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Narrating codex history: the case study of a psalter-hymnal from Alcobaça Monastery, Portugal

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ABSTRACT

This article provides the first in-depth study of historic content and materials used in the production of a liturgical codex from the collection of manuscripts of the Monastery of Alcobaça: the Psalter-hymnal (Lisbon, National Library, Alc. 11). To answer provenance questions and trace the manuscript's history, a multidisciplinary team studied the entire procedure of making the codex, which went from in-depth textual, liturgical, and codicological analyses, to examining material composition and bookbinding methods with complementary analytical techniques. The team was able to track the manuscript's historical trajectory through successive additions and interventions/alterations. Interpretation of the historic information and the resulting technical data confirmed the belief that this is a twelfth-century manuscript produced in the scriptorium of Alcobaça and underlined the role that the manuscript played in this Cistercian monastery during the Middle Ages, and possibly throughout the following centuries. This led the team to approach the codex's "cultural significance" and perceive later alterations and interventions as evidence of the monks' intensive use of this manuscript and the great care they took to preserve their monastic library. The new data and knowledge acquired about this precious codex proved to be fundamental for future digital access policy definition and the conservation making decision.


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Introduction¹

In this article we present the first results of a research project carried out by a multidisciplinary team to study a liturgical codex from the collection of manuscripts of the Monastery of Alcobaça, currently kept in the National Library of Portugal: the Psalter-hymnal Alc. 11 (Figure 1).²

The Monastery of Alcobaça, affiliated with Clairvaux Abbey³ and founded around 1153, had a prolific scriptorium production between the twelfth and the sixteenth centuries. The Alcobaça scriptorium is a singular case in Portugal and Europe due to its high number of surviving manuscripts⁴ (around 467 codices),⁵ with original material features and with a significant number of liturgical codices, which can be dated more rigorously than other codices. It is believed that most of these surviving manuscripts from the Alcobaça library were produced in the monastery's scriptorium, but it has already been proven that some came from other Cistercian monasteries or were acquired by Alcobaça's monks from the university.⁶

In recent years, manuscript studies have gained momentum, namely through the interdisciplinary work of Hamburg University's well-known Centre for the Study of Manuscript Cultures. However, studies of the rich corpus of manuscripts of Alcobaça have mostly focused on textual and iconographic interpretation,⁷ and more recently on the analysis of pigments.⁸ A full material analysis of the codices, including their bookbinding, is yet to be undertaken. A study of Alcobaça bookbinding was done in the 1990s⁹ and more recently a few other works have mentioned the bindings,¹⁰ but a comprehensive material analysis of the whole collection still needs to be carried out. The following full study of Alc. 11 responds to this purpose, developed under the framework of the research project Cistercian Horizons.¹¹

The Psalter, deemed “the oldest liturgical book,”¹² was a central book in the founding of a new Cistercian monastery.¹³ Psalters were used to celebrate day-to-day liturgical offices and also to teach novices. The monks were required to memorize all 150 Psalms, not only because this knowledge was fundamental for the teaching of reading and writing, but also because in the monastic *cursus* the Psalms were recited throughout

¹Acknowledgments are due to the Portuguese national funding agency, Foundation for Science and Technology (FCT/MCTES), the Associate Laboratory for Green Chemistry - LAQV, the Forest Research Centre (CEF), the HERCULES Laboratory, the Department of Conservation and Restoration of NOVA School of Science and Technology (FCT-NOVA) and the Portuguese National Library (BNP), namely to the *Reservados* Area team and the Conservation-Restoration Lab team.

²The digitized manuscript is available at <http://purl.pt/24657/1/index.html#/1/html> (accessed 5 August 2020).

³Barreira et al., “Through the Eyes of Science and Art;” Gomes, “Revisitação a um velho tema.”

⁴Barreira et al., “Through the Eyes of Science and Art;” Jamrozik, *The Cistercian Order*, 210–11; Nascimento, “Le scriptorium d’Alcobaça.”

⁵Nascimento, *O Scriptorium de Alcobaça*, 283–84; Nascimento, “Em busca dos códices alcobacenses;” Barreira, “Abordagem histórico-artística,” 33–4.

⁶Barreira, “Manuscritos universitários,” 99–128; Pereira, “A pecia em manuscritos universitários,” 245–67, who refers to books made by the “pecia” system concerning studies of theology at the University of Paris.

⁷Miranda, “Iluminura românica,” 149–62.

⁸Melo and Miranda, “Secrets et découvertes;” Miguel, “Le vert et le rouge,” 31–75; Oliveira, “The Book of Birds,” 180–84.

⁹Nascimento and Diogo, *Encadernação portuguesa medieval*, 1–104.

¹⁰Barreira et al., “Through the Eyes of Science and Art;” Miguélez Caveró et al., “Beatus Manuscripts;” Castro et al., “The Romanesque Collection of Santa Cruz.”

¹¹*Cistercian Horizons: Studying and Characterizing a Medieval Scriptorium and Its Production. Alcobaça, Local Identities and Liturgical Uniformity in Dialogue* (PTDC/ART-HIS/29522/2017), <http://cistercianhorizons.fcsh.unl.pt>.

¹²Palazzo, *A History of Liturgical Books*, 129.

¹³Waddell, *Twelfth-Century Statutes*, 512.



Figure 1. BNP, codex Alc. 11: a) Front page with illuminated capital; b) Bookbinding, back wood board. Source: authors.

the seven days of the week. Therefore, Alc. 11 also played an important role at Alcobaça, and it could either have been sent by the motherhouse of Clairvaux or produced early on at the Alcobaça scriptorium. Answering this research question was one of the main aims of our study. This Psalter-hymnal, whose liturgical content was previously studied by Catarina Barreira,¹⁴ is a composite item, not only because of its liturgical content (which besides the Psalms contains hymns), but also because it combines numerous materials, such as different types of animal skin, wood, threads, pigments, and inks. It has a complex format and structure, and it also shows later additions and interventions. One of its most striking features is the amount of repair work done in the textblock to recover missing texts and lost areas, revealing the monks' preservation praxis. Also, the binding reveals a medieval intervention (i.e., sewn structure, lacing-in path, and wood boards of a later medieval period, all contemporary), plus a leather cover repair of the nineteenth or twentieth century. Thus, several relevant questions can be raised: can it be considered one of the first codices produced in Alcobaça's scriptorium? Might it have come from the motherhouse of Clairvaux? Is the material evidence in accordance with liturgical content and historic findings? What is the importance of the additions and alterations in terms of the "cultural significance"¹⁵ of this codex? And finally, how can we reconcile conservation and access requirements with the need to fully safeguard the integrity and identity of this codex?

To answer these questions the interdisciplinary team adopted a multi-analytical approach and used a series of combined methods, from human to natural sciences. The research approach focused on 1), liturgical text content and codicological study; and 2), characterization of the different materials of the codex and its repairs by a multi-analytic approach using optical microscopy (OM), fiber-optic reflectance spectroscopy in the ultraviolet and visible range (UV-Vis FORS), handheld energy-dispersive

¹⁴Barreira, "Abordagem histórico-artística," 33–62.

¹⁵The Australian ICOMOS Charter for Places of Cultural Significance, *Burra Charter*, 2013, http://portal.iphan.gov.br/uploads/ckfinder/arquivos/The-Burra-Charter-2013-Adopted-31_10_2013.pdf.

X-ray fluorescence (h-EDXRF), Raman microscopy, and scanning electron microscopy (SEM). Liturgical and material analyses corroborate the findings: the codex dates to around 1175–1190, and it was one of the early books produced at Alcobaça. In fact, the results allow the research team to argue that this book is one of the very first codices to be produced in the Alcobaça scriptorium. Furthermore, the later additions and interventions reveal its considerable use and the community's process of care, and therefore these additions must be preserved as evidence of the manuscript's unique trajectory and complete "biography."¹⁶

Research methodology and experimental techniques

Codex content and form

To study the content and form of the Psalter-hymnal, two main approaches were used: liturgical research and codicological investigation. The first approach allows for precise dating by comparing the data and elements analyzed with records of historic sources such as the surviving annual General Chapter of the Cistercian Order, which closely records the evolution of the feasts commemorated.¹⁷ The second approach considers the book as "an archaeological object that carries information about the environment that produced it."¹⁸ In fact, liturgical manuscripts are an extraordinary source for history, since they work as repositories of memory for the communities that produced, read, annotated, and preserve them, as we attest in the case of Alc. 11.¹⁹

Codicological characterization also involves defining qualitatively the structural and material features of a codex, as well as the technical skills involved in its making and its changes over time. Text characterization was attempted mainly through the description of the text's organizational elements (i.e., composition), iconography, and decoration of capitals. The principal features of bookbinding, from the composition of gatherings to covering materials, were examined. All these elements were systematically registered in a digital tool (Microsoft Excel file) developed for data comparison, under the project Cistercian Horizons;²⁰ and the comparative exercise regarding binding methods and book construction was supported by reference bibliography.²¹

Materials' characterization

Within the framework of Cistercian Horizons, non-invasive techniques such as h-EDXRF, UV-Vis FORS, and Raman microscopy were applied to codex Alc. 11 for the characterization of pigments and ink formulations found in the textblock. Different

¹⁶Gosden and Marshall, "The Cultural Biography of Objects," 169–70; Casanova et al., "Tracing the Historic Meaning," 1–14.

¹⁷Legendre, "Some Tools for Dating and Localizing Manuscripts;" Barreira, "Approaches to the Study of a Fourteenth-Century Breviary," 253–62; Barreira, "Abordagem histórico-artística."

¹⁸Muzerelle, "Dating Manuscripts," 167.

¹⁹Barreira, "Approaches to the Study of a Fourteenth-Century Breviary;" Barreira et al., "Through the Eyes of Science and Art."

²⁰Tourais, "Development of a Material Characterization Method."

²¹Nascimento and Diogo, *Encadernação portuguesa medieval*; Casanova, "Restauro de 100 Chancelarias," 32–6; Szirmai, *The Archaeology*, 140–71.

inks found in later additions, and repairs to the textblock were also analyzed (see Appendix I, 1 and 2, in Supplemental Materials).

The sewing threads used for sewing the gatherings of the textblock and the threads used in later repair work were identified by OM. Fiber micro-sampling was prepared for morphologic identification²² with simple polarized and cross-polarized lights under the OM (see Appendix I, 3, in Supplemental Materials).²³

The SEM analyses were performed using mixing image (Mix) standard observation mode, with different magnifications, on micro-samples of the wood boards of bookbinding. This allows for the determination of the morphology and anatomy of the wood and, by comparing it with reference bibliography,²⁴ opens the possibility of plant species identification (see Appendix I, 4, in Supplemental Materials).²⁵ Genetic and proteomic analyses were also considered for the skin materials identification,²⁶ but difficulties with equipment facilities and the concerns of National Library with the heavy handling of the book moved us away from the proposal at this stage. OM was also used for full visual examination of skins.

Results and discussion

Codicology and content analyses

Concerning the Alc. 11 liturgical analyses, this manuscript is a Psalter-hymnal that contains the Psalms required for the daily Divine Office, along with a set of Cistercian chants and hymns. A fragment from a Sacramentary that belonged to another manuscript precedes the text (an excerpt from the prayer of Saint Ambrose, to be recited before the Friday Mass). The Psalter begins at folio 2v, with the largest decorated initial of the manuscript, a B (of *Beatus uir*), the first letter of Psalm 1. The Psalms are highlighted with foliate initials on nine different folios, ending with the last Psalm on folio 188v. These are followed by a set of Cistercian chants intended to be sung in the hour of Lauds. This section of the manuscript ends at folio 207v. On folio 208, a set of hymns begins for use in the different hours of the Divine Office. It is worth mentioning that on folio 232v, Saint Bernard is referred to (*De Sancto Bernardo ad vespertas*) by an initial I, but the corresponding text was not copied in (as observed also in another manuscript from Alcobaça, Alc. 140). Is it possible that Alcobaça did not have the hymn available at the time the manuscript was written?

At folio 240 a Litany of Saints starts. The marginal notes, added later, display a second level of saints; they were apparently all written by the same hand and they exhibit the same color of paint. These marginal notes demonstrate that the codex was used over a long period of time. Considering the saints mentioned and the ones indicated in the margin, it is possible that this Litany predates 1191, as there is no reference to Saint Malachi, or that it was copied from an earlier manuscript. Furthermore, because of the absence of Saint Bernard's name, one can suppose that this Litany is from no later than 1200.

²²Marshall, "The Identification of Flax," 28–45.

²³American Institute for Conservation, "Fiber Identification."

²⁴Ilvessalo-Pfäffli, *Fiber Atlas*, 196–211; Vidal, *L'analyse microscopique*.

²⁵InsideWood, <http://insidewood.lib.ncsu.edu/search>; Wheeler, "InsideWood."

²⁶Fiddymment et al., "So You Want to Do Biocodicology?" 1–20.

Folio 242 also deserves our attention because it shows another Litany; in the margin is information added after that Litany was written. These marginal indications are all present in the 1195 Definitions (*Definitiones anni 1195*) and refer to the statutes of the previous year.²⁷

On folio 245v, there are two prayers (*Deus cui soli competit* and *Commendamus ti, domine*). The following folios (246 and 247) are additions, having been inserted at the end of the last quire: the first contains the hymn of Saint Vincent (*Sanctissimum Vincentium mundi*) on the front and the hymn of Saint Bernard (*Bernardus doctor*) on the back. These two additions mean that the primitive nucleus of the manuscript was written before 1175, when the celebration of Saint Bernard was authorized (*proprium officium et due misse*).²⁸ Another hypothesis is that the manuscript that served as a model for this Psalter-hymnal was written before 1175 (in fact, it could be one of the manuscripts that Clairvaux lent to Alcobaça when it was founded in 1153). In this case, when the scriptorium of Alcobaça copied the manuscript, the codex that served as model did not have the hymn of Saint Bernard, which is mentioned at folio 238v but was not copied.

On the last folio, 247, recto and verso, further references are made to the 1195 Definitions by prayers written in red. We can ask, why this request with the liturgical orientations of the *Statuta* of 1195? According to Waddell, the collects to be used in the prayers against Saracen invasions are explained here, and therefore the collects of the previous year, the *Statuta* of 1194, had to be amended.²⁹ Thus, this addition to the core of the manuscript is after September 1195. In short, considering the absence of Saint Bernard in the Litany and the information on folio 247 copied after the General Chapter of 1195 and probably added to the core of the manuscript, we can assume that this Psalter-hymnal was produced between 1175 (because it refers to the hymn of Saint Bernard) and 1195 (because of the *Statuta*).³⁰ This concurs with the twelfth-century date proposed by Nascimento and Barreira.³¹

The Psalter-hymnal manuscript, in parchment, comprises a total of 247 folios and measures about 245 × 155 mm. In codicological terms, it is made up of thirty-one gatherings of four bifolia, with some exceptions: in quire 4, folios 27 and 32, instead of forming a complete bifolium, single leaves are stitched individually (possibly due to a mistake); in quire 14, folio 105 is pasted to folio 112, forming a false bifolium; quire 26 is missing a folio and quire 31 has two added folios at the end (see Appendix II, in Supplemental Materials). The parchment shows signs of surface deterioration, but OM allowed the observation of the follicular pattern: a zigzag pores' shape and overlapping of smaller and larger pores, similar to sheep-skin pattern. This is consistent with the fact that, in the thirteenth century, the Monastery of Alcobaça held the largest flock of sheep in Portugal.³² Apart from the already-mentioned marginal notes, another aspect confirming the heavy use of this codex is the extent of early repairs. Through detailed observation of the repair typologies, three different moments of intervention can be identified.

²⁷Barreira, "Abordagem histórico-artística," 33–62; Barreira et al., "Normatividade;" Waddell, *Twelfth-Century Statutes*, 306–07.

²⁸Canivez, *Statuta Capitulum Generalium Ordinis Cisterciensis*, 82.

²⁹Waddell, *Twelfth-Century Statutes*, 307.

³⁰Barreira, "Abordagem histórico-artística," 53.

³¹Nascimento, *Inventário dos códices Alcobacenses*, 523; Barreira, "Abordagem histórico-artística," 53, 56.

³²Serrão and Marques, *Nova história de Portugal*, 3:432.



Figure 2. Details of the different repair typologies: a) original parchment support repair, fol. 54r; b) glued repair probably done at Alcobaça, fol. 80v; c) sewn repair, probably done at Alcobaça, fol. 123r; d) glued repair, probably made at the holding institution, fol. 220r. Source: authors.

The first typology (Figure 2a), probably contemporaneous with the book's production, consists of neat needlework to repair holes and natural damage of the parchment. The second typology (Figure 2b-c), probably carried out at different times in the monastery, demonstrates the care monks took in prolonging the life of the manuscript when it showed signs of decay and loss. It consists of new parchment patches, evenly pared, glued, or sewn on the original folios, which were rewritten. As will be explained in the next section, the materials used in this repair typology are consistent with the raw materials available at the Alcobaça scriptorium: iron-gall ink applied in different moments, showing some variation in metal composition; and the linen fiber used as the sewing thread for repairs.

The third and later typology (Figure 2d), probably performed by the bookbinder in the holding institution, is slightly crude, and consisted of gluing in new patches of heavy parchment.

The liturgical text is circumscribed to a textbox of about 163 × 100 mm, where the first line is above the respective textbox. The text is divided into sixteen lines of writing, which

corresponds to a transitional letter style (or *littera protogothica formata*³³), in accordance with the proposed date.³⁴ The color and decorated initials are very similar to other manuscripts produced in the scriptorium at the end of the twelfth century, such as Alc. 166, a Collectar-ritual dated between 1185 and 1191.³⁵ According to Stirnemann, these similarities in the decoration were very common in monasteries because illuminators were creatures of habit and used the same types of forms repeatedly.³⁶ Although there are no clues concerning authorship of this anonymous Psalter-hymnal, the script presents similarities with the diplomas of the same period.³⁷ These facts, plus the text composition and the liturgical content, allow us to suggest that this codex was likely produced in the scriptorium of Alcobaça.

The bookbinding also displays a later medieval technique: a continuous compact straight sewing structure and a lacing-in path where the thick thongs go over the wood board and fit a top channel made on the outer face of a rounded wood board,³⁸ instead of being introduced into a carved tunnel at the inner edge of the board. However, the usual three split thongs of alum-tawed leather, forming strong raised bands and a straight spine, frequently found on early Alcobaça bindings,³⁹ are still present, corroborating the reuse of elements and the continuous process of caring for the codex. Besides the split thongs being attached to the boards in a manner unlike what was used in primitive bindings, headbands are missing, the boards are thinner and narrower, measuring 155–260 mm, and the wood is beveled and shows a slight curve next to the spine on the outer face and exhibits a 30 mm square. Also, the spine is reinforced with transverse linings of reused parchment in the panels, between the sewing stations. These are all features of a later binding methodology. In addition, the front leaf, folio 1 (a fragment from a Sacramentary) and two folios of quire 31 were added later, reinforcing the idea of later alterations. For further studies about Alcobaça medieval binding, it will be interesting to check if this lace-in technique and the board shape are present in later Alcobaça manuscripts or in altered ones. However, this comparative work has not yet been done, since Nascimento's work⁴⁰ was limited to the pristine bindings, and other studies do not refer to material features.⁴¹

Finally, plain vegetable-tanned leather covers the entire set, but this could have been done at any time. The leather turn-ins form a square corner; the skin from the front edge of the board overlaps the leather turn-in of the head, and tail board edges also exhibiting a later technique. The covering material of the binding also reveals a much later

³³Amos, *The Fundo of Alcobaça*, 21; Derolez, "The Nomenclature of Gothic Scripts," 307–8. According to this author, *Protogothica formata* or *Praegothica formata* is a type of letter/script that succeeds Caroline, but it is not yet Gothic or Textualis and is used for varieties of script in this period (eleventh and twelfth centuries).

³⁴Barreira, "Abordagem histórico-artística," 53.

³⁵Barreira, "Abordagem histórico-artística," 33–62.

³⁶Stirnemann, "Dating, Placing and Illumination," 155.

³⁷Guerra, *Os diplomas privados*, 75, 238–39. According to Guerra, at Alcobaça from the second half of the twelfth to the early thirteenth century, the diplomas' scribes and the scriptorium's copyists were the same person.

³⁸Szirmai, *The Archaeology*, 150–56.

³⁹Nascimento and Diogo, *Encadernação portuguesa medieval*, 80–88; Castro et al., "The Romanesque Collection of Santa Cruz," 106–19.

⁴⁰Nascimento and Diogo, *Encadernação portuguesa medieval*.

⁴¹Gonçalves, *O património do Mosteiro de Alcobaça*, 327. In Livro 14 (Livro da fazenda) there is information about payments related to the binding of books: the monk Nicolau Vieira, who works in Alcobaça's scriptorium as copyist, was also taught to bind books. Also, Estevão Eanes Lourido (da Maiorga), proctor of the monastery, copied and bound manuscripts for at least two decades, as corroborated by the Books of Usages of 1415 (BNP/Alc.208, fol.111).

intervention with a darker brown skin, probably carried out in the National Library. As mentioned above, the sewing and the lace-in method were redone, the wood boards replaced, and the spine reinforced with parchment linings, probably between the fourteenth and fifteenth centuries.

Instrumental techniques main achievements

An analysis of the decorated capitals in Alc. 11 identified the use of a color palette restricted to the use of reds (brighter and dark red), blue, deep green, and light brown. This is in agreement with studies of other early manuscripts produced in Alcobaça's scriptorium, showing a system of three dominant colors (red, blue, and green) and the absence of metal pigments.⁴²

The UV-Vis FORS analysis of inorganic reds (bright red) allowed the identification of vermilion-based paints (see Appendix I, Figure 1A, in Supplemental Materials).⁴³ This was confirmed by the presence of mercury, identified by means of h-EDXRF. In contrast, the FORS analysis of dark red paints revealed the presence of two low-absorption bands that might be related to the presence of an organic, red-based paint (see Appendix I, Figure 1B, in Supplemental Materials).⁴⁴ Due to experimental restrictions, it was not possible to identify the source for this organic red dye. However, comparison with other deep reds found in Alcobaça manuscripts where previous FORS analysis was performed, together with the results corroborated by molecular micro-FTIR and SERS analysis,⁴⁵ revealed a similar FORS profile, suggesting that a scale-insect dye was used to produce these dark red paints (see Appendix I, Figure 1B, in Supplemental Materials). It is important to stress that, despite being extensively used as a source of deep red in the Alcobaça decorated initials, this expensive pigment made from scale-insect dye is not often found in other contemporary monastic manuscripts, such as those produced in Alcobaça's motherhouse of Clairvaux.⁴⁶ It is possible that Islamic cultural heritage influences, which played an important role in Portuguese territory, contributed to scale-insect dye use at Alcobaça.⁴⁷ The power and economic resources of this monastery may have facilitated the acquisition of such expensive pigments for its scriptorium.⁴⁸

The UV-Vis FORS analysis of blue paints allowed for identification of the characteristic maximum absorption band of lapis lazuli (see Appendix I, Figure 2A, in Supplemental Materials).⁴⁹ The Raman analysis of a micro-sample representative of these blue paints also identified the characteristic bands of lapis lazuli (see Appendix I, Figure 2B, in Supplemental Materials).⁵⁰ This is another pigment commonly found in manuscripts from the Alcobaça scriptorium.⁵¹

⁴²Melo and Miranda, "Secrets et découvertes;" Miguel, "Le vert et le rouge," 31–84; Miguel et al., "Scientific Study," 134–45; Muralha et al., "Micro-Raman Study."

⁴³Cala et al., "The *Messale Rosseli*."

⁴⁴Aceto et al., "Characterisation of Colorants."

⁴⁵Miguel, "Le vert et le rouge," 46–7; Oliveira, "The Book of Birds," 180–84.

⁴⁶Miguel et al., "Scientific Study," 134–45.

⁴⁷Miguel et al., "Scientific Study," 134–45.

⁴⁸Melo and Miranda, "Secrets et découvertes;" Gomes, "Entre memória e história."

⁴⁹Aceto et al., "Characterisation of Colorants;" Cucci et al., "The Illuminated Manuscript Corale 43."

⁵⁰Hayez et al., "Identification of Pigments."

⁵¹Melo and Miranda, "Secrets et découvertes;" Muralha et al., "Micro-Raman Study."

The UV-Vis FORS analysis of deep-green paints reflected an absorption band at ca. 720 nm related to the d-d transitions of ligand field of copper ion (see Appendix I, Figure 3, in Supplemental Materials), which was also identified in these paints by h-EDXRF. Although some authors attribute this absorption band to the presence of verdigris (a copper acetate),⁵² the fact that these paints present a strong match with the FORS spectra profile of contemporaneous greens with other Alcobaça manuscripts, already characterized as copper-proteinates by means of molecular analysis (FTIR),⁵³ together with its morphological characteristic (that is, a glossy fractured appearance), does not rule out the hypothesis that these greens may also result from the complexation of verdigris in a proteinaceous binder, causing a chemical reaction throughout time between the amide and the acetate groups into these copper-proteinates, as has already proposed.⁵⁴ Finally, the analysis of light-brown paints proved inconclusive by the experimental means available.

h-EDXRF analysis of the inks used for the textblock and for later repairs enabled the identification of iron-gall-based inks in both sets of paints, composed essentially of iron salts and presenting some copper content and minimum quantities of zinc and manganese. These compounds were present in both inks used for the textblock and for the later repairs, but with higher variations in the case of the repair inks, suggesting that repairs were made at different moments, using different ink formulations. On the other hand, end-leaf inks (corresponding to the fragment, which belonged to another manuscript) present residual amounts of iron, suggesting the use of a carbon black ink and corroborating the idea of an addition of a fragment from a previous manuscript (see Appendix I, Figure 4, in Supplemental Materials).

A material study of the bookbinding reveals some interesting features. The morphological characteristics of the fibers of sewing threads, such as the presence of lines going across forming knots, a narrow lumen, and the typical areas of fiber crushing, apparently indicate the presence of linen vegetable fibers for sewing threads used in the sewing structure as well as threads used in repair work (see Appendix I, Figure 5 A, B, in Supplemental Materials).⁵⁵ The identical nature of vegetable fibers in both cases suggests that the repair work was done in the same context, probably in Alcobaça Monastery. Furthermore, the type of fibers found is in accordance with the natural fibers available during the medieval period.

The morphological and anatomical appearances of the samples from the wood boards of Alc. 11, observed by SEM and OM, indicate the presence of an angiosperm plant. Sample features such as the presence of spiral thickenings and the lack of larger rays allow us to discard previous proposals that pointed to oak species,⁵⁶ frequent in early days at Alcobaça manors.⁵⁷ The dimorphism of vessel elements, simple perforation, and spiral thickenings only in narrow vessel elements appeared (see Appendix I, Figures 6, 7, in Supplemental Materials), that is, *Ulmus glabra* sp. or *Arbutus unedo* (strawberry tree, in Portuguese *medronheiro*), two species native to Europe⁵⁸ and

⁵²Aceto et al., "Characterisation of Colorants."

⁵³Miguel, "Le vert et le rouge," 53–4; Miguel et al., "Scientific Study;" Miguel et al., "Green, Blue."

⁵⁴Miguel et al., "Green, Blue;" Miguel, "Le vert et le rouge," 84–104.

⁵⁵American Institute for Conservation, "Fiber Identification," https://www.conservation-wiki.com/wiki/BP_Chapter_1_-_Fiber_Identification.

⁵⁶Nascimento and Diogo, *Encadernação portuguesa medieval*, 29.

⁵⁷Maduro, "O espaço florestal de Alcobaça."

⁵⁸InsideWood, <http://insidewood.lib.ncsu.edu/search>; Wheeler, "InsideWood."

common in the region.⁵⁹ This is in concordance with codicological features (e.g., board shape and lace-in technique) of the bookbinding intervention in a medieval period.

Main conclusions

This interdisciplinary study, including preliminary analytical data, codicological and codex production technology information, plus historical findings and liturgical analyses, allowed the research team to reach two main conclusions: first, Alc. 11 is a twelfth-century codex, probably produced in the Alcobaça scriptorium, and one of the oldest manuscripts of this Cistercian library, belonging to its primitive nucleus of books; second, it is a particularly significant case study, as an object displaying signs of considerable use, including various texts layers, additions, and repair work from different historical moments.

Liturgical content study indicates that it was probably produced between 1175 and 1195, given the reference to the hymn of Saint Bernard in the main text, the analyses of the saints in the Litanies, and the reference to the *Statuta* of 1195 in an added folio (fol. 247). Codicological evidence corroborates the proposed date and place of production, including different elements of the textblock, such as the letter style (*Proto-gothica formata*), text organization, and type of decoration, as well as certain features of the binding structure, such as the sewing structure supported on three split thongs of heavy alum-tawed leather. Also, the analytical data confirm and reinforce historic findings. Pristine materials used in the production of this book, such as the iron gall ink and pigments in the textblock are common materials in the period. The rich and expensive pigment palette in the decoration of the capitals of the textblock, including lapis lazuli for blue and scale-insect dye for the deep red, together with the three dominant colors (blue, green, red), are all features in accordance with materials in use at Alcobaça's scriptorium. Lapis lazuli for blue and the proposed copper-proteinates for deep green can also be found in other Cistercian scriptoria, such as Clairvaux. But it was confirmed that the scale-insect dye for deep red used at Alcobaça and other Iberian monasteries does not appear at Clairvaux. This may uncover an Iberian tradition corresponding to Iberian trade relations and the main influences at the time.⁶⁰

The analytical data also corroborate this codex's historical trajectory, namely the additions and the intervention moments with different ink formulations on the textblock and repairs. The bookbinding wood board, which is not recognized as the most common in early Alcobaça's bindings but was frequent in the land of Alcobaça, reinforces the findings of the codicological study, attesting to the book's alteration in a later medieval period.

Finally, considering the influence of the object's biography on conservation decision-making, great effort should be put on digital means, avoiding further interventions that could alter its "cultural significance." This is a key question since in the past different improper interventions have affected the Alcobaça collection, changing the codices' identities and bindings.⁶¹ Thus, the possibility of recording all findings with digital tools under development in the Cistercian Horizons framework is an important achievement. These online tools, hosted at the Institute for Mediaeval Studies web page, involve a full

⁵⁹Maduro, "O espaço florestal de Alcobaça," 40.

⁶⁰Oliveira, "The Book of Birds," 159–63.

⁶¹The *Commentary on the Apocalypse*, Alc. 247, is an example of such procedures. For more information, see Miguélez Caverro et al., "Beatus Manuscripts."

description of the manuscripts (see Appendix III, in Supplemental Materials), binding characterization, and material analysis,⁶² thereby making the detailed new data of Alcoça's manuscripts available for the first time.

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⁶²Tourais, “Development of a Material Characterization Method.”

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