to the cistern. The construction is very remarkable: there are some gargoyles on a somewhat higher level, which function as emergency drains (figure 6) to prevent a possible obstruction of the downspout from causing a section of the vault to fill with water. The builders undoubtedly knew the serious risk of allowing the accumulation of water in the vaults and more if they are asymmetric and they solved it with great skill.

Figure 6. S. Saturnino de Artajona. Roof, downspouts and gargoyles.

5.3. *Torres del Oeste. Catoira. Pontevedra. Spain.*

The "Torres de Oeste" are a set of defences that due to their strategic position had been fortified since pre-Roman times. In medieval times the king of León Alfonso V ordered the construction of the Castellum Honesti on ancient Roman and Asturian fortifications from the time of Alfonso III (Núñez Rodriguez, 1978). Their function was to stop the incursions of the Normans and the Saracens towards the city of Santiago on the island of Oneste, from where their toponym surely comes. The bishops Cresconio and Gelmírez reinforced these defences that were essential to protect their domains.

[7] A bestorre is a hollow tower inside without a rear wall. They were built so that if the enemy took one of them he could not protect himself from a counterattack.

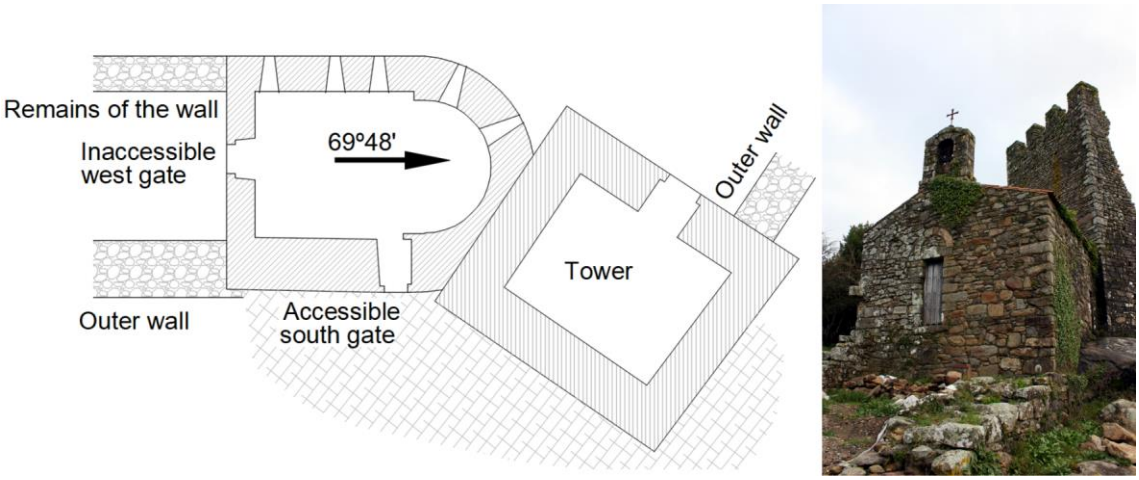

Figure 7. Santiago de Oeste

The enclosure has oval shape and contains seven towers, which three of them are in reasonable condition. A chapel was built attached to one of them in the time of bishop Gelmírez, which is attached to the exterior wall of the fortress (figure 7). It is accessed through the south door located on a rock. The west door is on a higher level, which would surely be accessed from the upper floor of the adjoining building, well defined by the perimeter walls. This chapel was dedicated to Santiago and has an orientation of 69.8º with a horizon altitude of 3.20º. This supposes that it should have been stakeout on May 1 or July 31, which would be a date close to the Santiago festival, July 25. However, this assumption is very dubious. In the first place, the horizon is closed by the tower, no doubt former, since it corresponds to the reconstruction of bishop Cresconio–(Chamoso Lamas, 1951). It is also located between two defensive walls, which define its layout. It seems evident that the reasons of a military nature have been decisive in this case, until the point that the apse has been fitted onto the defence tower.

5.4. Border fortifications in Aragon. Spain.

Within this study, the border fortifications in the ancient kingdom of Aragon are especially interesting. While in León and Castile, at the end of the 11th century the Tagus line was reached, the kingdom of Aragon only occupied a small strip of northern Huesca, the counties of Aragon, Sobrarbe and Ribagorza. The Muslim danger was great and its relations with the kingdom of Navarra and the Catalan Counties were not particularly good. Under these conditions, the defence of borders was an urgent need that had to be met with scarce resources. For this, Sancho III, Ramiro I and Sancho Ramírez built a series of advanced points in especially rugged areas. The borders moved southward, making these fortified points no longer useful militarily after the seizure of Huesca in 1096. It is the main reason for its excellent conservation in its initial state with few subsequent additions.

5.4.1. Castle of Loarre. Huesca. Spain

The castle is located in a very steep place that has been occupied since ancient times. In fact, the remains of a pre-Romanesque church are preserved. Probably served a small settlement, which in any case would have a not very strong wall that has not been preserved. King Sancho III el Mayor ordered to build the first medieval fortification, one first enclosure with two towers to which Ramiro I, first king of Aragón, added an albarrana tower and transformed into the current homage tower later. It was an advanced fortification that controlled the town of Bolea, located on the plain and in Muslim hands. At this time the chapel of Sta. María de Valverde was built. Circa 1071, during the reign of Sancho Ramírez an enlargement was carried out, completing the castle. Within the policy of this king of approach to the Pope, he decided to settle in this castle an Augustinian community, building new enclosures so that this community could function autonomously and the great church of S. Pedro. The current walled enclosure was built in 1287 (figure 8).

Figure 8. Castle of Loarre.

King Sancho Ramírez built the castle of Montearagón in 1086 as support for the siege of Huesca, with which Loarre lost strategic importance. After taking this city, the border moved south. Also his son Pedro I transferred the head of the congregation from Loarre to Montearagón, with what Loarre loses the monastic use. In 1413 it was besieged by royal troops and from then the population was settled on the plain and the castle was abandoned. His condition is excellent, being the most important Romanesque castle in Spain.

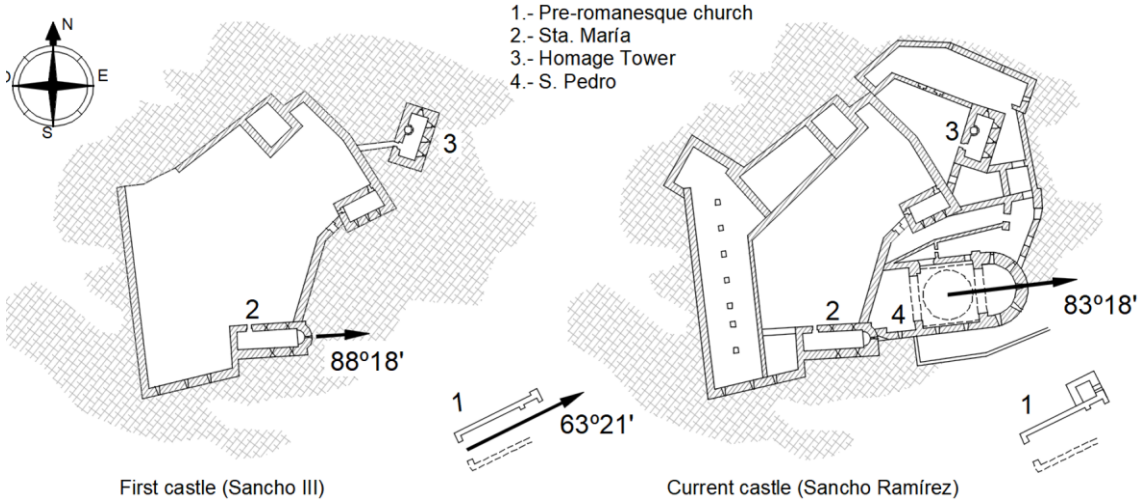

Figure 9. Evolution of the Loarre castle.

Three churches are located in the Loarre castle (figure 9). The oldest of them is pre-Romanesque located on the hillside, outside the main enclosure. The preserved remains are scarce, so there is no unanimity in considering it as a church (Arco y Garay, 1916; Asensio Esteban, 2000). The authors think that it is really a church. To the arguments provided by Asensio Esteban, its orientation, frequent in the Spanish pre-Romanesque, can be added (González-García & Belmonte, 2015; Pérez-Valcárcel & Pérez-Palmero, 2018). Its orientation is 69.3º with a horizon altitude of 8º, which corresponds to May 17 or July 16. They are dates near to the summer solstice and after Easter.

The other two churches are within the castle enclosure and attached to the outer wall. There is a slight twist between them of 5º, surely because of the adjustment of the wall to the complex topography of the rocky summit. Sta. María de Valverde has got an orientation of 88.3º and S. Pedro of 83.3º, both with an altitude of the horizon of 4.05º. It was oriented on March 24 or September 6 in the case of Sta. María and S. Pedro on April 3 or August 27. In any case, clearly the predominant factor is its location with respect to the wall, which is what sets the orientation. However,

the intention to seek an orientation as far east as possible seems clear, since they could have been attached to other safer walls of the fortress.

5.4.2. Muro de Roda. Huesca. Spain

Muro de Roda is a fortified enclosure built since 1017. It was probably a small enclosure with not very strong walls, which had a chapel for the garrison, which is currently the hermitage of San Bartolomé de Muro de Roda built around 1040. This fortification is supposed to be around 200 m north of the present site. The current complex was built at the end of the 11th century (figure 10). In fact, the consecration of the church of Sta. María was in 1107. It was part of a series of strong points that protected the course of the Cinca river such as Aínsa, Samitier, Morillo de Moclús or Troncedo. They are visually connected, which suggests that they were part of an alert system, considering the danger in the area.

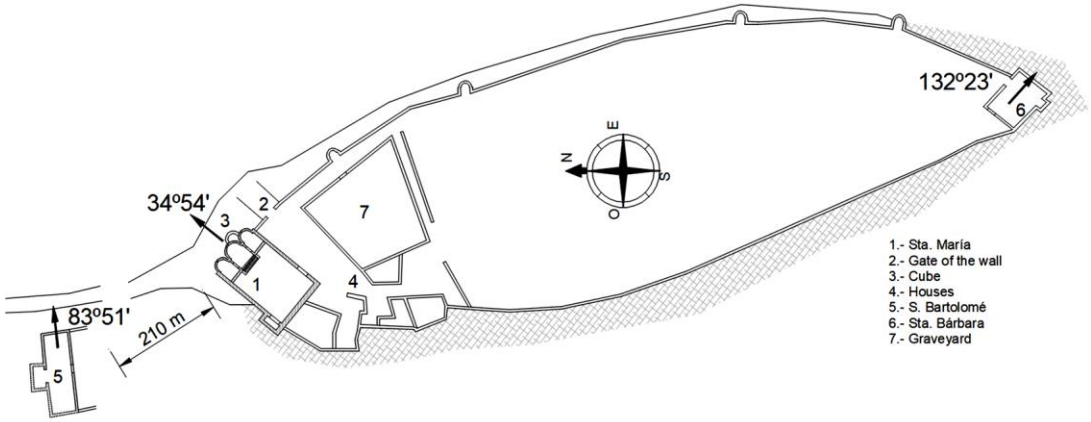

Figure 10. Fortified complex of Muro de Roda.

Figure 11. Church of Sta. María of Muro de Roda.

The church of Sta. María is part of the defensive wall and also in the most sensitive point, such as the door. In fact, its bell tower is the main defensive tower. The church is built on the remains of previous fortifications and it is preserved the start of a cube (figure 11).

This situation has clearly forced its orientation. The church of S Bartolomé has got an orientation of 83.75º with an altitude of horizon of 2.45º, so it should have been oriented on March 30 or September 1. It is a logical canonical orientation, since it was located inside the first precinct without conditions. At the contrary, the church of Sta. María has got an orientation of 34.9º, very far from any possible solar path. It is evident that this church was built forced by the military conditions of defence and that therefore it could not be canonically oriented.

The third church is the hermitage of Sta. Barbara. The current building belongs to 17th century, but it may have taken the place of a previous chapel. Its apse is located inside a tower, which suggests a reuse. Its orientation 132.4º is not canonical, but it is perfectly explainable, both for its situation in a previous element, and for its construction date, in which the orientation conditions were very lax.

5.4.3. Samitier. Huesca. Spain

The Samitier fortified complex is the most unusual in this study. It was part of the Cinca set of strengths, already mentioned, and it is located on a rocky ridge

that it is difficult to access and it is an important defensive element by itself. The fortification is made up of the church of Saints Emeterio and Celedonio and an irregular hexagonal tower. Some remains of the wall are preserved, which suggests that the entire enclosure was closed.

What makes this case almost unique is that church is the first defensive element completely covering the rocky spur, in such a way that the passage is extremely dangerous, even today (figure 12). The church has got a crypt that occupies the south façade and which is accessed at the present time. The access door was at the level of the naves at the beginning, so you had to climb a retractable staircase, probably made of wood. The defenders would become strong in the church and if they were overcome they could still take refuge in the tower. The climb is so arduous that there is no evidence that the castle was ever attacked.

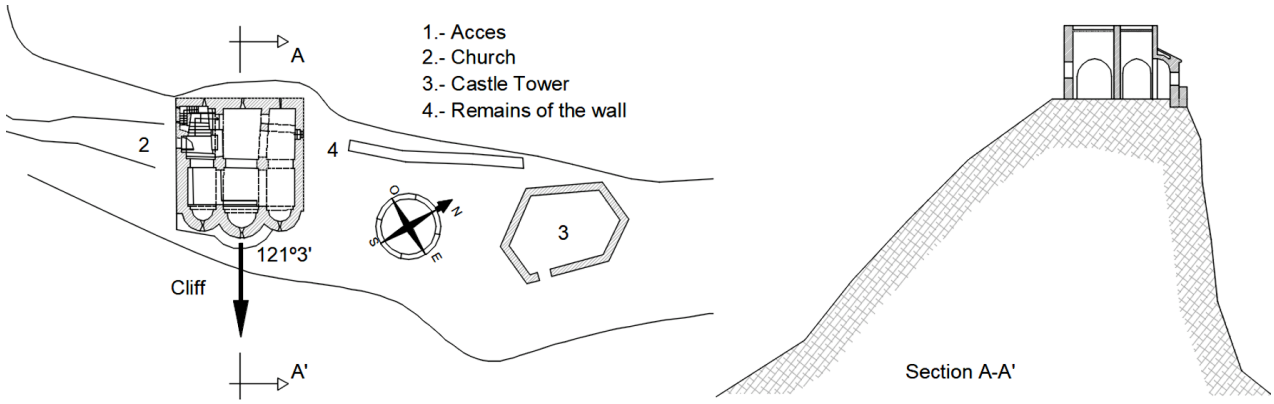

Figure 12. Samitier fortified complex.

The orientation of the church is winter, 121º. Despite of to be located at a great height, the horizon has a slight altitude of horizon of 1.80º, so it could be oriented on January 8 or November 22. These are very inappropriate dates for stakeout, especially in that place. In this case the orientation is clearly defined by the topographic conditions and especially by the defensive needs. In other cases, the Romanesque builders made a great effort to canonically orient the building in very unfavourable orography. It is clear what the main concern of its builders was. But in this case the conditioning factors were so strong that orientation was undoubtedly a secondary factor.

6. CONCLUSIONS

It has been possible to verify the extremely precarious conditions in the fortifications of the first period, pre-Romanesque and first Romanesque and especially in the areas with the greatest risk of Muslim attacks. In the most cases the enclosures are small and generally reduced to a strong tower with a walled enclosure to which auxiliary buildings were attached. In most of the cases studied, it was not possible to locate the place of worship, to be it a church or a simple chapel. For this reason, many studied fortifications have not been included in the database. The most probable hypothesis is to suppose that the place of worship would be in one of the auxiliary buildings that have disappeared.

In the preserved cases, the church is usually small and not very prominent in the set. The best-preserved case, Sta. María de Valverde in the Loarre Castle is a good example. As the Muslim danger receded, the churches are larger and they are built exempt, with the general characteristics of the Romanesque. Some of them are of great quality like Ansiães or S. Pedro de Loarre. They are also built inside the enclosure, although without being part of the fortification it is even outside it. Given the low probability of Muslim attacks, the possible enemies would be Christians who would not dare destroy the church.

The main conclusion of this study is to verify that, even in very unfavourable situations, the tendency to orient the church to the east continues. It is a general characteristic in the pre-Romanesque and Romanesque periods, which is imposed on defensive needs in the most cases. Of all the churches analyzed, only Calatrava la Vieja and Muro de Roda among the churches attached to the fortification have orientations below 57º (summer solstice). Among the interiors of the enclosure, it only occurs in Sta. María de Atienza and among the exteriors in S. Martín de Buil. This represents only 7.40%. As for those that exceed 123º (winter solstice), it only happens in Santa María de Pedraza and Santa María de Soutomaior. The latter is a doubtful case, so it is not included in the statistics.

The most unusual situation occurs in Samitier, clearly defined by the extreme defensive conditions of the place. Even so, an attempt was made to achieve a canonical orientation, although very to the limit.

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