## Abstract

Much of the literature on Portuguese vernacular architecture has conveyed the notion of a 'vaulted south', understood as the territory where a certain roof-building technique is preferentially used across all building typologies. In Portugal, the massive presence of vaulted houses in the Alentejo and Algarve is practically common knowledge, but scientific research on this topic is only slowly expanding. Other than the prevalence of timbrel vaulting and the ubiquitous use of clay brick, key characteristics of these traditional structures remain mostly unexamined, such as their true quantity and geographic distribution, their formal and constructive variety, their relation to spatial functions, and their symbolic significance. As for the origin and chronology of these vaults, explanatory myths persist in the absence of conclusive evidence.



## keywords

BRICK VAULTS
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ALENTEJO
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# Types of vaults in southern Portuguese architecture

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## Introduction

The notion of a 'Vaulted South', defined as a region where 'three-dimensional curvilinear self-supporting structures used as ceilings' (Rosado 2021a, 1) are predominantly employed across various building typologies – namely housing – has long been discussed in the literature on Portuguese vernacular architecture (Aguiar 1891; Amaral et al. 1961). In Portugal, specialists and the general public alike are aware of the prevalence of vaulted houses in the Alentejo and parts of the Algarve. However, although scientific interest in the matter has grown in recent years, its dedicated body of research still needs more output.

Based on several research missions conducted throughout the Alentejo and Algarve between December of 2022 and December of 2023,[1] this article aims to consolidate and expand upon the gathered information to clarify key questions regarding the precise geographical extent of this vernacular phenomenon, its distribution throughout erudite and ordinary buildings, the variety of vault types, the proportion of vaulted spaces within buildings, and the possible connections of the various types with the functions and social significance of said interior spaces.

The classification of vault types presents its own set of challenges, as the vocabulary used to describe these forms varies significantly across written sources, traditional jargon, and regions. To overcome this, a method has been adopted to systematise with greater coherence all vaulted forms documented during research.

[1] Research developed in the scope of the project FCT EXPL/ART-DAQ/0171/2021, 'Vaulted South – Vernacular vaulted houses in the south of Portugal' (DOI:10.54499/EXPL/ART-DAQ/0171/2021), coordinated by Mafalda Batista Pacheco and Margarida Tavares da Conceição.

This approach ensures that the analysis accommodates the full diversity of vault types while providing a structured framework for future studies.

## Geographical and Historical contexts

The concept of a 'South of Portugal', comprised of the Alentejo and Algarve regions, can be defined in its broadest sense as a 'meridional half' of the country that meets its northern counterpart at a frontier line drawn by the river Tagus. The south-westward trajectory of this major body of water – from its confluence with the Erges, at the border with Spain, to its mouth in the Atlantic, near Lisbon – demarcates stark differences not only in geology, climate, and vegetation, but also in land tenure structure, social norms, cultural heritage and, consequently, architecture. This pithy geographic dualism, which has already been dubbed as a contrast of 'civilizations' – of 'granite' to the north and 'clay' to the south (Ribeiro 1961) – pertains to the notion that Portugal, as a predominantly 'vertical' political territory, intersects a sequence of latitudinal natural/cultural ecologies of the entire Iberian Peninsula (Marques 1995).

The similarities that the South of Portugal may lack with the North can be found in the Spanish regions of Extremadura and Andalusia, adjacent to the East, especially in the *montado/dehesa* landscape characteristic of this southwestern quadrant of the Iberian Peninsula: a traditional agro-silvo-pastoral system covering 4 million hectares in Spain and 1 million hectares in Portugal. In this landscape, scattered holm and cork oak trees (crown coverage of 10%-50%) and olive groves are integrated with pastures and agriculture, thriving in a Mediterranean climate with hot, dry summers and mild, wet winters. Annual rainfall ranges from 400 to 800 mm, and soils are typically poor (Fra Paleo 2010, 149-151).

The restrained use of timber and the local presence of quarries and clay pits imprinted a particularly 'mineral' character to the local traditional architecture, whose visual effect is further exacerbated by the limewash treatment of walled surfaces, of virtually universal application up to the middle of the 20$^{th}$ century. Behind these walls, a habit of vaulting architectural interiors has developed with particular incidence in Alentejo's hinterland, or *Alentejo Interior* (Rosado 2021b), and with notable intensity in the only portion of Portuguese territory to the East of the river Guadiana (and without any other major geographical features acting as a natural border from Spain). This *além-Guadiana* comprises the municipalities of Mourão, Barrancos, Moura, and Serpa, the latter two being the largest urban settlements of the subregion and having long been recognised as the main epicentres of brick vaulted construction (Amaral et al. 1961; Rosado 2021b). Other than these known

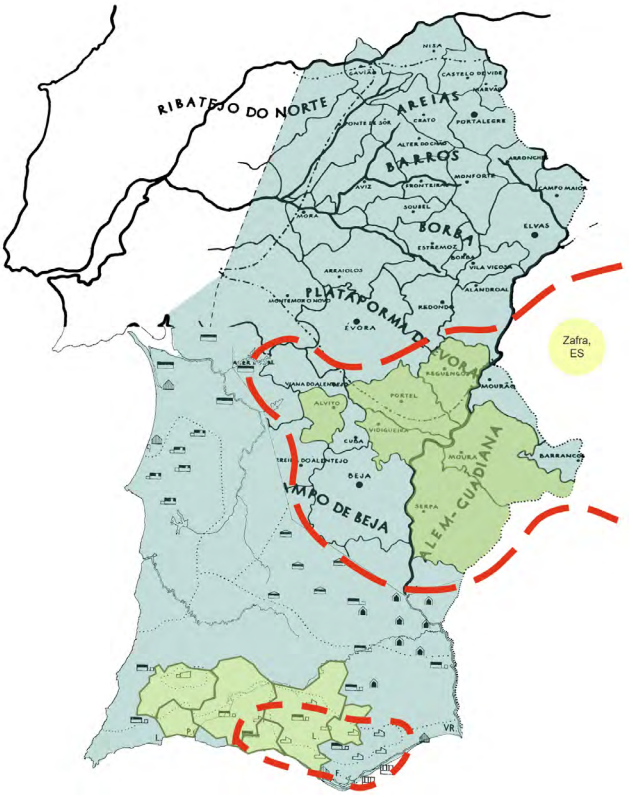


Fig. 1 Vaulted South. Dark green: general extension of the South of Portugal; light green: surveyed municipalities during the research project (see footnote 1); red dashed line: areas of prevalence of vaults. Source: authors, 2023; map source: Amaral, 1961, Zones 5 and 6.

cases, the significant presence of vaults in vernacular architecture has also been attested, by our survey missions, further east in Amareleja, Safara (civil parishes of Moura), Brinches, and Vila Verde de Ficalho (civil parishes of Serpa). To the west, the municipalities of Portel, Vidigueira and Alvito also hold many vaulted buildings. While the abundance of vaults in ordinary construction wanes beyond this nucleus, many such structures are otherwise generally known to exist throughout the entire Alentejo, especially in erudite civil and religious architecture of historically important cities like Beja, Évora, Elvas, or Estremoz.[2]

Compared to the Alentejo, the panorama of vaulted architecture in the Algarve is more restricted [Fig. 1]. Not only is the absolute amount of vaults lower and their locations within building layouts less varied, they are also rarely found in all the compartments of a house, with the notable exceptions of Olhão and Fuzeta (Caldas 2009; Pacheco 2009 and 2018). In these settlements of eastern Algarve (*Sotavento*), which originated as fishing villages, almost all vernacular houses are entirely vaulted (Pacheco 2009 and 2018).

While there is evidence of vaulted construction in ancient times in the South of Portugal (e.g. Roman villa at São Cucufate, Vidigueira), such edifices contain only

[2] Such a reckoning is provided by studies of Portuguese late Gothic architecture, such as in the work of José Custódio Vieira da Silva (1997).

Fig. 2 Narthex of Convento de São Francisco, Serpa. Source: authors, 2022.

barrel vaults, whose half-circular curvatures and brick placement indicates they were made with centering, relying therefore on techniques distinct from the self-supporting methods used only in later centuries in this part of the world. Although brick vaults in the vernacular architecture of the Alentejo and Algarve are often popularly associated with Roman or Islamic influences, the archaeological records do not support the hypothesis of a continuation between ancient practices and those developed in the Early Modern Era. Instead, the emergence of brick vaulting as a diffuse method of ceiling and roof construction appears to be tied to later historical developments. Brick vaults only began to play a significant architectural role after the definitive establishment of Christian states in the southern Iberian Peninsula during the late medieval period. Due to these territories' later period of annexation, the Romanesque mode is almost nonexistent. Vaults initially appeared in urban churches and convents, exhibiting clear stylistic characteristics of the Gothic mode, which amply spread south of the Tagus (e.g. Convento de São Francisco, Serpa, Fig. 2). These early examples are mostly erudite constructions, reflecting the growing architectural ambitions of the Christian Iberian kingdoms during this period. The technique involved in these medieval structures typically incorporated bricks for the web and key elements such as ribs and springing points, often complementing them with carved stone for structural elements such as corbels, and decorative details.

In the early Modern era, brick vaulting expanded beyond religious architecture and began to appear in residential buildings.[3] It first gained prominence in noble houses,

[3] The specific evolution of vaulted structures within military architecture is lacking in reference literature nor it was the focus of the research project that supports this paper.

Fig. 3 Ermida de Nossa Senhora das Pazes, Vila Verde de Ficalho. Source: authors, 2022.

Fig. 4 Dining parlour in Vila Mariana, Serpa. Source: authors, 2023.

where it was used to add functionality, comfort and prestige. Over time, this construction method became a feature of vernacular architecture, spreading across urban and rural areas. Rural chapels[4] [Fig. 3] are particularly notable for their vaulted interiors, which were constructed using local materials and often displayed a simplicity that contrasted with the more elaborate vaults of urban ecclesiastical buildings.

The 19th century marked the peak of brick vaulting in Southern Portugal, coinciding with the widespread adoption of timbrel vaulting.[5] This technique, which did not require centering, allowed for faster construction and a more efficient use of materials (Fortea Luna 2008). It became especially common in domestic spaces of relatively recent formulation (for the time and region), such as dining rooms, bedrooms, and corridors, particularly in the expansion and modernisation of older noble houses. Timbrel vaulting also became commonplace in new construction of the urban expansion of the time. The flexibility of timbrel vaulting facilitated its adaptation to various forms, including barrel vaults, groin vaults, and more complex geometries.

Even though some notable examples of 20th-century vaulted construction exist (e.g. Vila Mariana, Serpa, c. 1920, Fig. 4), the growing prevalence of reinforced concrete as a construction material and technique by the second half of the century led to a significant decline in the use of brick vaults. This shift marked the

[4] Portuguese: *ermidas*.

[5] Portuguese: *abobadilha*; Spanish: *bóveda tabicada*.

end of their widespread application in Southern Portuguese architecture. Today, the practice of brick vaulting persists primarily in restoration projects of old buildings and occasional new commissions by clients seeking to incorporate traditional architectural elements into their properties.

## Materials and assemblage methods

The construction of vaults in southern Portugal is deeply rooted in the availability of local materials and the ingenuity of regional techniques. The primary material employed in these vaults is red clay brick, which defines their structural and formal character.

Each arched row was fixed in place using mortar, and the structure stabilised progressively during construction, rendering centering unnecessary. This method is particularly associated with older vaulting traditions in the region.

While bricks were assembled in a variety of arrangements that reflected the necessity of the vault's self-support during the construction process, these would be placed in two main positions in relation to the vault's intrados: perpendicular **[Fig. 5]** and horizontal/tangential **[Fig. 6]**. The second of these methods is called timbrel vaulting – or *abobadilha* in Portuguese and *bóveda tabicada* in Spanish – and has been the most studied feature of Southern Portuguese vaults so far (Rei and Gago 2016, 2017 and 2018). In this technique, bricks were laid flat and tangential to the curvature of the intrados, each brick being held manually for a short period while the mortar hardened, often containing varying proportions of gypsum (Fialho 2009).

The mortar used in vault construction varies across periods and locations. Historically, lime-based mortars were predominant, providing a reliable binding material for perpendicular vault assemblages. However, the introduction of industrial gypsum-based mortars in the 19$^{th}$ century revolutionised construction practices, giving rise to timbrel vaulting. These mortars, which hardened more quickly, significantly reduced the time needed for individual bricks to stabilise, making them ideal for techniques that required minimal or no centering (Fialho 2009).

The bricks themselves were typically slender, a crucial feature for achieving the lightweight structures characteristic of timbrel vaulting. These bricks generally measured between 250-300 mm in length, 35-70 mm in height, and 120-150 mm in width (Fialho 2009; Rei and Gago 2017). This slenderness allowed for precise placement and alignment and also enhanced construction efficiency (Fortea Luna 2008).

This method enabled the construction of thinner, lighter vault webs and encouraged a generalised depression of their sections, reducing rise-to-span ratios and enhancing

Fig. 5 Vault with bricks assembled perpendicularly to the intrados.
Shop in Rua Cons. Augusto de Castro 11, Moura. Source: authors, 2023.


Fig. 6 Vault with bricks assembled horizontally/tangentially to the intrados (timbrel vault). House in Rua das Manhãs, Alvito. Source: authors, 2023.

Fig. 7 Vault built with segments of *pedra caliça* in the same fashion as brick vaults. Shop in 3-5 Rua 5 de Outubro, Loulé. Source: authors, 2023.

the self-supporting nature of the vault. The efficiency and adaptability of timbrel vaulting contributed to its widespread adoption in various architectural forms.

Within our territory of study, a notable variation occurs in the Barrocal sub-region of the Algarve, where *pedra caliça*, a locally quarried limestone, is cut into brick-sized pieces and applied in vaults either alone or mixed with clay bricks. Despite this material difference, the construction techniques for *pedra caliça* vaults are the same as those employed for perpendicularly set brick vaults **[Fig. 7]**.

Irrespective of their construction material and technique, all vaults were traditionally plastered and whitewashed for, among other purposes, protection against moisture. Stripping vaults of these protective layers is a contemporary phenomenon that endangers these structures' preservation.

Clay bricks were not limited to the vault webs but were also employed in structural ribs. In Gothic architecture, brick ribs were prevalent, supported by carved stone corbels.[6] Notable examples include the ribbed vaults of the Convents of São Francisco in Serpa and Carmo in Moura, which reflect the region's adaptation of Gothic architectural principles using locally available materials. While some vaults show ornamental features whose sizable dimensions insinuate that they are partly made from bricks projecting out from the intrados, the majority of decorative elements were made by modelling the plaster layer. These coatings, often whitewashed, served both aesthetic and protective purposes, seamlessly integrating the ribs into the overall visual composition. In cases where vaults featured decorative or figurative paintings, the ribs were incorporated into the design and either painted to imitate stone or highlighted to emphasise their structural role.

## Morphology of vaults in the south of Portugal

To avoid the limitations of language, a method of describing the vaulted form that is truly inclusive of all that is observable on the ground must detach from regional jargon or the metaphors employed by specific literary influences. It would even be advisable to avoid the word *type* altogether, as it might allude not only to a particular *shape* but also to a certain construction technique.[7] For our topic of discussion, a focus on *morphology* is being chosen. One of the easiest starting points to set apart vaulted forms is to adopt 18th-century architecture theoretician Amédé-François Frézier's distinction of 'simple' and 'composite' vaults (1737), in which the surface of the first can be (ideally) described by a single regular solid – say a cylinder or a sphere – while that of the second results from a combination – a mathematical *union* or *intersection* – of such shapes. In this strict geometric sense, barrel vaults, domes, and sail vaults[8] are 'simple', while groin or cloister/domical

[6] Portuguese: *mísulas*.

[7] Such is the case for regional definitions of timbrel vaults in Spain, either *bóveda catalana* or *bóveda extremeña* – they are in part set apart by their shape, in part by different assembly systems.

[8] Compared to half-spherical domes, the surface of sail vaults does suffer a transformation – the truncation of the spherical intrados by the confinements of the room it is placed upon. Still, this doesn't generate a groin in the intrados.

Fig. 8 Plaster decorations in the oratory of Casa da Quinta de São Brás, Serpa. Source: authors, 2022.

vaults are 'composite'. Additionally, some vaults have their intrados, or interior surface, composed of structural or ornamental components other than the actual shell, that can *add* or *subtract* volume to the final form. Some of these components play such a key role in the structural conception and construction process of a vault that they are distinguished by names of their own. Such is the case of a vault whose four webs are supported by an intersecting pair of diagonal ribs:[9] the ribbed vault. In this case, ribs are often the first to be built and act as centering for the remaining shell. Ribs, when existent, are the main load-bearers and can have a diagonal, transverse, or longitudinal placement below or interlocked with the vault's surface. Smaller, rib-like components like liernes and tiercerons,[10] found in some late Gothic buildings, do not play such a structural role as ribs, being mostly ornamental. Other components that increment the dimensionality of a vault include squinches, pendentives, keystones/bosses, corbels, and plaster mouldings.[11] Of these, only the last one is strictly decorative. Conversely, some other components render a vaulted form more complex by 'subtracting' material from its main shell, sometimes for structural design purposes, but mostly to provide lighting and ventilation to interior spaces. These include lunettes/penetrations and lanterns, which affect the vault's structure, as well as decorative wedges and creases on the layer of plaster [Fig. 8].[12]

[9] Portuguese: *ogivas*.

[10] Portuguese, respectively: *ogivas, arcos torais, cadeias, liernes, terceletes*.

[11] Portuguese, respectively: *trompas, pendentes, chaves, mísulas, molduras de argamassa*.

[12] Portuguese, respectively: *lunetas/penetrações, clarabóias, cunhas, alhetas*.

Fig. 9 Barrel vaults in ground-floor functional spaces. Cellar in Monte da Balsa, Portel. Source: authors, 2023.

Fig. 10 Barrel vaults in rural chapels. Ermida de Santana, Serpa. Source: authors, 2022.

## Vaulted forms and their relation to architectural space

Barrel vaults[13] are the most common type of vault, present across all historical contexts and building types. Their defining characteristic is their association with elongated compartments, where one length is significantly larger than the width. This structural efficiency has made barrel vaults a universal solution for a variety of spaces, both functional and representational.

In housing, barrel vaults are typically found in more utilitarian spaces such as kitchens, wine cellars, and granaries, which often feature elongated plans. They can also be found in alcoves. For instance, the central corridor in the Casa da Quinta de São Brás in Serpa exemplifies their use in circulation areas, while the cellars of Casa Gavião Peixoto in Serpa or of Monte da Balsa in Portel demonstrate their employment in storage spaces [Fig. 9]. Their simple form and straightforward construction method have historically linked barrel vaults to ordinary construction, reflecting their functional adaptability.

In religious architecture, however, barrel vaults take on a more prominent role, transcending their association with simplicity [Fig. 10]. Since the late 16th century, they

[13] Portuguese: *abóbadas de berço, abóbadas de canhão.*

Fig. 11 Spherical domes in noble houses. Chapel of Quinta de Santa Cruz, Alcantarilha, Silves. Source: authors, 2004.

have become the most prevalent type of vault in church naves (and some chancels), often enhanced by structural reinforcements such as transverse arches or by the inclusion of lunettes for natural light. Barrel vaults are also commonly found in lateral chapels and sacristies, as well as in circulation areas of convents, such as corridors. While less frequent in cloisters, their use is not entirely uncommon.

Of equally simple geometry but more complex assemblage are spherical domes.[14] Practically non-existent in domestic Alentejo architecture, they can be found in some chapels of noble houses in the Algarve [Fig. 11]. The celestial symbolism, or even representations of the Divine associated with this shape – especially from the Renaissance onwards – led to its multiplication in religious architecture of the South in the Modern era, chiefly in choirs and their adjacent chapels or even in square-plan lateral chapels. There are occurrences of elliptical or spherical domes

[14] Portuguese: *cúpulas esféricas*.

Fig. 12 Domes in rural chapels. Ermida de Nossa Senhora de Guadalupe, Serpa. Source: authors, 2022.

constructed above lateral chapels that are rectangular in plan. In urban settings, domes are also found covering the nave of small square-plan churches lacking the protruding choir body.

The use of these domes in the southern region of the country, however, extends unexpectedly to numerous peri-urban and rural chapels, where they came to replace the medieval preference for ribbed vaults. These small chapels, sometimes completely isolated, often display the whitewashed, semi-spherical extrados of the dome covering the chancel. Far less common is the appearance of semi-spherical or elliptical domes over the narthex [Fig. 12], when such a space is present in the

**Fig. 13** Sail vaults in domestic spaces. House in Fuzeta, Olhão. Source: authors, 2018.

chapel layout, and even less so their use in sacristies, particularly since these religious buildings also do not always include them. However, the apotheosis of the brick-built semi-spherical dome, within the context of southern chapels, is represented by the rare cases where this type of roofing rests directly on the cylindrical wall of a circular chancel, or, in extreme cases, where the nave itself has a circular plan (without a separate chancel) and is covered by a dome.[15]

The sail vault[16] can be understood as a 'sliced' variant of the spherical dome. While rare in Alentejo, it is common in the Algarve – particularly in the municipality of Olhão. In ordinary urban dwellings, like in Olhão or Fuzeta, it is frequently applied over the main parlour, which is almost always quadrangular. In rural houses, whose layout is drastically different from their urban counterparts, sail vaults are found

[15] This solution is not exclusive to the south of the country, but it stands out in the vernacular context of the region and its brick vaults. The principal Portuguese religious buildings with circular plans and dome coverings – such as the Chapel of Santo Amaro and the Church of Serra do Pilar – were conceived within learned contexts, located in major cities – Lisboa and Porto, respectively – and are constructed in stone masonry. The Chapel of Santo Amaro is, in fact, an extreme example, as it features a small chancel that is also circular and covered by a stone masonry dome.

[16] Portuguese: *abóbada de vela*.

Fig. 14 Groin vaults in first-floor domestic spaces in Alentejo. Living room in Casa Rocha, Serpa. Source: authors, 2022.

in the aforementioned living/dining rooms but also in vestibules and in alcoves. This vault type, usually placed above square rooms, is sometimes 'elongated' to cover rectangular alcoves, making its distinctive *calotte* no longer spherical, but still a continuous curved surface [Fig. 13]. Sail vaults produce a particular plastic effect when they are constructed (rarely) in smaller dimensions and placed in a row to cover corridors.

Within composite vaults – that is, those composed of multiple, intersected curved surfaces – the most common are groin vault and domical vaults. Both types essentially originate from the intersection of two cylindrical surfaces arranged perpendicularly to each other. Groin vaults, in particular, result from the crossing of two semi-cylinders with the same radius, such that their highest generatrices are at the same level. The intersections correspond to two curves with the same rise as the directrices of the cylindrical surfaces, which project onto the plane as the diagonals of the square covered by their intersection. Constructively, they correspond to the two protruding edges that meet at the highest point of this segment of a square-based vault.

Throughout the Modern era, groin vaults[17] are found in all types of buildings and placements. They're mostly located in urban houses in the Alentejo where they can cover rooms with the most varied functions, from entrance halls and ground floor service areas to stairwells and first floor bedrooms and living rooms (e.g. Casa Rocha, Serpa, Fig. 14). They are also common in rooms with different uses in

[17] Portuguese: *abóbadas de arestas*.

Fig. 15 Groin vaults in ground-floor commercial establishments. Loulé. Source: authors, 2023.

two-storey rural houses, sometimes extending to larger farm dependencies (e.g. the granary/cellar building in Monte da Balsa, Portel). Their association with timbrel vaults, although proven in previous literature, remains weak in the buildings surveyed in our study.

In central Algarve, where vaults are almost only built on ground floors, even in urban dwellings, groin vaults are also common in ground floor service areas, as well as in the commercial establishments of the main urban towns and cities [Fig. 15]. They are rarer in rural areas, even in two-storey houses, where they are found supporting the pavement of kitchens and terraces. Minor usage in small alcoves has also been detected (e.g. Monte de Ângela Clara, Tavira). Their presence in ordinary architecture, urban or rural, fades towards the eastern and western edges of the region.

In religious architecture, even if they can cover all sorts of spaces, they are more expressive in cloister galleries. They normally result from the intersection of each gallery's longitudinal barrel vault with small, transverse barrel vaults directed at the cloister's opening [Fig. 16]. This originates a succession of groin vaulted spans that may or may not be separated by transverse arches springing from the pillars. Domical vaults[18] (also less precisely referred to as 'cloister' or 'trough' vaults) result from the intersection of cylindrical surfaces that, contrary to the groin vaults' four corner resting points, spring from the full walled perimeter of the (rectangular) room they cover. From the point of view of a dweller, their webs form concavities toward the centre of the compartment that sometimes describe perfect half-circles, but

[18] Portuguese: *abóbadas de barrete de clérigo* or *abóbadas de engras*.

Fig. 16 Multi-span groin vaults in religious architecture. Cloister of Convento de Santo António, Loulé. Source: authors, 2023.

Fig. 17 Domical vaults in early modern erudite domestic architecture. Room in Palácio Ficalho, Serpa. Source: authors, 2022.

mostly follow a depressed curvature.[19] Two pairs of identical webs are formed at opposite sides, the largest of which would ideally form an intersection line ending at the vertices of the smaller webs and placed at the vault's maximum height. In built practice, however, this top line is rarely emphasised as a re-entrant 'groin'. Instead, the two pairs of symmetrical surfaces meet at the central section of the intrados whose curvature is abated by the layer of plaster.[20]

In domestic architecture of the Alentejo, domical vaults appeared first in noble residences in the earliest reform works, or as new construction, to show clear architectural intentions – such as the halls of Palácio Ficalho and Casa Gavião Peixoto in Serpa [Fig. 17]. They emerged much later in housing in the Algarve – from the second half of the 19th century onwards – and mostly in urban ordinary dwellings from Olhão and Fuzeta, with the same privileged position which, in this type of housing, is shared with sail vaults: as an emphasising spatial feature of the main, front façade-facing room (Pacheco 2018).

In the religious architecture of the entire South, domical vaults appear sporadically in sacristies or other flanking compartments of churches, and rarely in chancels. However, these vaults are not rare in convents and other religious houses, and are seen in the cubicles[21] of Jesuit colleges, in corridors and sometimes staircases.

[19] As Pacheco (2018, 222) elicits as the rule-of-thumb from several pre-industrial architectural treatises, depressed arches are often codified as three or five-centre composite agreeing curvatures.

[20] This is more the case for vaults with bricks assembled perpendicularly; timbrel vaults have such a smooth curvature that no creases between webs are left to be 'disguised' by the application of plaster.

[21] This is the term used within the Jesuit Congregation for *cells*.

Fig. 18 Domical vaults in 19th century domestic spaces. Living room in Quinta da Marreira, Serpa. Source: authors, 2023.

In the late 19th and early 20th centuries, the prevalence of domical vaults ballooned – especially in the Alentejo – due to the convergence of two factors: on one hand, the dissemination of timbrel vaulting as an efficiency improvement in traditional construction (Fortea Luna 2008) profited from a vaulted form whose rise is both linear and horizontal, expediting brick-setting; and on the other, housing construction in this period was marked by developments in private life that saw a specialisation of domestic spaces, resulting in the growing compartmentalisation of older multi-purpose interiors into clearly defined bedrooms, social rooms, bathrooms and subservient circulation areas [Fig. 18]. New buildings from this period were also conceived like this, making domical vaults almost as ubiquitous as barrel and groin vaults. Additionally, the gradual transition to timbrel vaulting lowered the average rise of practically all vaulted forms. In domical vaults, the abatement of the calottes trimmed down the re-entrant groins, merging the two pairs of webs into an almost continuous curved surface with short pleats at the corners.

All these types of vaults are composed of surfaces or calottes that can accommodate the insertion of lunettes or penetrations – small vaulted surfaces (ideally

cylindrical) that interrupt the main vault. These serve as 'light channels,' drawing light from vertical windows, or are simply used as decorative elements to introduce variation or animation on an interior space, at the junction between the calottes and the walls.

As 'light channels', they are commonly found in church roofs, particularly in the nave rather than the chancel, especially toward the end of the Early Modern period. When used as decorative features, they are frequent in southern vaults and appear in all types of dwellings, applied in various ways. The malleability of brick construction and the accumulated expertise of master vault builders lent themselves well to this effort to break 'monotony' [Fig. 19].

This basic morphological concept has a 'freer' variant, found in a handful of cases in the Alentejo, of a type of vault whose lunettes were enlarged to such an extent that there is no longer a main calotte or intrados. The lunettes are joined together at their edges that meet at an apical point in the vault's zenith [Fig. 20]. The lunettes themselves extend from the centre of the vault to the walls, intersecting them obliquely so that the separating edges vary in length: the longest edges project diagonally across the room, while the shorter ones align with its medians.

Naturally, as is often the case with vaults in general – and particularly with composite vaults – the most technically and formally elaborate examples of penetrations are found in religious buildings, despite their widespread use in domestic architecture in the South of Portugal. The repetitive use of 'decorative' penetrations produces an even greater effect in large spaces, as seen in the sacristy of the former Convent of São Paulo in Serpa [Fig. 21]. However, the evolution of a vault of this type into a continuous 'undulating' surface without edges (as seen in what currently is the laundry room at the former Convent of São Francisco in Serpa) or the intricate adaptation of lunettes and edges to the space and openings of the chancel in the Church of São Pedro in Moura [Fig. 22] evoke the greatest sense of wonder and admiration.

Ribbed vaults are also an example of composite vaulted structures, comprised of different surfaces, but they belong to an entirely different lineage, distinct from the families of vaults previously analysed.[22] Developing predominantly within learned contexts, particularly in religious architecture, they are a medieval European invention, closely tied to Gothic architecture's structural and spatial innovations, making them chronologically limited. While in some European regions late Gothic styles extended well into the 16th century – thus overlapping with the cultural context of the early Modern era – Portuguese ribbed vaults were also used in Renaissance architecture and, more broadly, in classicising architecture until the late 16th century. In such cases, either Gothic construction techniques were acclimated to a classical expression, as seen in the profiles of the ribs, the design of

[22] Although, according to various authors in the field of structural analysis, its initial conception may have been suggested based on the understanding of the unequal distribution of forces in a typical groin vault.

**Fig. 19** Elaborate lunette vaults. Staircase in Grémio da Lavoura, Moura. Source: authors, 2023.

**Fig. 20** Octopartite vault. House in Praça da República, Alvito. Source: authors, 2023.

**Fig. 21** Penetrations in the sacristy of the Hospital (formerly convent) of Saint Paul, Serpa. Source: authors, 2022.

**Fig. 22** Unconventional vault shapes. Chancel of Igreja de São Pedro, Moura. Source: authors, 2023.

supporting corbels, and the decorated keystones, or these elements ceased to serve any structural purpose, becoming merely decorative and less prominent.

The inclusion of ribbed vaults within the scope of vaulted architecture in southern Portugal is justified for both structural/material and prestige-related reasons. Many of the ribbed vaults found in the architecture of the Alentejo and the Algarve are constructed entirely from brick. This includes the surfaces of the various webs that compose the vaults and the structural ribs that join these surfaces, except for the springing corbels, which are often made of carved stone. These vaults are

Fig. 23 Ribs integrated with pictorial decorative programmes. Chancel of Igreja do Espírito Santo, Moura. Source: authors, 2023.

Fig. 24 Imitation of stonework. Sacristy of Convento do Carmo, Moura. Source: authors, 2023.

commonly found in a wide range of religious spaces, such as chancels, naves, chapels, cloisters, sacristies, and refectories (e.g., Convento do Carmo, Moura; Convento de São Francisco Serpa).

The material and prestige-related aspects of ribbed vaults are evident in religious, military, and civil architecture. In religious architecture, this is reflected in the relative complexity of the ribbed vaults, which tend to be more elaborate in areas such as chancel chapels or chapter rooms. In all architectural typologies, however, brick ribs were originally plastered and whitewashed. In cases where the intrados of the vaults feature decorative or figurative paintings, the ribs are integrated into the overall pictorial design **[Fig. 23]**. Conversely, in some instances, decorative programmes consisted only in the ribs being plastered or painted in order to mimic stonework, underscoring the connotation with the desired prestige of stone masonry construction **[Fig. 24]**.[23]

Such programmatic considerations, along with their implied technical complexity, meant that ribbed vaults (in brick) were rarely used in domestic architecture, except for some noble houses of the Alentejo. Even in these, their use was sporadic, appearing in a few late-built tower houses (16th century) commissioned by families aiming to assert their rising social status (e.g. Torre das Águias, Brotas, Mora). They are also found in the oldest surviving sections of urban noble houses, invariably on the ground floor and in spaces adjacent to the building's main façades. These spaces may have served representative functions, such as vestibules or chapels, or perhaps even shops, as the ribs were not strictly necessary to bear the weight of upper floors (e.g. Casa Rocha and Palácio Ficalho in Serpa). The simplicity of the rib sections used in these cases – often unnecessarily wide and sometimes crude in appearance – suggests a tendency toward vernacular adaptation, despite being found in the homes of privileged social groups **[Fig. 25]**.

## Conclusion

It can be confirmed that vaulted construction, though by no means exclusive to the south of Portugal, has a particularly significant presence in the regions south of the Tagus River, spanning all housing types, including ordinary dwellings. Combined with the predominant use of brick, most often assembled without centering, we can affirm that, regardless of its origins, this technique has solidified into a vernacular tradition.

Although it has not yet been possible to determine a clear 'boundary' for the extent of the use of this technique in vernacular contexts – and acknowledging that such construction questions rarely have exact limits – it is possible to propose

[23] The outward expression of solidity provided by stone likely explains its selection for constructing the ribbed vaults in some of the most significant military structures in the Alentejo, such as the keep towers of the castles of Beja and Estremoz.

Fig. 25 Detail of irregular ribbed vault in Palácio Ficalho, Serpa. Source: authors, 2022.

an approximate delimitation. The area dominated by brick vaults constructed without centering corresponds to a broad swathe of territory extending from the interior of the Alentejo to the eastern Algarve. This broadly coincides with the *Sotavento Algarvio*.

However, this general constructive continuity in southeastern Portugal, encompassing the assemblage method that dispenses wooden centering, does not translate into uniformities of employed vaulted forms, functions of the spaces they cover, areas with the highest density of vaulted constructions, or even the way materials are applied.

The entire Lower Alentejo on the Left Bank of the Guadiana River, the easternmost strip of its territory, has already been highlighted as the area with the highest concentration of vaults in terms of both number and variety. In the Algarve, where vaults are even rarer in the northern mountain range (*Serra*) than in the western region (*Barlavento*), the greatest density is found in the central zone, in an arc centred on Faro and roughly defined by the urban centres of Fuzeta, Moncarapacho, São Brás de Alportel, Loulé, and Boliqueime.

Although the constructive similarities between the brick vaults of these two regions are undeniable, the mixture of stone and brick in the central Algarve produces significant differences, albeit hard to perceive when these structures are plastered. In this zone, where the Barrocal reaches its greatest width, limestone predominates – often of varying quality. The so-called *pedra caliça* (a light and easy-to-work

limestone) is frequently cut into small parallelepiped blocks and mixed with brick for vault construction. Typically, the two materials are used in different parts of the same vault, though with zones of integration or at least adjacency. Moving westward, one begins to encounter vaults constructed exclusively in *pedra caliça*, albeit built using the same techniques as those employed for brick. This is not the case when moving eastward, where stone also appears in vault construction but not as an equivalent or substitute for brick. Instead, it is used as rougher, larger masonry blocks to form the starting segments of vaults with straight springing from walls.[24] In sail or groin vaults, this type of stone may also be used to form the springing points at the corners, acting as concealed corbels of considerable size.

These different combinations of stone and brick in vaulted coverings may be one of the reasons for the rare use of timbrel vaults (*abobadilhas*) in the Algarve. Stone, even when light and well-carved, was not compatible with the construction techniques of timbrel vaulting. Additionally, in the Alentejo, timbrel vaults are predominantly constructed on upper or ground floors that are not required to bear heavy loads. In the Algarve, even in single-storey houses, vaulted coverings are almost always constructed with bricks placed perpendicularly to the curved surface. In two-storey houses, vaulted ceilings are rarely found on the upper floor.

Even if, from a top-down perspective, the vaults of Alentejo and Algarve can be indistinctly grouped in the same territory of southern or Mediterranean architecture, up-close analysis of dozens of such structures demonstrates that they have developed in both regions with some degree of geographical and chronological autonomy. Furthermore, it remains clear that both of these regional constructive traditions arose mainly in the Early Modern period, making them historically separate from the attested vaulted construction of Iberian Roman Antiquity and the (so far) fictional vaulted construction of the Gharb al-Andalus.

[24] These correspond roughly to the lower thirds of a vault's curvature, known in Portuguese as *rins* and in Spanish as *riñones*.

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