THE WOOD SUPPORTS OF THE PAINTINGS IN THE HALL OF KINGS: A TECHNICAL STUDY OF ITS CONSTRUCTION, STATE OF CONSERVATION AND TREATMENT

LOS SOPORTES DE MADERA DE LAS PINTURAS DE LA SALA DE LOS REYES: ESTUDIO TÉCNICO CONSTRUCTIVO, ESTADO DE CONSERVACIÓN Y TRATAMIENTO

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ABSTRAC Within the framework of the integral intervention of the area called the "Patio de los Leones" of the Alhambra in Granada, between 2007 and 2010, action was taken on the wooden supports of the paintings on leather that decorate the ceilings of the vaults of the "Sala de los Reyes". In this context, the complete elimination of the roofs incorporated by the nineteenth-century architect Rafael Contreras was a historical milestone from the point of view of the investigation of the monument, allowing access to the reverses of the vaults for study and intervention.

Our work focuses, in the first place, on the exhaustive description of these pictorial supports, providing new data as the information so far known about their constructive system has been significantly expanded for; secondly, to present in a summarized way the alterations and state of conservation prior to the intervention as well as the main treatments carried out on the vaults for their adequate preservation in the future.

KEYWORDS Sala de los Reyes, wooden support, conservation, treatment, research.

RESUMEN En el marco de la intervención integral de la zona denominada del "Patio de los Leones" de la Alhambra de Granada se actuó, entre los años 2007 a 2010, sobre los soportes de madera de las pinturas sobre cuero que decoran los techos de las bóvedas de la Sala de los Reyes. En dicho contexto, la completa eliminación de las cubiertas incorporadas por el arquitecto decimonónico Rafael Contreras supuso un hito histórico desde el punto de vista de la investigación del monumento, al permitir acceder a los reversos de las bóvedas para su estudio e intervención.

Nuestro trabajo se centra, en primer lugar, en la descripción exhaustiva de estos soportes pictóricos, aportando nuevos datos al haberse visto ampliada notablemente la información hasta el momento conocida sobre su sistema constructivo para; en segundo lugar, exponer de forma resumida las alteraciones y estado de conservación previo a la intervención así como los principales tratamientos llevados a cabo sobre las bóvedas para su adecuada preservación a futuro.

PALABRAS CLAVE Sala de los Reyes, soportes de madera, conservación, tratamiento, investigación.

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The research, conservation and restoration work carried out between 2007 and 2010 on the wood supports that are the subject of this paper form part of an integrated approach undertaken in the area known as the Courtyard of the Lions at the Alhambra in Granada and of the agreements reached between the Andalusian Institute of Historical Heritage (IAwPH) and the Alhambra and the Generalife Board of Trustees (PAG) for intervention on the paintings on leather that decorate the ceilings of the Hall of Kings (Sala de los Reyes)[1].

In this context, the removal of the 19th century roofs was a historic milestone in terms of research on the building, as it allowed detailed study of the reverse sides of the vaults prior to intervention and enabled access to information on the construction and pathology of the wood support. For this reason – and in view of the fact that future researchers are unlikely to be able to repeat, at least in the short term, this cognitive experience – the work we present here focuses firstly on the detailed description of these painting supports, and then sets out the methodology and intervention criteria applied in their treatment[2].

In order to establish suitable and precise georeferencing of all the elements included in the project, the IAPH and PAG delimited the project by creating specific nomenclature for the space in which the intervention took place, allocating a number to each vault (1, 2 and 3) and using their orientation in relation to the palace to designate the sides of the vaults, from south to north ("Lion" and/or "Partal" sides). As in the project phase, we will thus refer to the "Ladies Playing Chess" vault as Vault 1, to the central or "Hall of Kings" vault as Vault 2, and to the "Fountain of Youth" vault as Vault 3. The shells of each of the vaults were labelled A and B respectively, with A corresponding to the north orientation.

TECHNICAL-CONSTRUCTIONAL DESCRIPTION OF THE SUPPORTS

Prior to this research study, the works of Bermúdez Pareja (Granada 1908-1986) were the main point of reference for the study of these paintings. Based on his description and direct observation of the reverse sides of Vault 1[3], Rafael Contreras drew up a planimetric map of these elements, describing them as follows:

> "Vaulted wooden ceilings, arranged in an extraordinarily elastic way with white poplar planks ranging from 12 to 28cm wide and about 7cm thick. The differences in width as well as the short length of the planks results in a seemingly anarchic coupling which would very possibly reduce the rigidity of the frame [...]. The wood has no resin, is light in weight, and is hardly affected by temperature variations. [...] The boards of these vaulted ceilings are assembled with tin-plated iron nails, without heads, ending in points at both ends, so that each of the points penetrates the thickness of the immediate boards, locking them to each other by means of pressure [...] The boards are laid lengthwise, in short unequal pieces, parallel to the main axis, without being joined or fastened to the ribs, except for a single nail at the upper end of each rib [...] Each of the ceilings, assembled in this way, was placed on an incline of the walls of the small chambers to be covered, where the vaulted ceiling is attached and fitted, with freedom of movement, without any dowel or beam, and coated with plaster only."[4].

Describing the construction system, he stated that the ribs are also made of white poplar and that they serve to secure the structure *"in the manner of a ship's hull"*. He gives an exhaustive description of the double-pointed nails, based on the writings of Contreras, which links them with the "*baúles mundo*" (large trunks) of Moorish tradition. These nails have not been located, however – their existence thus being ruled out – either by

1 With regard to the Hall of Kings project, please see the following documents related to the subject under discussion:
IAPH: Diagnóstico previo y propuesta de estudios e intervención de las pinturas sobre cuero de las Salas de los Reyes, Alhambra. Granada: Mayo 2001; IAPH; Proyecto: Conservación de las pinturas de la sala de los Reyes, Alhambra. Granada: Actuación de urgencia: propuesta de trabajo, calendario, presupuesto y equipo técnico, 16 de octubre de 2001; IAPH; Proyecto: Conservación de las pinturas de la sala de los Reyes, Alhambra, Granada. Fase: definición de la actuación de urgencia. Estado de los estudios a 23 de mayo de 2002

2 We have omitted both questions relating to paintings on leather and other aspects that, although related, are analysed with greater precision by other authors throughout this monograph, to whose works we refer.

3 After reading the various reports kept by the Board of Trustees and comparing the photographs, plans and descriptions provided, we know that Bermúdez Pareja and the rest of his contemporaries studied the hall we now call Hall 1, as the formal description does not correspond to the rest of the halls. Moreover, it is precisely this hall that was open (or at least partially accessible) between 1976 and 1978, with work being carried out on its reverse side in the summer of 1980.

4 BERMÚDEZ PAREJA, Jesús; Pinturas sobre piel en la Alhambra de Granada. Granada: Patronato de la Alhambra y el Generalife, 1987, p. 49.

direct examination of the pieces or by X-rays[5]. The technical description of the supports ends with a reference to the modification made by the 19th-century architect Rafael Contreras to the whole ensemble. They were topped by a single roof that created a large joint ventilation chamber, and its replacement by a number of roofs caused a ventilation problem in the upper part of the paintings[6]. The work on the roofs, like much of the other work carried out on the building during the 19th and 20th centuries, was characterised by a search for the "original" style of the complex, a quest for the "Muslim impact" on the visitor. As a result, the intervention criterion was somewhat capricious. Bermúdez Pareja acknowledged this himself when the first issue of these *"Cuadernos de la Alhambra" (Alhambra Notebooks) was published*[7]. Describing the state of the paintings in the 19th century, Contreras commented that they *"were on the verge of falling away in pieces from the hides"*[8].

After the studies carried out, we can conclude that the wooden vaults in question were built *specifically* for this location within the building. The walls surrounding each of them, which do not form part of the masonry that rises from the foundations, enclose them into a four-sided box, each of them a separate entity, resting directly on supporting beams or "sleepers" (Ill. 1). As regards their typology, we could classify them as false vaults, in line with the classification of Enrique Nuere or Ángel Luís Candelas[9]. The spaces where the vaults are installed have the following dimensions[10]:

-Vault 1: 435cm (13 and 1/2 feet) x 215cm (6 and 1/2 ft) x 120cm (3 and 3/4 ft).

-Vault 2: 450cm (14 ft) x 223cm (7 short ft) x 120cm (3 and 3/4 ft).

-Vault 3: 450cm (14 ft) x 220cm (7 short ft) x 120cm (3 and 3/4 ft).

Il. 1: Vault 2. Photograph prior to the intervention. Benjamín Domínguez, Vault 2. Photograph prior to the intervention.

If we transpose these measurements into Arabic foot units, which are equivalent to 32 centimetres, we find that the total length in vaults 2 and 3 is 14 Arabic feet. In vault 1 it is 13 and 1/2 feet[11]. The dimensions of the original forged nails used for the construction of the vaults are consistent with subdivisions of the Arabic foot, with at least three sizes being found:

- 1/4 foot round-head nails.
- 1/3 foot round-head nails.
- 1/2 foot round-head nails.
- Round-head nails measuring less than 1/2 foot.

5 Neither have we found any bibliographical or documentary references that identify these types of pieces and their relationship with the vaults.

6 BERMÚDEZ PAREJA, Jesús; *Pinturas sobre piel en la Alhambra de Granada.* op. cit. (no. 4), p. 50.

7 BERMÚDEZ PAREJA, Jesús. *Crónica de la Alhambra*. In: *Cuadernos de la Alhambra,* 1980, n 1, p. 99.

8 BERMÚDEZ PAREJA, Jesús; *Pinturas sobre piel en la Alhambra de Granada.* op. cit. (no. 4), p. 47.

9 NUERE MATAUCO, Enrique; La carpintería de armar española y su restauración. Ejemplos de Intervenciones. In: *Procedimientos y Técnicas constructivas del Patrimonio. Colección de libros de texto del Máster de Restauración y Rehabilitación del Patrimonio,* Madrid: Universidad de Alcalá 1999, pp. 145-174 *and* CANDELAS GUTIERREZ, Ángel Luis; *Carpintería de lo blanco onubense.* Huelva: Diputación Provincial de Huelva, 2001.

10 The measurements in brackets correspond to the dimensions in "Arabic feet".

11 The terms "short foot" or "long foot" can be translated as a rounding below and above the 32cm of the Arabic foot unit of measurement, which is very common in roofing. Our modern view of exact centimetres is not comparable with the measurement systems of the late Middle Ages (Arabian feet and rods), which make frequent use of fractions.

On the basis of this measurement system, the construction of these supports could be attributed to Arab labour. On the other hand – as Bermúdez pointed out – the system used to build the vaults is similar to that used by naval carpenters in assembling ship hulls, which leads us to think of a possible collaboration involving such craftsmen. However, far from being a complex or highly technical construction, it is relatively simple and involves the use of nails to join the pieces, with the wooden joints being left open in many places or imperfectly joined. It should be remembered, however, that the vaults have been the subject of many interventions over the years, especially since Contreras' conducted his. As a result, it may be the case that there was some supporting or anchoring element that has not survived to this day.

Every piece of the vaults has been made from long sections of wood cut from the heartwood of trees. Based on the marks found, it has been determined that the "*débitage sur quartier*", or quarter-sawing technique, was used to cut up the trunk. Study of the construction marks also reveals the tools used to build the vaults, such as pit saws, adzes, and drawknives.

The ribs have been cut almost straight out of the wooden trunk. An adze was then used to add curvature to them. These long sections of wood range from 8 to 11.5cm wide and from 8 to 10cm thick. The long sections used are not perfectly square. They are very irregular and their profile is not the same along the length of the wood. After being fitted in place, the ribs were touched up in places and some small modifications made to them.

Each vault comprises around 30 jointed sections, which are held in place by forged nails riveted at the top. These jointed sections were formed by means of a somewhat primitive connection system if compared to the contemporary vaults in the Alhambra, which are made with highly complex interlacing systems. The fact that they were made to be covered and hidden from view could explain why aesthetics were not taken into account in their construction.

The perimeter base rib is composed of eight to ten pieces, measuring approximately 8 x 10cm square. These pieces are connected by a half lap joint reinforced with a forged nail. The width of the boards that make up the mid-point of the vault vary in line with the curvature of the ribs. Single boards are used in the central part of the vault and run from shell to shell. As a means of attachment all the way along the ribs, we again encounter nails connecting the ribs to the boards and fitted from the inside (i.e. from the side of the paintings) and connecting each of the boards together. Complete semicircular ribs are composed of two pieces assembled, with half lap joints, at the top of the arch. Each joint is reinforced with two nails, one on each side of the joint. Each of the ribs is fixed to the base/perimeter by a large forged nail of around 10cm in length. In some cases, the rib is made up of three pieces, which are also joined together with a scarf joint or half lap joint, reinforced with a nail. The ribs of the lateral shells are all single pieces, except for Ribs 2 and 3 of Vault 3, which are each composed of two pieces. The upper part of the ribs of the shells is cut to create a tip allowing all the pieces converging at the top of the arches to be joined together (Il. 2).

The boards in the central part of the vault are complete for the most part, although there are some signs of joins in boards that were not the requisite length. The boards were nailed separately to the ribs, one by one, until the entire surface was covered. Boards of around 15 centimetres cover the flatter parts of the arch, with smaller boards being used on the most curved sections. The open joints between the boards have been sealed with wood chips pressed into the gaps. The thicker boards have adze notches in the areas of contact with the ribs. These were made to level the inner surface, which was later covered with leather. The covering was completed with the boards of the vault shells. The carpenters were able to cover this curving surface by cutting the boards in the shape of a triangle and then curving the tip. The ends of the boards are fixed to the adjoining boards with a headed nail. The head is embedded in the wood, where an incision was made beforehand with a curved gouge.

Plant fibres mixed with animal glue or small pieces of wood were used to fill the joints between the boards. Both the fibres and the pieces of wood were inserted from the reverse side. To ensure the fibres soaked in animal glue were applied correctly, a tool was needed to press the mixture into the open

Il. 2: Vault 1. Photograph prior to the intervention. Detail of the construction system. Benjamín Domínguez, Vault 1. Photograph prior to the intervention. Detail of the construction system, 2007. GESTIONARTE S.L.U.

Il. 3: Vault 3. Detail of the two covering layers, resinous layer and plaster. Benjamín Domínguez, Vault 3. Detail of the two covering layers, resinous layer and plaster, 2008. GESTIONARTE S.L.U.

joint. It is very likely that a caulking chisel was used for this operation during the construction of the vault support, as a sharper tool may have damaged the boards.

In Vault 3, we noted that lines had been drawn on some of the boards, where they were joined. These lines would have been used in the cutting and adjusting of the boards. Semi-transparent and dark red in colour, these lines may have been made with liquid sanguine, a mixture of ferric oxide and water, applied with a brush[12]. We know of the existence of other inscriptions written in sanguine in the Alhambra, specifically on the back of one of the slats or *zafates* in the ceiling of the Hall of Comares. These inscriptions, written in Arabic, were discovered in 1959, during work carried out on the hall's ceiling.[13].

12 Substance not aznalysed, visual identification.

13 CABANELAS RODRIGUEZ, Darío; *El techo del Salón de Comares en la Alhambra. Decoración, Policromía, Simbolismo y Etimología.* Granada: Patronato de la Alhambra, 1988, pp. 9 and 111.

The application of the protective coating completed the final phase of construction and left the vault support ready for the application of the leather and the film of colour on the obverse side. The layer closest to the wood is a brownish layer of pine pitch[14] that protected the reverse side and made it waterproof (Il. 3). The coating on the boards in the frame was applied more generously and unevenly than on the ribs[15], where the coating is very thin. Accumulations and lumps have also been found at the intersection of the boards with the ribs, which indicates that the layer was applied after the vault had been fully assembled. This layer covered the entire surface. In Vault 1, this layer has almost entirely been lost, due to the surface of the vault having been cleaned.

The second of the protective layers is the "plaster layer", which only appears on the boards and not on the ribs. Its main function was to provide fire protection for the wooden support. Its thickness ranges from 1 to 2.5cm and decreases progressively as it approaches the ribs. It has a heterogeneous composition.

DESCRIPTION OF THE STATE OF CONSERVATION PRIOR TO THE INTERVENTION

Many of the conservation problems encountered in the vaults of the Hall of Kings in general, and the supports in particular, were due to the fact that their original state had been undermined. Additions had been made to the vaults in the various actions undertaken, encasing them, while the climate conditions had been substantially changed, which had a direct impact on the vaults[16]. However, the quality of the wood used has contributed to the vaults having remained in a generally good state of preservation for nearly 800 years.

Without underestimating the undocumented work carried out beforehand, the intervention of Rafael Contreras in the middle of the 19th century was a turning point in the material history of the ensemble. This is due, first of all, to the replacement of the roofs between 1855 and 1857 and, secondly, because, after being ordered to repair them by the Granada Monuments Commission in 1871, seven years later, Contreras

14 Composed of plant-based tar and resin. IAPH. *Pinturas de la Sala de los Reyes de la Alhambra, Granada. Proyecto de Intervención en los reversos de las Pinturas.* Seville: February 2008, p. 219.

15 It was probably applied with a palm brush.

16 SALMERÓN ESCOBAR, Pedro. *Proyecto de Ejecución. Restauración de las pinturas sobre piel de la Sala de los Reyes en el Palacio de los Leones de la Alhambra. Memoria.* Granada: July 2005.

said he had restored them[17]. However, the precarious state of the supports prior to the intervention, and more specifically of the sides adjoining the Courtyard of the Lions, was a consequence of the alterations made by Contreras. This action – which followed a criterion based on the aesthetic perception of the roofs of the Palace in the area of the Partal Gardens – resulted in the construction of a new roofing system for these halls and consisting of multiple roofs to replace the single continuous roof that had served that purpose until then. In addition, prior to this time, the supports would have suffered from exposure to the elements as a result of the abandonment of the building and the occasional intervention on the obverse side for the fitting of wall hangings and curtains during its use as a church and/or Christian palace[18].

It did not take long for the dire consequences of the intervention to become evident. As early as 1892, Gómez Moreno identified the new roof as the cause of the deplorable state of conservation of the paintings. Furthermore, the roof had not been properly installed, with repairs continually being carried out for leaks[19]. These alterations brought about changes in the humidity and temperature conditions in the vaults, triggering a series of negative effects on the artworks and, in particular, on the wood, which is highly sensitive to any changes in climate conditions. As a result, numerous gaps were detected where the pieces that make up the wood structure were joined to each other. These gaps were caused by shrinkage and swelling. Although we cannot attribute every deformation to Contreras' actions, we can state that they did cause an acceleration in the deformation and deterioration process. Furthermore, the new design of the roofs included a rainwater channelling system that involved placing a "gutter" between the vault and the side wall of the before the rooms in the direction of the Courtyard of the Lions, which triggered the problems caused by excess humidity, leaks, and the accumulation of waste, making this area subject to even more deterioration than the side corresponding to the Partal Gardens.

In discussing the conservation problems relating to the paintings, Bermúdez Pareja also refers, on the back of the paintings, to *"burn marks on the lower parts of the wooden ribs of the ceilings and on the edges of the ceilings due to the use of a lime mixture in the construction of the floor of the gallery of Doña Clara's house"*[20].

In the 1970s, in response to the lamentable state of conservation of the vaults, plans were made to dismantle them and replace them with replicas. In an atmosphere of concern and alarm, both at the Board of Trustees and the Ministry of Education and Science – there is much detailed correspondence on the matter –[21] the roof of Vault 1 was raised for study and intervention in June 1976. A commission for the project was set up at the permanent assembly on 11 November 1978. This idea, despite being maintained for several years and different studies and proposals being carried out – including an initial phase of consolidation during the summers between 1976 and 1978 – was rejected. Work was ultimately restricted to a phased restoration undertaken by the Madrid-based restorer Juan Santos Ramos[22]. Among the documentation referring to this work we have found references to work on the wood support, carried out during the 1980 campaign on Vault 1. A report dated 19th October 1980 describes the different types of cleaning work, the use of brass screws for fastening, the bending of ribs, the replacement of rotten slats, and the use of wood chips to fill gaps, etc. These were easily located in this last intervention.

As described above, the vaults rest on beams or sleepers that rise from the wall. These masonry supports were in a heterogeneous state of conservation, depending on the vaults or areas, with those corresponding to the side of the Courtyard of the Lions being particularly weakened. This deplorable state had led, in some cases, to the displacement of the vault and, in others, to the deformation of its load-bearing structure. These general deformations or deviations of the vaults were also caused by the accumulation and effect of a series of materials (plaster, bricks and other sedimentary materials) that had been exerting pressure on the wood structure. This situation prevented the correct ventilation of the wood support, which

17 BERMÚDEZ PAREJA, Jesús; MALDONADO RODRÍGUEZ, Manuel; Informe sobre técnicas, restauraciones y daños sufridos por los techos pintados de la Sala de los Reyes en el Palacio de los Leones de la Alhambra. In: *Cuadernos de la Alhambra,* 1980, no. 6, p. 11.

18 Ibid, p. 63.

19 Ibid.

20 Ibid, p. 64.

21 We understand that, although the documents of the Board of Trustees speak of "roofs removed" or "uncovered", judging by the photographs that appear in Bermúdez Pareja's book, a "window" or partial access was opened to allow the vaults to be studied from the reverse side. Furthermore, the vault is said to have been accessible for at least two years. As a result, it could not have been completely exposed to the elements during that time. It was opened for intervention at a later stage.

22 The work was carried out from 1976 to 1983 – at the earliest – in phases and in summer campaigns in the months of July and August, with the exception of 1979, when he suffered a "painful illness", according to the minutes of the meeting of 21 June 1980.

Il. 4: Vault 3. State of conservation prior to the intervention. Benjamín Domínguez, Vault 3. State of conservation prior to the intervention, 2007. GESTIONARTE S.L.U.

Il. 5: Vault 3. Detail of rot in the ribs. Lions area. Benjamín Domínguez, Vault 3. Detail of rot in the ribs. Lions area, 2007. GESTIONARTE S.L.U.

led to the growth of a fungal colony as a result of the ambient humidity in the rafters, leaks from the guttering in the roof, and the accumulation of all this hygroscopic material. On top of the vaults, a thick layer of dust and surface deposits (including rodent droppings) covered the entire ensemble (Il. 4).

The attack by wood-decay fungus was without doubt the most destructive alteration suffered by the three vaults. It was more extensive on the side of the reverse sides adjoining the Courtyard of the Lions, although the fungus also appeared in some parts of the wood on the Partal side and in the ribs. As a result of this decay, the wood suffered extensive damage, revealing a friable surface typical of "brown rot" (Il. 5).

The pieces that make up the wood structure to which the leather is fixed had numerous gaps at the joins between them, caused by shrinkage and swelling. Furthermore, some of the original wood chips and burlap used to fill the gaps had disappeared or had been removed in later interventions, resulting in numerous gaps between the boards. The original metal features presented – given their nature and composition – natural oxidation typical of ferrous materials, with the consequent weakening of their structures and lack of effectiveness in their action. In vaults 1 and 2 there were also a number of metal features from the 1980 intervention that appeared to be rusting.

With regard to the layer of plaster applied for protective purposes, virtually 95% of it had been removed in the first two vaults. In Vault 3, the remnants were fragmented and located in different parts of the surface. The entire surface of the resin coating was cracked, the micro-cracks of which were parallel to the wood grain. This layer is brittle and very fragile. In vaults 1 and 2, the layer of resin was not in a good state of preservation, with only 50% of it remaining on the surface. Furthermore, in Vault 1 the original colour appears to have changed. In the interventions conducted in the 1980s, a liquid product with a greasy solvent was used, traces of which remain on the surface. In Vault 3, however, 80% of the layer of resin has been preserved. The state of conservation of the protective layer of resin on the boards was relatively acceptable. On the ribs, however, the layer had lifted across almost the entire surface.

Il. 6: Vault 1. Reinforcements added in the 1980 intervention. Benjamín Domínguez, Vault 1. Reinforcements added in the 1980 intervention, 2007. GESTIONARTE S.L.U.

Vault 1 was the focus of conservation efforts at the end of the 20th century presumably because it was in the most dangerous condition. It has been subject to more intervention than the other vaults, at least in terms of the support. As we have said, it would also not be surprising if it had already lost many of its constituent elements by the time of the 1980 intervention. These alterations can be seen, for example, in the central axis of the semicircumference, the highest part of the vault, which had come away by 4cm and was deformed, with evident signs of warping in the panels. Furthermore, the load of the structure is not well distributed, as several of the original parts that made up the ribs and the base ring have disappeared (Il. 6). The most noteworthy alteration in Vault 2 was the high incidence of the wood decay and the reinforcements or "crutches" added in the intervention of the 1980s. Their installation involved making cuts in the healthy ribs and cutting out the rotten ribs, which resulted in a loss of original volume (Il. 7). Following on-site observations of the method and the nature of this intervention, we can only assume that there was an event that prevented the intervention in Vault 2 from being completed.

JUSTIFICATION, DELIMITATION AND METHODOLOGY OF THE INTERVENTION

These works were included in the overall restoration project, prior to the phase described above. A general diagnosis had already been carried out, the film covering the paintings had been protected, and the safety supports or "counterforms" had been manufactured and positioned on the obverse side of the vaults[23]. Subsequently, as an initial approach to the subject, the IAPH drafted and presented the "Informe diagnóstico y propuesta de intervención del reverso de la bóveda nº 3" (Diagnostic report and proposal for intervention on the reverse side

23 *See the following documents:*

-Diagnóstico previo y propuesta de estudios e intervención de las pinturas sobre cuero de las Salas de los Reyes, Alhambra. Granada: IAPH Mayo 2001.

-Proyecto: Conservación de las pinturas de la sala de los Reyes, Alhambra. Granada: Actuación de urgencia: propuesta de trabajo, calendario, presupuesto y equipo técnico. IAPH 16 October 2001.

-Proyecto: Conservación de las pinturas de la sala de los Reyes, Alhambra, Granada. Fase: definición de la actuación de urgencia. Estado de los estudios a 23 de mayo de 2002. IAPH

Il. 7: Vault 2. Reinforcements or "crutches" added as part of the actions undertaken in the 1980s. Benjamín Domínguez, Vault 2. Reinforcements or "crutches" added as part of the actions undertaken in the 1980s, 2007. GESTIONARTE S.L.U.

Il. 8: Vault 3. Conservation-restoration treatment. Difficulty in accessing some areas significantly hampered the application of some treatments. Benjamín Domínguez, Vault 3. Conservation-restoration treatment. Difficulty in accessing some areas significantly hampered the application of some treatments, 2007. GESTIONARTE S.L.U.

of Vault 3) in November 2007, after which it continued with the study of the three vaults as a whole, giving rise to the intervention project presented in February 2008, which set out the methodological and technical guidelines for the entire intervention referred to in these pages[24].

In this respect, the project envisaged a conservative intervention with the main objective of acting on present alterations and restoring the integrity of the vaults as a whole, thereby enabling them to continue performing their function as supports. The main criteria for intervention were that interventions on the wood support were reduced to the strict minimum. However, the missing parts that would otherwise have continued to fulfil a supporting function were restored under the criteria of architectural restoration[25]. Secondly, and though many options were considered, it was decided not to correct, move or lift any of the three vaults due to the risk involved and out of an acceptance of the principle of minimum intervention.

Two types of treatment were considered for areas that had suffered the effects of wood-decay fungi: removal of the affected areas and subsequent restoration with new replacement timber; and consolidation of the affected areas with epoxy resins. After assessing the advantages and disadvantages of both methods – and though we were mindful that both were irreversible and would alter the original support – the commission chose the second method, as it meant that the original parts of the support could be maintained. Nevertheless, in some places – again for technical reasons, as mentioned above – it was necessary to remove some of the affected areas and to replace pieces. Finally, no protective coating was applied to the wood so as not to disturb or "contaminate" the original protective resin.

As regards the "in situ" action, it is worth highlighting the physical difficulties involved in carrying out the intervention, as space limitations also restricted the application of some treatments (Il. 8). In fact, treatments such as anoxia were rejected because of the impossibility of carrying them out. Similarly, direct contact with the building's fabric did not, a priori, allow access to the surface of the vaults' in its entirety, an issue that was partially resolved during the course of the intervention by working in parallel with civil engineers. Furthermore, the few centimetres that separate the vaults from the plasterwork posed a major obstacle when it came to addressing technical solutions for supporting and anchoring the vaults on the "sleepers". Once a consensus decision had been reached by the technicians and the committee in charge of the project, the team of conservators and restorers had to adapt to this reality in some cases and, in those areas where it was technically impossible to carry out the work in any other way, the staff of the PAG proceeded to remove the necessary pieces of plaster so that the surfaces where the work was to be carried out could be reached.

24 IAPH. Proyecto: Intervención de los reversos de las pinturas de la Sala de los Reyes de la Alhambra, Granada. Seville: IAPH. February 2008.

25 It should not be forgotten that the wooden reverse sides are roofing systems that have to remain in place several metres above the ground and pose no risk of collapse.

TREATMENT

Planning of the project and auxiliary resources

The operational or intervention phase began in May 2008 and ran until June 2009. It was divided into several periods or phases[26]. To carry out the conservation-restoration work, a team of five conservator-restorers with degrees in Fine Arts and specialising in conservation-restoration was formed. A senior woodworking technician was also appointed to provide carpentry services. Clearance work was carried out by the main contractor, under the supervision of the restoration team.

Prior to the intervention on the supports, an access and scaffolding system was put in place for the entire area of the Hall of Kings, which was used throughout the process. It enabled access from both the top (roofs) and the bottom (paintings), once the safety "counterform" had been removed. As a functional solution, the intermediate upper areas of the vaults were used to create workspaces, a workshop, and storage and management spaces.

Although several procedures were considered for the temporary covering of the vaults during the project, a "cover" or covering was created for vaults 2 and 3 to prevent dust from accumulating and to protect them from the elements[27]. A fabric covering was made from[28] a template. This allowed it to fit the vault and cover it completely. During the winter months and to prevent low temperatures from having an impact, another protective surface made from thermal insulating material used in the construction industry was added to the system.

To enable better identification of the results obtained and their visualisation, at the beginning of the project an exhaustive architectural plan was created. Making use of the notes made on site by the project team, the plan provided appropriate information in a comprehensive and effective way.

Removal of debris, elimination of dust, and cleaning processes

The cleaning of the surface and surrounding areas of the three vaults was conducted selectively. In carrying out the work, the architectural project team used their own tools and implements under the supervision of the head conservator-restorer and with the assistance of the restorers in the project team. The debris was sifted prior to disposal with the aim of retrieving elements from the vault for further analysis or storage. Following the removal of larger pieces of debris, the surface was thoroughly vacuum cleaned to remove dust and encrusted dirt, with the aid of brushes of various sizes. The vacuum cleaning was relatively low in intensity so as not to remove the layer of resin or damage any original tool marks or traces of later interventions on the reverse side of the vault.

Preliminary tests for selecting the solvents to be used in surface cleaning were carried out and took into account the presence of a layer of resin on a large percentage of the extrados of the vaults[29]. This layer of resin, which, according to the analyses conducted at the IAPH, is a compound containing pine resin, is soluble in alcohols and ketones. The surface of wood used to build the vaults was cleaned with solvents to remove the dirt and dust encrusted in it. These extraneous deposits were removed mechanically with the aid of absorbent paper towels, cotton swabs, and cotton wool (Il. 9). The surface was treated using the same methodology as used for cleaning a polychrome surface, with the layer of resin being cleaned at the same time as the bare wood. The two solvents used were ethanol and isooctane, a few drops of which were added to water. Deionised water was used to remove surface dirt in areas that did not appear to have been attacked by micro-organisms. The surface of these areas was dampened with the aid of absorbent paper towels, cotton swabs, and cotton pads. Similarly, the areas that had suffered wood decay were cleaned with isooctane, using a similar application methodology.

Binding of the resin coating

Where the resin layer on the surface of the vaults had peeled it was fixed back in place using a fixative based on Mowiliith DMC 2 diluted 1:2 with deionised water. The fixative was applied with the tip of a brush and gentle pressure exerted on the area with an absorbent paper pad, thereby removing the excess fixative at the same time.

Treatment of metal features

Metal features were cleaned mechanically with a small, hard-bristled brush, on the surface area of the element not

26 These phases came about because of various masonry incidents during the execution of the work and by stoppages brought about by decisions made in response to unforeseen issues and events arising on site. We can thus divide the work into four phases or periods between the following dates: First phase: 5 May 2008 - 1 August 2008; Second phase: 20 October 2008 - 24 October 2008; Third phase: 17 November 2008 - 22 December 2008; Fourth phase: 14 April 2009 - 10 June 2009.

27 Given that reinforcement beams had been installed in Vault 1 in 1980 and remained in place, it could not be covered with this system.

28 Boat sail fabric was used for the covering as it is light, clean and easy to make.

29 Preliminary surface cleaning tests on the reverse side of the vaults can be found in the document: Pinturas de la Sala de los Reyes. Alhambra, Granada. Fase: Intervención en los reversos. Protocolos de aplicación de los productos de tratamiento. Seville June 2008. Pp. 18,19 and 20.

embedded in the wood. Forged iron nails without any surface treatment that were cleaned in this way were later treated with benzotriazole.[30]. Finally, the metal elements were protected with an acrylic resin, Paraloid B72, which was diluted in a nitrocellulose solution and applied directly to the nails.

Consolidation of the areas attacked by wood decay

At the request of the external technical adviser, Jean Albert Glatigny, the wood support attacked by wood-decay fungi was consolidated using an epoxy resin based on Araldite AY103 and HY926 (base resin and catalyst) despite its irreversible nature. It should also be noted that this operation was particularly difficult, given the characteristics of the work site: limited space, verticality, difficulty in finding a position in which to work in, etc.[31] (Il. 10).

The filling of cracks and fissures

A distinction must be made between the openings corresponding to the joints between the boards that make up the vaults and the gaps created as a result of the material nature of the pieces (wood). With regard to the former, the spaces to be treated were practically all the joints in the three vaults. This is particularly noteworthy in the highest part of Vault 1, where there are gaps of a considerable size.

Taking into account the general intervention criteria of this project, which are focused on strict conservation and intervention on elements with structural problems, some of the cracks and fissures in the ribs and boards were sealed in order to eliminate any space where insects can breed and dirt can accumulate. The filler used was made of resinous wood dust sifted at 0.5 microns and bound with Mowilith DMC 2 diluted 1:2 with deionised water.

Once suction cleaning had been performed in each of the joints and openings, they were measured, assessed and checked against the damage mapping undertaken during the project study phase. In general, in all openings larger than 1mm, a chip of red cedar wood[32]was inserted in the same direction as the wood grain so that it would interact with it, according to the changes in temperature and humidity. The inlays were glued with a water-based polyvinyl acetate (PVA) emulsion on one side of the joint only (so as not to prevent the wood from shrinking) and at the top of the board to limit the amount of dust falling from the board should it contract. Prior to this, each of the pieces was adjusted and cut – depending on each case – mechanically so that they could be inserted as neatly as possible. Any unevenness in the fissures was reproduced in the inserted pieces[33]. As expressly indicated in the project, the inlays do not pass through to the side bearing the paintings. On the reverse side, the parts exceed the dimensions of the boards by (+/-) 5 mm in order to retain dust (Il. 11).

Il. 9: Vault 3. Conservation-restoration treatment. Cleaning process. Benjamín Domínguez, Vault 3. Conservation-restoration treatment. Cleaning process, 2007. GESTIONARTE S.L.U.

30 This rust inhibitor was recommended by the IAPH's Department of Preventive Conservation. A product used in the institute's intervention workshops, it has been tested extensively in the last few years.

31 This is something that Glatigny warned about in his technical report, dated October 2007, where he stated that *"the consolidation of wood by gravitation with a liquid epoxy resin is a complex and delicate technique"*. GLATIGNY, Jean Albert. *Rapport de visite. Étude des trois voûtes en bois, revêtues de cuir peintes (vers 1380). Salle des Rois, Palais de la Cour des Lions, Alhambra, Grenade, Spain.* Brussels: October 2007, p. 6.

32 Recommended in his report by Jean Albert Glatigny.

33 For example, there are a large number of chips that have grooves to enable their insertion without removing the forged nails that hold the boards together.

Il. 10: Vault 2. Conservation-restoration treatment. Consolidation of wood affected by rot. Benjamín Domínguez, Vault 2. Conservation-restoration treatment. Consolidation of wood affected by rot, 2007. GESTIONARTE S.L.U.

Il. 11: Vault 1. Conservation-restoration treatment. Filling of the openings between the boards with pieces of cedar. Benjamín Domínguez, Vault 1. Conservation-restoration treatment. Filling of the openings between the boards with pieces of cedar, 2007. GESTIONARTE S.L.U.

Positioning of safety hangers and fastenings

Among the intervention needs set out in the civil works project was the need to secure the vaults once the cleaning and consolidation work had been completed, in order to proceed with the task of consolidating the supports or sleepers in the vaults. This new solution – which was adopted instead of the positioning of counterforms at the bottom – was motivated by the need to access the lower part of the vaults, which was impossible with the system described above. To this end, hanging support systems were installed in the vaults to allow work to be carried out. This allowed for supports to be suspended without any risk of them falling during their removal. This also ensured that they would not move or become misaligned during the process. The system thus involved placing a series of through bolts in the ribs, all the way around the perimeter of the vault. These were held in place by tensioners hanging from a structure attached to the scaffolding in the work area. As the possibility of correcting the displacement of the vaults was initially considered, these tensioners had a height-adjustable thread system used, if necessary, to suspend or lift the vault – even by only a millimetre. This also allowed, if possible, displacement towards the wall of the Lions to be corrected[34].

Replacement and reinforcement of the structural support (ribs and base ring)

As described in the constructive analysis of the vaults, the pieces known as "ribs" perform the function of supporting the whole ensemble. This task mainly falls on the rib that runs along the entire lower support area – which we will call the "base rib" – from where run the rest of the ribs, which are linked together to hold the supports. This is why the project indicated that the areas of the "ribs" that had been lost – either due to previous interventions, wood decay or other agents – had to be reconstructed, albeit limited to cases where this was needed to achieve overall structural stability. The optimal preservation of these elements was a priority of this process, as it would allow them to continue performing this constructive fastening function following the intervention[35].

Once the intervention began, we could see how the areas not visible during the drafting of the project had suffered significant deterioration – as much as or more than expected. As a result, if this premise were true, the base ring in the area of the Lions wall should, at least, be the piece in the worst condition in each vault. This was confirmed in vaults 1 and 2, where the piece corresponding to Lions was all but lost. Fortunately, the same was not true in Vault 3, with only half of its length on that side being in danger. Similarly, as work progressed, we were able to see how some areas that were apparently in

34 Once the intervention had been completed, it was decided to keep the tensioners in place so that these pieces would remain braced to the roof, solely for prevention and control purposes. In Vault 1, this suspension system was temporarily placed over the reinforcement beams from the 1980 intervention, and was complemented with additional horizontal elements. Once these beams were removed, the tensioners were fixed – as in the rest of the vaults – to the scaffolding so that they could be permanently braced to the vaults when the roof was completed.

35 Civil engineering managers insisted that aesthetic considerations had to be of secondary importance in an action that, even if carried out by conservators-restorers, fulfilled a construction purpose in covering the top of the building.

a healthy state were not able to support jointed sections that were not merely "conservative" or "aesthetic" in nature. In response, sufficiently large boxes had to be made to secure the union or replace certain elements and ensure a correct fitting.

In addition to the areas "in precarious condition" due to their evident deterioration, there were others that were not self-supporting and which had been subject to previous intervention, such as Vault 1 as a whole or Vault 2, which was unique to the others in that it was supported by a series of "crutches", as described above.

Consequently, and with the same criteria as for the base ribs, the ribs in the upper area were analysed, manufactured and replaced. We already had a precedent in this area, namely the 1980 intervention, and which has been maintained in those pieces that did not need to be removed for other reasons[36]. The reinforcements essentially consisted of making one or two pieces (depending on whether the requirement was to reinforce on one side only or to perform a "sandwich" type function) in wood and with the same curvature as the original rib. They were then put in place and joined to it by means of through dowels. Although the project envisaged the fitting of stainless steel bolts, it was felt during the process that it would be better to use wooden dowels as they would interact better with the other materials. However, in the "double ribs" from the 1980 intervention, the rusted iron bolts were replaced with stainless steel bolts with a thread diameter of 8mm and of the corresponding length. These were fitted with the corresponding washers. In some places, these rib reinforcements had a dual function: apart from reinforcing the upper area, they acted as a link with the base rib, as the original rib had rotted and disintegrated and could not be refitted. This function was mainly used in Vault 1, with the same criteria being applied in Vault 2, this time not only using pieces fitted as part of this intervention, but also existing reinforcements from previous interventions. Prior to assembling these pieces, it was essential to consolidate and restore the original wood in order to enable the correct adhesion and positioning of the reinforcements. Along with the positioning of the upper reinforcements, the pieces were replaced and the structure of the base ring consolidated, with all areas and supports being checked exhaustively to ensure they were safe (Ill. 12 and 13).

36 The reinforcements in the base ring were replaced for the reasons explained in the text, though not the upper rib reinforcements, which performed their intended function correctly.

The replacement of the base ring and the "sandwiches" or replacements that were fitted and which have been described above, were made and fitted in line with a project that stated they should be made from Scots pine (*Pinus Sylvestris*), assembled in the same direction as the "wood grain" to enable interaction with it, according to changes in temperature and humidity. All newly manufactured parts were protected with a permethrin-based impregnation to protect them from biological attack and a Paraloid B-72 impregnation for the same purpose. The volumetric replacement pieces were fixed to the original support or to each other using a deionised water-based PVA emulsion. In many cases, due to the unevenness of the wood surface, Araldite SV 427/ HV 427 was used as an adhesive, which in turn allowed for the consolidation of the surrounding spaces. In addition to the adhesive, each of the pieces was tenoned to the original vault with wooden rods measuring 8mm to 14mm in diameter. This ensured they were mechanically fastened to them and provided a network of joints between all the pieces. The lower ends of the ribs and reinforcements in Vault 2 had to be partly cut so that they could fit the assembly boxes envisaged in the project. The pieces, once in place, were left in their original colour so that they could be identified from original parts in the future.

Although the intention was for all the technical solutions to be homogeneous, an exception had to be made in Vault 1 with regard to the fitting of one of the ribs to the base ring. This rib was the one providing the transition between the Lions side and cupola B. The impossibility of accessing this point and placing clamps, screws or other elements that would allow correct assembly and the setting of adhesives in positioning the reinforcements meant that a different solution was required. The chosen solution involved joining the two pieces of wood by means of a stainless steel bracket using screws of the same characteristics. This material and system were used not only because they work but because they were used in other areas of the overall vault intervention. They were accepted by the technical committee as they met the needs of this intervention perfectly. Threaded bolts were also placed in the base rib of the Lions area to allow for a secondary or optional hanging system to be installed in the future.

Removal of obsolete supporting elements

Although the intervention project initially provided for the conservation of the elements incorporated in the intervention of summer 1980, the project managers deemed that the vaults should have their function as covering elements restored. As

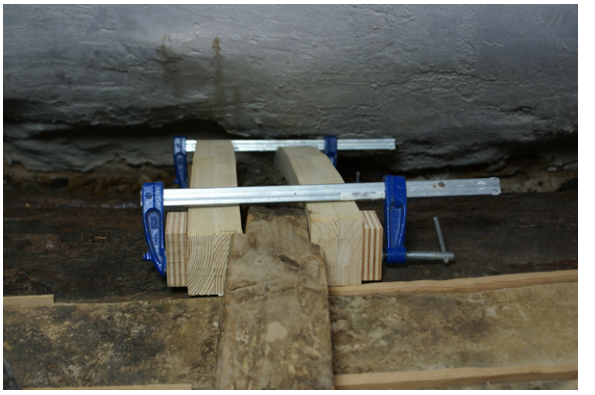
such, they would be supported by the same system on which they were built, i.e. on the sleeper beams built into the walls. It was for this reason that the restoration team was informed that the various bolts, braces and tensioners, etc added in previous interventions should be removed. This was because they would they be unable to fulfil their supporting function once the work was complete and because they would also prevent the vaults from being supported properly. As a result, the cross beams in Vault 1 were removed and, in Vault 2, the stakes or supports surrounding it were removed, after the lower section had been reinforced. The spaces resulting from the removal of these elements were refitted with the same replacement wood as the rest of the vault. Replacement was necessary in this particular case for mechanical reasons, namely thrust forces. Once all the supports were removed and the vaults were sitting on the "rib-base", the civil engineers proceeded to install additional supports made of stainless steel to ensure, if possible, that the vault supports functioned correctly. The holes created by the fitting of threaded bolts were not sealed, the reason being to protect the material history of the building and to leave a record of the intervention.

Metal reinforcement brackets

Sensory analysis of the work revealed that several of the boards nailed to the ribs in each of the three vaults had come away from them completely or in part. At the suggestion of Jean Albert Glatigny, it was decided to reattach the weakened boards to the ribs by means of an elastic fastening system, which would restore the original consistency of the overall structure of the vault and would allow the wood to shrink and contract. Once the proposal was approved, the stainless steel fastenings, which are 2mm thick, were designed and made. The brackets were attached using six stainless steel self-tapping screws, three of which fasten the bracket to the board, with the remaining three securing the bracket to the rib.

Removal, treatment and replacement of mortar slabs

Some groups of fragments of the original mortar slabs on the vaults were removed by hand, followed by an initial arrangement on semi-rigid supports reproducing the original curvature of the vaults. In other cases, these fragments were replaced without being removed from the surface of the vault, as to do so would have meant losing reference points for their location. Due to the very porous surface of the mortar slabs, other removal techniques using the *stacco* method with adhesives were not considered. Furthermore, the amount of dirt and



Il. 12: Vault 2. Conservation-restoration treatment. Positioning of reinforcements. Benjamín Domínguez, Vault 2. Conservation-restoration treatment. Positioning of reinforcements, 2008. GESTIONARTE S.L.U.

Il. 13: Vault 1. Conservation-restoration treatment. Reconstruction of the "base rib". Benjamín Domínguez, Vault 1. Conservation-restoration treatment. Reconstruction of the "base rib", 2008. GESTIONARTE S.L.U.

soil in the micro-cracks and crevices in the slabs made them difficult to move. The fragments were then joined together, reproducing the original, slightly curved shape on the vaults. The adhesive of choice was again Mowilith DMC 2 diluted 1:2 with deionised water and thickened with Carbopol. This adhesive was applied by dotting the surface of the joints[37]. The grouting and filling of the gaps in the mortar slabs was vital to the optimal preservation of the pieces that would remain in the vaults. At the request of the project managers, an action protocol was established, with Ana Bouzas Abad, a conservator-restorer from the IAPH's archaeological material workshop[38], advising. As a preventive measure to stop the central mortar slab in Vault 3 from moving, a detachable additional support bracket was fitted on the downward curve of the plaster section. Made of MDF wood, this bracket has a detachable mechanical fitting system.

Conclusions

The work undertaken has resolved the conservation needs of the reverse sides, without separating them from either their obverse sides or their architectural environment, as they form a complex work as a whole, both from a technical, material and conservation point of view.

At the same time, applied research work has filled in many of the gaps in our knowledge about these wood supports, helping us to rule out some of the hypotheses put forward by Rafael Contreras and upheld by Bermúdez, and providing unpublished information on the materials and techniques used to make them.

37 This mixture was tested beforehand to assess the adhesive power and strength of the mortar (a high-porosity material) against this dot adhesive system. The results of these tests appear in the document: *Pinturas de la Sala de los Reyes. Alhambra, Granada. Fase: Intervención en los reversos. Protocolos de aplicación de los productos de tratamiento, págs. 7-11.*

38 *Remontaje in situ fragmentos de mortero bóvedas de "Sala de los Reyes". Protocolo de ejecución. Seville, 17 October 2008.*