

Absolute Dating of Construction Materials and Petrological Characterisation of Mortars from the Santalla de Bóveda Monument (Lugo, Spain)

Rebeca Blanco-Rotea (✉ rebeca.blanco.rotea@arquitectura.uminho.pt)

University of Minho

Jorge Sanjurjo-Sánchez

University of A Coruña

David M. Freire-Lista

University of Trás-os-Montes and Alto Douro

Rosa Benavides García

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Abstract

The construction materials of the Santalla de Bóveda Monument, one of the most studied buildings in Galicia (Spain), are analysed to date the mortars and bricks of walls and vaults by combining three dating techniques: optically stimulated luminescence, radiocarbon and thermoluminescence. Petrological characterisation of the mortars themselves is carried out. Until now, the paintings on the vault have been interpreted as Roman, early Christian or pre-Romanesque, depending on the interpretative framework used by the researcher who studied them. There is also no consensus on their functionality. A total of 21 samples were collected and 39 datings were made. The results are conclusive: the original building dates from the second half of the 4th century AD, the paintings date from the beginning of the 7th century or the upper floor from the 10th-12th centuries. These results make it necessary to review the history of Galician architecture between Late Antiquity and the Early Medieval Ages.

Introduction

The Santalla de Bóveda Monument is located fifteen kilometres southwest of Lugo, in the northwest of Galicia (Spain), in a rural area of the Mera valley (Fig. 1). It is a small semi-buried building, under the Bóveda Parish Church, built in the 18th century, with an apsidal quadrangular floor plan, which was divided into three naves. The small apse has a rectangular floor plan and is vaulted; it is accessed through a brick voussoir arch. Only the parts of the vault in the lateral naves have survived, where paintings depicting birds and plant elements have been well preserved. There is a shallow pool in the flagstone pavement. The *aula* is preceded by a two-column portico in antis, and in its narthex the remains of the vault that covered it, decorated with geometric paintings, have been preserved. The doorway of the *aula* has a central opening crowned by a light horseshoe-shaped brick arch, above impost, and framed by a chambranle and a granite moulding with vegetal decoration, *alfiz* type. Two rectangular lintelled windows with a mitered arch above them are on either side of the door. There are several bas-reliefs depicting various types of birds and human figures in the portico, both on the outer façade and in the narthex (Fig. 1). Part of the north elevation of a first floor is preserved above this structure (Fig. 2).

The monument has aroused great interest since its discovery, both for its uniqueness and for the interpretation of its well-preserved paintings as Roman. But its chronology and functionality has always been the subject of controversy. Some of the most recurrent interpretations are as nymphaeum of the 4th century AD (Castillo 1932; Chamoso 1952; Abad Casal 1979) or from the end of the 3rd century AD in the orientalising style (Gómez-Moreno 1949); as a possible salutary waters place (Ares 1962, 1963, 1964), remodelled in the second half of the 4th century (Chamoso 1952).

It has also been interpreted as a Roman funerary monument of oriental character of the 4th century AD, transformed for Christian worship around the 9th century AD following pre-Romanesque Asturian models (Schlunk 1935); or as the baths of a villa of the 4th century AD and a later transformation, around the 5th century, into a Prisciliano tomb (Fernández de la Vega 1970) or with a Christian reuse before the 8th century AD (Guardia 2002).

Several authors define a Roman origin with later stages in the 5th, 8th or 9th centuries (Acuña 1973; Núñez 1978; Rodríguez Colmenero 1992, 2018; Singul 1997, 1998; Vidal 2003; Carrocera 2016). Arias (1979, 1980) sees a single structural phase to which construction, painting and sculpture are assigned and it is reused with the passing of time. Finally, Montenegro (2016) defends the statement of the space to an Alto Imperial funerary monument no later than the 2nd century AD with Dionysiac character.

Research carried out by our team in 2007–2008 identified a complex stratigraphic sequence thanks to an Archaeology of Architecture study of the monument, applying stratigraphic analysis of walls (Benavides and Blanco-Rotea 2008; Blanco-Rotea et al. 2009) (see Fig. 6 below):

- Phase I. First underground building consisting of a narthex, the vaulted *aula* without division into three naves and with a swimming pool, and the W apse, also vaulted.
- Phase II. Alterations to the *aula* modifying its appearance: division of the aula into three naves; decoration of the interior of the *aula* with paintings and possibly decorated plaques; possible alteration of the entrance door to the monument; and a possible modification of the main façade.
- Phase III. Construction of a vaulted room above the *aula* and with access from the W.
- Phase IV. Specific alterations affecting the W door of the *aula*, the vault of the narthex or the vault of the upper floor.
- Phase V. Interventions in the contemporary period, which took place between its discovery in 1929 and the last intervention by the architect César Portela in 2006–2007.

Stratigraphic reading is a well-proven method of archaeological analysis of architecture (Domingo and Sánchez, 2010) that provides a relative sequence of construction phases. To date absolutely, other methods are used, such as the use of chronological indicators or absolute dating techniques applied to materials, such as radiocarbon or optically stimulated luminescence (OSL).

But, in case of using chronological indicators, three points must be considered at the Santalla de Bóveda Monument:

- 1) It is a *unicum*, there is no known similar example in the Iberian Peninsula and even less in the NW that would allow us to establish a comparison on which to build an interpretative model for the Santalla de Bóveda Monument, although some parts of the complex could have similarities with other constructions.
- 2) The materials and construction techniques used in the Santalla de Bóveda Monument, as well as the motifs of the paintings, are documented in a wide chronological range, from Roman times to the Early Middle Ages. This has meant that each author has given greater or lesser weight to one or other chronology, depending on the interpretative framework used. This is the case, for example, of the decorative scheme of the central part of the vault which has now disappeared, which is compared both with the motifs of Roman *villae* and with the paintings of pre-Romanesque Asturian art (Blanco-Rotea et al. 2009: 192–196).

3) The scarcity of studies of Galician Early Medieval architecture from an archaeological point of view that would allow us to establish well-defined contexts, on a stratigraphic basis, between the 5th and 10th centuries, there is an aspect that it has changed today thanks to the development of different projects focused on the archaeology of Early Medieval architecture (Blanco-Rotea et al. 2015; Sánchez Pardo et al. 2017, 2020; Sanjurjo-Sánchez et al. 2020).

Taking these points into account, in the present study it was considered essential to characterise and date precisely the construction materials used at the Santalla de Bóveda Monument. Construction materials of historical monuments generally come from the vicinity of the building (Drdácky et al. 2013; Furlan 2017; Freire-Lista and Fort 2019). The geological setting where the Santalla de Bóveda Monument was built conditioned its construction materials, especially the aggregates of the mortars which come from the grinding of granite. The historical quarries are superficial in the area, and the granite is weathered to different degrees. While quartz is resistant to chemical weathering, clay minerals are a product of the weathering of feldspars and micas. Therefore, aggregates from weathered granite have more clay minerals than aggregates from fresh granite. The aggregates will have a large amount of clay if the aggregates are extracted from a highly weathered and sandblasted granite saprolite, which reduces the mortar quality. Masons could improve the mortar quality made with granite aggregates from saprolites by concentrating the quartz grains. That is, washing and removing the clay minerals.

From a geological point of view, the Santalla de Bóveda Monument is in the south of Hombreiro-Santalla (HS) pluton, on a syn-kinematic two-mica granite (Aranguren 1997). Two-mica granites occur usually as small plutons late in a plutonic sequence that intrudes high-grade metamorphic rocks of an orogen. They are usually leucocratic, massive, hypidiomorphic granular granitoids that consist of about 31% volume percent quartz, 26% K-feldspar, 31% plagioclase and about 10% mica in which muscovite may exceed biotite. In some, muscovite is absent in which event total mica is about 5%, except for a few types that contain abundant biotite. In two-mica granites hornblende is absent, magnetite is sparse, and sphene is rare. Common accessory minerals are apatite, zircon, monazite, garnet, and tourmaline.

Petrographic characterisation is a very useful technique for construction materials (Germinario and Török 2019; Parracha et al. 2020; Careddu et al. 2021). It allows for the techniques and source materials used in the preparation of historical mortars to be identified (Elsen 2006; Ergenç and Fort 2019; Freire-Lista et al. 2020).

In terms of obtaining the date of the materials, in recent years, both ^{14}C and OSL dating of mortars have made it possible to obtain ages of historic buildings (Sanjurjo-Sánchez 2016; Urbanova et al. 2020). Radiocarbon AMS dating enables the dating of the layering of a mortar from the analysis of the lime binder, although the calcite can be mixed with geogenic calcite, secondary calcite due to dissolution and re-precipitation, or affected by very slow setting processes that can cause the overestimation or underestimation of ages (Ringbom et al. 2014; Sanjurjo-Sánchez et al. 2010; Urbanova et al. 2020). OSL dating of quartz aggregates has also been used (Goedicke 2003). However, OSL dating can also

overestimate the age if the quartz aggregate has not been well exposed to daylight when the mortar was prepared before layering (Sanjurjo-Sánchez et al. 2016; Urbanova et al. 2020).

The aim of this work is to obtain an absolute chronology for the Santalla de Bóveda monument and its different construction phases for a correct interpretation of their architecture and decoration.

Materials And Methods

Dating of mortars and bricks by Optically Stimulated Luminescence (OSL), Thermoluminescence (TL) and ^{14}C

There are currently several methods for dating mortars, such as radiocarbon or OSL, as discussed above. However, the dates obtained are often flawed, or have very wide margins of error that do not allow for a refined chronology. Nevertheless, there are three possible strategies to identify inaccurate ages in mortars: (i) cross-checking results with independent dating methods (e.g. ^{14}C vs. OSL), (ii) dating several samples of the same construction phase, and/or (iii) comparing the ages obtained with those of other materials, such as wood, charcoal or bricks from the same structure. Such strategies have been used simultaneously in this work, allowing both the reduction of uncertainties and the removal of biased ages.

In order to obtain a robust chronology, a total of 39 datings were performed from 21 samples taken from different walls of the studied building (Fig. 3). They correspond to each of the phases previously identified in the monument (Blanco-Rotea et al. 2009), always from inconspicuous places that did not affect the paintings. 20 OSL and 15 ^{14}C ages were obtained for mortars, on quartz aggregates and carbonates or charcoal, respectively. Thus, for some samples two or even three ages were obtained. Thermoluminescence dating (TL) was also performed on 5 brick samples. The list of samples, dated material, location in the building and age result are shown in Table 1.

The 'Cryo2SoniC' method (Nonni et al. 2018) was used for ^{14}C mortar dating, which involves several steps of cryogenic fragmentation, fragment selection, ultrasonic cleaning and centrifugation to separate the calcite of interest (archaeological calcite). This archaeological calcite was sent to the ICA laboratory (Florida, USA) for AMS dating. Charcoal samples were directly sent to the same laboratory. Ages were calibrated using the curve of Reimer et al. (2020) with Oxcal 4.4 software (Bronk Ramsey 1994).

Both OSL and TL dating were carried out at the Luminescence Laboratory (University Institute of Geology) of University of A Coruña (UDC). The outer part of the samples was removed and pure quartz aggregates were extracted following the procedures described in Viveen et al. (2014). Multigrain aliquots were mounted and analysed in two readers: a Riso DA-15 TL/OSL and a Lexsyg Research, equipped with $^{90}\text{Sr}/^{90}\text{Y}$ beta radiation sources providing doses of $0.095\pm 0.003 \text{ Gy s}^{-1}$.

OSL dating requires the assessment of the accumulated charge in the quartz grains. This is estimated as the equivalent dose (D_e) by measuring the luminescent signal. The radiation dose rate is also estimated as the dose-rate (D_r) (Aitken, 1985). For OSL dating, to estimate D_e the SAR (single-aliquot regenerative

dose) protocol of Murray and Wintle (2000, 2003) was used. For TL dating the Additional Dose (AD-TL) protocol (Aitken 1985) was used. The D_r was estimated by analysing the U, Th and K content in the samples and surrounding materials by X-ray Fluorescence (XRF) combined with Inductively Coupled Plasma Mass Spectrometry (ICP-MS) in some cases, and Instrumental Neutron Activation Analysis (INAA) in others. Conversion factors of Guerin *et al.* (2011) were used to assess the beta dose. For the gamma dose, a geometric model similar to the one proposed by Feathers *et al.* (2008) was used, estimating the cosmic dose according to Prescott & Hutton (1994). The result was compared with the estimations obtained using both Al_2O_3 OSLD/TLDs dosimeters and a portable gamma spectrometer GF Instruments Gamma Surveyor Vario.

Mortars petrographic characterisation

Four mortar samples, one from each construction phase of the Santalla de Bóveda Monument, were embedded in resin in a vacuum chamber to consolidate them and to avoid disintegration in the preparation of thin sections. The thin sections were studied under a Leica DM750P polarised-light microscope.

Results

Dating of mortars and bricks by Optically Stimulated Luminescence (OSL), Thermoluminescence (TL) and ^{14}C

Very high D_e s were obtained, ranging from $\approx 3 \text{ mGy a}^{-1}$ to $\approx 11 \text{ mGy a}^{-1}$. This is due to the high concentration of U, Th and K in the building granite and mortar aggregates. The observed OSL and TL signals were bright. The Central Age Model (CAM) proposed by Galbraith *et al.* (1999) was used to assess the D_e s for most of the mortar samples, as the measured aliquots provided symmetrical dispersions with low overdispersion values. Asymmetric and more overdispersed distributions were observed only in few samples. In such cases the Minimum Age Model (Galbraith *et al.* 1999) was used. The brick TL analyses provided bright signals, but the uncertainty obtained was high for the assessed D_e s (20%), except for one sample.

Calcite separation for ^{14}C dating provided enough material for AMS analyses, that provided calibrated ages which are shown in Table 1. It can be observed that ^{14}C ages of calcite, charcoal and OSL in mortar and TL in bricks provide consistent results for most samples, providing very consistent ages for the different construction phases. A Phase I/II has been considered because some doubtful features were observed in some structures of both phases, being difficult to assign a clear phase to them. The obtained ages show that these structures fit better chronologically into Phase I.

The four construction phases are clearly separated chronologically, being possible to estimate a precise interval for each of them (Fig. 4). Phase I corresponds to the second half of the 4th century, while Phase II

fits the first half of the 7th century. Phase III ranges between the 10th and the first half of the 12th century. Finally, Phase IV ranges between the second half of the 17th century and the 18th century.

Mortars petrographic characterisation

Fig. 5 shows the petrographic micrographs of the four mortar types studied. Phase I mortar has centimetre-sized aggregates of bimetallic granite (altered and unaltered), and centimetre-sized ceramic fragments. The monocrystalline aggregates are mostly quartz $\approx 70\% < 1\text{mm}$.

Phase II mortar has absence of aggregates of rock fragments. It has aggregates mostly of quartz with a slightly homogeneous grain size $\approx 2.5\text{ mm}$. In addition, small aggregates of biotite and muscovite. Presence of unaltered microcline and carbon.

Phase III mortar also has absence of aggregates of rock fragments. But it has ceramic aggregates. Lime cement is very differently and, to a lesser extent, contains lumps of lime cement. The aggregates are smaller ($\approx 1\text{ mm}$) and the percentage of quartz is lower than in the other types of mortars ($< 50\%$).

Phase IV mortar has aggregates with heterogeneous mineralogy: $\approx 15\%$ Biotite, $\approx 10\%$ muscovite, $\approx 35\%$ potassium feldspar, $\approx 40\%$ quartz and homogeneous particle size $< 1\text{ mm}$.

Discussion Of Results And Relation To Stratigraphic Reading

The stratigraphic reading of the walls had documented the existence of five phases in the Santalla de Bóveda Monument. The samples taken in 2007 and 2020 were collected considering this sequence with the aim of dating and characterising the construction materials, specifically the mortars. As can be seen, both in terms of characterisation and dating, the mortars are divided into four large groups.

In Phase I (Fig. 6), the mortars collected roughly oscillate between the year 28 and 602, with the second half of the 4th century being the time when they coincide with each other. However, there is a group of mortars dated by ¹⁴C that fall outside this range, one (BOV20MU001_A_P) dating from 1175-1324 AD, another (BOV20MU002_B) from 1607-1506 BC and two others (BOV20MU003_A_P and BOV20MU003_B_P) from 760-363 BC and 43-209 BC respectively. However, this disparity does not occur between the dates obtained by OSL. As for the bricks, the pattern is repeated, ranging from 55 to 602 AD. Thus, considering the coherence and coinciding range of the mortars dated by OSL, the phase corresponding to the construction of the *aula* was placed in the second half of the 4th century.

There is a series of mortars and bricks collected in the vault of the apse and in the horseshoe arch of the entrance, whose interval could be placed in both Phase I and II, as they present very large margins of error. In the case of the apse vault, the mortar corresponds to 344-920 AD and the brick 364-894 AD, both of which coincide quite closely with each other. Our assessment is inclined to place them in Phase I, considering the results of the reading of the walls, which indicate that the vault would have been made with the rest of the *aula*, as no cuts can be seen in it.

In the case of the *aula* entrance door, the mortar dates from 248-557 AD and the brick from 63 BC-597 AD. The reading of paraments placed this doorway as part of a Phase II alteration. In part, the most recent dating results lead us to a time immediately prior to the construction of the paintings, but it could also fall within Phase I, so we believe that either hypothesis would be feasible. In fact, if we look at one of the dates of the mortar used to prepare the paintings, it is very similar to these (346-526 AD). We thus leave both hypotheses open in this case.

The mortars collected from elements of Phase II (Fig. 6) were taken, on the one hand, from the remains of the central vault conserved in the Provincial Museum of Lugo (Spain), obtaining dates of 607-774 AD (MUSEB-001_P) and 434-603 AD (MUSEB-002_P), coinciding in the interval 603-607. On the other hand, the mortar used to prepare the paintings preserved *in situ*, dates ranging from 346 to 680 AD. In this case, they all coincide with the beginning of the 7th century, although one point must be made: in Phase II, all the mortars have been dated by ¹⁴C except for one BOV20MU008, which is slightly older and coincides with the dating of the horseshoe arch of the doorway to the *aula*, which would date to the end of the 6th century. In other buildings it has been found that the carbonation of the mortars is not immediate, but occurs some years after the time of laying (Lindroos et al. 2020; Daugbjerg et al. 2021), so it could even be hypothesised that this reform corresponds to the end of the 6th and beginning of the 7th century.

Understanding these data in context requires further research, an intensive analysis of the environment of the Santalla de Bóveda Monument, and of the place where the building is located. But three aspects should be highlighted that open up new hypotheses on which to continue working. The first building is framed in a historical context in which in *Gallaecia* there was a ruralisation of the territory with the increase of *villae* and other types of rural settlements and their functions, especially in the surroundings of the cities. The 4th century sees the greatest development of this type of settlement (Carlsson-Brandt 2021: 690), a phenomenon also closely associated with the occupation of the vicinity of the roads that articulate the territory; in fact, the Santalla de Bóveda Monument is located in a central place between the XIX and XX Roman Vias, in a flat area and close to several hillforts (Gómez 2005: 191), a fairly common proximity in relation to the *villae* (Carlsson-Brandt 2021: 688-689). From our point of view, the Santalla de Bóveda Monument would most probably be part of a type of Roman rural settlement that, at least, would have a phase in the second half of the 4th century, but determining its typology without a detailed knowledge of the whole is adventurous. See the current case of the Roman site of Proendos (Sober, Lugo), whose geomagnetic prospecting has identified an important complex which is currently being excavated (Alonso et al. 2021) and which yields contexts from the 1st to the 6th-7th century AD. In the case of the Santalla de Bóveda Monument, there are few interventions that have been carried out in the area that allow us to advance this hypothesis. The excavations carried out by Gimeno (1989) point to the existence of Roman materials, most of which were dated between the 3rd and 5th centuries (Motenegro 2016: 284), coinciding with the dating of the first phase of the building. It should be noted that in the area around the Santalla de Bóveda Monument there are other settlements whose materials are also linked to Late Roman dates, such as the capital of Santa Cruz da Retorta Church from the 4th - 5th centuries (Gómez 2005: 193). Therefore, in view of the confirmation of the initial phase of the Santalla de Bóveda

Monument in the second half of the 4th century, it would be necessary to review from this perspective these nearby contexts which point, as several authors point out, to a high degree of organisation and development of the rural settlement during this period (Tejerizo 2020: 165) which in the Santalla de Bóveda Monument has a continuity in the following centuries, if one considers the dating of the reform of the *aula* and the paintings of the vault, or the construction of the upper floor.

Focusing on the paintings, the samples collection was limited to the mortars of the preparatory layers of the painting without affecting them. In spite of this we count on the stratigraphic analysis made by Cabrera (1992) of four samples of painting. He emphasises the polishing of *intonachi* and the superposition of painting layers (Blanco-Rotea et al. 2009: 186-187). The identified pigments are: cinnabar, green earth, Egyptian blue, bone black, lime white and also *verdaccio* which he identifies with the description that Cennino Cennini gives for it[1].

Recent studies about the Egyptian blue, the use of which many authors claim was abandoned in the Roman age, demonstrate that it was still being used years later[2]. Thanks to new technologies, its use has been confirmed even in the paintings of the Cinquecento[3]. As for the *verdaccio* we have not found references to it before Cennini[4], although it is possible that a similar technique for the flesh colour was used in the Byzantine[5] and Romanesque[6] wall paintings.

These researches allow us to confirm that the absolute dates obtained in this study are not contradictory to the use of the pigments identified by Cabrera.

The dating of the paintings to the 7th century, far from being a problem, reinforces the initial hypothesis of the survival of Roman structural techniques, both because of their wide circulation over an enormous territory and because of their efficiency, which have proved to be of great quality and durability.

Thus, the permanence of the techniques, materials and pigments used in the paintings, while leading some authors to consider them Roman, others argued that the pictorial technique used in the Santalla de Bóveda Monument remained almost intact until the first centuries of the Middle Ages (Murat 2021: 17-19, 27), it occurs here with the technical realisation, the master lines and the colours palette (Benavides and Blanco-Rotea 2008: 68-72; Blanco-Rotea et al. 2009: 184-187).

An exact parallel with the paintings of the Santalla de Bóveda Monument is yet to be found, although there existed numerous partial parallels. Also, it is true that there are not paintings of the 7th AD century so well preserved apparently without restorer interventions and not even hidden by later plasters. Maybe because of the unusual conservation in painting it is more frequent to find parallels in mosaic of the same age, so much for the greater resistance of the materials and for the conservation of pavements with hardly any walls around them.

The decoration of the lost central part of the vault is documented in such a long period that it is possible to find parallels from the 2nd century BC, as Polybius house in Pompeii (Croisille, 2005: 74) to the Royal Palace of Caserta from the 18th century AD; although/even though the nearest are in the Asturian Pre-

Romanesque (Arias Páramo, 1999) (Fig. 7). The vases with branches and flowers that we can see in the intrados have parallels in the Byzantine world[7] and once more in the Asturian Pre-Romanesque (Arias Páramo, 1999: 77).

Birds, grapes, *rosaceae* and lozenges also appear during a long time in buildings whose functions are different and in territories very far apart.

Although in wall paintings we can rarely see them, the graticules made by successions of motives are frequent in the Roman world[8] and also in much later moments as it is the case of the apodyterium of Qusayr' Amra built in the 8th century AD (Almagro et al., 1975; Vibert-Guigue, 2004: 210-213; Manzano, 2007: 339) or the Sala delle Oche in the Palace of Bonifacio VIII (Anagni, Italy) (1294-1303)[9] (Fig. 8).

In mosaics (Fig. 9), the model which presents more similarities with the Santalla de Bóveda Monument is the one of the vault hall of the chapel of Sant'Andrea in the Archiepiscopal Palace of Ravenna[10], from the era of the bishop Pietro II (494-519). The floral lozenges are populated with various species of birds.

With variations on the same theme we can find several mosaic floors, in some cases like in Apostles Church of Madaba[11] (Jordan) another mosaic is preserved with the same geometric pattern of the lost vault (Fig. 9). Also in Madaba, and from the same century, we find this scheme in the Church of al-Khadir[12] or the Church of the Martyrs, representing birds, flowers, grapes and other fruits. All of that leads to show the chronological, geographical and functional dispersion of the pattern of the *aula* vault.

Regarding the remains of the vault preserved on the upper floor, we had already raised on other occasions (Blanco-Rotea et al. 2009) the complexity of linking them to phase I or II, as the relationship between them was severed in the reform carried out by Gallego and Portela in 1985-1993. However, the difference in the construction technique used between the vaults of the *aula* and the upper floor led us to assume that these were different phases, as corroborated by the results of the dating, which lead us to firmly establish the existence of a third phase in which a room was built above the *aula*. However, in this case the dating is also somewhat disparate. There are two OSL mortar dates that we consider to be in error, AUE110 gives a date of 3267-2091 BC and AUE017 of 417-127 BC. The remaining ones range between 764 and 1475 AD, with the 10th-12th centuries being the coinciding dates. On the other hand, in the case of the bricks used in this vault, the dates range between 336 and 919 years, coinciding in the interval 648-739 AD, which leads us to wonder if they are not reused bricks from another building or from the lower structure.

We also link to this time a series of replacement mortars documented in the vault of the *aula* over earlier mortars and structures, also dating from around the 11th-12th centuries.

The Baroque phase, which should perhaps be associated with the time when the current Parish Church was built in 1750 and a ceiling was placed over the remains of the *aula* now filled with rubble from the upper floor. It corresponds to a mortar dated 1646-1799 AD.

- [1] 'burnt sienna, bone black, lime white and cinnabar' (Cabrera 1992: 38).
- [2] 'In the wall paintings of the church of San Saba (Rome), dating to the first half of the 8th century AD, Egyptian blue and lapis lazuli have been detected mixed together within the same pictorial layer' (Gaetani et al. 2004: 13). 'Egyptian blue has been identified positively in a Roman medieval fresco of the lower church of San Clemente' (Lazzarini 1982: 84).
- [3] 'Egyptian blue was optically identified in a single thin section from a painting by Giovanni Battista Benvenuto from 1524, a period from which Egyptian blue is normally considered not to exist' (Bredal-Jørgensen et al. 2011:1438).
- [4] Cennino d'Andrea Cennini (c.1370-1440), a painter who describes the techniques of the master Giotto in *The Book of The Art*. The *verdaccio's* description is very accurate in chapter LXVII, whereas it is quite simplified in chapter LXXXV.
- [5] Dyonisius de Fournia (1670-1745), in his treatise *Erminia picturii bizantine* describes: 'The flesh-colours are made with green earth, (...) dark ochre, (...) lime white (...) and black. Grind them well and use as base colour' (Villarquide 2015:117).
- [6] Eraclio says in *De coloribus et artibus romanorum*: 'For the flesh-colours is sometimes used, mostly in Italy, a layer of *verdaccio* as in Byzantium, in which case the work is made basically from dark to light' (Villarquide 2015:143).
- [7] In Ravenna, in Gala Placidia mausoleum and Neonian Baptistery, both from 5th century AD and the Albenga baptistery, 5th-6th AD, all of them made in mosaic.
- [8] Pompeii (Croisille 2005:92), Domus Aurea (S-Segala, Sciortino, 1999: 80), Villa di Arianna (Guinouves 1987:8-9; Formoso 2006: 87), villa di Popea in Oplontis or Villa di Minori in the Amalfitan coast (Laken 1998: 297 and 395). In these two last cases, the succession of motives that made the lozenges are interlaced just as in Santalla; Abad Casal (1979: 920; 1982: 368) makes an interesting reflection of on? this 'knot'.
- [9] Although much later than Saint Eulalia, this painting has in common with it the interlacing of the losanges, a large variety of birds - although only the geese give the room its name - and the hypothesis that the paintings were inspired by a treatise on birds (*De arte venandi cum avibus* in this case and the Dioscorides of Vienna in the case of Saint Eulalia).
- [10] In this case it is pergolato (arbour: mosaic and tempera painting).
<https://www.ravennamosaici.it/cappella-di-santandrea-e-museo-arcivescovile/>
- [11] A mosaic inscription (later destroyed) indicated the name of the church and 578 as the year of the completion. <https://universes.art/es/art-destinations/jordania/madaba/church-of-the-apostles> (last search 28/11/2021).
- [12] <https://eldiwan2010.blogspot.com/2018/07/jordania-madaba-la-ciudad-de-los.html> (January 2022 consultation).

Conclusions: New Perspectives

The results of the study of mortars and bricks from the Santalla de Bóveda Monument have allowed us to obtain an absolute chronology for the entire sequence previously identified, which leads us to open up

new hypotheses about the interpretation of the monument and to raise a series of methodological reflections.

In terms of dating, this is a complex that was constantly reused until it was filled in the second half of the 18th century:

- First Late Roman building: second half of the 4th century AD.
- Alterations to the *aula* and vault paintings: late 6th and early 7th centuries.
- Construction of the first floor and occasional repairs: 10th-12th centuries.
- Occasional alterations and clogging of the monument: 18th century.

These results are also supported by the petrographic characteristics of the mortars, which are different in each phase.

These four periods are coincident with important events of change in *Gallaecia*, and subsequently in Galicia, some of which are currently in the process of revision due to new archaeological findings, making it possible to reinterpret the transition from the Late Roman period to the Early Medieval Ages. We refer to 1) the process of ruralisation in the Late Roman period and the generation of new types of settlements that will transform the Galician rural landscape from the second half of the 4th century; 2) the moment of transformation that takes place at the end of the Suebi period and the beginning of the Visigothic period, at the end of the 6th and beginning of the 7th century, which happens to be much more complex than previously thought; 3) the great impact of the proliferation of the construction of churches in rural environments that took place in the 10th century ; and, finally, 4) the transformation of these churches in the 18th century, a time when demographic changes and the spread of the Baroque style from urban centres led either to the abandonment of the previous temples or to a major remodelling that masked the remains of the first churches in Galicia. This opens up new working hypotheses that will have to be tested by extending the study of the Santalla de Bóveda Monument to the territory in which it was implanted, and which it surely contributed to structure with other elements of which it would form part.

Finally, the work carried out, together with previous experiences, will allow to establish a working protocol which can be summarised as follows, although further specific work on this area will have to be developed: 1) Samples should always be collected after a previous archaeological study that allows us to identify the stratigraphic sequence or either original mortars. 2) In order to obtain accurate and reliable results it is desirable to perform combined OSL and ¹⁴C analysis on carbonates of lime mortars. But these techniques are destructive, so we have limited ourselves to collecting samples from the base of the paintings and the interior of the vault. If the results of Phase I are analysed, the mortars studied by OSL, the bricks by TL and OSL, and the charcoal by ¹⁴C, show consistent dating, although the carbonates dated by ¹⁴C show inconclusive results. In Phase II, however, the results are consistent between ¹⁴C and OSL, except for one sample which corresponds to a replacement mortar.

Declarations

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Conflicts of interest

Not applicable

Ethical approval/statements - Consent to participate

Not applicable

Consent to participate / Availability of data and information

All authors consent to the publication and availability of their data and information.

Availability of code (software application or customised code)

Not applicable

Authors' contributions

RBR wrote the main manuscript text. JSS wrote the sections on methods and results of mortars datings and DMFL on methods and results of petrographic characterisation of mortars. RBG wrote the parts of the paintings. RBR prepared figures 1-3 and 6, and with JSS prepared table 1; JSS prepared figure 4; DMFL prepared figure 5, and with Rosa Benavides prepared figures 8-9; Rosa Benavides prepared figures 7. All authors reviewed the manuscript.

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Tables

Table 1 is available in the Supplementary Files section.

Figures

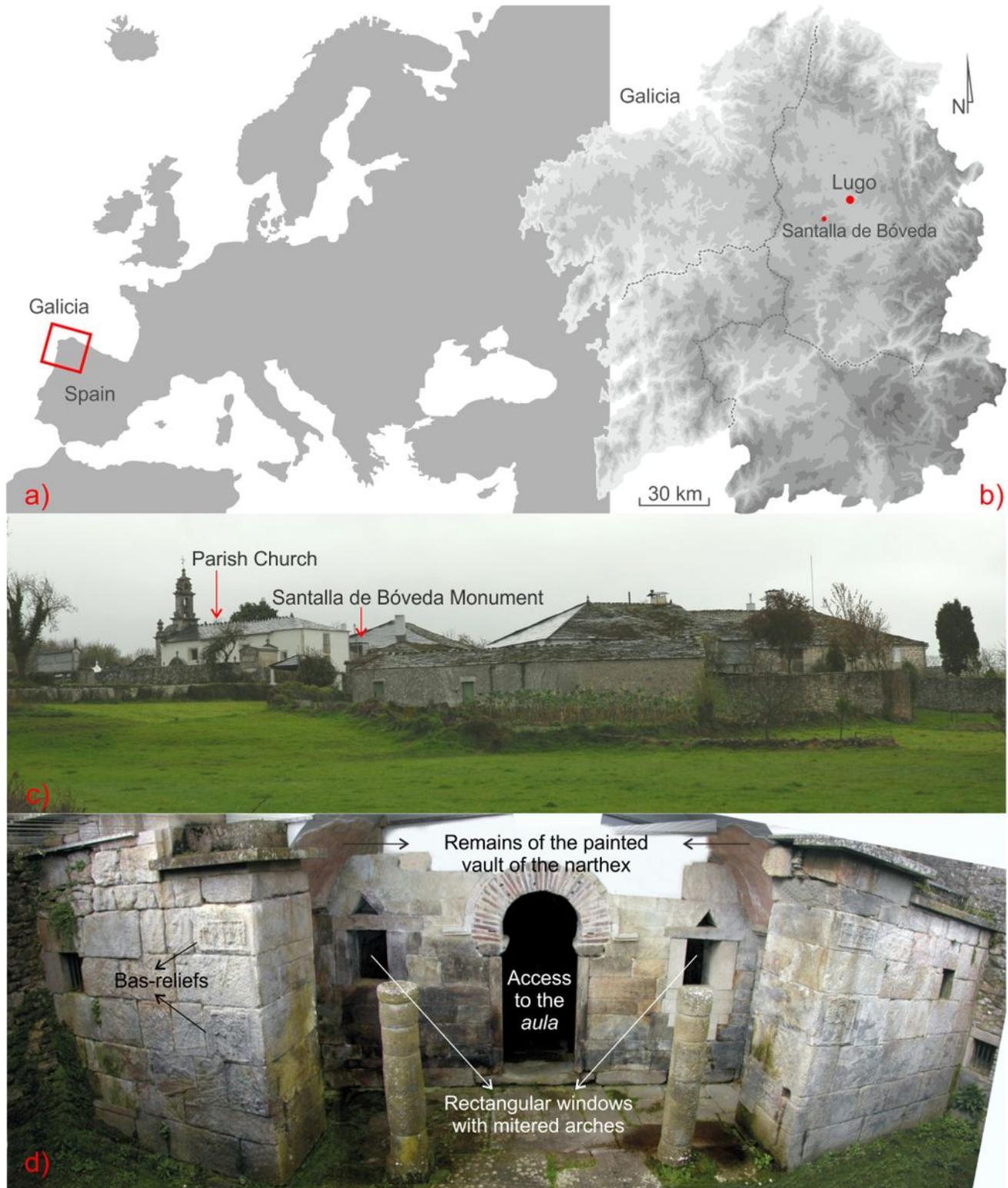


Figure 1

a) Map of Europe with the location of Galicia in Spain. b) Situation of Santalla de Bóveda Monument in Lugo province. c) Location of the Santalla de Bóveda Church and monument in Bóveda. d) East façade of the monument and narthex with columns *in antis*.

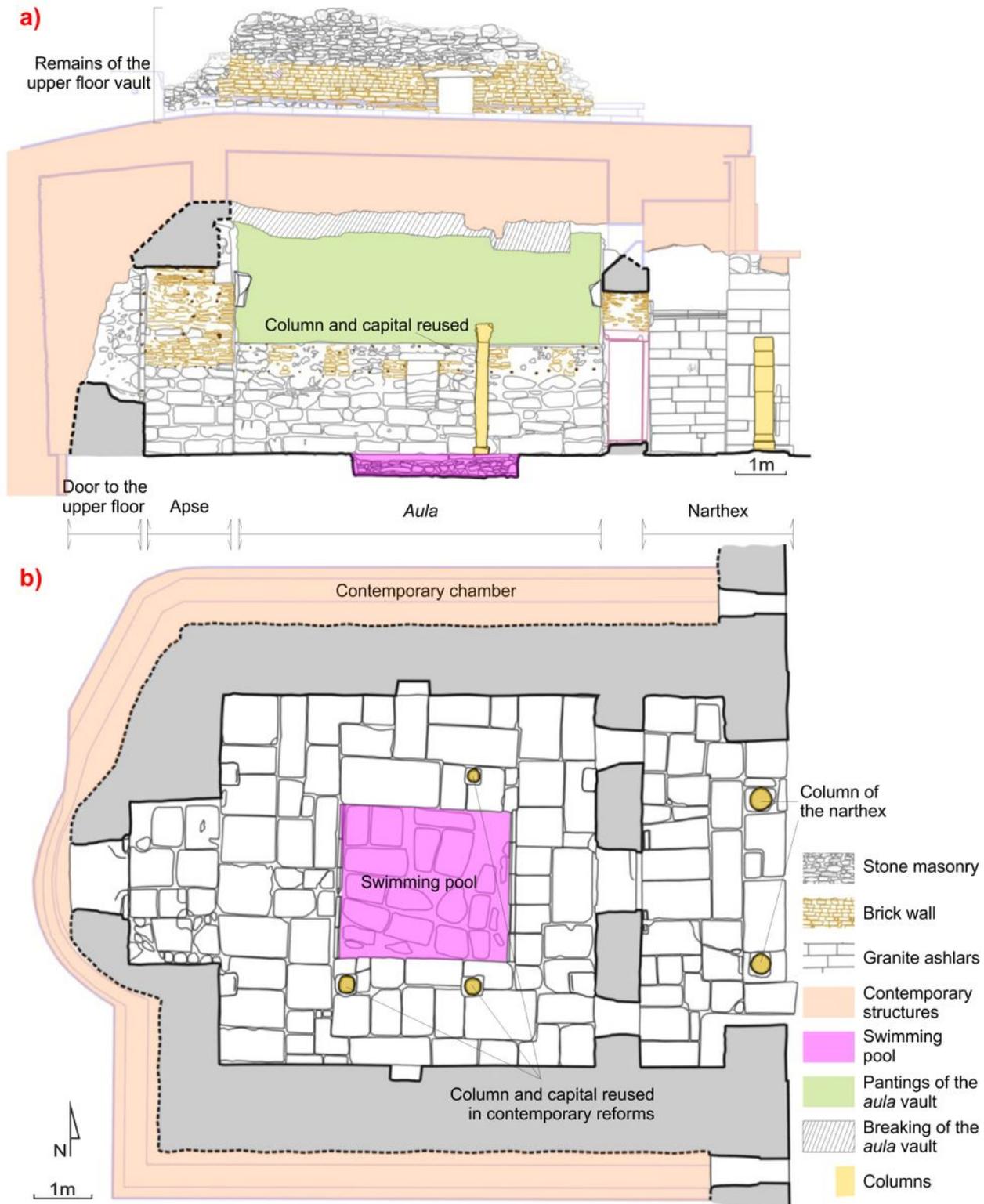


Figure 2

a) North elevation of the aula and remains of the upper floor. b) Plan of the underground building of the Santalla de Bóveda Monument.



Figure 3

Samples location. a) North wall of the aula; b) South wall of the aula; c) East wall of the aula; d) West wall of the aula; e) Remains of the vault of the upper floor.

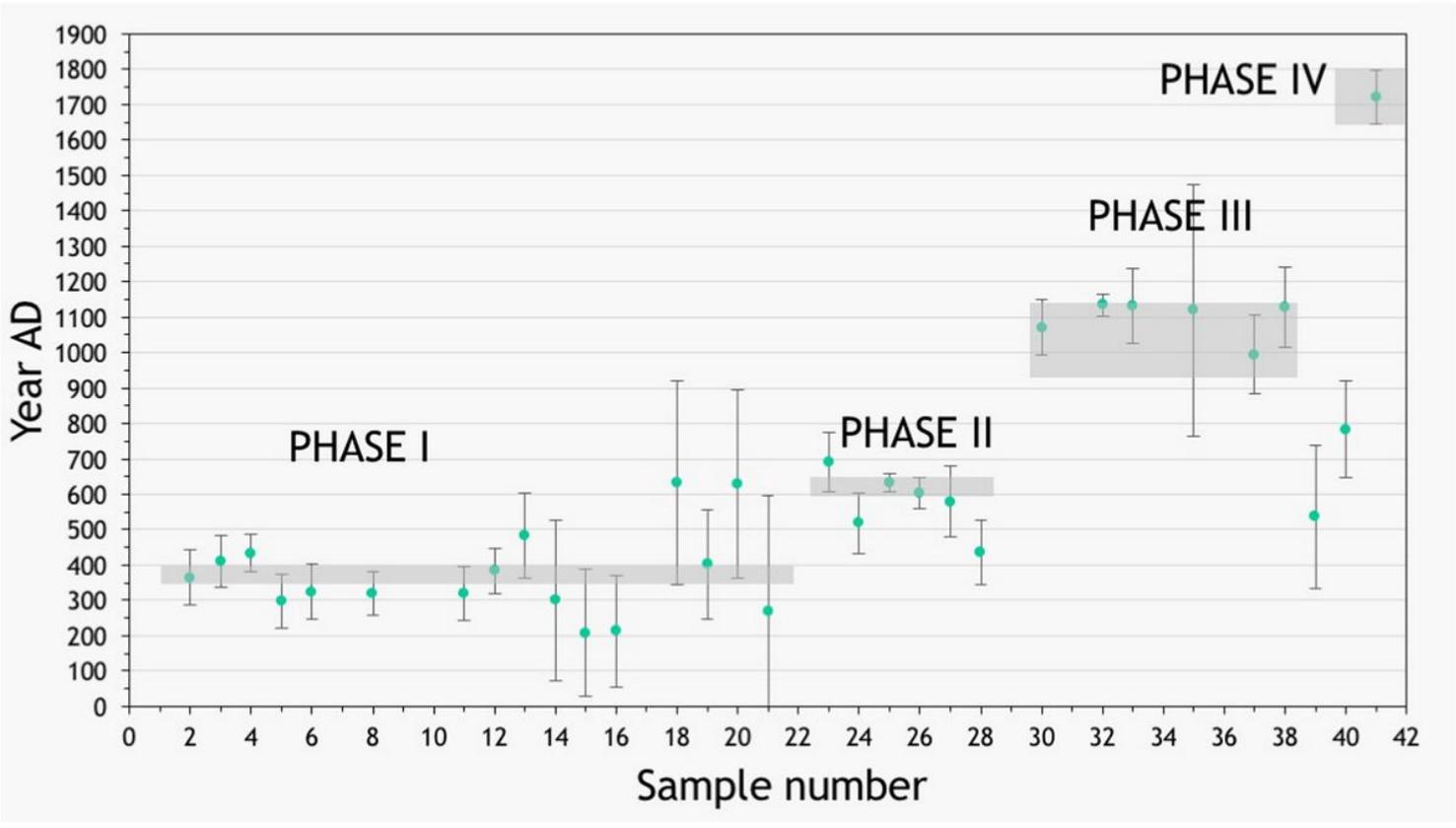


Figure 4

Chronology of the four constructive phases of Santalla de Bóveda Monument after comparing phases and absolute ages.

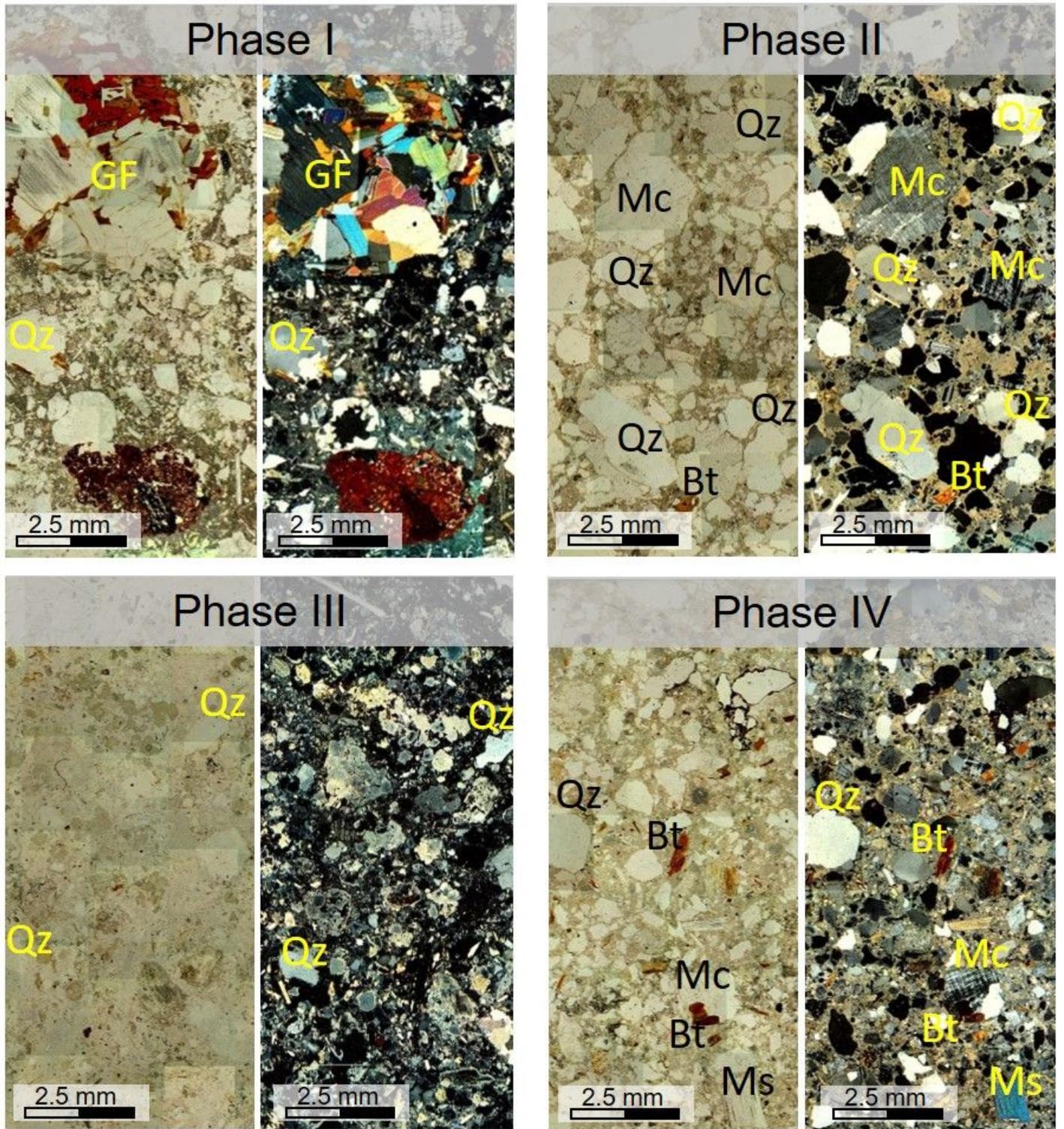


Figure 5

Parallel (left) and polarised (right) light petrographic micrographs of the four mortar types studied. Bt: Biotite, GF: Granite Fragment, Qz: Quartz; Mc: Microcline, Ms: Muscovite.

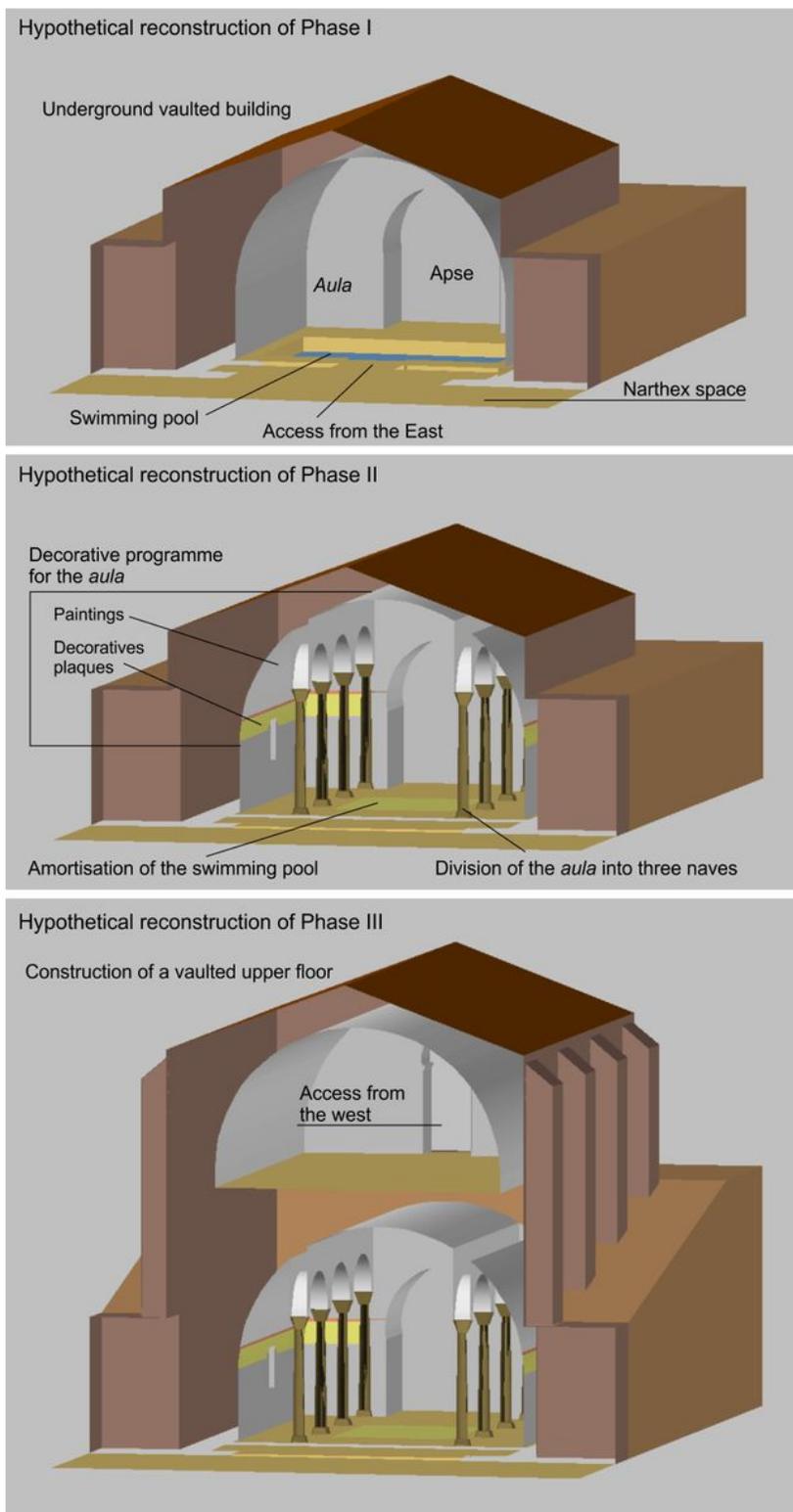
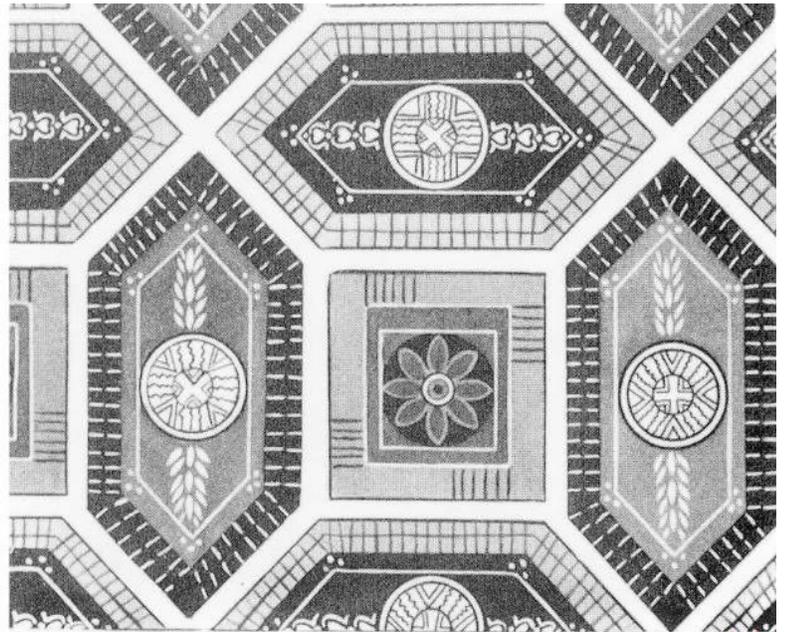


Figure 6

Hypothetical reconstruction of the first three phases of the Santalla de Bóveda Monument, based on the previous reading of walls (Benavides & Blanco-Rotea, 2008) and the results of absolute dating.



a)



b)



c)



d)

Figure 7

Examples of motifs used in pre-Romanesque Asturian paintings and comparison with the Santalla de Bóveda Monument, drawings by Magín Berenguer (Schlunk and Berenguer 1957): a) San Julián de los Prados Church (Oviedo, Spain), 8th-9th century; b) San Miguel de Liño Church (Oviedo, Spain), 10th century; c) San Salvador de Priesca Church (Villaviciosa, Spain), 10th century; d) Santalla de Bóveda Monument (lost central vault), 7th century.



Figure 8

Lozenges in mural paintings in different times and buildings: a) Villa di Arianna, Stabiae (Italy) (fragment in the MANN), 54-69 AD (Photography by Rosa Benavides); b) Tepidarium of Qusayr'Amra, Jordan, 712-715 AD (Almagro et al. 1975); c) Salle delle Oche in the Palace of Bonifacio VIII, Anagni (Italy), 4-1303 AD (www.palazzobonifacioviii.it, January 2022 consultation); d) Santalla de Bóveda, South wall, 7th century AD (Photography by Rosa Benavides).



Figure 9

Similar parallels in age built in mosaic. a) vault of the chapel of Sant'Andrea in the Archbishop Palace of Ravenna (Italy), 494-519 AD (<https://www.ravennamosaici.it/cappella-di-santandrea-e-museo-arcivescovile/>, January 2022 consultation). b) floor mosaic of Martyrs or Al Khadir Church (<https://eldiwan2010.blogspot.com/2018/07/jordania-madaba-la-ciudad-de-los.html>, January 2022 consultation). c) floor mosaic of Apostles Church (<https://universes.art/es/art-destinations/jordania/madaba/church-of-the-apostles>, January 2022 consultation). Both of them in Madaba (Jordan) 6th century.

Supplementary Files

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- [floatimage4.jpeg](#)