Structural Conservation of Panel Paintings at the Opificio delle Pietre Dure in Florence: Method, Theory, and Practice

Edited by Marco Ciatti and Cecilia Frosinini
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**On cover**
Ambrogio Lorenzetti, *Triptych of the Badia a Rovero*, c.1330–35,
Museo d’Arte Sacra, Palazzo Corboli, Asciano. The back after the conservation treatment

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STRUCTURAL CONSERVATION OF PANEL PAINTINGS AT THE OPIFICIO DELLE PIETRE DURE IN FLORENCE: METHOD, THEORY, AND PRACTICE

Edited by Marco Ciatti and Cecilia Frosinini
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For more than thirty years, the Getty Foundation has fulfilled the philanthropic mission of the J. Paul Getty Trust by supporting projects that advance the understanding and preservation of the visual arts in Los Angeles and throughout the world. The Getty has had the distinct pleasure of working in partnership with many Italian institutions; most notably in the field of art conservation with the Opificio delle Pietre Dure (OPD) in Florence. Our two organizations share basic values related to heritage preservation, among them an emphasis on careful planning and research before intervention and a commitment to training future generations to keep the field of art conservation strong for years to come. We have had the opportunity to manifest these values on various projects over the years, especially through the Foundation’s Panel Paintings Initiative that was launched in 2009 to train a new generation of conservators for old master paintings on wooden panels before the current experts retire.

The structural care and conservation of panel paintings has been a concern of the Getty for over two decades. In 1995 colleagues at the Getty Conservation Institute and the J. Paul Getty Museum organized a symposium dedicated to panel painting conservation, followed by a second one joined by the Foundation in 2009. The symposia signaled the importance of this field of conservation, and pointed to an imminent skills gap due to the pending retirement of many senior specialists and the lack of a younger generation entering the field. We were keenly aware that specialists at the OPD had been conserving panel paintings for over three decades and had generated an impressive list of publications detailing treatment challenges and the development of novel conservation strategies and techniques. As part of this work, the OPD had also been training conservators where they could. The OPD has drawn on this expertise to join the Getty Foundation as an ideal and respected partner, with Soprintendente Marco Ciatti serving as a key advisor to the Panel Paintings Initiative.

In 2010, the Getty Foundation awarded an initial Panel Paintings grant to the OPD to conserve Giorgio Vasari’s monumental altarpiece The Last Supper (1546) and, in the process, train a team of international conservators at all levels. Vasari’s painting was one of the most damaged artworks to survive the historic 1966 Florence flood, and literally sat in pieces for over four decades until conservators felt they had sufficient technical skills to attempt an intervention. After intensive study and treatment, the OPD team reunited the once-separated panels for the first time in nearly fifty years, returned the restored painting to the Florentine public on the 50th anniversary of the flood in November 2016, and trained numerous conservators who are now in a better position to implement complex treatments on their own.

In 2013, the Getty Foundation awarded another major grant to the OPD for training and treatment related to four major paintings by Leonardo da Vinci, Simone Martini, Fra Angelico, and Alessandro Allori, as well as the translation from Italian into English of some twenty critically important texts in the structural conservation of painting on wood. Through the hard work of Cecilia Frosinini, with the support of Adele Leccia and Cristiana Massari, the translation by Helen Spande and Diane Kunzelman and publisher Edifir, it is with tremendous pride that we see the fruits of their dedication to the field in the form of this handsomely produced publication. It will, no doubt, become the next standard work for the field.

The OPD has made a lasting impact on the field with Structural Conservation of Panel Paintings at the Opificio delle Pietre Dure in Florence: Method, Theory, and Practice, and with the training it has facilitated for a number of conservators at various stages in their careers. We congratulate our colleagues on this remarkable achievement.
The production of panel paintings has been especially significant in Italy and particularly in Tuscany, where painting on this kind of support continued for a good portion of the Cinquecento, unlike what is found in other regions. In Tuscany, the large quantity of panel paintings, their extensive distribution across the territory, and the long history of a preservation culture has produced a tradition of restoration treatment practices on these supports and has allowed for the accumulation of deep experience in this area. I have had the opportunity to consider the formation and the development of a “Florentine school” of restoration beginning from the Renaissance onwards and documented in the writings of Giorgio Vasari, Filippo Baldinucci, Giovan Domenico Bottari, Ramírez di Montalvo, Ulisse Forni, and in the twentieth century by Ugo Procacci and Umberto Baldini, on several previous occasions. As for the supports of panel paintings, a tradition of prudent maintenance treatments, as seen for the paintings of the Grand Ducal gallery, is not so visible and what is found in this context, as for old ecclesiastical properties, is a certain nonchalance that appears for example in the noted practices of stylistic revision of Gothic polyptychs, recorded in the history of restoration as the “squaring-up” or *riquadatura* of polyptychs, accomplished in order to adapt those paintings to the changing artistic climate and the return to forms derived from the classical orders of architecture. Let us not forget that up until the new kind of Counter-Reformation altar that was defined in Florence by Vasari, panel paintings were micro-architectures and, therefore, either in their Gothic or Renaissance dress, the structure would have had its own construction and static logic. Another typical example of “historic” treatments of wood panels is seen in altering the dimensions of paintings, due to either concrete requirements of the spaces connected to a change in location, or changes tied to the iconographic content of the painting. Recently, an incredible example of enlarging a panel and a new arrangement of the individual constituent figures is provided by a *Crucifixion* attributed to Alessandro Allori, today in the storage of the Soprintendenza and of unknown early provenance. In the course of the nineteenth century, new methods coming from France, that of flattening and attaching cradles, were introduced by the Lorenese carpenter Pietro Rombergh, responsible for the treatments in the first decade of the century on the *Madonna of the Long Neck* of Parmigianino and the *Madonna del Baldacchino* of Raphael. And from here, it is possible to trace a path that is quite rich in documented treatments, beginning with the guidelines expressed by Ulisse Forni, restorer at the public Florentine galleries in his *Manuale* of 1866, up to the foundation on the part of Ugo Procacci of the Gabinetto Restauri in 1932. Again for this particular category of treatment, the disastrous flood of 1966 signals a turning point for various reasons. The enormity of the damage suffered forced everyone to question their own technical habits and find innovative answers. The Italian scientific world hastened to the rescue and since then there has been a close and constant collaboration with specialists such as Guglielmo Giordano, the leading Italian wood technology expert of that time. In addition, the generous international aid for Florence brought together restorers from many countries at the Fortezza, each with his or her own experiences and treatment techniques, including for wood panels. The great merit of the Florentine restorers was gathering the best of what each foreign colleague offered and fusing it with their own traditions, based on meticulous and adept hand skills. The carpenters of the Fortezza became, with specialists like Renzo Turchi and Gianni Marussich, the
energetic center of quite an intense, often frenetic, activity that followed some predefined guidelines. The treatments were based on repairing cracks and separated joins by means of V-channels into which were inserted short wedges of the same kind of wood with the grain running parallel, and on the application of curved crossbars that follow the shape of the panel with a trapezoidal cross-section, inserted into tracks formed from two parallel series of elements called nottolo or cleats. This method sought to allow movements of the panel in plane with its phases of dilation and contraction, and left the degree of flexibility up to the crossbar, which was determined by the choice of wood and thickness, and the eventual tendency of the support to warp. In order to limit the exchange of humidity with the environment and confer greater stability to the panel, where possible a layer of nearly cold wax was applied to the back with a spatula, so as to form a surface coating that did not impregnate the wood. Elsewhere, I have gone into the virtues and defects of this technical practice which was though, based on extensive experience and remarkable finesse. On this occasion it seems useful to underscore how beginning in the mid-eighties, one of the members of the group of restorers for the panels, Ciro Castelli, became central to introducing a broad series of innovations and refinements that radically changed the former habits and laid the foundation for the modern direction of this field. In this volume we have tried to collect some of the texts about the restoration treatments carried out by Ciro Castelli along with colleagues Mauro Parri and Andrea Santacesaria which, thanks to the Getty Foundation’s Panel Paintings Initiative, can thus be better known in the international arena. We don’t appreciate how in the conservation world, especially among more senior restorers, the language barrier makes a genuine exchange of experience difficult with foreign colleagues, though it can be very valuable for both parties. The modernity of the treatment practices of many foreign colleagues with their positive relationship to the scientific world could draw added benefit from the sensitivity, the many experiences, and the procedural refinements of the treatments illustrated here.

Very briefly, the activity that is portrayed here in this volume has used some guiding principles that are good to highlight beyond their relevance to a particular treatment. First of all, there has been a continual development of knowledge on the traditional methods of constructing panel paintings, and the functioning of these structures, activities that have brought to light real discoveries. Among which, for example, we note the diversity of supports of the twelfth century with respect to the paintings of later centuries, both in terms of wood species and assembly methods, and the various attempts at creating crossbars with new systems of attachment to the panel (in contrast to medieval nailing), which was put into play in the era of experimentalism of the Quattrocento. The system of floating iron latches, found in various paintings and with some more or less sophisticated variations, had never been noted before, just as the turn toward the so-called system of “little bridges” (ponticelli) in its two different forms, Sienese and Florentine, had not been shown. A greater awareness of all of the original construction characteristics is then linked to a greater respect for them, at least as long as these are not the proven causes of damage to the painting, with a constant effort to progressively reduce the invasiveness of our treatments, often inventing technical solutions designed for each single painting, and often improving the functionality of the old structure. Greater attention is paid to the needs of each specific case, avoiding unfortunate automatic routines. The most significant procedural change, in my opinion, consists in establishing a comprehensive plan for all the phases of the restoration of a painting conceived as a whole and marked by a necessary balance of approach. Within this is the essential connection between the active restoration treatment phase and that of preventive conservation, connected by the circumstances of its display and the lifestyle of the painting after treatment. In fact, if we intend on solving all the preservation problems of very deteriorated paintings only in the restoration phase, this can then only be very invasive, but if we look for solutions that unite the restoration practices with that of preventive conservation, then the level of invasiveness is lower. It should also be stated with the greatest clarity that while valid contemporary tendencies to consider the reduction of invasiveness a positive value, the risk is that “minimal intervention” becomes an empty refrain, used to justify what is, in substance, an inability to act. Thus the degree of invasiveness of a restoration procedure can be evaluated only in relation to its capacity to deliver the results that are defined in the planning phase, otherwise a term of comparison is lacking to judge if the restoration has had a greater or lesser invasiveness. In the case where the
proposed goals are not reached, we can assert that even a “minimal intervention” is too much, given that it has not brought about a positive result.

Within this selection of texts produced in the last thirty years, it is useful to remember that though perhaps not particularly well-known at the time, the particular significance each treatment has assumed in the modern history of panel painting restoration is that it forms part of the development of this technical research and practice, a value that sometimes has emerged in its full importance only later.

Part of this history could begin with the treatment on the support of a painting damaged in the flood of 1966 by Giovanni del Biondo, a triptych depicting San Giovanni Gualberto and four stories from his life, from the Museum of Santa Croce. The excellent construction technique, both of the support and the layers of the ground-paint complex, with the latter having the double protection of canvas and parchment glued onto the panel, had meant that the painting could withstand the onslaught of the flood much better than the sixteenth-century panels from the same collection. It was moreover decided, from a structural point of view, to carefully review the adhesion between the paint and ground layers and the support and to give the triptych new crossbars, as the old ones had been removed during its stay in the environmentally-controlled storage of the Boboli Gardens Limonaia where the flood damaged panels were slowly dried over a period of almost two years, free from rigid constraints as then the nailed-on crossbars were thought to be. This meant, therefore, planning and applying new crossbars and the search began to surpass the performance offered by the models then in vogue, based on lengths with a trapezoidal section held in a track made from pairs of nottole screwed to the panel. The goals we had in mind were to reduce the invasiveness of so many attachments and to be able to have a restraint that could be adjusted over time and respond flexibly to the tendency of the planks to warp. An early attempt in this sense saw the use of single anchorage points in which threaded bolts were inserted with their heads held to the upper surface with a metal washer inserted into the crossbar. A further development made in 1985 consisted in inserting in addition to the washer, a steel leaf spring with a force regulated according to the behavior of the panel in relation to the microclimate of the preservation environment. This was one of the first attempts, from a theoretical point of view, to envision the restoration as an open process, in which it is possible to intervene over time, thereby establishing the first link between the restoration phase and that of maintenance, and beginning a relationship with preventive conservation to be implemented with the return of the painting to its installation location. This treatment set off research on systems of connecting crossbar and panel based on adjustable springs, seeking to improve the technical solutions gradually, making them more durable and less invasive. One of the next steps was a brass track with a Teflon channel (or analogous slippery synthetic material) in which was inserted a dowel that passed through the crossbar inside of a little cylinder, also made of brass, which contained a spring, regulated by a simple nut on the outside surface. This was a very complicated system, but effective and aesthetically not disturbing as it was entirely hidden from view. The actual invasiveness though was not negligible, as the track was held to the panel with screws. Various modifications and adjustments made over the years have brought us to the system now in use, and that is small round wood pieces with a flared base that are attached with a dot of glue to the panel. These house the head of a floating rod that connects to a tapered spring housed in a recess in the crossbar, equally hidden from public view.

For the major Sienese exhibition on Domenico Beccafumi in 1990, the OPD was charged with some restorations, and two of these brought about converging conclusions on the possibility in some cases of substituting crossbars with a fitted, supporting strainer or framework. The first case was the Coronation of the Virgin from the church of Santo Spirito, a painting made by enlarging an already existing support with a half-lap addition, quite damaged by wood-boring beetle attack, and violently restored with crude crossbars held with cleats. The second case, instead, concerned a rather rare art form, but one well-known in Siena, the cataletto, a sort of bier for transporting the deceased in use by religious confraternities. These were originally made with a panel painted on both sides and they were given rich frames and carved decorations. Our cataletto, coming from the Arciconfraternita della Misericordia has been over the centuries deprived of all of its other parts, frames included and the two panels had been sawn through their thickness so as to obtain four paintings. To make matters worse, to reinforce the weakened support, they had been glued to wooden backings with
the grain running perpendicularly. For varying reasons, all deriving from the intrinsic fragility of the original panel, in both cases it was found to be inappropriate if not actually impossible to apply crossbars whose weight would burden such weak panels. The solution was to create a strong framework with strips of wood, curving to fit the deformation of the old panels after restoration, connected to them by means of the aforementioned spring system. This is a reversal of the traditional structural logic: the load-bearing structure is no longer the panel itself but the backing framework which is given little feet that bear the weight at the bottom, also freeing the original panel from its mechanical function. This system has been largely used with panels that have been thinned in previous treatments involving flattening and attaching cradles and also carry out the positive function of reinforcing the painting along the margins which are vulnerable when the painting is moved. There are many such examples that can be cited among which Giovanni Bellini's *Madonna of Alzano* (Bergamo, Accademia Carrara), Ludovico Mazzolino's *Madonna Enthroned with Saints* (Cremona, Museo Civico "Ala Ponzone"), Giorgione's *Three Ages of Man* (Florence, Palatine Gallery), and Niccolò di Pietro Gerini's large panel of the *Deposition in the Tomb and the Ascension of Christ* (Florence, Church of San Carlo). These illustrate well how the system can be adapted with some variations to paintings of every type and format. This solution, allowing for a better distribution of weight, proved particularly useful in the case of panels made with horizontally-oriented planks in which there is cumulative pressure on the lower planks, as in the *Polyptych of the Intercession* of Gentile da Fabriano from the church of San Niccolò in Florence. The research carried out in those years with the department of preventive conservation and the environment of the same Opificio increased our focus on the need to limit the exchange of humidity between the panel and the environment and thus stabilize the behavior of the panel. Beyond the experimentation carried out on various types of vitrines, excellent results were obtained from prototypes in which the empty areas of the backing framework were filled with loose strips of wood, so as to increase the mass and protect the back of the panel. This last innovation became a practice of the laboratory from the beginning of the 1990s.

In 1989, the complex treatment of the *Coronation of the Virgin* by Botticelli from the Uffizi was concluded. In the past, the problematic painting had been restored repeatedly for continual lifting of paint that appeared so intractable that it remained flat in storage for more than seventy years. Examination showed that the problem was substantially due to a defect in its execution technique. The various coatings of gesso and glue of the preparation had not been applied adequately and with the slightest, normal movements of the panel, there was an internal separation between those layers that immediately translated into flaking of the paint. Given that this was a defect intrinsic to the painting there had also been those who suggested that the only solution was the radical task of transferring the paint. Sticking instead to the integral preservation of all of the component materials of the painting brought us to an important innovation that turned out to be very useful in other treatments like some of the flooded panels that had an analogous problem of a weakened ground. We sought to execute the best possible consolidation, using heat and vacuum pressure to ensure penetration and evenness, but we stopped trying to solve the whole problem just in this restoration phase, trusting in part to prevention. The frame of the large panel was built up with a thick wood box and a backing panel; the volume of air thus obtained was stabilized by means of conditioned silica gel. The space was sealed as well as possible with neoprene along the rebate between the painting and the frame. The enclosure was equipped with a detector for monitoring the relative humidity of the interior. The painting returned to the Uffizi Gallery at the beginning of 1990 and since then, this problematic painting has not shown any paint lifting. The success of this experience pushed us to both perfect this technique of enclosing the back and controlling the exchange of relative humidity between the panel and the environment, and to underscore always the centrality of this practice that bases the preservation of a work of art on an overall planning vision in which the three instruments at our disposal must find their places in a synergistic and natural way, that is restoration, preventive conservation, and maintenance. In order to appreciate the full import of this technique, it should be taken into consideration that in Italy the overwhelming majority of places where early panel paintings are located do not have climate control systems and therefore the paintings are exposed to continual fluctuations in relative humidity with all of their clear negative consequences. One very positive consequence of this approach consists in the
clear reduction of the invasiveness of restoration which is no longer called on to resolve by itself all the problems of a painting but is part of a studied interaction between action and prevention. There are also numerous cases of the further application of this method from the Lamentation of Christ by Ortolano in the Galleria di Capodimonte of Naples, returned in 1993, to the large, flood-damaged panels of the Museum of Santa Croce of the Descent of Christ into Limbo by Agnolo Bronzino and the Deposition from the Cross by Francesco Salviati, presented in 2006. In these last two cases, as with the large Last Supper by Giorgio Vasari, it was possible to preserve all the original materials, avoiding transferring the paint layer, or other more refined techniques of internal restructuring of a painting on a flood-damaged panel.

The numerous texts offered here may help show the breadth of experience acquired and the flexible practice in adapting the techniques to the features of each specific case, with a constant search for improvement in the effectiveness of the treatment and respect for the work of art. Into this context, the involvement of the Getty Foundation has arrived, with the successful inclusion of the Opificio delle Pietre Dure in the Panel Paintings Initiative and of its current Soprintendente within the advisory board of the project. The contribution of the Getty Foundation has been decisive in making possible, in terms of human and financial resources, the first and fundamental part of the restoration of Giorgio Vasari’s Last Supper dedicated to structural reinforcement, working contemporarily on the re-adhesion of the paint and ground layers and on the structure of the wood panel. This subject was chosen as a project of excellence and around this in-house restorers, external former students of the Opificio, and fellows of the Panel Paintings Initiative who come from various international laboratories have converged.

In a second phase of the Initiative other paintings have replaced the Vasari as the treatment subject, but this painting, whose rebirth after the damage of the flood and the near certain impossibility of it being recovered have truly represented for many of us the fulfillment of a dream. It has maintained a value and a significance of unparalleled level and this aspect has been received very well, beyond the complex technical problems, both by the Florentine public, and the international media. In addition to the concrete results brought about by the Panel Paintings Initiative the major importance that this initiative of the Getty Foundation has had for the personnel of this laboratory should be emphasized, beginning with Ciro Castelli, Mauro Parri, and Andrea Santacesaria, who have been able to interact with colleagues from the entire world, directly seeing different techniques and sharing different approaches from those in our tradition, thus enriching in an incomparable way their mental repertoire of possible solutions to the problems of a work of art, immediately producing new and interesting results.
Historical context for the development of altarpiece types: Some notes

Cecilia Frosinini

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The art historical study of the altarpiece as a functional category has recently seen incredible progress. From the remote, but in a certain way still interesting contribution of Jacob Burckhardt of 1898,1 to the very important catalogues of Sandberg Vavalà2 and of Garrison3—respectively of 1929 and of 1949—and Hager’s even now not duplicated attempt at a historical panorama from 1962,4 research in recent years has moved to concentrate in an ever more thorough and specialized way on liturgical standards,5 iconographic choices,6 details of the commissions,7 location problems,8 connections between the carpentry and architecture of the surroundings,9 social analysis of the craftsmen,10 and to considering the classification of specific structural forms.11 All of these different approaches to the material evidently have different purposes—analyzing the means through which the appearance is created, or the purposes to which this continues to evolve. But only if the complex history of the altarpiece is examined from each of these different points of view can we clarify its function. Therefore, at the beginning of each and every study that has as its subject an artistic creation as a functional category (as the “altarpiece” is in a specific way, as seen even by its very name), it is ever more indispensable to ask H. W. Janson’s provocative question, “Form follows function – or does it?”12

The origins of the altarpiece

Retracing the evolution of altarpiece forms is necessarily dependent on a careful examination of liturgical regulations. Especially for the early centuries, the few surviving paintings, their dispersion, and their transformation allows for only a fragmentary and episodic view. It is perhaps surprising, but just for this reason essential to note the fact that at least for the first ten centuries of the history of Christianity no religious image appears to have been considered necessary, nor much less a compulsory element of the furnishings of the altar.13 This simple observation can perhaps help us understand and in part explains the absence of altarpieces painted in the first centuries of the history of Western art. Since, and a basic clarification in this regard is again indispensable, it should be repeated that the Byzantine icons present in great number in the Christian West were never intended as functional objects for the celebration of the Mass, but always and only had a role in private devotions, even though situated in public locations. In Eastern Orthodox Christianity this, moreover, was and in part continues to be the role that the very existence of the iconostasis gives to sacred images by means of the separation between clergy and congregation and of the consequent invisibility of the liturgical celebration. To this is added the fact that in the West, for some centuries, there was a habit (beyond this it is hard to say, there not being precise rules concerning it) of celebrating the Mass versus populum a fact that certainly excluded the possibility of raising images on top of the altar.

At least beginning in the fifth century it seems clear that every church should have had a fixed altar at the center of the holy space and that it should contain relics. But only at the beginning of the Fourth Lateran Council in 1215 do we begin to find canonical laws
for altars, Masses, and celebratory procedures; until then only in the *De Missarum Misteriis* of Cardinal Lotario Conti (the future pope named Innocent III) do we find the habit of furnishing the altar with a cross and two candles cited as already existing in the Roman church, which after the Council, was established as a rule: “*Numquam celebrat sacerdos nisi cruce ante se posita.*” At this point, many of the possible correlations between liturgy, sacred images, and altarpieces are already evident:

a. The celebration *versus populum* especially favored the emergence and the development of the *antependium*, first in precious materials, and later painted panels for which the frame and relief elements imitated “noble” materials. Naturally, the location under the altar table is reflected in their shape and structure.

b. The appearance of monumentally-sized sacred images on panel predating the precise codification of liturgical standards but that were...
most probably not directly connected to either the altar or the liturgical celebration (including the great Lucchese, Pisan, and Umbrian painted crucifixes of the twelfth century), but only to popular devotion; as indeed would suggest the renowned portrayal of holy images on an iconostasis left to us by Giotto (Fig. 1).

c. The possible correlation, in the development of true and proper altarpieces, with the presence of relics.  

At the same time as the provisions of the Fourth Lateran Council, a little innovative liturgical unpredictability could be found all over in the Church: in these years the bishop of Paris decreed that after the consecration of the host, it ought to be elevated to be offered for the adoration of the faithful. In Italy, Pope Honorius III cited the elevation as a then common practice. The liturgical innovation marks an evolution in the thinking about the need to offer a visual element to the worship of the faithful. This convergent attention toward the altar table—and not only toward the relics contained under it—this enlarging of the verticality of the sacred space can certainly have been one of the stimuli for “furnishing” this new space of worship.

From this period onward, different canonical and liturgical documents appear providing precise information about the existence of altarpieces. In 1240, the synodalia of the Bishop of Durham required that “insuper que altaria et superaltaria fuerint consecrata, et, si consecrata sint, crucis caracter est sigillata.” In 1266, in Magdeburg, it was established that panel paintings were placed permanently on the altars. First Les instructions de Guillaume Durand and then the Council of Trier established that “in unaquaeccelesia ante vel supra qualibet altar sit ymago vel scriptura seu pictura vel scriptura express designans et cuilibet intuenti manifestans in cui sancti nomen et honorem sit ipsum altare constructum.”

Only sixty years after the date of the opening of the Fourth Lateran Council, in 1271, we find two examples epigraphically documented that demonstrate the formal and functional evolution of these objects: from antependia to real altarpieces. These are the dossal of Meliore at the Uffizi and the Deesis from the church of San Silvestro of Pisa.

At the same time, another factor increased altarpiece production: the multiplication of altars themselves within churches. There were many factors that led to this numerical increase, from the establishment of the religious mendicant orders that promoted the participation of the laity in the liturgical functions and Marian worship; to the encouragement offered to the emerging bourgeois society to securing divine forgiveness through the establishment of altars and the celebration of Masses for indulgences. Even judgments like that of the German Sinod of 1261 (“Altaria superflua per ecclesias parochiales omnino tollantur . . . ad plus tria sufficiunt”) are a manifestation of the increase, seen as excessive, of the number of altars in churches. Thus began the unstoppable shift toward the proliferation of altarpieces that were increasingly complex and vertical, with the subsequent creation of more rows of images to fill up expanded architectural spaces but also to underscore hierarchies between altarpieces within the same church or between churches belonging to the same religious order.

The progression toward a Renaissance structure

In fourteenth-century polyptych structure, the division into compartments emphasized the isolation of each figure, represented according to a precise hierarchical scale, also often supported by proportional relationships between the dimensions of the individual figures. The need for the characters to interact is accommodated by degree even before the adoption of the altarpiece with a unified scene. In the fourth decade of the fifteenth century, in fact, research has identified the appearance of the category of the unified pala as an altar furnishing based on a document of 1434 recording the plan for furnishing the church of San Lorenzo in Florence, in which for the first time there...
is mention of a "tabula quadrata et sine civoriis." In reality, the transition was not so sudden, nor was the shift toward the unification of the pictorial surface only emergent in those years. Through a slow process that perhaps was underway well within the fourteenth-century with the Strozzi Altarpiece of Andrea Orcagna (Fig. 2), carpentry structures began to develop over several decades that attempted to respond to the evolution of taste that called for a compositional field that was no longer divided by architectural partitions. As evidence of this first transitional phase, there are a series of altarpieces in which the internal boundaries imposed by frame elements between elements (like the spiral columns and pilasters) have been eliminated, but that retain the upper partitioning of the arches. Only the corbels remain to support the arches, suggesting the original subdivision of the internal spaces, though often the hierarchical proportions between the Virgin and saints remain.
This new unified space, beyond allowing for the developing the new “genre” of the Sacra Conversazione, lends itself to the depiction of choral narrative themes. The pala of Lorenzo Monaco, from the Camaldolese monastery “degli Angeli” (Fig. 3), is one of the grandest examples. The angels and two tiers of saints attend the coronation of the Virgin which is reserved for the central compartment; the relationship is established by the continuity of the celestial spheres on which the scene is situated.

Studies on the subject must always take into account the partial survival of the artistic production of the period, and in contrast to what has until now occurred, they benefit from the precious historical evidence furnished by the diffusion of a “taste” through retardataire Masters. This is how, far more than for the big names—even those tied to later works—it can be very instructive to consider how just after one year from the cited document of San Lorenzo, in 1435, Bicci di Lorenzo,
a retardataire artist though one of great commercial success, created two works that were worlds apart in terms of architectural structure: the great, flaming Gothic polyptych of Bibbiena (Fig. 4), and the square pala with the Adoration of the Child, for the Florentine church of San Giovannino dei Cavalieri. It is clear that faced with these kinds of cases, it is essential to consider ever more the very important role played by the patron: precociously up-to-date in the case of the Florentine painting, and ornate, but still a most traditional taste in Bibbiena. This offers valuable evidence for the coexistence between aesthetic forms that are today perceived as antithetical but absolutely reconcilable, aside from being contemporary, in the moment of their appearance. Meanwhile, it becomes more and more necessary to reexamine the too hasty theories on the comprehensive planning of a polyptych, that is including the architectural part on the part of the painter.

The emphasis on the “invention” of the traditional square altarpiece coming from the circle of Brunelleschi in Florence is certainly well-placed, at least in relation to the requirements correlating the rationalized architectural spaces and their furnishing. It remains equally important to avoid reducing to a single picture a much more complex and variegated reality that sees the development of many other types, adaptations to different situations and functions, and not without the involvement of local traditions. Among these are included, for example, the arched Sienese pala destined to fit into a niche in a masonry wall. Or the many examples of polyptychs that retain their Gothic structure unaltered, with ogival arches and mixtilinear cusps that built into another squared frame that functions to normalize the colour. The resulting spaces above the pinnacles are similarly painted with figures of prophets or saints, like the polyptych of Andrea di Giusto a Ripalta (dated 1436). Or the arched structure of the Rinieri pala, painted by Francesco d’Antonio, probably for the convent of San Girolamo dei Gesuati in Siena, today at the Musée du Petit Palais of Avignon. Or the altarpieces with a single pointed arch, a point of departure toward the gabled entablature of the fully Renaissance altarpieces (Bicci di Lorenzo, Coronation of the Virgin, (Fig. 5) for San Firenze, now in Santa Trinita, datable based on documents between 1431 and 1435, or the pala of Giovanni dal Ponte, for San Salvatore al Monte, inscribed 1434).

Another very common type in Florence and one that paralleled the genesis of the classical square pala is that of the supracaelum, a term referring to a barrel vault projecting from the top edge of the pala, decorated with a starry sky. This is a Renaissance progression from the cross vault often present at the top of late Gothic polyptychs, supporting the upper register.

Alongside the spread of the new taste for unified altarpieces was the thriving activity of adapting the arched panels and triptychs to this new rectangular format with the addition of painted wood inserts that normalized the Gothic architecture assemblies. Neri di Bicci often mentions this “squaring up” (riquadrature) in the invaluable records of his working practices, describing one such instance “the panel which had been made traditionally with ciboria and foliage as customary in that past time, and I shortened and reduced it to today’s style” (la quale tavola fu già fatta antichamente chon civorì e fogliami sechondo s’usavano a quello anticho tempo, ed io la fe’ rachonciare e riducere a l’uso d’ogidi.) The precocious use of squaring up, as seen as early as 1428 in a commission by the Captains of Orsanmichele with Bicci di Lorenzo points to the need to reexamine the timeframe for the diffusion of the taste for the unified pala. As seen previously, the minute analysis of “minor” facts and archive documents can probably shed new light on the subject in the future.

Completing the examination of the complex issues raised by the emergence of the Renaissance pala, is in any case the fact that the relationship between Brunelleschi and this kind of altarpiece ought to probably be reconsidered in less direct terms (though this is according to sources and codifications that post-date him). Probably, the general impulse toward the rationalization of spaces, both architectural and painted, is transmitted and assimilated more through the general environment rather than through a relationship of direct descent. As for Brunelleschi, it is interesting to remember that no information exists about the altarpiece for the Barbadori Chapel, for the Old Sacristy, or for the Pazzi Chapel: here furthermore, the altars are detached from the walls—isolated. Presumably, the altars of the tribune of the Duomo were also originally this way in the arrangement established by Brunelleschi. There can be different reasons, among which that of the inversion of the liturgical position of the priest seems quite significant, as wished by Brunelleschi and in keeping with his noted interest for the Paleochristian world. A reception of humanistic tendencies
that perhaps tend to exclude the altarpiece there we find in the well-noted position of Alberti who neither mentions it in De Pictura nor in De re aedificatoria; here instead he inveighs against the use of many altars, particularly underscoring the tendency in classical times for the placement of statues of divinities in temples.

The organization of the woodworker's craft

There is ample information on the social circumstances of woodworkers between the fourteenth and fifteenth centuries due to the exceptional survival of archival and historical material from the period. Though this kind of worker has not yet received as much attention with respect to the numerous social studies flourishing around the category of the “painter,” we can, in any case, indicate some guidelines for further study. Within the Florentine republic, organized according to a rigid corporate subdivision of work, the woodworkers were able to enroll in two different guilds, that of the legnaioi grossi and that of the maestri di pietra e legname for which the distinction mostly addressed the different handling of the material: the first were occupied with supplying timber; and the second with its further processing, be they carpenters, carvers, or masters of intarsia. The distinction between the two categories of activity is perpetuated through the following centuries, so much so that traces of it are found in Garzoni’s La Piazza universale di tutte le professioni del mondo. And from this text, which despite the intervening centuries reflects a very traditional and artisanal continuity of the craft, such that one can find the most mentions of the tools and the practices “of the ingenious art of wood working” along with some curiosities like the belief that “it has its origins in the perfidy of Cain... so that... woodworkers, since antiquity... [were thought to be] despicable and cowardly.” Along with a list
of the sub-disciplines that belong to the craft of the woodworkers,\textsuperscript{34} the identification of wood essences according to use, and a detailed list of tools, among the most interesting notes is the one that ascribes theoretical knowledge to the craftsmen: “It is still necessary to know how to use a square, use compass and paper, and know how to round off a square, and square a circle, and know how to reduce on many faces what you will.” (È necessario ancora sapere adoprarlo squadro, usar il compasso e il cartone, e saper fare d’un quadro un tondo, e d’un tondo un quadro, e saperlo ridurre in tante faccie quanto si vuole. . .), aspects of the craft that today are confirmed by observations and by studies of the dimensions and the divisions of spaces made by the woodworkers in the construction phases of their carpentry.\textsuperscript{35}

Various statutes have survived from the guild of the woodworkers (Arte dei Legnaiuoli) from 1301 to 1394,\textsuperscript{36} legislative proceedings characterized by a rigid prohibitionism governing the artisan activities of Florence, that moreover do not provide much information on the actual working activities of the members.\textsuperscript{37} More interesting is an examination of the register of the guild of the masters of stone and wood (Arte dei Maestri di Pietra e Legname),\textsuperscript{38} in which often painters also appear to be members, probably to facilitate specific activities such as that of the forzerinai and cofanai (chest and casket makers), that is, painters dedicated to the decoration of painted furniture, or simply because “with the aristocratization of the major arts of the Medici and Speziale during the Quattrocento, the craftsmen had more chances to qualify for the offices in the minor arts and therefore tended to opt for the cursus honorum in Legnaioi.”\textsuperscript{39}

The art treatises, with an exception for the encyclopedic Cennini, are skimpy as far as regards the practical construction of altar panels; but certainly not because of a lack of esteem between the contemporaries of the practice as an artistic activity; as proof, the passage from the Novella del grasso Legnaiuolo, attributed to Manetti, the biographer of Brunelleschi, who in describing the protagonist of a vicious prank, remembered that “this carpenter had his bottega up in the piazza of San Giovanni and he was at the time in this craft among the number of good masters of Florence; and among the other things that he had a reputation for making well were little tabernacles and altarpieces and similar things that were not then the practice of every carpenter” (questo legnaiuolo faceva la bottega in su la piazza di Sant’Giovanni, e era in quel tempo di quella arte nel numero de’ buoni maestri di Firenze; e infia l’altrre cose egli aveva fama di fare molto bene e colmi e le tavole d’altari, e simili cose, che non era per allora atto ogni legnaiuolo).\textsuperscript{40}

Alberti deals with wood in De re aedificatoria\textsuperscript{41} but essentially as a raw material, referring to the classical treatises that dedicated ample space to the materials, treating techniques for the felling of trees over three chapters, remedies for the diseases of wood, techniques of drying and preserving trunks and cut planks,\textsuperscript{42} and the properties and uses of various wood essences.\textsuperscript{43}

The documents of the period instead often offer detailed information on what was expected from a woodworker’s bottega at the conclusion of the construction of an altarpiece; for example in 1495 a contract stipulated by the Augustinians of Perugia with the carpenter Matteo di Tommaso da Regio recorded “Also, that said Mattia is held and obliged to make said panel at his expense for wood, hardware, and glue . . . and that the surfaces he has to paint have to be glued and joined on the back with swallow tails, that is so they don’t open. . . and also that said panel be worked as much on one side as another, and that it has not one deformity.”(Item che detto Mattia sia tenuto et obligato di fare dicta tavola a tucte soje spese de legname, ferramenti et colla . . . et che i piani che se hanno a depingere le debbia incollare et comnettere da riverso cum code de rondine, aciò non se abbia aprire . . . Item che la detta tavola sia lavorata tanto da un canto quanto dall’altro, che non abbia niuna deformità.)\textsuperscript{44}

A well-run practice should have allowed for earnings of a certain substance, as shown by contemporary documents. For example, in 1395 the Santa Felicita convent paid as much as 80 gold florins for the carpentry of a polyptych for the high altar of the church.\textsuperscript{45} The number seems rather exceptional given the need to negotiate on the estimates of the painting, but in any case, in general the expenses of carpentry account for a good 15–20% of the total expenses necessary for the creation of an altarpiece.\textsuperscript{46}

\textit{Toward the great “altar constructions”}

The rationalization of space imposed by Renaissance demands, the limiting of the number of altars—often even the removal of numerous panels without altars from the walls of the church that had accumulated over time—are all factors
that lead, in a sort of historical appeal, to renew our attention on the altar and its relevance. The great period of preaching (which opened in Florence well before the Counter-Reformation with Savonarola) posed the problem of concentrating the attention of significant crowds on a main visual focus. Hence the motivation for creating great altarpieces, visible even from a distance.

At the same time, the special sanctity of the Mass and the necessity of keeping the laity far from the altar was established. But at the same time, great effort is applied to ensure that the sacred image is iconographically clear and that above all, it doesn’t interfere with the liturgical action. Especially significant in this context is an exchange of letters between Vasari and Vincenzo Borghini about the creation of a major altarpiece in Santa Maria Novella depicting the Resurrection. The learned Abbott expressed perplexity over the positioning of the guards at the tomb of Christ within the pictorial composition, explaining that his eyes fell on them when raising the sacrament during Mass. Thus the principle is established that the devotional image should not interfere with the sacred event for which it is the background. At the time, the educational aspect of religious art is not valued as much as its supporting role for the location that it furnishes and for the function that this has. And there is a need to assign the figures and iconographic choices an ever increasing transcendence.

At the same time, the altar became a place of adoration outside of the Mass because it is increasingly there that the consecrated Host is preserved. The exclusion of the laity from the vicinity of the sacred place is increasingly justified and becomes reinforced by suitable architectural divisions, such as the raised floor with steps, and the creations of railings and gates. It is evident that in the face of all of these combined reasons, the paintings had to achieve ever greater dimensions (and greater compositional clarity) to be visible from afar, a focus of attraction, or of a song, but not a distraction from these, and that these new formal and architectural compositions of the altarpieces are directly connected to the establishment of new formulas designed to render religious themes sublime.
1 J. Burckhardt, Das Altarbild, Beiträge zur Kunstgeschichte von Italien, Basel 1898; the attention that the German historian’s text is still given in the field is shown by the recent translated re-edition, (The Altarpiece in Renaissance Italy, edited by P. Humfrey, Oxford 1988).

2 Sandberg-Vavalà, La Croce dipinta italiana, Verona 1929.


13 1224, Peter des Roches, bishop of Winchester, cited in J. Gardner, “Altars” (note 5).


20 J. Gardner, “Altars” (note 5).


23 Among the most famous documented examples of wood structures ready-made for a polypych see the polypych of the Pieve of Arezzo of Pietro Lorenzetti (A. Guersini, “Intorno al politico di Pietro Lorenzetti per la Pieve di Arezzo,” Rivista d’Arte, 60, s. IV,
Monte is cited from 1499 in which old altars are reference). Filippini, (note 28), p. 200 (with the preceding n. 717. 


Statuti dell’Arte dei Legnaioli di Firenze, edited by E. Morandini, Florence 1958 (who published those of 1301, 1315 and 1346; others, unpublished, are held in the Florence Archivio di Stato.

The regulations concerned especially the means of obtaining timber, and the evaluation of the quality of the raw materials, while for the actual craft practices, they were limited to taking into consideration the production of coffers, chests, and casks “to the measures given by the Guild” (a misura data per l’Arte).

The statutes from the guild of stone and woodworkers are lost but books recording enrollment and registers from 1358 to 1534 remain. Here there are members carrying out various crafts tied principally to the construction of buildings (stone cutters, tilers, kiln workers, rope makers, carvers, woodworkers). Among the painters mentioned in these studies are Smeraldo di Giovanni (a colleague of Giovanni dal Ponte for a certain period), Mariotto di Cristofano, and Giovanni di ser Giovanni called lo Scheggia.


Similar procedures are also described by Cennini (chap. CXXIII) and by Leonardo (Trattato della pittura, chap. 847).

According to Alberti, in antiquity they preferred to paint on “female larch” but white and black poplar, willow, hornbeam, rowan, elder, and fig were also cited. “Il legno di questi alberi infatti è non solo ben secco e uniforme, il ché lo rende adatto a ricevere le colle e gli impasti dei pittori, ma anche estremamente duttile e tale da potersi foggire in varie forme.” (p. 128).

C. Gardner, “Fronts and Backs,” (note 9).


The percentage deducted from the expenses undertaken for the polyptych of Monte Oliveto, painted by Spinello Aretino, can be seen: A. S. Fehm, “Notes on Spinello Aretino’s So-called Monte Oliveto Altarpiece,” Mitteilungen der Kunsthistorischen Institute in Florence, 17, 1973, pp. 85–89. for which, in 1384, 55 florins were paid for carpenters in relation to 100 for preparation and gilding and 100 for painting; in the case of the Adoration of the Magi of Sant’Egidio by Lorenzo Monaco (M. Eisenberg, Lorenzo Monaco, Princeton 1989, p. 215), 28 florins for carpentry, 7 for gesso, and 144 for painting, or expenses relative to the polyptych of the Carmine of Pisa by Masaccio where, in 1426, 80 florins were paid to Masaccio and 18 florins to the carpenter Antonio di Biagio (J. Beck, Masaccio: The Documents, New York 1978, p. 31).

Pensava per che que’ soldati che di necesità vengono sin medio, luogo che negli altari dove si dice messa non mi piace mai, perché gli occhi nel levare il Sacramento, non vorrei che percottessino in questa tal veduta…” K. Frey, Der literarische Nachlass Giorgio Vasari, Munich 1930, vol. II, p. 291, n DLXII.

P. Rubini, “Commission and design in Central Italian altarpieces c. 1450–1550,” in Italian Altarpieces (note 5), pp. 201–211.

Sandro Botticelli, *Lamentation over the Dead Christ*, c. 1495, Poldi Pezzoli Museum, Milan.
Botticelli’s Lamentation over the Dead Christ from the Poldi Pezzoli Museum in Milan: Notes on a Minimal Intervention and Non-invasive Imaging Analysis

Ezio Buzzegoli and Ciro Castelli

The loan of Botticelli’s painting to the exhibition held in Florence in 2004 was an occasion for the museum administration to ask our institute for an assessment of the possibility of improving the general preservation state of the painting. In fact, the prior restorations were showing all the limitations of their time—especially, the decision to create channels in the panel for the insertion of a total of three trapezoidal crossbars made of oak wood. This situation, as we will see, negatively influenced the preservation of the wood support, to which can be added the heavy color alterations of the many retouchings. As the painting was examined and analyzed with the non-invasive methods available, a conviction took shape that an urgent treatment of the wood panel was necessary, while a cleaning procedure would also have been opportune to remove the numerous retouchings that interfered with reading the painting. Treating the wood support seemed to be the absolute immediate priority, but it was thought appropriate to postpone the treatment to remove the discolored retouching since the time available was considered insufficient. However, a removal of atmospheric deposits was carried out as these subtracted no small amount of saturation from the vividness of Botticelli’s colors.

We ought to underscore how the approach put to work in our laboratory was, especially in this case, inspired by “minimal intervention,” a genuine ideological exercise that, though eschewing dogmatic suggestions, increasingly has the connotation of a new frontier toward which to lean from the planning stage. Moving from a conscious deliberation, giving thought to a fair historical evaluation of the previous work should be the point of departure for each restoration project. In our case, the dictates of minimal intervention find meaningful expression in the consistent approach for both the practical phases of work on the object in question: the process of reestablishing the mechanical integrity of the support and the removal of the surface particulates. Although these are different problems for their circumstances and procedural content, the two phases of work are both inspired from the same working philosophy that involves a time of questioning before carrying out any individual operation in which the restorer must give an answer that resolves the question on the effective need to carry out each operation, within the framework of preservation requirements, display intentions, and general use of the work of art. There is no single answer to this question, nor much less one without compromise; each of us at the time gives an answer commensurate with our experience, putting in play all the past outcomes of our own preservation background. In our case the practical choices, among which giving up gluing inserts into the crossbar channels, take into account the role of the painting as an essential historical anchor in the Florentine exhibition and the fact that this transitory situation, though perhaps not exceptional, meant in part different valuations for the indispensability of some of the practical choices. In fact, it is certainly different to think in terms of necessity in the case in which the painting is considered in a museum context,
as opposed to foreseeing its inclusion in temporary exhibitions at different sites from the usual one.

Let us begin to examine the treatment carried out on this occasion, therefore, with the first part on the support, assigned priority as already mentioned: the panel is made of poplar wood and measures 106 cm high, 71 cm wide, and has a thickness of 1.6 cm. It is made of two planks oriented vertically, one 50 cm wide, the other 21 cm, joined with a butt-join and without internal connecting elements. From direct observation, in addition to reading the X-radiograph (Fig. 1), the wood is thought to be overall of high grade, even though the wider plank, with a sub-radial cut, has a large knot passing through the upper central part with the surrounding area affected by some torn grain (Fig. 2), and more pronounced growth rings on the outer side. The 21 cm plank is a radial cut and does not show any noticeable defects. Both the planks have relatively straight grain, with a relatively homogenous texture, with wide, diffuse porosity. From the examination of the panel, there are no apparent traces or other indications of an original system of reinforcement in the form of supporting crossbars. Regarding possible systems of restraint for the deformations and structural reinforcement, the dimensions and the thickness of the painting suggest methods employing a frame or a backing board, both structures which, in addition to having an aesthetic effect, can also perform a structural function. The back of the panel is partially covered with a gesso coating (ammannitura) that seems original, covered by a red wine tone, and seems to have been damaged by a water leak about which, however, nothing is known.

The restoration of the 1950s, as already mentioned, transformed the wood support of the painting, inserting the trapezoidal crossbars horizontally in channels carved into the panel, by itself already rather thin. The crossbars were of oak and 5 cm wide on average and 1.4 cm thick (Fig. 3). The choice of wood of these crossbars is quite poor, considering the tangential cut of one length, the inclusion of part of the sapwood, the figured grain, and areas with clusters of knots halfway along the span. As for placement: one crossbar was positioned at the center, and the other two about 7 cm from the upper and lower edges. This profound alteration, in terms of changing the equilibrium in the object, turns out to have been quite invasive and damaging. At the top right, six or seven centimeters from the edge, there is a crack along the grain that has been repaired with a rectangular patch made from coniferous wood (fir), inserted by demolishing the original wood to half of its thickness (Fig. 4). When we speak of the necessity of questioning a procedure to determine the real need and the need to consider the damage produced by an excess of interventionism from the past in service to the new vision of minimal
intervention, we want to introduce the idea that Botticelli’s painting is in this sense, unfortunately, a symbolic case. A large part of the preservation problems are due to the old restoration treatment, for example the slight longitudinal crook (falcatura) that is seen around the lateral exits of the crossbars. The phenomenon is probably caused by the crossbars themselves, by applying lateral forces on the sliding faces of the channels, they have induced, over time, the deformation of the support, reduced in those areas to less than half of the original thickness (Fig. 5). These channels were made in an approximate way, so much so that the central crossbar came out of the channel midway (Fig. 6), while the other two, even though not equal in size, show clear imprecisions in contact along the sloped borders. Despite these issues, in general the support is still in good condition: the wood-boring beetle holes are few and old; the mechanical characteristics of the wood are good.

As we said, adopting the theory of minimal intervention requires asking the painting about its true “individual” needs. In our case, the aspects that called for the most attention in executing the treatment were controlling the warping deformations and that of the vertical crook; furthermore, we had to evaluate how and what to do to the crossbar channels, the real “wounds” in the load-bearing structure. On the other hand, exactly the conditions of stability in the ground in relation to the characteristics of the wood and its natural aging made us lean toward the least invasiveness possible.

3. Reverse of the panel with the crossbars from the 1950s restoration.

4. Fir wood insert filling a cavity more than half of the thickness of the panel.

5. The channel for the crossbar during the preparation for the repair.

6. The central crossbar from the earlier treatment that comes out of the channel.
Considering the fact that the four corners, already slightly warped (concave toward the painted surface), could be affected by the traction of the framework on the anchorage points to the support, the only elements glued to the original structure were applied to these points (Fig. 9). The only material impact of today’s treatment on the original integrity of the painting is thus from adhering these truncated cones of wood, with a maximum diameter of 22 millimeters and 5 mm thick. The system of attachment between the painting and the supporting framework (Fig. 10), as published several times, consists in these wood pieces in the shape of truncated cones, through the center of which passes a 3 mm screw, housed in a way as to be free to oscillate in different directions. The screw, which passes through a slot in the framework, is capped by a conical spring that is housed in a carved-out notch in the framework.

The plan foresaw therefore providing the painting with a perimeter framework, an already widely proven system, with internal crossbars able to provide the necessary support for the panel and at the same time restrain any horizontal and vertical warping deformations. With the aim of interfering as little as possible with the original object while removing material and devices foreign to the original substance and structure, we thought to take advantage of the patched crossbar channels in order to anchor the framework. This was made to the dimensions of the perimeter of the painting and equipped with, aside from the perimeter lengths, three arched crossbars with a shape in line with the average curvature of the support, positioned so as to match up with the insert repairs made to the existing channels. The crossbar channels (Fig. 7) were trimmed along the sides and reinforced halfway with inserts, made with small pieces of aged poplar wood, glued together with the wood grain parallel to the grain of the original panel (Fig. 8). This repair, on which the anchorage points of the framework was glued, did not require being glued down because it was held fast to the support by the undercut of the sloping walls of the channel. Without the four corners, already slightly warped (concave toward the painted surface), could be affected by the traction of the framework on the anchorage points to the support, the only elements glued to the original structure were applied to these points (Fig. 9). The only material impact of today’s treatment on the original integrity of the painting is thus from adhering these truncated cones of wood, with a maximum diameter of 22 millimeters and 5 mm thick. The system of attachment between the painting and the supporting framework (Fig. 10), as published several times, consists in these wood pieces in the shape of truncated cones, through the center of which passes a 3 mm screw, housed in a way as to be free to oscillate in different directions. The screw, which passes through a slot in the framework, is capped by a conical spring that is housed in a carved-out notch in the framework.

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11. The back of the painting after the treatment with supporting framework mounted.
relationships and the luminosity, so important for a painting by Botticelli (Fig. 17).

The imaging carried out (X-radiography, infrared reflectography, false-color infrared, false-color ultraviolet, and ultraviolet fluorescence) provided important information thanks to the possibility of being studied and compared with the use, now indispensable, of the computer. The capacity provided by modern computer technology of managing an ever increasing quantity of data allows for referencing images and information obtained by the imaging techniques used on the painting using different wavelengths of the electromagnetic spectrum. They can be directly compared, especially by superimposing images of the whole painting or of details, obtained with visible light, or with different types of infrared and ultraviolet detection, radiography, etc. (Fig. 18). We can envision reading the painting with an immediate and coherent response, point by point, like flipping through a book where each page holds the same view at different wavelengths. Proceeding in this sense requires an ability on the part of the restorer to use the latest generation software and computers and to employ the necessary technical support in the handling and management of digital...
least, restorers are called on to enrich their toolbox of abilities, so as to engage with and interact with this new professional figure, whose collaboration is clearly becoming ever more essential.

Ultraviolet fluorescence, known generically for its peculiar characteristic of differentiating retouching from original, also earns an added value if the results are compared with the other images. In our opinion, this ought to be taken into consideration for future professional development in the field of cultural heritage: in a laboratory like ours to which is also trusted research, we are witnessing a new professional figure located with those who are concerned with traditional image documentation, though, specifically, focused on digital images acquired with the aim of restoration analysis. At

15. Detail of the pink robe of the Madonna with discolored retouching.

16. Surface cleaning to remove superficial deposits.

17. Recovery of the luminosity of the paint during cleaning.
non-destructive methods. Through this technique, we have been able to demonstrate the presence of some major retouching on the right sleeve of the red robe of Saint John which comes from a very recent treatment as it is clearly on top of a varnish applied in a prior restoration campaign. The manipulation of the digital image has improved the interpretation of this kind of traditional examination, above all for the ability to optimize in different ways the overall versus the details of interest (Fig. 19). Again with regards to ultraviolet wavelengths, another technique has been added recently, that though already in use, has shown little adoption due to the difficulty of interpreting the resulting tones of grey. This is the technique of UV reflectance transformed, specifically for ease of interpretation, into a false-color image (Fig. 20).
The X-radiography imaging, beyond the issues concerning the panel, has revealed a series of adjustments and shifts to the faces and other anatomical details. Aside from the quality of the result which takes advantage of the ability of obtaining the image on a single film, the possibility of compensating for heterogeneous areas on a digital image, for example where the crossbars are removed, or superimposing the visible light image with variable transparency, or interpolating with the other imaging, adds a significant value to the analysis. We are able thus to appreciate every detail of the modifications made by the artist when he was executing the painting. These corrections, quite visible in the X-radiograph, do not change the composition, but serve to adjust profiles and gestures, part of an entirely comprehensible modus operandi within the creative process of the master, who is certainly not in awe of his own design, drawn out or sketched on the panel; he adjusts and corrects it humoring the impulses of the creative act. In artists of less substance, these variations tend to be rather less frequent (Fig. 21).

An entirely different category is instead the true pentimenti brought to light by the infrared reflectography, an imaging method that, as mentioned, reads the layers of the painting down to the preparatory drawing. The superior quality of the images that we rely on is assured by a custom-made scanner, in use at our Institute, and which, as rarely happens, was planned and constructed just for reflectography of works of art. The resulting images are by far superior in terms of resolution and sharpness to any other analogous system (Fig. 22). In the Lamentation, as in all the paintings by Botticelli examined in the infrared, three types of marks are seen: one lighter than the others, made by a dry tool that appears occasionally; another, also a dry tool, quite strong and deliberate that outlines faces and other anatomical contours (Fig. 23); and finally a third, a brush mark, meaning a liquid technique, that renders robes and anatomy in a kind of monochrome (Fig. 24). One suggestion on the use of these three materials is the following: on the prepared panel the artist marked out the composition with charcoal, following what was certainly planned first on paper; then with the brush dipped in what Cennini called acquerella d’inchiostro or watercolor ink, he reinforced and traced over the drawing, and with the same, sketched in monochrome the scene, except for obviously the areas where the final color would require the absolute luminosity of the ground; then the rigid mark of a pietra nera or black chalk is used to indicate the features of the faces and those passages that in his opinion the brush had not sufficiently indicated.

In the painting, two changes were detected that were made in the course of the work that
21. X-radiographs showing the changes; interpretation is aided by superimposing a partially transparent visible light image.
are significant for the study of the composition in general. In comparison with the final version, the head of Saint John (Fig. 26) appears in the underlying brush drawing to be angled more toward the shoulder of the Madonna, almost as if to enfold her in a gesture of compassion; on the other hand, the face of the saint, made with more foreshortening, shows less expressiveness than that evident in the actual painted version. On the left side of the scene, the plane on which the mantle of the Maria who covers her face is painted is shifted forward in a primarily compositional adjustment: in the preliminary version, her arm dressed in blue covers part of the red sleeve of Saint John, leaning forward toward the bottom, and it is found in the same spatial plane as the body of the Madonna. This change appears in the final version as an overall retreat of the body of the saint to a more oblique position, so as to conform to the more angular dynamic of the depiction of this figure, central to the representation from a formal point of view, but also for the emotional strength expressed by the image. The hypothetical reconstruction of the earlier idea⁹ (Fig. 25) shows a greater circularity of the composition, especially
25. Digital reconstruction showing the underlying first version of the composition as revealed by the IR reflectography.
in the central part which in some way tends to isolate more the figure of Nicodemus (or Joseph of Arimathea, according to an alternative iconographical interpretation) captured in the gesture of showing the tangible signs of the Passion of Christ. The final compositional plan foresaw, instead, an interruption of the circular flow created by the figures kneeling around the Madonna with the dead Christ in her lap, defined by the more upright head of the saint which helps connect the principle group with the background figure, positioned on a plane farther away from the viewer but certainly not less meaningful.

Other passages of the drawing belonging to an earlier design, aside from the modifications of the features already highlighted by the X-radiograph, are associated with the arm of Christ (Fig. 27), which was positioned more toward the sternum, in a less relaxed way from the final painted version. The drawing marks and the tools used are distinctive to the artist and have been documented by other infrared reflectography on securely known works.

The images in false-color IR have shown, with a non-destructive technique, the use on the part of the artist of two different pigments to make the same color. The mantle of Maria with her face covered appears in small part to be made with ultramarine (lapis lazuli) and in large part with smalt (smaltino). This curious detail, certainly identifiable with the randomness of the creative moment, appears clear when the images taken with two types of false-color IR are compared (Fig. 28). At the two different wavelengths, thus two different false colors, the ultramarine doesn’t change color, remaining red, while the smaltino generates a blue tone at 1600 nm. With the same technique, the
28. Comparison using false-color showing the mantle of the Mary with her face covered.

29. Different types of retouching in false-color.
necessary to carry out a treatment. The work then becomes ever more careful of “economic productivity” because its absence from the display environment is considered a loss. Our idea, therefore, is to take advantage of modern technologies of mass (or not) dissemination, to create effectively a direct line for the restoration, a service of cultural aid that transforms that loss into opportunity for collaboration and growth. This idea will certainly be developed and enriched by programs that consider case by case all the associated implications. For our part we are however already able to establish the creation of this kind of event, and willing to take the opportunity to share knowledge and awareness of restoration.

2 See the technical records from the official museum website: www.museopoldipezzoli.it.
3 On minimal intervention, see the acts of the conference: Cesmar 7 in Thiene (VI) 29–30 October 2004.
5 On this subject, which represents an absolutely new finding, see OPD Restauro, vol. 16, 2004, for the explanation regarding the executive technique and associated interpretation.
9 The reconstruction and the associated processing of the images from the infrared reflectography was carried out by Diane Kunzelman.
The structure, condition, and treatment of the panel of Rosso Fiorentino’s Pala Dei

Ciro Castelli, Mauro Parri, and Andrea Santacesaria

At the end of the seventeenth century, along with other panels of the Palatine collection, this painting was subjected to an invasive treatment expanding its dimensions and affecting its entire perimeter. This change, aside from modifying aesthetic and formal qualities as illustrated in the contributions of Marco Ciatti and Serena Padovani, has overloaded the original structure of the support with tensions. This was found to be due to the presence of the added planks arranged in an unorthodox way with respect to the original panel whose movements were affected by fluctuations in relative humidity. Though this practice of making panels larger also affected other paintings of the same collection (examples being the Assumption of the Virgin and the Annunciation of Andrea del Sarto, the Pala Pitti of Fra Bartolomeo, and the Madonna del Baldacchino of Raphael, paintings restored previously by the laboratory of the OPD), the Pala Dei represents a case apart, as the extensions and the requirements of this treatment involved all four sides of the panel.

A preliminary assessment was carried out on the painting to evaluate its condition, including both the original part and the late-Seicento extension, with a view to its likely inclusion in the exhibition “L’Officina della Maniera.” What was found was a series of damages directly due to the attachment between the original and the addition; this made us evaluate whether or not it was right to continue to keep the two parts together or, alternatively, consider the possibility of adjusting the connection so as to neutralize the tensions. This latter operation was not only possible, but found to be preferable, given the condition of the painting. From a critical examination of the painting, numerous signs emerged of structural suffering that had been underway for a long time and was even now still active; there was evidence of numerous treatment campaigns carried out over time (both on the original and the extension) with the purpose of repairing damage produced by this union. The most serious effects were due to phenomena in the original panel that resulted in repercussions for the ground and paint layers. The condition of the painting brought us to differentiate between causes of deterioration that were superficially similar. Specifically, the complete detachment of the added external plank on the left from the remaining planks of the panel could be interpreted, from a rigorously conservative viewpoint, as a point of release for the forces generated within the modified wood structure, while the cracks developing on the upper and lower margins and within the central panel are from a different cause. The first phenomenon is, in fact, the final result of the discharge of induced and ultimately stabilized tensions, the second, instead, with the white ground exposed, illustrates a developing process still underway and consequently much more dangerous.

A large part of this damage could be blamed on the complex and overly rigid attachments between the original and extensions which consisted of the following: an L-shaped join carved out of the internal perimeter of the added part which housed the full depth of the original panel; a series of iron brackets inserted into the edges of the addition and screwed into the back of the panel; some
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connecting screws placed along the area of the L-join; and a series of nails diagonally inserted into the sides. Furthermore, a coating of tow (stoppa) and hide glue was applied to fill the imperfections around the joins between the two parts.

Certainly from such an assembly, formed from planks arranged with the grain running perpendicularly, the stresses induced are strong. Along the upper join, the lines that define the architecture in the added part compared with the original provide a gauge of this. Along this junction, the lines of the architecture show a misalignment of two to three millimeters, varying from area to area. This situation indicates that the original painting, about three hundred years after the extension was added, has contracted by about 2 millimeters. This gives a concrete idea of the forces that the original panel would have had to use to move, notwithstanding the existence of the strong attachments described earlier. We can hardly imagine that such movements are stabilized once and for all; it is certain instead that they will continue, though not constantly in terms of extent and direction.

Another critical aspect is the original crossbar system still present. The two crossbars have been covered on the sides by the extension and therefore any check or adjustment would have been impossible. To this end, it is also unclear how much its “function” may have contributed to the formation of the cracks at the center of the panel. It cannot be ruled out that over time, the two fir wood crossbars inserted into trapezoidal channels carved into the back of the panel were excessively rigid. Also worth bearing in mind are not just the dimensions of the painting, but rather the characteristics of each plank, especially the three cen-

1–4. Details of the paint surface showing original and addition. The misalignment of the lines is evidence of the contraction of the main panel since the time of the enlargement to today.

5. Diagram of the panel of the Pala Dei.
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The structure of the panel incorporates the three widest planks at the center with two pairs of narrower planks on the sides. The dimensions and the cut of wood of the individual planks, beginning from the right to left (as seen from behind) are as follows:

Plank 1: 247.6 cm high, 19.8 cm wide, sub-radial cut
Plank 2: 247.6 cm high, 19.5 cm wide, sub-radial cut
Plank 3: 247.6 cm high, 36.3 cm wide, intermediate cut
Plank 4: 247.6 cm high, 43.6 cm wide, intermediate cut
Plank 5: 247.6 cm high, 38.4 cm wide, intermediate cut
Plank 6: 247.6 cm high, 24.6 cm wide, sub-tangential cut
Plank 7: 247.6 cm high, 29 cm wide, sub-tangential cut

method of attachment, rendering it harmless but at the same time functional, and above all to harmonize the life of the structure of the original with the extension. Separating the parts was possible without damaging the original paint surface thanks to the presence of fills and retouching along the junction remaining from past treatments carried out to compensate for the shrinkage of the wood occurring over centuries. At this point, some details of the plan needed to be verified with the help of the X-radiographic examination, specifically if there were other connections between the extension and the original that were not visible. This examination of the structural connections confirmed the presence of deep gaps between elements of the support, and also the positions of nails placed diagonally along the joins. These had been bent back into the wood, filled, and subsequently covered with ground.

With these conditions in mind, it was possible to develop a plan to separate the pieces within a treatment of limited scope, allowing us to improve the system of attachment, rendering it innocuous but at the same time functional, and above all, seeking to harmonize the original with the addition.

Construction technique:
The painting is composed of seven poplar planks. The dimensions of the panel are 246.7 x 212.2 cm with an average thickness of 3 cm.

7. Diagram of the assembly of the panel with the double-dove-tail inserts.

8. Diagram showing the application of the crossbars in tapered, trapezoidal channels. Both were inserted from the same side of the panel.

The structure of the panel incorporates the three widest planks at the center with two pairs of narrower planks on the sides. The central planks have an intermediate cut, close to sub-tangential.

The dimensions and the cut of wood of the individual planks, beginning from the right to left (as seen from behind) are as follows:
Observing the reverse, we can ascertain that the wood used is free from obvious defects; the grain is slightly diagonal in the sense of both the width and depth of the panel. This phenomenon is mostly apparent on the upper part of the central plank and its borders; there is a decisive tendency for grain separation due to ring shake in correspondence with the crossbar channels.

The planks were partially planed on the back individually. They were then arranged vertically with the internal sides facing the ground, assembled with butt-joins and glued with casein; no internal connecting elements were found. All of the joins have been reinforced from the back with walnut, double-dovetail inserts (excluding that between the first and second plank which was only glued). These inserts have an average size of 14 cm wide, and range in height from 2.5 to 5 cm. These were placed in a relatively even way about 8 cm from the top and bottom edges. The back of the panel was partially smoothed horizontally with a tool like a scrub plane (sgrossino) with a relatively flat blade; the front side shows similar planing, as is visible in the X-radiograph.

The panel is supported by two fir wood crossbars that measure 8 cm high and are 6.5 cm thick. They fit into tapered, trapezoidal channels carved in the panel 1.3 cm deep. These are located 31 cm from the edges of the panel. The restraint from the crossbar system is not very consistent, but makes contact only in certain points, as the execution of the channel is very imprecise. The crossbars were finished on the back with an adze.

The materials chosen for the construction of the panel are of good quality; the same cannot be said for the execution technique which appears rather rough. Furthermore, the presence of some holes passing through the crossbars, absolutely not inherent to the structure, suggest that the lengths were recycled beams or other wooden pieces used before.
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The structure of the extension

The conservation history of the Pala Dei is tightly tied to the work incurred when it was moved from the church of Santo Spirito to the Palatine Gallery. The painting was extended on all sides by a poplar structure composed of four planks arranged like a frame with half-lap joins in the corners. The two verticals are 351 cm long and 27 cm wide, while the horizontals are 260 cm long; the one at the bottom is 21.5 cm wide, at the top, 83 cm. The upper plank was further extended at the ends with two strips and a small insert. The average thickness is about 6 cm. Incorporating this extension gives the painting a total size of 260 cm x 351 cm.

The original panel was first planed down on all four edges, creating a slight slope toward the back; this operation is discernable both because of the total lack of traces of original workmanship such as drip marks or slightly rounded margins from finishing of the ground and paint layers, and...
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by checking with a 90° square. Such a procedure probably facilitated its insertion into a support in the seventeenth-century structure without incurring friction from the movement of shims. The painting rests on a perimeter rebate carved out on three sides of the structure and at the top made of a strip glued and nailed to the upper plank. The pictorial surface was therefore at the same level as the front surface of the extension. The panel was fixed along the perimeter with hide glue, tow, handmade screws with large heads, and nails detected thanks to the X-radiography. (These are about 7.5 cm long with a shaft of 5 mm in diameter, inserted diagonally from the front through the surface of the addition and anchored into the panel, seven along the right, six on the left, and one at the top). The attachment is further reinforced by sixteen iron brackets, four along each border, in slots carved in the internal sides of the extension and held on the back of the original panel with pairs of handmade screws and twenty longer screws inserted along the border of the internal rebate. The original panel has one further link to the extension: two fir crossbars are nailed to the vertical added side planks, rest against the original crossbars and are connected to them with two long metal screws tightened with wingnuts.

As mentioned in the introduction, the preservation history of the Pala Dei is one of an extensive series of examples of paintings that were tampered with for display in the Palatine Gallery. While our painting is an extreme case, we can observe some similar unusual features and parallels with what has happened to other paintings. In the case of the Pala Pitti of Fra Bartolomeo, the seventeenth-century upper addition (that follows another earlier one from 1588 made for the church of
that the process of dimensional modifications affected the original panels in different ways; though Rosso's panel has stayed flat, the tendency to warp of the Madonna del Baldacchino probably rendered necessary the treatment of 1830 in which it was thinned and cradled.

The condition of the panel

The modification to the structure of the panel has seriously undermined its condition. The restriction imposed along the perimeter has created dangerous stresses in the panel that have been released along three sides along the joins between the original panel and the additions; on the left edge, instead, the attachment to the original panel has remained mostly intact while the plank on the left has completely detached from the rest of the panel with a gap of 3–4 mm. The transverse contraction of the planks of the extension and the original panel across its width has certainly contributed to the situation. Within the support, the
stresses have caused numerous splits that pass through to the paint surface. The surface of the panel appears flat and the well-adhered paint layers indicate that the induced stresses generated over time are along the areas mentioned earlier and do not cause compression contraction of the grain on the front surface, thus do not cause diffused lifting typical of supports under strain thanks also to the flexibility of the ground. In addition, the particular conformation of the wood grain with diagonal growth rings induced numerous cracks and ring shake in the central panel in the area above the upper crossbar. Analyzing the damage caused by the construction of the panel itself, we also see small cracks that are not very deep at the ends of the double-dovetail inserts, a sign of poorly absorbed tensions in the panel centered on the original internal joins.

The structure of the extension has a vertical cut in the plank positioned at the bottom in correspondence to a separating join in the original panel. This cut, carried out in a period after the extension, caused an interruption in the grain that was repaired with glue, plaster, a nail inserted diagonally through the edges, and a metal mending plate (29 cm long, 2.5 cm high, and 5 mm thick) screwed to the back with four machine-made screws. Furthermore, on the same line, the separated join in the panel was reinforced with four metal plates, similar to the ones described; and the application of the elements at the top and bottom near the edges made it necessary to remove the seventeenth-century brackets located in those areas. Along the join, tow was adhered with hide glue. This operation was required, most likely, in order to reconnect the edges of the join and diminish the gap caused by the detachment of the planks of the original panel.

**Restoration treatment**

The painting was set up vertically on its side so that both surfaces were easily visible during the various operations. Along the line of the joins between the original and the extension, earlier subjected to cleaning and removal of the fills, the screws and metal brackets were removed. The location of each element was noted with care. Then an oscillating saw with the smallest width blade
(0.5 mm) was inserted. This power tool, with the brand name Fein, allows thin blades to be used with an oscillating movement similar to that of a manual tool. Thanks to the extremely good handling, it was possible to carry out a very precise cut and therefore work along the entire perimeter of the original painting, perpendicular to the paint surface, cutting through the diagonal nails, and along the back of the rebate along the surface of the panel. In this way, the L-section on which the painting rested was completely detached. The screws with the wingnuts that held the transverse lengths of the extension to the original crossbars were removed and then, the freed painting was removed and set up on shaped and padded rests.
in order to be worked on. As mentioned, we had to be careful that the freed panel did not undergo any deformations that would compromise its re-insertion into the structure. Therefore, before dismantling the structure, the shape of the upper and lower edges of the panel was measured and strips were cut to fit which were clamped to the surface after it was taken apart.

On both parts of the support, a preliminary cleaning was carried out, removing the thick residues of hide glue and tow; the procedure was done by swelling the material with demineralized water in a 2% Klucel poultice followed by mechanical removal. On the back of the panel, the wood was cleaned by simply vacuuming the deposited dust.

The panel, above all, needed to be reinforced by stabilizing the connection between the left plank and the rest of the panel. The splits that extended through the panel also needed to be repaired. For these procedures, the crossbars were extracted as it was apparent from the beginning that they were made poorly and did not fit well in their channels.

The plank on the left was aligned to the panel so as to achieve planarity overall. The procedure turned out to be rather complex because in some points the wood had broken in an irregular way. Consequently, along the upper and lower margins, the reinforcement began with re-adhesion where the contact between the elements was greatest. Two short grooves were cut with the electric router with the aim of minimizing the opening and reducing the invasiveness of the repair. Aged, poplar wedges were inserted into these with a PVA adhesive. Next, the remaining groove for the wedges was cut in straight sections. The join was repaired with the alignment and leveling of the edges of the paint surface with tie-rods and the insertion and gluing of small wedges along the groove. This procedure was carried out following a technique developed by this very laboratory in which the objective is to bring back into plane, where possible with slight pressure, the separated paint surfaces. With the same technique of reinforcement, the cracks present in the rest of the panel were addressed. These cracks had developed along the grain of the wood and followed a diagonal path with respect to the thickness of the wood; notwithstanding this, it was possible to cut very narrow triangular channels with an electric router resting on a sloped surface; in this way it was possible to completely follow the path of the cracks.

Improvements were also made to the panel in the area of the double-dovetail inserts which had shown signs of breaks in the grain located around, as

29. The painting detached from the extension seen from the back.
30. Removing the glue and tow and other residues on the back of the support.
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is typical, the points of the inserts due to differential movements of the wood. In fact, these elements, positioned with their grain perpendicular to the panel, restricted normal micro-movements and were a source of tension and possible cracking in the panel. These were certainly very old marks of tension and therefore, in order to respect the integrity of the whole and seek a coexistence without risk of new stresses, the edges of the inserts were trimmed with the blade of the oscillating saw, creating a gap that could allow the elements to coexist without conflict. This choice represents the recent practice of the laboratory which meets the requirements of respect for the inherent characteristics with a simple and rather limited procedure, visually nearly imperceptible, but functioning to neutralize eventual conflicts between the elements placed with perpendicular grain.

The channels of the crossbars appeared from the beginning to be imprecise and the contact, as
mentioned, was only in certain points. Additionally, the larger spaces were associated with the ends where the restraint preventing deformations of the panel was nearly nonexistent. The practical priority required regaining greater functionality from the crossbars, especially for when the original panel is remounted into the extension and only they act to prevent deformations. Therefore, the sloped borders of the channel were slightly straightened without interfering with the bottom, using a circular saw placed on a guide fixed to the surface of the channel. In the new channels, the lower parts of the crossbars were inserted with precision; these were made by separating the old original bases and making them thicker with fir wood strips, suitably straightened. These pieces were 14 mm thick, not much more than the height of the channel and were worked in such a way as to concede a certain freedom to the central part of the panel, while fitting well at the edges. The reason for this choice was to recreate that slight play that is achieved naturally between crossbar and support over the centuries;
33. Steps in the treatment of the separated joins. Some fragments of wood and paint are re-adhered before the reinforcement is completed with wedges.

34. Cutting the grooves for reinforcing the joins with the electric router.

35. The router in position over the groove. The angle is about 14°.

36. The repair of the join carried out with aged poplar wedges.

37. Reinforcement of cracks carried out with the electric router for short intervals, reducing to a minimum the removal of original material.
38. The oscillating saw allowed for the creation of a minimum of space between the double-dovetail insert and the panel to reduce tensions between the two.

39. Detail of the double-dovetail insert. The contact between the edges and the panel was reduced and a thin gap was opened to prevent tensions.

40. Detail of the original channel of a crossbar seen from the side. Imperfections and irregularities are visible from its workmanship.

41. The sloped borders of the channels were straightened. The lower parts of the crossbars were widened to fit the new channels.

42. A stress test for the crossbar in the channel and the margin of play of about 1 mm between the elements. This play has the function of lightening the tensions between panel and crossbar.

43. The base of the crossbar built out and the main body adapted to the slight curvature before the final gluing.
additionally, in our case, it meets another detail of the anatomical conformations of the planks of the panel which, as seen, though on one side they have proven very stable in maintaining a general planarity, they have in any case a tendency, when faced with tensions, to warp. Furthermore, the greatest tensions were concentrated in the central plank with unstable and deep cracks; these were caused by the imprecise crossbar channel which created stresses on the center, and by a certain weakness in the grain of the central plank which
showed signs of ring shake. We believe these procedural choices should compensate for these deficiencies of the support.

The main body of the crossbar was adapted to the slight curvature of the base and the two elements were glued with PVA adhesive.

Checks were made to verify if there were tendencies to particular deformations in the planarity of the panel by using two shaped strips placed at the top and bottom; this was carried out with the aim of reapplying the crossbars. At the end of the work on the support, the strips were removed and the panel was seen to have maintained its initial surface shape.

The back of the extension was also cleaned at the beginning of residues of glue and tow. Then, some small splits were reinforced and the mechanical continuity of the bottom piece was regained; this had been sawn across the grain in correspondence to the separation in the original panel to allow, in a past period, the realignment of the paint surfaces. The cut ends, after the removal of a diagonally placed nail, were given a channel in the center to house a false tenon, again of aged poplar. The channel had a thickness equivalent to a third of the total and was hidden on the inside.

The re-insertion of the painting inside the extension foresaw, as is clear, that the two elements would coexist in an independent way both in terms of the wood and for the ground and paint layers. Just as the paint surface remained marked by a line of interruption all along the perimeter of the original, so too the support was fixed in such a way as to not jam or create tensions and therefore allow movement that is absolutely not impaired, similar to that of being housed in a frame.

This is why the rebate was lined with Neoprene so as to guarantee a cushioned surface to rest on. Next, the reinstallation of the painting foresaw the use of the brackets and screws that were already present without resorting to using additional materials that would have necessitated new anchorage points. The original heart would find a stable position without risk of tension.

The brackets holding the painting to the extension were cleaned of rust and slightly reduced in volume to be able to fit again easily into their spaces. In addition, the parts in contact with wood were protected with Ferox in order to impede new oxidation. The holes were enlarged and the seventeenth-century screws, both those for
the straight brackets and those on the L-shaped brackets, were cleaned of rust, reinserted with the use of PVC washers and Bauer springs, so as to render their action frictionless. The two transverse lengths of the extension were replaced in their original positions and secured with screws; the area of contact with the vertical planks was built up with aged poplar. Finally, the long screws that connected these lengths with the crossbars were reinserted into holes that were made slightly more spacious and tightened lightly with the original wingnuts.

To prevent wood-boring beetle damage, the back of the support was treated with Permetar insecticide dissolved in mineral spirits. It was then protected with 4% microcrystalline wax dissolved in petroleum ether 100°–140°.

These procedures are protective measures as part of a preventive conservation approach against eventual biological attack and for the exchange of relative humidity with the environment. The painting will be displayed initially without the frame into which it will be inserted on its return to the Palatine Gallery. At that point, the back of the painting will be closed with a panel which will have the job of slowing the exchange of environmental humidity and offer a significant protection to the painting. With this last touch, the treatment of the panel will be concluded, making a positive transition between the phase of restoration and that of preservation.
Painting in Pisa in the Duecento: Observations on artistic technique

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Introduction: Problems of technique and of method

We received an invitation from our Pisan friends and colleagues to contribute to the catalogue of the exhibition Cimabue a Pisa with an essay on artistic technique both with great enthusiasm and with apprehension about not being up to such a difficult task in a short timeframe. However, the opportunity appeared too attractive to be missed and we did not want to be discourteous by declining. Therefore, we tried to follow a path that would allow us to reach some conclusions, albeit in a limited way, but that would not presume to exhaust the vast subject, but rather sow some seeds that could be cultivated more in the future. The research project therefore foresaw examining and gathering data on a limited number of artworks, chosen among those included in the exhibition so as to be sufficiently representative of the different artistic personalities. Given that the scope of research was to identify characteristics of the execution technique and not a systematic study of each single painting, some kinds of analysis, such as x-radiography and infrared reflectography, were not carried out as blanket procedures, but only on significant areas, after a preliminary examination. For this reason, the title of this contribution does not refer to a systematic identification and cataloging of techniques used in all Pisan painting of the Duecento, but rather to some findings that we hope can define the challenges that can be delved into further in the future.

At this point, we want to offer two clarifications on why, in our opinion, this type of study is so difficult to do and also why an institute of conservation and restoration such as the Florentine Opificio has such great interest in research on artistic techniques. An average museum visitor, and many of our art historian colleagues as well, might believe that the problem of correctly identifying an artist’s technique is almost trivial and that it is done with an easy visual assessment that can frequently be reduced to a few words like “tempera on panel” or “oil on canvas.” In reality, the problem is much more complex and nuanced. Experience teaches us that we must avoid simplifications and individually confirm each case even for what we think we already know because it is not uncommon to uncover distinctive traits or significant variations. The variety of painting schools through the centuries in Italy obviously lays the groundwork for the possibility of wide technical variety, but we have to keep in mind that for each artist, the technical choices are directly correlated, in an inseparable manner, to the expressive effects that are intended. Thus, even in a homogeneous technical tradition, the single artist is capable of using the same materials in slightly different ways in order to create specific formal and stylistic effects.

To this basic difficulty, we should add those that derive from the scarcity of studies produced in Italy on this theme which has instead been studied more carefully internationally. It is obvious that a substantially idealistic turning point in art historical studies in Italy contributed to this, often offering a refined reading of stylistic and expressive values without addressing the artwork’s material nature. In the international sphere,
however, the nineteenth-century positivism for the multifaceted, polyvalent reality of the work of art created a greater tradition of attention for these material qualities. The beginnings of a technical literature including that for Italian paintings can be traced back to Eastlake and Thompson while to Merrifield can be ascribed the assembly of the first and fundamental collection of treatises on medieval art. This entirely Italian, partial disinterest sometimes led to an art criticism that evaluated an artwork in an abstract manner, as if it were only a two-dimensional photograph, detached from its context both in the sense of its original historical environment—for which, though, we have the support of document-based historical research that is well-represented in Italy—and in the sense of its material creation. The misunderstandings and the incomplete assessments resulting from this approach are apparent to anyone and have recently received more than one revision.

The theoretical approach of our group, while not backsliding into the naive, positivistic determinism of Semper who saw stylistic evidence as a consequence of material requirements, proposes a discrete re-assessment of technical aspects in the context of a more systematic reading of the artwork. We see a painting as made up of a series of materials produced according to specific technical methods, as well as values, meanings, and content that are instead intangible, and to which the artist and the passage of time has added layers. The two moments are, therefore, not separable, just as the substance and image are not, according to the theory of Brandi, in as much as the values, the meaning, and the content that we admire so much in the artworks achieve fruition only through their constituent materials with which they are indissolubly linked. The material form is therefore the location—to put it in the noble terms of the Sienese scholar—of the epiphany of the image. This brings us to consider very carefully the materials themselves, especially for those focused on preservation, in that each change, limitation, or loss of the material must immediately, and without the possibility of reversal, mean an alteration, a limitation, and a loss of the values of the artwork itself. This coexistence of many, diverse series of significances is at the root of the ambiguity in reading a work of art that contributes to the fascination that it exercises on each of us. In this accretion of materials, we find the values, the significance, and the content of a defined historical moment concretely represented, in substance the expression of a society that we read not only in scholarly pages, but that we observe in its physical concreteness.

Therefore, this complex nature of a work of art leads to the possibility of applying many different keys to reading it, each one of which highlights an interpretive layer: thus we have a reading connected with the application of an artistic technique; a historical reading in which its reality is defined by a patron, a workshop, and the viewer; a formal and stylistic analysis of the whole made up of shapes, lines, and colors; an iconographic analysis of the forms that the content has assumed; and so on, as many readings as there are critical trends. As semiotics would say, it is a signifier with many meanings.

Therefore if we intend on arriving at a correct reading of this object from the many possible interpretive angles, it is evident that we can not privilege some to the detriment of others, imposing a hierarchy on their relationships. Only an analysis conducted simultaneously using most of these methods can provide us with the fullest understanding of the artwork. In this sense, research on artistic techniques—though complex and difficult in part because it requires the use of varied instruments and specializations—can certainly not be considered secondary and it is a merit of this initiative of our Pisan colleagues to have also included this aspect in their project, which aims at last at furnishing a well-rounded historical reading of Pisan painting of the Duecento.

Some might think it strange that the Opificio, dedicated institutionally to conservation and restoration of works of art, has such a great interest in research on artists’ techniques. Therefore, I would like to clarify the reasons and explain that it is not a secondary aspect, but is of fundamental importance. The theoretical tradition of the Italian school of conservation holds that restoration—before being a collective series of more or less complex and delicate technical procedures—represents a moment of encounter between subject and object, and therefore of understanding and interpretation. As we have already mentioned, we see the constituent materials and the intangible values as simultaneously present in the artwork: only from the most thorough understanding of each can the elements be found that determine the choices that lead to the development of a restoration plan together, naturally, with some general theoretical guidelines. Therefore, a restoration should have two purposes that converge and unite in the treatment plan: on one hand ensuring that the constituent materials can
continue to survive through time without alterations that change their natures; and on the other, that the artwork can communicate to the viewer in a faithful way all of its values, meaning, and content. In order to completely fulfill these purposes, knowledge is the indispensable starting point. Specifically, knowledge of materials and techniques can allow us to understand the functioning of these extraordinary apparatuses, born to carry out various functions, but substantially to communicate their content to the viewers of their times and that we read today loaded down by further historical properties. Along with the interpretation of intangible factors, the basic information for setting up a conservation plan includes the materials, their method of execution, and their behavior over time, both in relation to aging in the environment in which the artwork is preserved and the effects from preceding human actions, carried out for the purposes of restoration or other reasons. This is exactly why a laboratory that deals with the conservation and where necessary, the restoration of works of art has its obligation first of all to understand as clearly as possible how these are made, with which materials and techniques, and how these are connected to producing expressive properties. This is the only way to have the tools to make that journey of continuous and successive choices that constitutes the activity of conservation.

If we ask ourselves which tools we should use to reach the desired level of understanding, we can list the specific literature of research on artists’ techniques, though rather limited in Italy for reasons already explained, supplemented by gleaning what we can from publications on restorations of individual artworks; medieval art treatises with the necessity of interpreting and contextualizing them so as to not risk historically untenable ideas; and finally the works of art themselves. These objects are true documents of themselves and of the technological culture of the environment that made them and they can reveal a lot of information if properly queried. In this regard, besides meticulous visual observation with various aids, technical analysis provides consistent support for us today: above all methods using light of various wavelengths which do not require invasive sampling procedures, those being in any case destructive, independent of the way in which the analysis is conducted on them. Over the last twenty years our laboratory has sought to develop these non-destructive techniques and especially to make them part of daily operations.

In establishing these firm methodological points, we don’t pretend to claim something new: we contribute to developing an approach that our predecessors in this field already had. We cannot omit, in fact, the numerous studies and keen interest that Ugo Procacci, the founder of the Laboratorio di Restauro dei Dipinti, and active until 1932, demonstrated in research on artists’ techniques. As everyone knows, it was his research that shed light on the technique of fresco painting through some famous exhibitions and publishing initiatives, and that he reintroduced the close reading of the text of Cennino Cennini’s treatise on art as a guide for the interpretation of fourteenth-century Florentine painting. Even for Procacci, however, the interest in artistic technique was not isolated, but combined in a usefully synergistic way with conservation. It is enough to reread his writings in the introductions to some of the periodic exhibitions on restoration organized by the Soprintendenza, quite appropriately, as a public accounting of the activities carried out by the Laboratory, or rather the more detailed reports at the restoration conference held in Pistoia in 1968, in order to understand how grasping the inner workings of art is the basic foundation for the concrete tasks of restoration. His capacity to effectively put together the results of research using historical documents in archives with a detailed knowledge of the heritage spread across the territory when it still had a real sense, along with an understanding of artists’ techniques laid the foundations for one of the most exemplary and effective periods in the history of conservation in our country.

Umberto Baldini, who inherited the facilities and the approach, developed and updated it repeatedly, establishing the foundations for his actions on two pillars: one being the method, that is the methodological rigor derived from a study of the Italian theory of restoration, and the other science, seen as the best tool for investigating the physical reality of the artworks as was reiterated by the title of the famous exhibition of 1982. And since that time, the laboratory at the Fortezza has favored the progressive changes in the world of science and technical analysis, enjoying continuous collaborations with the research institutes developing these. One of the undeniable historical merits that Umberto Baldini was recognized for, at a national level at the least, was transferring this methodological approach and use of the latest analytical techniques to the other fields of restoration brought together under
Another fundamental milestone was in the catalogue of the exhibition *Le muse e il principe: Arte di corte nel Rinascimento padano* of 1991 at the Museo Poldi Pezzoli, Milan, in which, for the first time, technical examinations were not linked to the execution of a restoration treatment. Since then, there have been many occasions in which the laboratory has concentrated on investigations tied to artistic technique, both within practically all our restoration treatments, and for independent projects. It happened that it is exactly that technical analysis, both in terms of history and that of the materials, that brings us to, as in the case of the Madonna of Santa Maria Maggiore in Florence, a totally new assessment of the artwork with serious consequences for chronology and the history of art, in part connected with the themes presented on this occasion.

After this methodological preface, so important to us for underpinning the role and meaning of our contribution, we must approach the specific characteristics of the research case that has been proposed to us by our Pisan colleagues which has raised so much interest. Art in Pisa in the thirteenth century, or rather beginning in the last decades of the previous century, played an essential role for the entire regional and national artistic development. As has been highlighted by historians over time, the arrival of a series of influences from Byzantine painting brought a renewal to the expressive language with respect to the local Pisan and Lucchese traditions, represented by a series of painted crucifixes still present in the two cities (especially the Lucchese one of Sarzana restored at the Opificio) and to the oft-pointed out, mysterious Roman-Umbrian strain that is never critically defined. This renewal seemed to consist of, above all, a decided accentuation of the suffering aspect of the figure of the crucified Christ in service to the diffusion of the new mendicant orders and those of the Franciscans especially, in which the precocious worship of the founding saint began the phenomenon of an “icon-narrative” in which the main figure is surrounded by episodes from his or her own legend which was influenced by examples that were still Byzantine but were essentially unprecedented in Western painting. According to a simple diagramming typical of a certain art history that seeks to organize the complexities of history, all of what happened in the early thirteenth century achieved its apex in Giunta Pisano, from whom spring the champions...
of the renewal of Italian painting, Cimabue and Giotto, each one overtaking his predecessor. For a long time and in other venues, I have reflected on some points that seem particularly meaningful. The first consists of investigating if these new influences that arrived from the great artistic school of the Christian East consisted only in stylistic and expressive elements, or rather if they involved also the technical means of execution. In this sense, the enormous technical distance existing between the cited examples of painting in the twelfth century and the more well-known painting of the second half of the thirteenth century can, in some way, be explained. In fact, we have found in the Crucifix of Sarzana and, currently, in that of the chronologically similar one of Rosano, some common attributes: the structure of the support is made of chestnut wood and the preparation layers use a fine-weave linen and very thin ground layers of gesso and glue, so carefully prepared so as to allow for the application of gold leaf with a water-gilding technique that did not require bole, which later on became obligatory.

On reflection, it is clear that the bole contributed in two ways: besides its structural function, it had an aesthetic value as a colored underlayer and therefore its absence is connected to the similar lack of other colored underlayers that then became common later on—the most famous of which is the verdaccio under the flesh tones. It is difficult to determine when these two elements were introduced into Tuscan painting, but it is certain that in Pisa, Giunta and his circle contributed to establishing them and this practice then appears in Florence with Coppo and Cimabue. But where does this new way of working come from and what expressive meaning does it convey? Even the density of the paint layers, aside from the quality of the preparation, seems to vary both in consistency and in method of application. In the paintings of the twelfth century, the paint is thinly applied, without much body, and quite analogous to that of contemporary illuminations. Its application is often area by area, with a clearly, quite liquid consistency allowing for uniform coverage. In the following century, what appears is instead a denser paint with more body that calls for and allows application with the tip of a fuller, blunter brush, used first only for flesh tones. The purpose of this is the gradual shift from a schematic painting that relies on a structural assembly of graphically drawn elements to one that seeks to obtain more naturalistic effects with chiaroscuro and the volume of forms with the aim of evoking greater pathos from the whole. This is, in turn, not by chance connected to the iconographic shift from the Christus triumphans with all of its mysterious links with the Lucchese Volto Santo to that of the Christus patiens.

Luciano Bellosi’s monograph on Cimabue presents a critical step in the modeling of the limbs of Christ in the passages of his early Arezzo Crucifix, still based on Giunta’s prototype, compared with that of Santa Croce. And in the catalogue in which we presented the Madonna of San Giorgio alla Costa after the restoration of 1995, it was stated that a similar transformation was seen in the drapery passages using an incredible weaving of light and dark brush strokes to construct the robes of the Madonna three-dimensionally. In a later companion study to the restoration of the Crucifix of Santa Maria Novella, there was an attempt to trace these changes across the span of the entire Florentine Duecento: from the beginning with the Casale Madonna with liquid passages and graphic stylization, both in the flesh tones and in the drapery; to that with the new, blended paint application only in the flesh tones as in Meliore, the Master of Saint Agatha, and Coppo again; up to Cimabue and the young Giotto when the process of achieving naturalism reached its height. Thus, the role played by Pisan painting in this context at the beginning of the thirteenth century may have been essential, receiving new Byzantine influences and developing the implicit possibilities, perhaps with
partly original intention, in keeping with the new expressive demands that were just then finding their highest achievements in Pisan sculpture.

It is therefore important to understand if this working hypothesis is realistic and this is one of the themes tackled in depth in the following essays by Maria Luisa Altamura, Roberto Bellucci, Cecilia Frosinini, Pierluigi Nieri and Eleonora Rossi: the presence of traditional, local elements mixed with Byzantine innovations is rather broad and variegated and seems to echo, in the few cases examined, a lively melting pot in which different practices and artistic techniques are mixed and contrasted, often with varied and diverse results. What is certain is that the solution that Giunta Pisano offers (though he is not identified as the author of the Saint Francis which appears more archaic and very different technically) will become dominant and spreads beyond Pisa, also thanks to his role in Assisi and Bologna in defining the painting criteria that will be followed up until the 1280s when Cimabue first and next the young Giotto will make further steps forward. All this though does not follow chronologically synchronized movements. The material events that the paintings and the human protagonists may have experienced in large part cannot be reconstructed today, but what is revealed shows a crossover of archaic techniques that reappear in later works of art. For example, consider the use of an integral frame carved out from the panel, or the use of gilding without bole in the Florentine milieu that survives up to the Master of Saint Agatha in the great panel of the Brancacci Chapel of the Carmine, the Madonna del Popolo. The evolution is not linear nor synchronous and the influences and the relationships are linked in such a way as to only allow the identification of trends.

One defining role of great interest for our research is the great Crucifix Number 20, from the Monastery of San Matteo, hypothetically situated just at the beginning of the Duecento, as an example of exactly this Byzantine influence, even suggesting the contribution of an Eastern painter. In partial contradiction with the clear stylistic and iconographic innovations that are present in this painting is the use of a ground layer applied over a thick parchment (or even sometimes leather according to Theophilus in his treatise17). This refers to a practice seen in Italy, for example, in the *Alberto Sotio* Crucifix in Spoleto of 1187 in which the Byzantine influence is certainly absent, and in Germany in the panel of Aschaffenburg or in other rare examples of the twelfth and thirteenth centuries. As mentioned, the Pisan Crucifix Number 20 poses the question of whether there were Eastern artists actually working alongside local craftsmen: in a city with commercial relationships like Pisa this possibility can certainly be entertained, just as the importation of paintings made in those areas and brought back as prizes for the most varied devotional reasons. One example, in my opinion, could be that of the so-called Madonna di sotto gli organi for the typological and stylistic characteristics of the composition as a whole. This is an opinion based on simple visual assessment, as it is not possible to examine the painting from a technical point of view which I hope will be possible during the course of the exhibition itself.

The question of chronologically placing the arrival of these new Byzantine influences also seems to require a different manner of interpretation than what has happened so far. Some paintings with these qualities were already present in the last part of the twelfth century: the miniatures of the Bible of Calci dated 1168–69, or the relief of San Michele degli Scalzi, like the aforementioned Madonna of Santa Maria Maggiore of Florence, now dated to the last quarter of the twelfth century, clearly shows the acceptance of this new current along with the last appearances of the previous phase. In Pisa, the transition was in any case swift, and therefore the overlap was limited, while in Florence, with less exposure, the process demanded longer periods, arriving at completion only with Coppo, leaving the two lines to coexist for almost a century, creating misunderstandings for those who still try to organize the surviving
artworks according to a single, logical, developmental progression.

Seeing that the *Madonna* of Santa Maria Maggiore has been brought into play, we can pause to consider one of the themes that this represents: the double value of the image in the Christian world as the depiction of a sacred figure and of the object of worship itself, and in this case, connected to the relationship between the images, or the painting in our case, and reliquaries. This is obviously a much broader and more complex topic that can be mentioned only briefly here but that immediately becomes clear when observing the extraordinary discovery by the restorers of the Soprintendenza di Pisa, Eleonora Rossi and Pierluigi Nieri, and which makes the entire exhibition worthwhile. The finding, relating to the painted *Crucifix* of San Pierino, whose unusual shape, never before explained, now seems to be because, in the Duecento, an old crucifix was embedded in a new one; evidently the former was of such value as to make them want to preserve it with this unusual procedure, just as if it were a relic. Let’s ignore, for now, the historical reasons for this, but some thoughts come to mind on the value of a mysteriously incorporated object inside of another, and this practice of medieval “preservation.” Some famous medieval crosses have been shown to have hosted reliquaries: from the *Crucifix of Gero* from the Cologne cathedral of the tenth century to the aforementioned “Alberto Sotio” *Crucifix* of Spoleto. Therefore, if our painting had contained a reliquary, it is well understood how by means of the transitive property of the value of the reliquary and with its contact, it made that which was around it equally miraculous. In this way, the earlier one could be saved and transformed into a new artwork. On the other hand, the will to preserve the object of worship, even if ragged and worn, is the reason why some of these precious fragments of early medieval painting, as well as Paleochristian like some Roman Madonnas, have survived until now. This is also why, in the full Counter-Reformation, the preserved fragments, often of early faces, were inserted into canvases made and painted for them, so as to create a style that has involved the partial presentation of artworks that were nearly undamaged such as the *Crucifix of Sarzana*, whose face was revealed in the opening of the Solimena canvas made for it. The concept of preservation and restoration was, moreover, very different in the Middle Ages compared with our times in direct relationship to the different concept of meaning and value in artworks. An artwork was not just seen as having the intrinsic value of artistic quality but in an instrumental sense as a devotional or liturgical furnishing, if not as already mentioned, as an object of worship. In the first case, it was transformed, adapted, and even substituted in relation to its greater or lesser capacity to fulfill the function to which it was called. And from here repainting follows, and iconographic and dimensional changes of all kinds are often seen. The fierce desire to preserve the material itself is found in the case of the *Crucifix* of San Pierino, a further example of its having intrinsic value as a reliquary and not only instrumental value as a painting and further illustrating for us the sense of that procedure.

In light of this, it appears even more difficult to understand the recent and highly debated document of 1179 attesting to the transfer of the Lucchese *Volto Santo* to the monks of Sansepolcro, that then concluded an impeccably conducted critique carried out by our late colleague Anna Maria Maetzke. The total substitution of the material with a replication of the image implies that this is only a representation and not an object of worship. Many years ago, the Opificio restored the small processional panel from the Museo dell’Opera del Duomo of Florence showing *Saint Agatha* on the back by the thirteenth-century master who takes his name from this, and on the front, she is repeated in exacting detail, though without concealing the style of a painter of the early fourteenth century, perhaps the work of Jacopo del Casentino. In this case, there is not a substitution, but a portrayal. Of course I asked myself many times if these paintings were separate, and if the older one

4. *Crucifix no. 20.* Museo di San Matteo, Pisa. Infrared reflectography of the face of Christ shows the first placement of the eyes that are lower with respect to those painted afterward.
it without a qualm, as in the case of the polyptych of Pietro Lorenzetti in Arezzo, whereas elsewhere it is the painter who heavily modifies it to adapt it to his needs, as with Giotto and the Crucifix of Santa Maria Novella. What were the planning capacities of the carpenter and painter, how did they interact, and how much in relation to the design vision of the figure who we tend to forget, that is, the patron who commissions the craftsmen and artists and who more or less decisively influences the work?

In the course of the twelfth century, in Tuscany, we are increasingly seeing the importance of the choice of chestnut wood as a standard for its sturdiness, while in the following century, poplar became the wood most commonly employed. To what do we owe this change and when can we detect the first signs of it? In the construction of more complex supports and those of larger size like the painted crucifixes, chronological variation as well as local differences are assumed. Among the first we noted, for example, was the peculiarity up to now seen only in Lucca of the two horizontal arms planned as separate pieces inserted with joins into the central weight-bearing body. Instead, we noted a kind of chronological development in the shift in preferences for the join between horizontal arm and vertical using continuous panels, in that the horizontal element in front was the continuous surface or vice versa as seen, for example in the progression from the one of San Domenico in Arezzo (and that of Giunta with the cited structure), to that of Cimabue in Santa Croce of Florence. The interest is not only structural: in both cases, due to the inevitable contrasting movement of the panels, there will be aesthetic consequences that are easily foreseen. In the first case, the separation between the planks created a prominent horizontal crack through the center of Christ’s torso while in the other, the disturbing separations ran through the arms vertically. Therefore, it was not only an issue of the panel structure, but it affected the aesthetic result.

As mentioned, late Cimabue and Giotto chose the second option, establishing a standard that would be frequently followed. But what was the situation between the twelfth and thirteenth century in the productive and lively hotbed that was Pisa? Without revealing the conclusions of Ciro Castelli, Mauro Parri, and Andrea Santacesaria, it seems to me that the most interesting aspect has been finding all the various options used over a span of time that show how they were not choices defined...
attributed to Meliore, but for this writer, from the first half of the century, and even in the *Madonna* of Santa Maria Maggiore. Of course it would require a census taken over a much broader sample to arrive at and establish the relationships and connections, but the findings that we present here begin to furnish some concrete elements for consideration. In the famous panel of Saint Catherine of Alexandria with stories from her life, even the first visual assessment by our late colleague Maria Luisa Altamura detected a remarkable difference between the execution technique of the stories on the two sides, so much so as to suggest, in my opinion, the presence of two different hands. It is difficult to understand how the head of the workshop given this task would not have obliged all the craftsmen to respect certain technical standards, but certainly the evidence is irrefutable.

In the initial consideration of the tools available to us for the study of artistic technique we include, among others, the medieval art treatises. Among these, the most famous and often cited is that of Cennino Cennini, and rightly so, for the richness of its detail. This means that often it is by a kind of evolution, but as various possibilities available to the discretion of the craftsmen. This is another aspect that would confirm Pisa in the role of a highly creative artistic center as can be inferred from many different factors.

Another technical issue of great importance is the way in which the composition, worked out elsewhere, is transferred to the prepared panel: transferred or drawn freehand, using brush, chalk, incised lines, etc. and what is the technique for that which today the English term *underdrawing* is used, which better renders its meaning with respect to the term *preparatory drawing*, easily confused with a drawn study made as an end in itself. This drawing is both the transfer of the design, but also the first stage of painting, and it will influence the entire pictorial result.

If, for the subsequent centuries, from Giotto onward, we have sufficient information to develop hypotheses that contribute to the art historical studies of those same periods, for the earlier paintings we are only beginning to collect data and have the humility of supplying only a few answers, knowing the limits of our knowledge. Limits that may still be shifted with our quite sophisticated equipment, the digital scanning IR reflectography, invented by the Istituto Nazionale di Ottica and developed with our laboratory, which can reveal materials that absorb infrared, in particular, carbon black. In some works from the twelfth century, like the *Crucifix of Sarzana* and the thirteenth century, like the *Madonna del Popolo* there is a linear drawing probably made with a brush, initially quite simple and almost always coinciding with the outlines but that evolves to a more detailed, minute linear system for all the defining features of the figure, like the face, as seen in the *Crucifix of Arezzo* by Cimabue. This becomes the method by which the young Giotto will draw the figure of Christ in the *Crucifix* of Santa Maria Novella. From this, Giotto’s drawing will continuously evolve, as already seen in the mourners in that painting, continuing in his subsequent works, as seen in the study dedicated to this.20

However, in the Duecento, the variety of methods and techniques available is always such as to mix up the cards for anyone who seeks easy schematic solutions. In some paintings, the use of direct incisions, normally used to separate the area to gild from the rest, is instead extended to areas inside the figures up to the point of defining the most minute features, as has been seen in the *Dossal* in the church of San Leolino a Panzano, usually
as mentioned, a mentality and many techniques that are quite different. Our considerations should also be extended to other even older technical sources, certainly not as broad and exhaustive, but sometimes more interesting. Heraclius and the already-mentioned Theophilus can provide us with some useful starting points, as in the already noted case of preparation layers incorporating parchment.\(^{21}\)

We cannot avoid mentioning one of the drawbacks that applies to everything described so far which is the lack of technical literature on Byzantine painting with enough content to present material for comparison in a relationship that we often hypothesize about, but with little objective comparative data. I think that one of the most interesting initiatives that the study of medieval techniques can take on would be a technical analysis mission with the appropriate equipment and specialists to study the very famous collection of Byzantine icons in the legendary Monastery of Saint Catherine of Sinai that begins with the fifth century. Since these were often given by the emperors of Constantinople, they are therefore quite representative of the principal trends of that kind of painting. The fallout of useful knowledge not only for that artistic school, especially rich in iconographic interpretations but also for the understanding of Italian medieval painting would be in my opinion, incalculable.

This exhibition in Pisa presents the most fascinating proposal of new attributions to Giotto of two small panels coming from a church in Livorno whose provenance has not been possible for now to reconstruct. Seeing the interest and the results achieved by the Opificio on the works of this artist, we can’t avoid trying to offer an informed contribution on this topic, even if it is far from the main theme. The information derived from this first analytical campaign is presented next, but it seems important to note that, from a strictly technical point of view, nothing contradicts that attribution as the materials and the techniques used are consistent with that of the Florentine artist.

Of course, I understand that the problematic areas highlighted here on various themes under discussion risk being more extensive than the answers that we can try to formulate in the following pages, but the overall value of this study is to put the questions into focus and to start to whittle away at the material, establishing some clear and objective technical information and
rendering further studies possible in the future for all those interested. It is therefore good that in the field of this new discipline that our Anglo-
Saxon colleagues call technical art history we sometimes limit ourselves just to supplying data, restricting to a minimum the guesswork that is not sufficiently supported, with the knowledge of how complex the material is that we are only grappling with recently. This introductory note can be closed here with the forewarning of our colleague Spike Bucklow: “So, no matter how sophisticated our examination becomes, our interpretation of the results will remain the critical factor. The willingness to accept ambiguity and uncertainty in the results of technical examination may be the sign of a maturing discipline.”

Marco Ciatti

Research on the wood supports

The examination of even a limited number of wood supports of Pisan paintings from the twelfth and thirteenth centuries has identified very interesting details both in terms of the variety found and for the specific techniques used. The general picture that emerges is that there was such a thorough understanding of materials and their behavior that it suggests workshops specialized in painted wooden structures were already present the twelfth century. This always makes us think even more about how few paintings have survived from that period—and as a consequence, how limited our knowledge is—so therefore, what has come to be considered the first painted cross, the Sarzana Crucifix, dated 1138, should be located, at least mentally, within established technical expertise and practices. A limited literature that deals with the history of wood technology confirms this, describing the high degree of quality reached around the year 1000 by furniture craftsmen in Southern Europe, especially Italy. We must take advantage of this, given that panel painting examples from before 1138 are almost all lost.

Furthermore, it can be stated that the paintings examined on this occasion belong in large part to the same structural traditions found in the Florentine and Sienese areas, distinguished though by some significant details; and furthermore, that these reflect methods present for example in the oldest panels of the Luccesche school like the Sarzana Crucifix. Pisa constitutes, therefore, an important crossroads of influences in central Italy, almost a composite preparatory phase for the construction that is codified in more established and geographically diffused forms from the end of the Duecento onward.

Delving into the specifics, we see that for the Pisan paintings, as for the Florentine and Sienese examples, the planks that are chosen are most often poplar and the cuts of wood are parallel and longitudinal, of an average quality, and even thickness. Though poplar seems, from the limited number of paintings analyzed, to be the main species, examples such as the Crucifix of San Paolo all’Orto and that of San Pierino are made instead with chestnut. The assembly method is with butt-joins—this comes to define a specific characteristic for the assembly of planks to make painting supports—and in the case of larger scale carpentry, we find the presence of tapered dowels (cavicchi) between planks in order to guarantee planarity during gluing. The cavicchio inserted into the edges of the planks can be of remarkable length. The Dossal of Saint Catherine measuring 118 x 114 cm has, in fact, a hollowed-out channel of 24 cm, the Madonna of the Master of San Martino measuring 130 x 163 cm has one of 23 cm. This is quite a different size from that present, for example, in the Crucifix of Santa Maria Novella by Giotto where the cavicchi are on average 15 cm long and the support is instead 530 x 400 cm. The same proportion discrepancies are seen measuring the diameter of the cavicchi in the X-rays which can reach half of the total thickness of the support and not one-third, as in later examples. A more careful examination of the internal connecting elements leads us to see how the panel was assembled with whole planks, not preliminarily cut down, with trimming then occurring when the panels were put together. In fact, some cavicchi are present very close to the margins of the cut, as in the Story of Saint Francis.

The crossbar system is connected to the support by anchor points using nails distributed close to the ends of the panels. This would seem logically to correspond to an unwritten rule, typical of craft knowledge and detailed technological understanding of the materials and their behavior that we find among all the medieval craft societies. In fact, anchoring according to these criteria assured a greater support for the joins and allowed less range of movement for the planks to warp in the center. Additionally, an anchorage in the center of each plank can be considered almost a
complementary defining feature of carpentry for panels found during the entire period from the twelfth to the first decades of the fifteenth century.

A protective layer of minium applied after the attachment of the crossbars was found in almost all the panels examined. This material has the function of aesthetic finish along with protecting the back of the support from attack by wood-boring beetles. Around Florence, it was often used in panels in the Giottesque era, among which are the Madonna di San Giorgio alla Costa, the Crucifix of Santa Maria Novella, the Madonna of Borgo San Lorenzo, and the Madonna of Ognissanti. Earlier, we find an application of a gesso and glue layer on the back with the function of protecting the support from fluctuations in relative humidity in the environment, forming an equilibrium between the front and back surfaces. Examples of this include the Crucifix of Sarzana and the Crucifix of Villa Guinigi from the area of Lucca, while Pisan examples include San Paolo all’Orto, and Crucifix Number 15, and a Florentine case is the Crucifix of Rosano. In the Crucifix of Rosano, we even find a local application of minium on the inside of the join between arm and body and under the halo, with the scope of impeding insect attack in the structurally and mechanically significant areas though that can’t be seen.

In our examination of Pisan structural techniques, we see additional construction details that may be specific to the Pisan area such as the thickness of the crossbars: with respect to those present on Florentine supports, Pisan ones are slightly narrower though with a sturdier thickness. The type of nail is also slightly different that that used in Florentine supports—it appears to have a smaller, more rounded head. These structural features, therefore, can be hypothetically considered to be characteristics of local woodworkers. Furthermore, in light of this, other interesting observations previously made on the support of a painting by Giotto for the Pisan church, that is the Stigmatization of Saint Francis today in the Louvre, can be re-read in a contextualized way. These include the analogous characteristics of the support construction. This reflection could lead, when further substantiated by more thorough research, to the interesting possibility that the Giottesque painting may have been made in Pisa and not therefore made in the Florentine bottega of the artist, differentiating it within the oeuvre of Giotto with these structural findings.

In examining the construction of the individual supports, we will consider them according to category beginning with painted crosses and then looking at panels. When we examine the support of the painted crosses, varied construction methods are seen and it is anything but codified or dependent on fixed rules. We can categorize the structure of the crosses according to their dimensions. In fact, we see in the small crosses, like that of San Ranierino and the Processionale, the junction between body and arms was made with a half-lap join so as to obtain, in a simple way, good mechanical stability.

In the larger crosses, we find the arms are attached to the body with mortise-and-tenon joints. We have encountered similar structures in the Lucchese crosses like that of Sarzana and in the Crucifix of Villa Guinigi in which the independent arms were sustained by a join, by resting on side strips about 10 cm wide, and by the support on the back of a single horizontal crossbar placed along the central axis of the arms. In the Pisan crosses, the arms, inserted and joined as separate pieces, are sustained by supports (lateral extensions of the apron) of about 24 cm in the Crucifix of San Matteo and/or by a double horizontal crossbar (see the examples of the Crucifix of San Matteo, Crucifix Number 15, and Crucifix of Santa Marta). The
carpentry present in paintings belonging to these two geographic areas differs substantially. In our estimation, the Pisan crosses, while maintaining the construction feature of having arms with a central tenon, seek increased solidity thanks to a wider area of support in the form of the two wider lateral planks and a greater reinforcement from behind with the double crossbars. These measures, combined with the presence of parchment in the Crucifix of San Matteo, make the line of the junctions between arms and body practically imperceptible with an aesthetic result that is certainly an improvement over the older examples already cited.

The Croce di San Paolo all’Orto is distinctive in part due to its being made of chestnut and having an integral frame carved out from the panel itself. Additionally, the arms are made from a single unbroken plank that attaches to the body with a half-lap join, appearing continuous from the front side. Even if no part of them remains, the restraints on the back included a horizontal crossbar nailed along the plank of the arm in order to hold it firmly against the vertical body.

The panels with a pointed gable, among which we can include the Madonna with Child of the Master of San Martino—which originally had this shape—along with the Saint Francis and the Dossal of Saint Catherine, do not follow a fixed canon of construction. We can see how on Saint Francis and the Madonna of the Master of San Martino, the crossbars formed a perimeter framework with crossbars inside, as seen in examples of both Duccio and Giotto. In the Saint Francis, the planks are positioned horizontally while the other two are vertical. In the Dossal of Saint Catherine, the crossbars are linear and placed at the top and bottom near the edges, with one in the center. Furthermore, the frames of Saint Francis and of Saint Catherine are carved out from the panel, while that of the Madonna of the Master of San Martino are made from strips glued and nailed onto the perimeter.

Other examples of the technique of the carved-out support in the museum collection that were examined include the Deposition by Enrico di Tedice, the Madonna and Child of Santa Chiara, originally from the Convento of San Marco, in addition to the Croce di San Paolo all’Orto. As we will see later, this feature gives us a glimpse of a proximity to the Eastern icons where it is frequently present.

Proceeding to examine works in a later period, likely already affected by the major current in uniformity of artistic technique introduced at the beginning of the Trecento and identified with the formidable presence of Giotto on the Italian artistic scene, the similarities with the structures of Florentine panels are clearly seen.

An example of similarities with the Florentine technique is the support of the Maestà of Deodato Orlandi which is made of a large central panel to which have been added strips along the sides. This choice, seemingly trivial, instead reveals a precise structural plan that gives precedence to the quality of the materials; in this case it attempts to reduce to a minimum the risk of seeing the join lines in pictorially important areas. Moreover, the two slender strips correspond to practically the width of the frame on the front. In Florentine and Sienese paintings, many examples of this construction style are found, especially for polyptych panels.

The supports examined show a broad range that developed inside a tradition that became standardized into more clearly defined types towards the end of the Duecento. These represent a group that is shown to have exchanged influences with nearby regions such as the Lucchese, the Florentine, and the Sienese, that we can not precisely quantify or qualify. What it seems we can determine is that this
Pisan tradition also reflects to a greater degree the influence of Byzantine techniques from a point of view of construction technology. In fact, the examples of the panels that are carved-out where the outer frame is carved from the solid whole, typical of this school, are rather rare and still not adequately understood within the study of artistic technique. This is a true structural category parallel to the most common one with an attached frame, and that likely contains within it values associated with the devotional significance of the image. Furthermore, as with Byzantine panels, this structural characteristic contributes to concretely establish the aesthetic quality of the painting in that the carved-out portion becomes the surface for the image and might not be perfectly geometric and planar but slightly protruding, so as to provide a greater visual impact for the sacred figures represented there. In Pisa, this type is more widely seen. Specifically, the Croce di San Paolo all’Orto is an exceptional case, both because for now it is the only cross made with this technique, and because it is made of chestnut. In fact, if it is true that this wood species was mostly used for supports in the twelfth century because of its good mechanical strength and resistance to wood-boring beetle attack, on the other hand, chestnut is a type of wood that is less workable than poplar especially with regards to cutting details and carving out. The fact that the frame was carved out from a solid panel made of chestnut highlights the choice as strongly deliberate and prioritizes other qualities than that of affordability and ease of working. It would seem almost that this is a patron’s “iconographic” choice that dominated and overrode the knowledge of the materials.

For some other paintings from different areas made with the carved-out technique, we can cite: from Siena, the Dossal of the Redeemer and the Madonna of the Big Eyes by the Tresa Master; in Florence, the Dossal of Saint Zenobius by the Master of the Bigallo Crucifix and the Madonna del Casale by the Master of Greve; some Roman icons like the Madonna Advocata of Santa Maria in Aracoeli, the Madonna Enthroned with Child of the Museo Civico of Viterbo, and finally the Badia Polyptych by Giotto.

Ciro Castelli, Pierluigi Nieri, Mauro Parri, Eleonora Rossi, and Andrea Santacesaria

Pisa between East and West: Observations on artistic technique

The intersection between Byzantine art and Western or Latin art is one of the still unresolved knots in the history of medieval art. It is often circumvented through recourse to citation of the importation of objects from Byzantium, sporadic contacts through ecclesiastical or clerical travels, or the transmission of iconographic motifs and styles through the circulation of illuminated manuscripts and works in gold and precious materials like ivories, enamels, etc. But if in the field of art history the question seems to still be open, still more it would seem to be the case for the study of artistic technique. This is for a sector that suffers from a delay in research because only in relatively recent times has it assumed the dignity of a historical discipline, to use alongside of art historical studies. Another difficulty is that tied to the collection of information that necessitates skills, equipment, and work circumstances (that of restoration, for example) not easily accessible for those outside of a specific and quite narrow sector.

In the case of the relationship between Western art and Byzantine art, the most interesting and problematic issue for which an answer might be found, based on the study of technique, would be that of addressing the possibility of the actual presence of Byzantine artists in Italy. How, indeed, can we distinguish between merely stylistic influence and a true contribution of different techniques if not on the basis of working methods and the use of different materials than those that can instead be included in the “Italian” technical tradition?

The traditional history of art, in fact, has never taken into account that the real working methods and the use of specific materials are not things that are easily learned simply by seeing an imported painting in a different cultural context. These “apparitions” can be as dazzling as you like, crucial for the history of taste and form, but an artist of the period would only have tried to imitate the formal aspect from reading the outside and would never have replicated procedures and specifics of technique. The shift from painting in tempera to painting in oil in Italy is a worthwhile comparison: the artists of the mid-Quattrocento were certainly struck by Flemish paintings that circulated in Italy and they tried in various ways to imitate the effects of light and of layering with glazes, but for decades an infinite series of mistaken attempts were made with uncertain results and frequent failures,
demonstrating how in reality the creation and the experimentation of a such a different method can be learned only through direct contact—by training in a workshop.

For the aim of understanding the relationship with Byzantium, the opportunity to examine Pisan art from a technical point of view is particularly intriguing: both for the historical context (one of the privileged centers, along with Venice, due to its relationship with the Eastern Empire), and because, contemporary with these historical relationships, Pisa was, along with its neighbor Lucca, one of the centers that marked the debut of real Italian art as painting on panel, with a period of extraordinary painted crucifixes. It is also because of historical accident that many paintings in Pisa from the period survived (something that has happened a lot less in Venice) offering the chance to examine a meaningful sample, not only historically but also numerically (although it must be remembered that what we see today corresponds to a very small percentage of what would have been produced at the time.)

In the close examination of the artistic technique of the paintings studied on this occasion, the inevitable beginning is with the great painted crucifix (so-called Number 20) from the monastery of San Matteo for its obvious stylistic qualities for which it has always been appreciated as one of the most significant examples of the Byzantine style in Pisa. Various areas of competition between the Latin and Byzantine worlds can be seen in the way the artwork is made. It represents, in fact, the Christus patiens which, iconographically, is a new arrival in the West, while it seems to have been already established in the East, at least since the eighth century. At the same time, though, this depiction, usually found in narrative scenes, here is incorporated into an exclusively Italian kind of painting—a painted crucifix. Thus the whole becomes an absolute novelty for the mixture of Byzantine and Italian elements, even if only from the point of view of the image.

The probable dating of the splendid object (with reference to the catalogue entry) to the beginning of the thirteenth century allows us to insert it at the beginning of a critical journey that first examines the influences and the direct contributions of Byzantine art in Pisa and secondly, sets up a comparison with the recognized head of the thirteenth-century Pisan school, Giunta. This means therefore, an examination of the technical peculiarities of Crucifix Number 20 compared with what is known of “Latin” art between the twelfth and thirteenth century to single out characteristics related (and here possibility influenced by the Italian tradition) and specific features that can eventually be interpreted as “Byzantine,” if following the idea that has been put forward for some time now that the Crucifix was the work of a Byzantine craftsman who arrived in Pisa perhaps after the historic events of 1204.

Naturally, in approaching the study of artistic technique, one premise should be that much if not all of the artistic production came about in the environment of an organization: the artisan’s guild that had its basis in an often rigid craft tradition, and in which continuity was assured by the transmission of technical knowledge within workshops. This structure also corresponded to the social and political organization of medieval Italian towns for which it seems even more understandable that the organization of professions and the working practices were codified in the sense of standardized and that moreover there were relatively few possibilities for introducing new ideas. Acting with an expressive and aesthetic freedom was all but unknown at the time. Therefore, if we were to find ourselves in front of a Byzantine artist, he would have necessarily had to cooperate with the local customs and artisans and procure work materials within their tight network of production. For

example this includes the wood carpentry for the support on which to paint, materials for making the preparatory layers, and the acquisition of pigments.

The technical analysis of Crucifix Number 20 seems to confirm this interpretation given that the materials used and the working methods seem to belong to a local Italian tradition. The construction of the support, given the dimensions of the painting, would have been made by local craftsmen and therefore does not relate to the stylistic influences of the Crucifix. It follows the construction methods of crucifixes known and present in Tuscany beginning with that of Sarzana. Not only the fact that the whole support has among its preparatory layers an entire layer of parchment, far from appearing as exceptional as often has been said, this connects Crucifix Number 20 with other examples of painting that are undoubtedly “Latin” like the so-called Crucifix of “Alberto Sotio” of the Duomo of Spoleto, or the Mourning Madonna of Baltimore (fragment of a lost painted crucifix), or the small head (fragment from a Maestà) of the Pinacoteca of Brera, both attributed to the same “Alberto Sotio.” For evidence that the use of parchment in the preparatory layers is not exceptional, nor can it be interpreted as a feature that indicates the same maker, we can cite the Crucifix of Polling and the panel of Aschaffenburger, both Germanic examples.28

Furthermore, to have found the parchment in strips in potentially critical areas from a structural point of view (those of the wood joins along the lateral arms and central body of the cross) in the Crucifix of Sarzana would indicate a technical appreciation of parchment as a good cushioning layer and furthermore, its use shows a type of technical practice that endured for some time (ranging from the twelfth to thirteenth century) and which is found across a wide geographical area.

This same use of parchment as a preparatory layer has triggered many theories, including fanciful ones. One study proposed that in this one can read the origins of Italian painting (or of the single artists that used it) as deriving from the workshops of the illuminators. Another study, referring to the specific case of Crucifix Number 20, spoke of leather or of a single skin belonging to a very large animal. Given the dimensions, the idea that this could be a single skin is almost certainly impossible. In any case, the fact that the boundaries between the different pieces are not noticeable on the painted surface shows a high level of precision in the workmanship—a fact that is not technically impossible, as seen from the rare examples of large scale painted parchment.

It should also be stressed that in the treatises, as in Heraclius29 and in Theophilus,30 skins (of horse, donkey, or cow, and by the way, not tanned) are mentioned as being used as preparatory layers for paintings.

In Crucifix Number 20, along the edges of the wooden panel, the turned-over and nailed borders of this supporting layer are visible; its thickness is considerable and its surface is very irregular, leading us to think of skins that have not been worked much, certainly not like a true vellum. It seems (but only from these extremely general observations) that in effect this could be a leather (though not tanned) as leather and not parchment is the term used in the treatises. As to its application on the support, we can only hypothesize that the skin was glued, as it seems likely from the perfect planarity of the surface and the lack of impact of the joins of the planks on the paint surface. If it is the case that the skins are essentially glued to the wood support, it would be interesting to know the kind of glue—to evaluate if this matches the treatises of the period in that Theophilus proposes the use of a cheese glue for this procedure. From our point of view, we can do nothing but underscore how the parchment (or un-tanned skin) has perfectly carried out its role of cushioning between the wood support and the painting, also facilitating the perfect adherence of the gesso and glue preparatory layers.
The ground is very thin, as was found also on the Crucifix of Sarzana and others, and well-adhered to the support despite the numerous losses of paint and ground that, in some cases, follow the outlines of certain color passages. This is probably due to the underlying presence of the skin, whose craquelure has a shape and irregular texture different from that typical of canvas, which is generally more dense and regular.

For the organization and planning of the composition, the situation is difficult to assess as a whole because after the cross was installed in the museum, it was not possible to carry out a thorough examination of the surface with the high-resolution infrared reflectography scanner. It should be, however, a given that by using the term drawing what is often meant is a specific but restrictive concept of creating a linear design while really disegno in the treatises, in Cennini even before Vasari, always had a broader meaning of designing or planning both in a general sense and in a specific sense, and therefore establishing the true nature of drawing as a foundation of art, of any kind of art. Therefore, when speaking of a preliminary drawing for a painting, what is intended is the organization of the composition, the relationships of the figures with each other, and with the space so as to render the represented theme, even before the linear design that serves to define them. This may seem like a complex intellectual theme, but in reality, it is already present in the conceptual world of the craftsmen's workshops, as seen not only from reading the treatises (which, even if somewhat later, express the craft traditions that created them) but also identifying traces of preliminary planning that are often found on the supports, or through infrared imaging, looking beneath the paint surface.

In ordinary practice, it was usual to proceed on the gesso through successive phases of development that structured the arrangement of the design of the image, qualifying it with the dimensions and the forms through which it is possible to still appreciate it today. The first of these operations was undoubtedly the definition of the space of the composition, in particular, the subdivision of the parts to be gilded with respect to those painted. This already proves, by itself, that there had been a preliminary plan of the surface to be painted and the likely existence of drawings that haven't survived. Such planning would have been necessary both for the organization of work, which in some cases could have included the contribution of other specializations—the gilders, and for reasons of economy—so as not to use more of the precious material than necessary. Then there followed the real drawing of the composition complete with all of its features, which would then serve as a guide for the painting and could have been made with either incisions or drawing media. From the first planning stages of Crucifix Number 20, there are quite clear incision lines for the architectural parts and also those relative to the areas inside the painted parts such as for example in the figure of Christ which stands out from the blue background of the cross. It appears more difficult to see the incisions on the figures of the lateral scenes, perhaps because in these smaller areas, where the painting corresponds exactly to the incisions, the painter has used less pressure.

From the infrared images what we consider the second phase of establishing the design becomes clear, as indications of drawing emerge in many areas, carried out both with a dry method and by brush with a carbon-based material. It seems clear that after first marks are made with a metal point, the painter passed over the fine lines, not in order to define the spaces to be painted at this point, but with the intent, in this phase, of constructing in a pictorial sense, the placement of the whole representation. Thanks to the transparency to infrared of the flesh tone areas, the parts...
that show this drawing the most are the eyes, the mouth, the line of the neck, the arms, and the hands of Christ. From some of these details—the hands in particular—it is possible to determine how the painter had the intention of defining, even at this level of drawing, some features of the musculature of the hand, or how he carefully paid attention to defining the blood that emerges from around the nail in the half-closed palm. From observation of other details, the mental process that guided the painter and the steps taken as he approached the painting phase can be retraced in that between underdrawing and the definitive painting stage there are some variations with a certain significance. For example, on the face of Christ where, compared to an early application, the right eye has been raised slightly and the left eye even more, shifting the axis of the eyes with the intent of increasing the tilt of the head. Also, in the right arm, the muscles of the forearm have been shortened.

The whole, therefore, suggests a relationship between drawing and painting as a continuum across all the phases of work with a search on the part of the painter to define more precisely the image that progressively emerges in front of his eyes. This is one way of proceeding that certainly ought to be compared with other contemporary paintings because it dates to a period which, by rule, is instead marked by a general absolute separation between the phases of drawing and painting.

Once the spaces of the composition have been defined with the drawing, the next step was certainly the application of the gold leaf that often, as in the case of Crucifix Number 20 was the background color for the whole painting. As already mentioned, often this operation was carried out by specialized artisans who proceeded to gild the areas circumscribed by the incisions of the painter. In this period, the gold leaf was applied, in the majority of the cases we have seen, directly on the gesso of the preparation, with the use of a mordent that could be animal glue, egg white, garlic juice, milky fig sap, or whatever could serve to create good adhesion for the metal leaf. Obviously, it is practically impossible to succeed in indentifying the nature of these adhesives because these are transparent materials without body that would have been mostly absorbed by the ground. In the case of the Crucifix, we can only note the absence of bole and the extreme care taken in the execution of the gilding. The pieces of leaf are clearly distinguishable in some areas of the painting and striking for the extreme precision and regularity with which they have been applied; they are small, 4.5 to 5 cm, rather thick, and regular.

There are no punch work decorations or graining; the halos of the figures in the small scenes are simply defined by the incision line and the halo of Christ has rays decorated with a stylized acanthus leaf painted with red earth, a motif that seems to have been very popular at the time, given that it is also found on the fragment of the crucifix from the church of Santa Cecilia also in Pisa and in quite different territory, on the Crucifix of “Alberto Sotio” of Spoleto. The same motif, though rendered with a punch, is also in the halo of Saint Francis in the panel with stories of the saint once attributed to the circle of Giunta Pisano in the same Museo di San Matteo.

One further decoration on the Crucifix consists of raised bosses of various shapes situated along the perimeter of the cross at a regular intervals: in the outer corners they are oblong, in the inner corners they are in the form of hearts derived from the intersection of two oblongs, in the halo of Christ they alternate between low relief circles and squares, and along the border they are hexagonal. Unfortunately, many bosses are missing but the losses of these have left the parchment perfectly intact, a sign that they were simply glued on to it, so as not to leave any damage. Each relief element is in wood and is covered by a thin, glued fabric that merges with the parchment, creating a smooth base on which the gesso and gilding were then applied. We can imagine that this layering is due to the necessity of substituting the parchment with a more ductile material, more suited to covering the small relief elements. Finally, about halfway between bosses, there are incisions on the gold in the form of two concentric circles close together. The central hole from the compass is quite visible. It is unlikely that this is meant to be another decorative motif because it is practically invisible from far away: probably these are the only traces of a decorative plan that was not executed.

As for the painting itself, the first thing that strikes us is that the color scheme, using vivid and precious pigments, is different from that typical of the period. In fact, there is a dominant brownish-red that makes the image on gold stand out like “a dark arabesque, seen against a light background.”

The painting technique appears to adhere strictly to the treatises of the period, not only in the choice and preparation of pigments, but
also and above all in their sequence of application. In the writings of Theophilus, some chapters deal with the pictorial technique needed to create anatomical details of faces of the figures to be depicted. He even advised the use of one pigment or another depending on whether the character to be represented was “pale” or “ruddy.”55 While the description of the painting process is detailed in Theophilus (a good fourteen chapters of the treatise) here the steps are much reduced in number.

The painting technique is therefore close to that which can also be found in the majority of paintings from this period in the Latin world. The paint application is flat and opaque and starts with a medium tone as a base which then, with successive applications, becomes shadows and highlights by darkening or lightening the tone. There is no shading of the colors; the modeling is obtained in a very schematic way, underlining the lights and the darks with graphic strokes. The final effect is that of a precious, enamel-like color and the images appear cut out on the gold background which pushes them to the fore to carry out their liturgical and didactic function, almost as if it were a written text. The body of Christ, however, has a different impact, a physicality; this perhaps serves to show a different type of message that places the emphasis on the sacrificial aspect of Christ, felt in its mortal reality and therefore closer to humanity.

Contrary to what we know of Byzantine painting, verdaccio is not found as an underpainting layer in the flesh tones. First there is a homogenous base of an intermediate tone of ochre; then the shadows are obtained with a reddish-brown painted out with distinct, fluid strokes; the highlights are practically white, drawn with small graphic strokes, quite distinct and decorative. All the outlines of the flesh tones are in red paint; this is a red earth, probably the same used in a mixture with black for the shadows.

The drapery of the figures is depicted with care, with richness of detail and of decoration; unique in this regard is the drapery that wraps around the dead Christ—very sumptuous, in green with pale ornamentation. Again, with the drapery we see the sequence of a mid-tone on which shadows and highlights are applied. The brightest highlights are almost always white, while the shadows are not always the same color as the base hue: for example, in the grey drapery, the shadows are red while in the green, they are black. In the mantles painted with cinnabar red, the highlights appear, strangely grey; this is probably due to an alteration of a white that is not lead white (perhaps a carbonate).

The architecture that appears as a background in some scenes is decisively Eastern, with small cupolas that overlap and thin columns far from the Romanesque art typical of Italian culture of the period.

The background of the cross is painted a very dark blue, probably a mixture of indigo and black; in this area there are numerous losses of paint and ground layers which are also found in the mantles painted the same color, suggesting a technical kind of problem. The trunk of the cross and the lateral compartments have a type of decorative border pattern checked with white, red, and blue derived from mosaics.36

In Pisa, in the same years in which Crucifix Number 20 was painted, an artistic personality known as Giunta Pisano began to work, the creator, as far as we know, of important, not only stylistic innovations. His training has always been seen as connected to a cultural environment with a Byzantine mark, and especially akin to Crucifix Number 20. For this, so far, critics have also held that he would have contributed to that operation of integration, from a technical point of view, of the Italian tradition with such peculiarities as could be introduced from Byzantine art. However, an examination of some paintings by the artist at the Museo di San Matteo clearly shows how these were made using materials and employing an artistic technique so well characterized as distinguishable in considerable ways from that which marks the painting of Crucifix Number 20. It is difficult to explain such discrepancies as a chronological leap—as long as no other training occasions are proposed—for, as we will see, the technology that produced them was completely different. In our opinion, in dealing with the research on the artistic training of Giunta, one ought to, therefore, also take into account these interpretive parameters in that they are intrinsic to the characterization of a painter. We know in fact how artistic technique, above all in the medieval world, was shaped through direct learning in workshops, where master and apprentice worked side by side for years, exchanging not only their understanding of materials, but also the very manner of working them. These are the traits with the most stability and continuity in the technical heritage of an artist, that which almost constitutes a fingerprint, a map of artistic DNA. Therefore, it is difficult to argue on this basis that Giunta would have been trained
in the bottega that produced Crucifix Number 20 given that in his artistic production we find totally different techniques. The small crosses of Giunta in the museum—or rather that of San Ranierino and the recto of the Processional Cross—are marked by the clear presence of verdaccio as a toned underlayer for the paint of the flesh tones and by the presence of bole as a layer under the metal leaf. On both, canvas is found as a layer in between the wood of the support and the preparation of glue and gesso. These elements are enough, on their own, to indicate the significant technical diversity between the milieu of Crucifix Number 20 and that which Giunta goes on to represent. Undoubtedly, there were occasions to learn techniques that seem to be designed to satisfy specific expressive needs, a method that required the use of specific materials, applied in a distinct phase of work and only then if thoroughly mastered.

From Giunta we know how Franciscan spirituality was interpreted in the medium of painting, developing an iconographic tradition of the crucifixion with the intent of rendering an image full of dramatic and emotional tension, representing prolonged suffering even after death. For this reason, the body of his Christ is always shown, from cross to cross, with a cold tonality, like a cadaver, an effect obtained thanks to the presence of the green underlayer that affects the final result through the semi-transparency of the paint applied over it. The death of Christ is represented not only by the dramatic abandon of his body on the cross, but also by the vivid coloring of his body which is distinctly different, in terms of hue, from those of the mourners. This is an important change, not only with respect to Crucifix Number 20, but also for the Crucifix of Berlinghiero in Lucca at the Museo di Villa Guinigi which has often been compared to paintings by Giunta.

Continuing on the issue of the presence of verdaccio for pictorial aims, the suspicion arises that this underlayer is not only important for characterizing the body in terms of hue, but it is also used in order to establish a different sequence for the definition of the anatomy. One way of evaluating the extent of this is provided by the comparison between the rendering of the flesh tones in the two crosses by Giunta mentioned previously. In the processional cross, the underlayer in verdaccio of the flesh tones is almost completely covered by a whitish paint that blends into warmer and darker tonalities as it proceeds toward the areas of shadow, leaving the underlying base uncovered only in areas of the abdomen. However, because the overlying paint appears to be applied in the shadow areas with semitransparent glazes, the effect that emerges is still that of a body characterized by a cool tonalities. In the Crucifix of San Ranierino, the degree of transparency of the overlying paint is greater, as are the areas of the underlying green left uncovered. The amount of blending is different, as is the anatomical rendering. This is, if it is possible to formulate a hypothesis for further study, painting for transparency may seem from that moment a device that best answers the search for expressively representing the anatomy of a body that iconographically shifted from triumphans to patiens.

The other radical element of change in pictorial practice from the period is the presence of bole under the gilding that we find in both the crosses. With the bole, the possibility of color variation is introduced—it seems to be the most important reason for its choice; it creates a series of tonal variations in the gold due to the various colors of the bole, as well understood at the time. We must not forget, in fact, how the production of the metal leaf was tied to the metal in the form of coinage or as a raw material and how this period is one of scarcity of circulation. The choice of the precious metal would have been limited in terms of carats and therefore colors. Another element not to underestimate in the choice of introducing bole in the process of gilding should be a consideration relating to the economy of the work. In fact, the bole, a clay, is already present in nature with a particle size that is finer with respect to gesso; in order, instead, to obtain a fine gesso suitable to receive gold leaf you would have to carefully grind it and this therefore entails a not insignificant additional workload. Furthermore, the bole creates a substrate that is relatively elastic even if applied in the thinnest way, allowing decoration with punches, stippling, and incisions once the metal leaf has been applied on top. As far as we know, the cases of stippling or graining on gold leaf without bole are actually quite rare, while there are generally more decorations that are limited to a light incision around the halo, as we have seen in Crucifix Number 20.

Among the paintings examined, three of them can be tentatively grouped together because of their common characteristics. These are rectangular panels with a pointed gable (at least originally so): they are the altarpiece with Saint Francis and Stories from his Life, the Dossal of Saint Catherine...
which is also close to Berlinghiero or the Maestro di Vico L’Abate, and the Madonna and Child and Stories of Saint Anne and Saint Joachim by the Master of San Martino. For the first two, the dating is controversial. Some scholars put them toward the 1230s connecting them to the Guin-tesque milieu while others date them to the sec-
ond half of the century, putting them closer to the production of Berlinghiero. Instead, the third has a later suggested date, in an arc of time that spans from 1270 to 1290 with features that have an affinity to the painting of Cimabue.

It is therefore very difficult to try to make a stylistic connection among these paintings but it is possible to make observations on some of their comparable formal and technical aspects. First of all, these paintings are characterized by the same type of composition, consisting in a portrait of the sacred figures in conjunction with a series of narrative scenes illustrating the saint’s hagiographic cycle. The origin of this kind of iconographic solution seems to be Byzantine and more precisely, it seems to derive from icons destined for personal devotion. Another element that they have in common is the shape of the panel and the type of liturgical use: these are in fact paintings destined to be displayed on the altar with a celebratory and didactic function.

From the technical point of view, we can try to compare their individual components.

Above the wood support we find the canvas, with a function of cushioning the movements between the support and the preparatory and paint layers. This is a piece of textile glued in various ways: in the dossals of Saint Francis and Saint Catherine, there are strips only along the joints between planks. In the panel of the Master of San Martino, the entire surface is covered with canvas, even if they are irregular pieces and come from different types of textiles, as evidence of the bottega’s practice of using materials and procedures based on chance and convenience. This is a historic and practical reality that should always be considered so that we are not surprised by examples such as these in contrast to studies that teach us to think of the intrinsic value of the painting in that it was an object of worship, attributing to this period a great search for technical perfection. In this framework of perfection, there is also the thought that the application of canvas or parchment across the whole surface was the result of greater care while in a later phase, much later, it was limited to only the most critical areas, almost as a simplification of the technical step tied to the increasing importance of the image with respect to the object itself. Instead, we don’t have enough elements for considering this observation as a general rule nor even to call it a local characteristic given the continuous alternation of the procedure over time.

Another element to point out in these three paintings is that only in the later one, that of the Master of San Martino, do we find the use of red bole as a base for the gilding. Likewise, the decoration of the gilding with punches and graining seems to have only gradually entered into common practice. In the panel of Saint Catherine, there are no decorations on the gold, the halos are simply incised with a compass. Instead, in the Dossal of Saint Francis, we find one of the rare examples of punch work carried out without bole—a single punch with a circular shape (1 mm in diameter) repeated in succession to form a design with stylized acanthus leaves in the halo of the saint, very similar to that found in Crucifix Number 20 in the halo of Christ and also in other crucifixes. The decorative motif is unusual in that it varies in shape and size inside the halo which constrains it to adapt to the pointed form of the panel, as if adapting itself to the available space. In the third panel, meanwhile, we find incised decoration with graining combined with the use of bole; again this is a single punch in the shape of a little flower with six petals (3 mm in diameter) used to delineate the outline of the halo while the inside is filled with floral motifs incised freehand. It seems, though, to be decoration executed with a lot of uncertainty, with many imprecisions that make us think of an inexperienced hand in contrast to the strong technical abilities demonstrated by the painter in the same artwork; referring to the initial discussion in which it is suggested that this is an experimental phase of the bottega of the master.

In the panel of the Master of San Martino, we also find the use of mordant gilding in the chrysography of the robe of the Child, in the border of the mantle of the Madonna, and in the decoration of the throne and the cushion, though it is not present in the other panels. In the panel of Saint Francis, even the small gilded areas in the small lateral scenes are water-gilded; there are remnants though of traces of shell gold in the flowers that decorate the altar cloths. Both of these gilding techniques were certainly known at the time even if they evolved from miniatures and were intended to be used more than anything
for that. Theophilus also writes of this in his treatise in a very detailed way but again he was referring to books.

As for the painting itself, it is also possible to find points of comparison between the three panels in consideration. As mentioned, the composition is very similar and also the spatial setting follows nearly equal criteria. The graphic technique for laying out the composition is with incisions both for delineating the areas to be painted from the areas to be gilded, and for the definition of details of the composition.

The color choices are quite similar while the painting technique shows some differences. In the panels of Saint Francis and Saint Catherine, the technique is that of successive applications of paint using the Byzantine graphic formulas in the definition of details, close to that of Crucifix Number 20. In the Madonna and Child of the Master of San Martino, meanwhile, the paint is applied with thin, opaque strokes that allow for soft blending, above all in the flesh tones, for a very realistic effect. This technique, together with the introduction of naturalistic elements and echoes of antiquity, show different points of contact between this artist and the works of Cimabue; there are also elements of Byzantine icon painting which tie into Pisan culture of the thirteenth century.

Generally, an important characteristic of Byzantine artistic technique is thought to be the presence of colored underlayers: the verdaccio for flesh tones, the bole for the metal leaf. But it is quite strange, or perhaps significant, that even in the limited group of paintings examined in the Museo di San Matteo in Pisa, these two technical devices were found in a discontinuous way and above all that they were absent in one that was considered to be the most Byzantine of them all, that of Crucifix Number 20. Again regarding the use of ornamentation of the gilding with punches or burin, that generally are associated with the presence of bole, we always find in this small group a clear exception as in the case of the Dossal with the Stories of Saint Francis and his Miracles. What does this mean? Are the differences evidence of the gradual shift with which the technical changes were received and implemented? Are they indications of working procedures that refer to the time necessary for the painters to mature, experimenting directly and in a practical way with the procedures they wanted to carry out? Or rather is it our modern forma mentis that searches continually to lock all of this into predetermined categories? Are we still indebted to Cennini’s pithy remark at the beginning of the Quattrocento, “Giotto translated the art of painting from Greek into Latin and made it modern”?

The fact is that the examination carried out shows substantial differences in a very narrow context, moreover, despite being strongly compromised by the numerical losses, (and perhaps substantial) due to the inevitable passage of time, we ought to reflect on this and avoid making generalizations that verge on presumption.

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Appendix: Technical considerations for the attribution to Giotto of the two panels depicting a deacon saint and Saint Nicholas of Tolentino

The technical examination of parts of a polyptych from Livorno, attributed to the workshop of Giotto in this exhibition, has revealed some important details that are worth describing even if summarily in that, in our opinion, they may be useful to the attribution debate.

The dimensions of the panels are 77.5 cm high and 42.7 cm wide; the thickness is 3 cm. They are made of a single panel each of poplar wood, with a sub-radial cut, arranged with the grain running vertically. The wood chosen is not of good quality due to its uneven texture, and due to the distinct presence of knots, and for the curving grain. On the painted side of the deacon saint, in the upper part of the panel, one strip of a different pattern of crenelature a reveals a difference in thickness of the gesso in correspondence to an indented part of the panel.

Thanks to the original application of red lead on the back of the panel, we have information on the dimensions of the crossbars and their location in that the marks of where they were have remained clear since the red lead was obviously applied after they were nailed down. The upper one, placed at the base of the gables, measured on average 7 cm in width, while the lower part of the support only has one mark of where the crossbar was which is about 3–3.5 cm from the lower margin. The connection between the crossbars and the plank was made by a pair of nails for each panel, inserted from the back of the crossbars on each side and bent back under the preparation. (In the X-ray,
The points of the nails are still visible in the support. The difference in width of the two crossbar spaces tells a story of the alterations that occurred to the panel after the polyptych was dismantled. In this phase, not only were the panels separated, but the little predella that overlapped them (which likely had an inscription) and all the frame components, including the narrow lateral pilasters were removed. We suppose that in order to present the two panels as independent, part of the lower margin was cut and consequently the width of the unpainted border would not have been equal around the whole perimeter.

An element that indicates the external position of the two saints in the context of the polyptych is the way that these would have connected to the outside lateral pilasters: this evidence is in the form of a notch on the back in proximity to the right side for the deacon saint and on the left for Saint Nicholas of Tolentino. It is clear that within these notches there were wood pieces, held with nails that connected the panels and the presumed lateral pilasters. From the observations made and from the analogous dimensions and shapes in comparison with the Polyptych of Santa Reparata, these findings lead us to believe that our panels belonged to a five-part polyptych.

The paint surface is in quite poor condition due to numerous and invasive repaintings and subsequent cleanings of the past. In many areas, the paint is worn to the point of showing the ground; a similar fate has befallen the gold of the background in that it is consumed to the point of making it hard to see the punch work decoration of the haloes and along the margins of the panels.

The IR reflectography shows that the volumes of the faces and the hands of the two saints (as the flesh tones are much easier to penetrate with infrared radiation than other areas of the painting) were constructed in an extremely similar way to those found in the Polyptych of Santa Reparata. The underdrawing seems to have been created by first establishing the outlines in chalk, then reinforcing them with a brush. The ink washes, always applied with a brush, go on to build the volumes, emphasizing the areas in shadow.

Beyond the layering of the elements of the drawing, which correspond to the typical technical tradition of Giotto’s workshop, and will be given legendary status in Cennini’s standard-setting pages: “take a wash of this ink, and, with a rather blunt miniver brush, shade in some of the folds, and some of the shadow on the face. And you come out with such a handsome drawing, in this way, that you will make everyone fall in love with your productions” [abbi una acquerella del detto inchiostro, e con pennello mozzetto di vaio va’ aombrando alcuna piega e alcuna ombra nel viso: e così ti rimarrà un disegno vago, che farai innamorare ogni uomo de’ fatti tuoi]. The reading of the reflectography of the two saints reveals a quality in the underdrawing that is extremely close to those in a narrow Giottesque sphere. In fact, if we are able to resist being influenced by the condition, there is a careful and intelligent gradation of wash brush strokes which from the darkest dark, in a few steps, becomes light and whose smooth texture leads us to think of just the same blunt brush (pennello mozzetto) that Cennini spoke of.

Another meaningful element to consider in regard to a possible important commission and the high quality of the workshop that created the painting is that of the rich decorations of the gold background—with punches but especially freehand incisions. The perimeter decoration of the panel of Saint Nicholas is made of flower clusters, and that of the deacon saint has an inscription with Kufic lettering. These types of decorations are also found in the Polyptych of Santa Reparata (though this is not exclusive to Giottesque painting, or
more generally painting of the period)\(^4\) and it is worthwhile mentioning the coincidence, in that it is a further possible connection between these paintings and the circle of the so-called Parente di Giotto [relative of Giotto].\(^4\)

However, we do not want to establish a direct relationship here between painters’ workshops and the decorative motifs on the gold, as the scholarly discussion has not yet been conclusive regarding whether these belonged to the actual painter’s bottega\(^5\) or to specialized craftsmen who worked for them. It is still interesting to see how the examination of these two pieces, until now largely unpublished, can reinforce Giottesque lines of research that certainly need further work.

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9. Examples in each of the two camps can be found in the study on the crucifix of Giotto in Santa Maria Novella, compared with the other early works by the master in Giotto: La

In this field, a research initiative on Tuscan painting of the twelfth century is underway at the OPD and is based on the comparative findings of paintings being restored, or already restored, like the two mentioned of Sarzana and Rosano, which relate to the Lucchese and Florentine(?) schools. Broadening the comparisons and the investigations to Pisan and Sienese paintings provides a more comprehensive picture of the main artistic centers of the same period, of which we know so little. For this, close examination of paintings like Crucifix no. 15 from the church of San Sepolcro and that of San Paolo all'Orto has been interesting, as will be that of San Frediano and the one called "delle Stimmate" now in the Oratorio di Santa Caterina in Siena, but originally from Santa Cristina in Pisa.


See Dipinti su tavola: La tecnica e la conservazione dei supporti, edited by M. Ciatti, C. Castelli, A. Santacesaria, Florence 1999.


See, among the many possible texts, E. Sandberg-Vavala, La Croce dipinta italiana, Bologna 1929, pp. 674–81.


After the paintings were installed on the walls, the infrared reflectography imaging was made with a digital camera with a CCD detector.


E. Sandberg-Vavala, La Croce dipinta italiana, Bologna 1929, pp. 674.


E. Sandberg-Vavala, La Croce dipinta italiana, Bologna 1929, pp. 674.

The so-called processional cross from San Benedetto (Museo di San Matteo, inv. 2325) is particularly interesting in that the crucifixions painted on each side show a remarkable difference both stylistically and in terms of technique. On the side that we will call the recto, the quality is higher both in terms of technique and stylistically, and it is likely attributable to Giunta.


On the panel depicting Saint Nicholas of Tolentino, parts of this wood piece remains, held with an original nail.

Cennini Cennini, The Craftsman’s Handbook, Il Libro dell’Arte, translated by D. V. Thompson, Jr., New York, 1960, Chapter CXXII, p. 75. For the Italian quotation, see Cennini Cennini. Il libro dell’arte, edited by F. Frezzato Vicenza 2003, chapter CXXII.


This is, in a general sense, the idea of E. S. Skau, Punch Marks from Giotto to Fra Angelico, Oslo 1994, while others have in mind specific artisans among the batolloro who worked for the painters and carried out these decorations, see R. Bellucci and C. Frosinini, "Reading Underdrawing in Early Italian Paintings," in C. B. Strehlke, C. Frosinini, eds., The Panel Paintings of Masolino and Masaccio: The Role of Technique, Milan 2002, pp. 56–57.
Master of the Bigallo Crucifix, *Dossal of Saint Zenobius*, before 1230, Museo dell'Opera del Duomo, Florence.
The “carved-out” panel of the Dossal of Saint Zenobius: A starting point for evaluating a structural category of panel painting

Elena Bartolozzi and Andrea Santacesaria

The Dossal of Saint Zenobius, painted by the Master of the Bigallo Crucifix, was the subject of a thesis in which each aspect of the painting and its conservation was addressed, especially exploring the original construction technique and the treatment of the wood support. The panel, painted around 1230 originally decorated the altar erected over the tomb of the bishop Saint Zenobius in the crypt of the church of Santa Reparata.

Records relating to the painting document its movement and damage, with subsequent restorations, as early as 1379. In the most recent of the restorations, directed by Augusto Vermeheren in the 1930s, all non-original painted additions were removed, the missing areas of the frame were reconstructed, and the support was treated by thinning the planks of wood to allow for the insertion of a complex crossbar system. Despite the good intentions of Vermeheren’s restoration, still commendable for the choices made regarding retouching, the treatment of the wood support created consequences that can be blamed for the very poor condition of the painting. This includes the formation of numerous and extensive areas of lifting of the ground and paint layers due to the compression of the original planks by the crossbar system.

To describe the painting in brief: it is 278.3 cm wide by 112 cm high, and consists of the painted surface and the frame decorated with round, raised bosses, redone in part or completely over traces of the original in the treatment of the 1930s. Examining the panel in normal and raking light, with the help of photographs from Vermeheren’s restoration, the X-radiography, and the 3D scan of the surface made by the Istituto Nazionale di Ottica Applicata, it was possible to theorize what the original structure of the wooden support might have been like, despite the limits imposed by the transformations the painting was put through in the previous treatment.

The distinctive feature of the support of the dossal is that the frame and picture plane are a single unit: the two planks that make up the panel have been worked, reserving an outer border that became the frame and excavating the interior to create the area which is painted. Therefore, frame and picture plane were born as a single object.

From a careful study of the surface it was also noted that the painted area has a slight convexity with respect to the viewer. This characteristic can not be attributed with certainty to the execution technique of the artwork and it could simply be the consequence of warping of the support, but it represented a point of departure for us in the study of thirteenth-century wood panels, on the relationship between the surface and the image represented, on the influences of the materials in various kinds of paintings, and on the possible significance of technical choices.

The study involved collecting written information about construction techniques, but above all was based on direct examination of a series of examples that has served to deepen and enlarge our knowledge of this subject and define, thanks to the considerable quantity of carved-out paintings, a true category of panel painting.
The carved-out panels of Byzantine icons

An examination of the wood panels of icons shows the picture plane and the outer part that forms the frame are commonly made from the same planks. In texts that address the techniques for making these paintings, each component of the artwork is associated with theological meanings and references.

Here, it may be useful to look at some aspects inherent to the techniques of icon supports for the similarities encountered in the *Dossal of Saint Zenobius*, without going into the theological connotations ascribed to wood, which were probably beyond the intentions of the maker of this panel and all of those made in the same way in the non-Byzantine world. The recessed surface in the panel that holds the painting reminds us, for example, that the purpose of the outer border is not to frame the icon, but rather to preserve the image in a kind of coffer.6

The icons imported to the West were not only painted on panel, but also made of other materials and were appreciated especially for their preciousness. Moreover, their attraction was often linked to their Eastern origins.

In Italy, the majority of icons were made by local craftsmen copying an imported model. At the time, it was a technically and stylistically mature craft. The similarities with certain objects is clear, especially from a structural point of view, and including paintings far removed from Byzantine iconography.

The relationship between paintings and reliquaries

Hans Belting noted in his work on icons in the medieval period that in Italy, in the thirteenth century, there was a vast production of crosses, altarpieces, and devotional images, and there was an attempt to associate the Eastern icon with the sculpture of the West.7 Borrowing this assertion in regard to the relationship between painting on a flat surface and three-dimensional objects, the concept can be expanded on to look for a certain three-dimensionality in the support of a painting on panel, while maintaining the abstract and hieratic dimension of the depicted image.

This painting style that tightly connects the *Dossal of Saint Zenobius* and the works of the early Duecento to Byzantine culture is seen today in a wider context and freed of some stereotypes, so that for objects apparently conceived under the hallmark of two-dimensionality, sometimes one can infer a stretch toward the third dimension. If, for various reasons, from a pictorial point of view, this aspect could not be developed by the artists, some devices on the support have contributed, in a more or less evident way, to emphasize the image and make it emerge from the surface without having to alter the two-dimensionality. The connection between figure and reliquary was rendered more strongly when relics were inserted directly in objects, which became true “figural reliquaries.”8

The technical similarities between figural reliquaries and altarpiece panels demonstrate a fusion between the sculptural arts and two-dimensional images, useful for developing and clarifying our views on the variety of supports and panel shapes.

The influence of embossed surfaces on paintings

In an antependium of stone, marble, or metal, the important figures, the haloes, and the frames are in low or high relief based on the hierarchy of overlapping layers. The relief “material” of the central figure, as found for example in the *Dossal of the Redeemer* and in the *Madonna of the Big Eyes* by the Tressa Master and in the *Madonna Enthroned with Child of Santa Maria Maggiore* in Florence, or in the body of Christ on the *Crucifix* in the church of San Michele in Foro in Lucca clearly show the influence of embossed surfaces in paintings.

In the early dossals like that of *Saint Zenobius*, the use of wood supports rather than metal or stone was probably motivated by economic reasons. In fact, painted panels placed on the fronts of altars are connected to the art of goldsmithing in that they substitute the antependia made of precious materials. In these paintings, the care given to the application of paint, the use of gold or silver leaf, and the insetting of polished stones, gems, and glass for the decorations of thrones, crowns, and frames, continues to the end of the Duecento with the intent to imitate the large metal dossals, among which the most well-known example of the period is surely the *Pala d’Oro of San Marco.*10

The panel paintings of this period, with their characteristic decorations, with the shimmering gilding and the painting technique using bright colors, have also been compared to the enameled tabernacles made in Limoges during the first half of the thirteenth century.11
The established recognition of the antependium in painted wood as a derivation of the version in precious materials indicates implicitly that the execution technique can render the result more or less similar to the material being imitated.

From our perspective, the continuity of the surface of a panel that is painted and decorated with metal leaf, in which the frame and picture plane are carved out of the same planks of wood, can even better imitate a wooden supporting structure or approach the effect of a precious support made from working a single surface.

Some comparative paintings

As a starting point for our “alternative” journey examining supports, the structural features of the Dossal have been compared to two-dimensional artworks with sacred images where perhaps only small effects with apparently low visual impact give the surface a certain three-dimensionality or the picture plane has been treated in such a way as to allow the figure to emerge from the background.

The Cross of Sarzana by Master William (Maestro Guglielmo) represents an early example in which the handling of the support influences the way the image is perceived. The structure, which demonstrates a technical mastery surely derived from a long tradition, shows construction solutions that address the stability and anchoring of the most vulnerable part of the support, that is the arms. For example, there is the variation in thickness of the support: from the central plank the thickness is reduced gradually by some millimeters toward the extremities with the scope of diminishing the weight of the protruding arms. It is just this kind of detail that affects our perception of the figure, since the reduced thickness of the arms can have the additional function of visually bringing the painted image to the foreground.12 This second meaning, although it cannot be stated with certainty, finds an implicit recognition in the eye of the observer who naturally reads the figure of Christ advancing.

The painted Crucifix of the church of San Michele in Foro in Lucca by a Lucchese painter of the first half of the twelfth century is close chronologically to the Crucifix of Sarzana, and made with the same structural and technical criteria. Here, however, the relief effect of the figure is obtained by modeling the body of Christ with gesso. In Florence, the Madonna Enthroned with Child of Santa Maria Maggiore represents the most striking example where high and low gesso relief, alternating with painted flat surfaces, make the two principal figures and the decorations of the frame stand out, for an overall result that evokes the art of goldsmithing.

In the Sienese milieu, figures modeled with gesso are found in the Dossal of the Redeemer and in the Madonna of the Big Eyes by the Tressa Master. Besides being part of the antependium category, these have a frame and picture plane carved from the same planks like the panel of Saint Zenobius.

From our study, we found the largest number of paintings with picture plane and frame carved from the same planks to be from Pisa. In the thirteenth century, Pisa was an important artistic and commercial center in direct exchange with the Byzantine culture of the East, which resulted in a distinct influence on artistic production by the second half of the twelfth century, as seen in the miniatures of the Bible of Calci of 1168, in Crucifix number 20.
from the Museo Nazionale di San Matteo, and the Madonna "from under the organ" from the end of the twelfth century.\textsuperscript{13}

In several Pisan paintings from local churches and convents, there is a close stylistic and technical proximity to icon making. Thanks to the recent exhibition organized at the Museo Nazionale di San Matteo "Cimabue a Pisa: La pittura pisana del Duecento da Giunta a Giotto,"\textsuperscript{14} it was possible to identify a large number of paintings on carved-out supports, besides those already mentioned. Some have been defined in the catalogue entries as true icons, other are by Pisan painters who demonstrated the Byzantine influence.

One of the icons displayed in the exhibition is a Byzantine Madonna with "affectionate" Child (115 x 71.5 cm), dated to around the second half of the twelfth century from the Byzantine and Christian Museum, Athens,\textsuperscript{15} which has a carved-out support. The frame has a flat surface with an internal edge that slopes down to the pictorial plane. At the beginning of the thirteenth century, the Madonna and Child that bears a fragmentary inscription with the name of the maker, "...nellus," now at the Museo di San Matteo di Pisa but coming originally from the monastery of San Matteo di Soarta, (80.2 x 59.7 cm) was made the same way along with some paintings by the Master of Saints Cosmas and Damian, from around the second half of the thirteenth century, among them Madonna and Child from the church of Saints Cosmas and Damian in Pisa, (75 x 49 cm) and the Madonna and Child of the Acton Collection in Florence (34.5 x 48 cm).\textsuperscript{16}

The Deposition of Enrico di Tedice in the Museo di San Matteo, made around the mid-thirteenth century and coming from the church of San Bernardo in Pisa, (57 x 35 cm), is another example in which the frame has a flat surface of about 5 mm that then slopes down another 5 mm to the picture plane.

In another, Madonna and Child with Angels attributed to the Master of Saints Cosmas and Damian, coming from the church of San Giovannino dei Cavalieri of Pisa and now in the Museo di San Matteo, (85.4 x 56 cm) the two principal figures are enclosed by a gilt frame with a rounded arch, carved out from the same panel, while the upper arch where the angels are is certainly added on top.

A similar form is found in the Madonna and Child called Madonna Pisa attributed to the Florentine school, made in the mid-thirteenth century and now in the Gallerie degli Uffizi. The picture plane, surrounded by an arched frame raised a few millimeters above the surface, seems to be carved out by removing the wood of the support. The frame around the painted area descends from the inside edge, sloping slightly toward the picture plane. In the upper part, an outer arch made of an attached piece of wood is placed at the top of the painting, overlapping the aforementioned frame. The panel, more recently, has also been given a frame around the perimeter.

In other panels of the Museo di San Matteo di Pisa, depicting Saint Francis and Saint Catherine, we find the technique of the carved-out support on a larger scale than the panels cited above. The Saint Francis attributed to Giunta Pisano from around the first half of the thirteenth century and coming from the church of San Francesco, measures 163 x 129 cm. The support is made of six planks arranged horizontally. Observing from the side, the arrangement of the tree rings in the lower plank shows that the frame and the painted surface were carved out from the planks that make up the whole panel. The flat, undecorated frame surface descends about 5 mm to the picture plane with a slight slope. The Saint Catherine, from around the mid-thirteenth century by the so-called Master of the Calci Crucifix and coming from the church of San Silvestro, measures 115 x 107 cm. From the demarcation of the joins, it seems that the painting is made of four planks arranged vertically and, as seen from the losses in canvas and ground layers that allow the wood to be seen along the lower edge, the frame and picture plane are carved out from the same planks. The surface of the frame is again flat.


3. Detail of the 3D image of a vertical section obtained with the technique of laser line-scanning profilometry carried out by INOA. The slight curvature of the surface is evident.
Another painting, coming from Santa Chiara and now in the Museo Nazionale di San Matteo in Pisa, has characteristics similar to the panels described above with some additional features. The painting, depicting the *Madonna and Child* is dated between the twelfth and thirteenth centuries and portrays Mary gesturing to her Son in her arms. From the cracks between the joins and some losses in the paint and ground layers in the upper portion, it appears that the panel is made of two vertical planks that have been carved out to yield the frame and the painted surface. The band of the frame, decorated with *pastiglia* with animal motifs derived from Arabic designs probably in imitation of a precious material,17 has a flat plane that slopes down from the internal edge to the picture plane, emphasizing a sense of depth. The frame differs from those in the previous examples because of this transition. In the others, the picture plane is recessed by only a few millimeters but here the thicker frame gives a strong visual impact both to the relief decoration and to the deeply carved-out area with the Madonna and Child where the maximum height of the haloes in relief corresponds to that of the frame.18

The area in which the two figures are depicted is not perfectly flat but rather slightly convex with regard to the viewer, which is confirmed by the observation that the planks have been carved out more deeply in the four corners. This technical detail reduces the dominance of the frame and allows the figures to take on more prominence, while retaining a hieratic and abstract style for the figures.

Even in the icon of *Christ Pantocrator with Saints Peter and Paul* from the first half of the fourteenth century in the Museo di San Matteo but originally made for the girls orphanage of Pisa (76 x 60 cm), the surface inside the frame is carved out more at the corners, giving a slight convexity to the picture plane.

In two paintings examined in Rome, the *Madonna Advocata* of Santa Maria in Aracoeli19 and the *Madonna Enthroned with Child* from the Museo Civico of Viterbo, the phenomenon of convexity was encountered again. The frame of the Madonna of Aracoeli is made of a narrow, flat outer band, about 1 cm wide, which then descends straight down a few millimeters to a raised band with a slight upward incline, projecting toward the viewer and forming the broader part of the border. The internal edge of the frame meets the picture plane at right angles. The pictorial plane has a slight convexity with regard to the viewer which seems not to be due to the warping of the support but rather carving out between the frame and painted surface as it is deeper toward the corners compared with the central portion of each side. If it were due to the curvature of the panel from warping, the thickness of the frame would be equal throughout.

The support of the *Madonna Enthroned with Child*, attributed to a Roman master of the mid-thirteenth century and now in the Museo Civico
of Viterbo, also has structural and stylistic affinity to the icons. Besides finding an analogous structure using the same planks, the plane of the frame is sloped with the internal edges projecting toward the viewer as in the Madonna of Aracoeli, and the painted area has the same slight convexity due to having been carved out more deeply in the corners. These two paintings have a similar carved-out technique to the panels described earlier, but differ in the treatment of the surface of the frame which is not flat but projects toward the viewer.

The definite convexity of the picture plane, similar to that of the Pisan panel from Santa Chiara, is not though obvious enough to be seen at first glance, but implicitly influences the perception of the represented figures which despite their pictorial “flatness” emerge from the surface.

In Quaderno di un isografo, written by Aurel Ionescu, the recessed surface of an icon is described as possibly being either concave or convex. The image depicted on a concave surface, usually present in objects destined for private worship, radiates out to a focal point near the viewer. If the recess is convex, the image “radiates all around itself” and this type of surface turns out to be particularly suited for large spaces that can hold a group of people.

The examples in question generally show the relationship between the viewer and the image of an icon, but the similar technical feature
encountered on paintings of other types might bear this meaning to a greater or lesser degree. In fact, considering the scale, the function, and the original location of the Dossal of San Zeno-
bius, the slight convexity of the painting coincides with the idea of an image radiating out to a group of people, but the difference in meaning between this kind of painting and an icon makes a reference to this symbolism quite unlikely.

It should be emphasized that the slight convexity of the surface of the painting should not be interpreted with certainty as a feature of the execution technique, because, as mentioned, it could also be due to the warping of the planks. The slope
of the frame, whose outer border is set back with respect to the inner one, is actually due to a difference in thickness of about 7 millimeters but the partial loss of the original thickness of the panel, due to having been thinned in the restoration of the 1930s, has caused the loss of important information about the original geometry of the object.

In describing the conformation of the surface of the painting, we spoke of convexity, not curvature. In the Dossal, as in the other paintings described from Rome, Viterbo, and Pisa, a slight curvature is present not only on the short side of the painting where the horizontal planks follow the natural warp, but also along the axis of the wood grain, which should not deform in the same way.

Analyzing some features of the 1930s restoration, it is useful to focus on the choices and prudence of that treatment. For example, the completion of the missing half of the frame along the long sides, made to match the slope of the authentic surfaces which intersect at the corners with the lateral, completely reconstructed parts, create a slightly peaked junction like a raised miter. Despite some work on the support typical of the practice of the time, the choice of not forcing the surface into complete planarity, which could have been done extremely simply, shows an awareness of the original intent. In trying to offer possible explanations for this, we identified two likely ones. The decision may have resulted from the awareness that straightening the planks was damaging, showing an extraordinarily advanced thinking if we remember the years in which the restoration took place. But considering that the painting, before this treatment, in all possibility had planks with their original thickness, Vermehren and his team could have taken note of the convexity of the picture plane, thinning the back only so far as to create a flat enough surface for the cradle attachment, without changing the conformation of the surface.

This idea could be confirmed by the fact that the removal of the wood must not have been much and above all, by the choice of completing the frames. By continuing the missing upper and lower part, giving a slope and a different thickness to the outer edge compared with that remaining of the original, and having reconstructed the side frame elements giving them the same slope, leads to, as noted above, the formation of raised beveled junctions in the corners of the panel. The slope of the original parts, truly slight, could have been blurred to reconstruct the missing parts flat, especially if for those who carried out the treatment of the 1930s, the slope was the result of the warping of the planks. It is clear instead that the slope and the formation of the shallow peaks in the corners of the painting is a desired effect. Considering that Vermehren’s restoration had as a goal the elimination of all non-original parts and demonstrated innovation and respect for the authentic material in the retouching choices, it seems likely that the convexity of the pictorial surface was maintained and the choice of repairing the frame elements were meant as references to the construction techniques of the artwork.

In the Florentine milieu, a painting very close to the Dossal of Saint Zenobius in terms of date, style, and structure, is the Madonna of Casale by the Master of Greve. The panel, dated to around the first half of the Duecento, is held in the storage of the Soprintendenza at the Uffizi, and was restored at our facility in 1984–86. From the treatment documentation and from direct observation we have acquired data on the construction technique. The painting is 180 x 79 cm and is made of two planks of 4 cm thick poplar, arranged
10. *Madonna Advocata*, Santa Maria in Aracoeli. Detail of the profile of the panel. The red line shows the slope of the frame and the slight convexity of the painted surface.

11. Master of the Bigallo Crucifix, *Dossal of Saint Zenobius*. Detail of the fills from the treatment made in the 1930s. The slightly peaked junction between bevels in the corners is visible.

12. Master of Greve, *Madonna of Casale*, Deposit of the Soprintendenza, Florence. Detail of X-ray showing the continuity of the wood grain through the picture plane and frame.

13. *Crucifix* of San Paolo all’Orto, Museo Nazionale di San Matteo, Pisa. Detail of suppedaneum where the panel can be seen to have been carved out.
vertically, and reinforced by two crossbars at the top and bottom. The halo is made of coniferous wood, inset and glued along the upper margin of the panel. From the X-ray,23 the frame can be seen to have been carved out of the same two planks that form the panel, as in the construction of the Dossal of Saint Zenobius. The bosses in relief made with pastiglia and the band with the double volutes enclosing red diamonds echo the decoration of the frame of Saint Zenobius. In the Madonna of Casale there is no similar raised miter corner or slope of the frame though the support, being very deformed, does not provide a clear comparison. Though there is neither the convexity of the picture plane, given that the deformation of the surface is clearly due to the warping of the planks, nor is there an outward sloping frame, it would nevertheless be useful to study the painting in greater depth with a more objective system, for example three-dimensional scanning.

The Madonna of Casale, apart from the similarities to the Dossal of Saint Zenobius, is one of


15. School of Bernardo Daddi, Madonna and Child, Opera di Santa Croce, Florence.

16. Detail from the side showing how the frame is carved out from the panel.
the paintings in which a certain three-dimensionality is sought in the support which influences the perception of the image and where it draws on the choice of carving out a frame and picture plane from the same planks. This type of workmanship, typical of icons, is used in the Western world not only on small panels, but also on large artworks and even in some crosses.

In fact, Pisan examples include two large crosses in chestnut with carved-out supports: the Crucifix of San Paolo all’Orto (295 x 210 cm) from the beginning of the twelfth century, now at the Museo di San Matteo and the Crucifix of Enrico de Tedice (257 x 155 cm) from the mid-thirteenth century from the Oratorio of the Castello di Vicopisano and now in the church of San Giovanni alla Vena, of the same city.

Proceeding with the study of carved-out supports, it was also noted that this structural type is found among some panels made when the Trecento was well underway. Pacino di Bonaguida, who is documented in Florence from 1303 to 1339, provides an example of the lasting nature of this technique in the remaining three panels of the polyptych from the church of San Procolo, depicting Saint Nicholas, Saint John the Evangelist, and Saint Proculus and now in the Gallerie dell’Accademia. Examining the sides of the paintings, it can be seen how each piece is made from two planks arranged horizontally and how the painted areas, carved out from the wood, are given cusped tops. The same technique is used for the remaining panel of a polyptych from the school of Bernardo Daddi (98 x 55 cm), depicting a Madonna and Child, belonging to the Museo di Santa Croce but currently under restoration at the laboratories in the Fortezza da Basso. In the Badia Polyptych, Giotto also painted on partially carved-out panels. Painted in the first years of the Trecento and on display in the Gallerie degli Ufizzi, the altarpiece is made of five sections of poplar wood (142 x 337 cm in total) culminating in pointed arches, each with a central vertical plank enlarged on both sides by an attached strip. From the X-ray, the painted surface and the cusped trilobe frame that surrounds it at a slightly higher level can be seen to have the same wood grain; furthermore, there are no signs of metal nails or wooden pins. This detail reinforces the idea that the planks were carved out in order to make frame and picture plane, as seen in the earlier panels mentioned above. The join between the central plank and the side strips runs through the picture surface and cusped frame, confirming that particular construction technique. Less clear is how the lateral columns are made. Each one corresponds to a side strip of the plank and seems carved from the same wood as this, but some circular marks visible in the X-ray with the same radiopacity as the planks, (one for each little capital) could be little wood dowels used as connectors between the columns and the base. If the circular marks correspond to these elements, the columns were made separately and then applied to the support.

Again from a Roman or Giottesque circle, the Madonna and Child of the Master of the Altieri Madonna, from around 1310 and now in a private collection is painted on a carved-out support. In this case, the rectangular format panel (121.5 x 73.5 cm) has a simple flat frame that slopes down to the picture plane, exactly like in some of the previously described icons.
**Conclusions**

This study, arising from the lack of original structural elements to explain the construction of the *Dossal of Saint Zenobius*, has shaped interest in acquiring information on this particular technique of workmanship in panel paintings. Accordingly, a fascinating world has opened up in which values, symbolic meanings, and stylistic constraints take turns or are fused together, developing forms and solutions that are open to interpretation.

The carved-out technique, frequently found in Byzantine icon panels, has been found in various kinds of Western paintings of different dimensions, from early dossals, to crosses, up to fourteenth-century polyptychs, so many as to form a specific structural category.

Certainly the paintings cited here are not the only ones made in this way, but we hope our research can serve to lay out the basis for a more extensive study and contribute to the reading of the structural techniques of panel paintings.
According to the kind of construction of some thirteenth-century dossals placed in front of the altar, crossbars were not necessarily intended and sometimes the support of the panel was left to the perimeter frame; examples of this are the Dossal of Saint Michael Archangel by Meliore. These though are smaller for-meres to historical documents have been assembled. However, noted here are the essen-tial publications on the relocations and restorations of the Dossal of Saint Zenobius: G. Poggi, “La tavola di San Zanobi nella chiesa di Santa Reparata,” Rivista d’arte V (1907): pp. 112–117 and, by the same author, Il Duomo di Firenze: Documenti sulla decorazione della chiesa e del campanile tratti dall’archivio dell’Opera, (1909), anastatic reprint, edited by M. Haines, Florence, 1988.

For an in-depth discussion of the conservation of the panel, see “L’intervento sul supporto del Dossale di San Zanobi...”, op. cit., chapter III.

The original panel is made of two horizontal planks, whose assembly, modified in the restoration of the 1930s, would have probably been with butt-joins. Due to the thinning of the back of the panel, it is difficult to determine evidence of an original crossbar system. According to the kind of construction of some thirteenth-century dossals placed in front of the altar, crossbars were not necessarily intended and sometimes the support of the panel was left to the perimeter frame; examples of this are the Dossal of Saint Michael Archangel by Coppo and that of the Madonna and Child and Saints by Meliore. These though are smaller format paintings than Saint Zenobius, the first is 98 x 124 cm and the second about 95 x 155 cm. Some very deteriorated fragments of wood, coming from the panel of Saint Zenobius with small traces of gold decoration and gesso, were probably part of its outer perimeter frame, nailed to the support. Given the large dimensions of the painting it is in any case difficult to think that the perimeter frame could have restrained the movements of the panel and instead quite likely that the support had crossbars. Confirming this five circular fills can be seen on the center of the back of the painting, arranged vertically, with associated signs of burning that make us think of the presence of nails inserted “hot” to anchor a crossbar. Based on this finding and the large scale of the painting, it is possible to speculate that besides the supposed central crossbar, the support would have had, at each end, another two crossbars.


3 M. Boskovits, The Origins of Florentine Painting..., op. cit., p. 300. In the Corpus of Boskovits, all the previous studies and references to historical documents have been assembled. However, noted here are the essential publications on the relocations and restorations of the Dossal of Saint Zenobius: G. Poggi, “La tavola di San Zanobi nella chiesa di Santa Reparata,” Rivista d’arte V (1907): pp. 112–117 and, by the same author, Il Duomo di Firenze: Documenti sulla decorazione della chiesa e del campanile tratti dall’archivio dell’Opera, (1909), anastatic reprint, edited by M. Haines, Florence, 1988.

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**Gentile da Fabriano’s Polyptych of the Intercession: A panel outside the canon**

Ciro Castelli, Mauro Parri, and Andrea Santacesaria

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Gentile da Fabriano’s Polyptych of the Intercession was made at the beginning of the third decade of the fifteenth century, during the artist’s sojourn in Florence (Fig. 1). In so far as it is still possible to categorize the polyptych by size and shape after the events of its history that have profoundly marked the painting, delivering to us an altered object, missing many of its structural parts, it remains an unusual altarpiece in the panorama of Florentine paintings of the period.

The dimensions, 222 cm wide and 97 cm in the tallest part of the central section, give the composition a distinctive horizontal emphasis that in any case would have still existed even considering the likely loss of added elements such as a little predella (mostly likely with an inscription and not a painted scene) and architectural pinnacles (Diagrams I–II).

The typology, therefore, does not fit into the tradition of the period in which there is a strong push toward surpassing compartmental pictorial subdivision and there is a search for a unification that develops shortly into the creation of the single-scene altarpiece of the pala and its standardized form, the so-called square pala.¹

In the Polyptych of the Intercession meanwhile, we see an extreme of the idea of a polyptych, if you will, using the different sections figuratively as a succession of narratives, almost as if it were a pauper’s bible, or rather, a devotional treatise inserted in an altarpiece.

The iconographic theme of the Intercession of Gentile only has one precedent in Florence, that

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of the painting on canvas attributed to Lorenzo Monaco from the Duomo and today in the Cloisters in New York. The narrative of Lorenzo Monaco happens in a two-dimensional space, a rectangle with a vertical emphasis, in which the painter uses as his narrative technique the dialogue that develops between the Virgin and Christ and between these two and God the Father. A dialogue that emerges so strongly as to also be rendered in written words: a kind of antique comic strip that links and binds together the holy figures. The use of gestures is insistent, typical of emphatic narration: the Virgin shows with one hand the small population of faithful hidden under her mantle, and with the other, the breast with which she has nurtured Christ. And Christ shows with one hand the hand of the mother, and with the other indicates the wound on his ribs, symbol of the suffering of the Passion.

In Gentile’s polyptych, however, the narrative structure is articulated inside of an architectural space, internally punctuated with pilasters that divide the scenes into differently sized fields, two by two. The progression of five compartments diminishes in width from the central one toward the two sides, but this decrease is not harmonic. There is no proportional relationship between the width of the central compartment and those of the two adjacent; nor between these and the two outer side scenes. In the same way, the heights of the apex of
the arches of the polyptych slope down from the center to the sides but this decrease is neither harmonic, nor constant: the two side compartments adjacent to the central one are only a very small amount higher than the outer ones while the difference between their heights and the central one is more significant. On the other hand, the design of the curves of the arches of each single compartment seems planned according to geometry and a precise stylistic choice: a mixtilinear form that generally can be considered to derive from the Ghibertian tabernacles of Orsanmichele.

An unusual type, therefore, which even modern criticism has difficulty inserting into a more precise category, so much so that Christiansen, for example, prefers to call it a “dossal,” or rather a “low gable dossal.” Even the fact that at a certain point in its history the polyptych was incorporated in a surrounding structure that made it like a step of an altar or a large shelf has probably influenced us when considering it in this light. In reality, for our interpretations of the painting and our hypotheses on reconstructing the arrangement of the original, we need to always keep in mind its extreme fragmentariness, especially historical, as we do not know its destination or exact location. There is an entire series of conjectures based on categorical closeness or structural affinity to paintings of the same period or of the same school that are often applied to this kind of reconstruction that cannot be used here.

We begin from what appears immediately evident to an observer, that is, as mentioned, the dimensions of the painting, its horizontal emphasis, and then, to go into specifics, the criteria by which the materials were chosen and how they were assembled to make up the support.

The study of these elements bring us to enlarge on the concept of distinctiveness, which applies to more than the shape but extends to the workmanship and the choice of planks: in fact, in this regard, it should immediately be noted that the planks used almost certainly were recycled, assembled together both vertically and horizontally (see pages 112–113) to obtain a surface of the desired dimensions. Thus, this first distinctive feature is the combination of vertical planks with a horizontal plank, united by numerous nails, distributed along the entire length (Diagrams III–VIII).

The shape of the arches was cut from the panel made after the assembly of all of these planks (Diagrams IX–X). This working method contains two unusual features to underscore if we compare this structure to that of the more traditional construction practice. Generally, in the polyptychs made of more than one compartment, each of these was constructed and cut individually, separately, and then the different parts were assembled through a variety of connecting and supporting pieces. These joins were made exclusively with glue. Sometimes, if the sections were not meant to make up a single pictorial surface, but remain separated by colonnettes (the typical polyptych in the strictest sense), they would even be gessoed individually.

This other unusual feature is that the carpenter created the crowning shape of the cusped arches by cutting through the entire, already-assembled panel in the presence though of a surface divided into isolated compartments on the front and finished with the addition of the pilasters. The carpenter behaved, from a construction point-of-view, as if he were building a pala with a single scene, while then he went and made, from the front, a compartmentalized polyptych.
IV. Diagram of the arrangement of the planks.

V. Setting up the cut for the half-lap join.

VI. Executing the half-lap join.

VII. Assembling the vertical portion.

VIII. Assembling the entire panel.

IX. Planning the arches.

X. Executing the arches.
Another aspect that may shed light on the planning and working process is retracing the elements that allow us to understand the use of a precise geometric method in constructing the contour of the polyptych arches. In fact, the lack of original frame elements along the entire upper perimeter has left visible a series of incisions in the wood occurring at regular intervals, based on which the perimetral cuts of the arches were made.

Though with modest imperfections, the incisions mark the arcs of the regular circumference that makes up both the concave and the convex curves of the arches. Of course between planning the work and thus tracing the arcs of
the circumference to the actual carpentry phase there were slight variations and adjustments made (Fig. 2 and Diagrams XI–XIV).

Strong planning and geometry abilities ought to have been a standard skill set for the carpenters and these abilities are often seen in the many traces left on panels over the course of planning the work and used to execute certain steps. It was rather the general discrediting of manual labor and craftsmanship from the eighteenth century onward with the beginning of the differentiation between theory and practice that relegated even past achievements into the shadowy area of manual labor seen as a repetitive action, performed by illiterates and generic laborers.

The incised lines detectable on the panel, tied to the preliminary construction phase, also provide evidence that defining the upper contour was done with the panels joined together: there are incisions that appear to be only the remains (the survivors of the cut) of the straight lines that run along the whole width of the panel, to guide the operation of cutting and to be certain that the height of the tips of the arches were the same for each pair of side compartments.

Regarding the choice of wood, we see again that there is a departure from the more common practice, that is one in which there was undoubtedly a lot of attention paid to selecting good quality material which, over time, was in large part trusted to preserve the work of art. Both the selection of the wood itself and the structural criteria were changed and adapted to the construction needs as they developed over the course of centuries, incorporating an excellent technological awareness of wood and its behavior in relation to temperature and moisture fluctuations, as well as the aggressive effects of microorganisms and aging. Also, the fact that the art treatises address the selection of materials more than construction techniques for woodworking shows how this phase was subject to objective scrutiny and controls. It is no little wonder then to find ourselves faced with the employment of recycled materials in the wooden structure of the polyptych, and not only that, but that their assembly shows practices that are difficult to justify if we assume an interest on the part of the woodworker for the long-term preservation of the object.

In fact, even if building with old wood might not be by mere chance, but have been deliberate in that it offered a guarantee of better stability for the object, it should still be noted that this is usually achieved with a normal seasoning of the materials, without necessarily resorting to reusing planks.

The wood used for the polyptych, furthermore, might have been used previously for another altarpiece, which was then dismantled into individual planks and then some of these were re-purposed to make up the panel of the new support. In particular, five of the eight could have even been cut from the same tree.

The recycled wood is also evident from reading the X-radiograph: from traces of a typical adjustment and assembling of the new panel that caused the collapse of insect holes and the cavities of dowels; furthermore, the trace left on the back of the first compartment on the left reveals
Ciro Castelli, Mauro Parri, and Andrea Santacesaria, Gentile da Fabriano’s Polyptych of the Intercession: A panel outside the canon

an overlying element in the longitudinal sense at a height of the impost of the arch, likely a cross-bar (Figs. 3–4 and Diagram XV).

If the use of recycled wood was a deliberate choice, given the fact that, in any case, the planks used have good physical properties (they are radial cuts, a guarantee of stability), we should also consider that since they were recovered from a similar structure, the selection had already been made at that prior time. And it therefore seems especially strange because the planks were not long enough to complete the required structure.

In fact, only this lack of length of the vertical planks seems to be the motivation that resulted in the use of a horizontal plank at the bottom to complete and to close the final panel. Having planks no longer than 80 cm available (this is the height of the vertical planks), the carpenter was constrained to work out a complex system of half-lap joins to connect to this a long plank (222 cm) that runs the entire length of the polyptych and that adds to this about 20 cm of height, just making up for the insufficiency of the vertical planks. The work, however, was even more difficult (and consequently, our ability to deduce the motivations becomes even more remote) in that the vertical planks do not make up a linear, horizontal panel, but end at different points. Therefore, adding the horizontal plank, brought about the need to adapt to a “stepped” shape. It certainly would have been simpler to straighten the base along the line of the greatest height obtainable of all the planks used vertically, so as to then join the horizontal plank along a straight line, but probably the stepped form was used to give greater strength to the join, exploiting the forces that the longer planks could sustain compared with the horizontal and in the joins between these.

Beginning with considerations relative to the dominant criteria in craft working practice, all of this is certainly rather difficult to explain: from the structural incongruences and the undeniable preservation repercussions that they would have in the future, we add a problem of economic management of the work: the loss of time, that is, derived from having to create a lap join along the entire length of the panel, and having to take care to keep the two parts of the support aligned, and, furthermore, not join along a straight line, but along a step.

Besides this, the join would be a fragile part if made with only glue, and therefore, the carpenter used a large number of nails (a good 45 of them) all along the length, inserting them both from the front and the back (and thus inviting the problems of contraction and lifting of the paint around the heads of the nails inserted from the front due to oxidation of the iron, as, indeed, has happened).

At this stage of the examination of the anomalies of the construction, other doubtful and thought-provoking aspects are seen in the lack of convincing signs of an original system of restraint on the back of the panel. Even accepting that it would have been superfluous to attach a cross-bar along the lower edge of the panel because the plank has a horizontal grain, the lack of a crossbar at the top, which we had thought would connect along the impost of the arches, remains to be explained considering Tuscan construction traditions. But in this area we found neither traces on

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4. Deterioration phenomenon on the right panel in which the wood surface shows furrows. The site of a collapsed dowel channel is visible.

XV. Diagram of the position of the dowel channels in the panel.
the X-ray (original nails cut but remaining in the panel), nor traces of planing of the attachment to the back, nor traces of a different coloration of the panel along its length that suggest it having been protected from light and dust in an area corresponding to a crossbar.

The back of the panel has numerous light brown, gesso and glue fills (Fig. 5). This procedure was often carried out on the back of supports with the aim of repairing parts of the wood that are thought to be imperfect or have imprecisions of workmanship (patches or joins that do not align perfectly, knots, incorporated metal pieces, cracks, etc.) with the scope of safeguarding the areas most likely to be affected by deterioration. In the case of the panel of the Polyptych of the Intercession this application and the areas it covers are important to interpret as it does not seem limited to the sensitive areas mentioned but relates to the general structure of the painting and the type of superficial deterioration of the back.

The fills cover, for example, the line of the join between the vertical panel and the horizontal plank and all the metal nails used to strengthen this attachment. Furthermore, corresponding to the first compartment on the left, the application of the fill material covers most of the surface; in the areas in which there are losses to this fill there is extensive deterioration underneath, that is on the panel, due probably to a biological attack, or in any case to a phenomenon of erosion of the wood substrate which has cut deeply along the grain.  

This is a type of deterioration that is not due to normal aging of the wood and that does not affect the horizontal plank. Therefore this leads us to think that the deterioration for which the area was extensively filled was prior to the panel being put together and belongs to its earlier use. Again on the same plank, at the top, at the base of the arch, the fill stops and, more importantly, a portion of healthy wood is revealed (Fig. 6).

It seems that this different area has been somehow protected from the biological attack that has affected the rest of the plank. From the shape of this “respected area” we think that this protection was due to the presence of an overlying piece, probably a crossbar.

If so, we infer that the plank was put to use before exactly in the same location as at the time of its second use (this one) so that the location of an old
Ciro Castelli, Mauro Parri, and Andrea Santacesaria, *Gentile da Fabriano's Polyptych of the Intercession: A panel outside the canon*

crossbar and the position in which a new one would have been inserted would have coincided, according to Tuscan polyptych construction criteria.

However, as mentioned, if there ever was a crossbar in the second and current polyptych, it is difficult now to detect traces of its anchorage to the support. It has to be honestly conceded that the wood of the panel does not show any relevant color change marking different exposures to ultraviolet light and atmospheric agents and therefore indicating where a crossbar was for a certain period of time.

In general, the absence of signs either by visual or radiographic examination of a continuous and unequivocal series of attachments for crossbar elements, above all in the area in which they would probably be found corresponding to the base of the arches, is a fact to emphasize. It remains possible though that there was, however, a restraint system.

The only signs of one that we can detect are less noticeable than radiographic traces but result, more than anything, from the study of the behavior over time of the vertical panel. In particular, the support shows slight warping deformation in the central part of each of the main compartments and additionally, the prominent cracks that appear even on the painted surface are caused by friction and restriction of the movements of the planks, like that generated by a system of restraint. In fact, a free panel would have deformed in a uniform way and would reflect the cut of the planks and not have the more regular rhythm arguably corresponding to regular intervals of crossbar attachments.

Furthermore, the cracks would have been mostly produced in the lower part, near the join with the horizontal plank that makes for a truly rigid body. We can therefore imagine that the panel had a kind of restraint (in the form of a crossbar) distributed in the spaces between single scenes, but it is not possible to jump ahead and formulate a hypothesis on its shape and anchorage points.

Regarding the general architecture of the painting, it is not possible to go beyond conjecture.

At the top of the small half-pilasters, custom-cut, rectangular notches were used to hold the ends of the pinnacles, now lost (Figs. 7–8). A curious detail is that one fragment of these remains. Beyond the pilasters closing the outsides, beyond the painted surface, there is a bare wood strip into which pilasters or colonnettes finishing the sides of the architecture of the polyptych probably fit (Fig. 9).

Of note, in fact, is how these outer pilasters are not finished on the external side. There is no gesso coating, but rather the dripping of the gesso from the ground; the outer corner is not rounded, as instead all the others are, and the abacus ends smoothly at the edge without continuing on the outer sides (where evidently it was not necessary due to the presence of a finishing element). On the
cornice of these two outer pilasters, furthermore, there was no original hole for housing the pinnacles, but one with a circular shape and a depth insufficient to sustain a pinnacle. The last element of our analysis is that of the presence in the panel of two dowel cavities, on each side of the polyptych, at a perfectly symmetrical height: these might indicate the presence of a lateral pillar to which the dowels would have served to reinforce the attachment.

These side elements would have therefore overlapped the area that is unfinished, resting against the outer pilasters, completing the rough side, and connecting with the (hypothetical but possible) upper crossbar and the aforementioned dowels located in the sides of the panel.

Though, as mentioned previously, the indications of the presence of a crossbar at the base of the arches are not clear. However, its presence would have served in an architectural structure of this type.

To conclude the hypothetical reconstruction of the original structure, we need to explain how it was likely that the panel of the current painting extended by about ten centimeters more at the bottom (Fig. 10). The current thickness of the lower side shows uncovered wood-boring beetle galleries and signs of an untrimmed cut. The hypothesis
regarding the dimensions of the lost part is based on the current position of the dowel holes on the sides of the panel. These are off-center by ten centimeters toward the bottom with respect to the entire height of the current support (arches excluded). These are most likely the only dowels used functionally for the structure (the others, detected in the X-ray, as already mentioned, are traces of the preceding use of the planks with a different structural purpose), they correspond to a structural logic that would place them at the center of the full height of the panel. We must therefore suppose that the missing portion measured about 10 cm, which serves to make up the average distance of 37 cm between the dowel and the base of the arches. The space of 10 cm, therefore, would not be such as to accommodate a proper narrative predella, but more likely, a band, perhaps with an inscription and associated framing (Diagrams XVI–XVIII).

In contrast to all of the considerations made up to now relative to the possible preservation precariousness conferred by the structural anomalies of the panel, the polyptych is in a relatively good condition from a structural point of view and its paint layers are generally stable. Most likely a good part of the merit of this goes to the application of a canvas over the entire support: carefully selected and applied textile lengths that contrast, if it is possible to say so, with the construction of the panel. In fact, the canvas is applied in a single piece over each pictorial compartment (in the X-radiograph, the edges of the pieces are only seen at the borders of the compartments). It should be noted that according to the narrow specializations of the workshops of the early Quattrocento, the phase of preparing the panel was in the hands of separate profession, that of the so-called gessoers (ingessatori) of whom we have evidence from numerous documents from the period and therefore the differences between the careful and the apparently unorthodox workmanship could be explained this way.5
**Construction technique of the wood panel**

The support of the *Polyptych of the Intercession* is 222 cm wide, 97 cm at the highest point, and 2.3 cm thick. It is made of nine poplar planks, eight of which are positioned vertically and one horizontally at the bottom as the base of the panel. The eight vertical planks have a radial cut; they show a distinct growth ring pattern that appears with regularity at a distance of about a centimeter; the direction of the grain is moderately sloped. In particular, the fifth plank on the left, central with respect to the overall composition, has a decisive curvilinear grain. The plank at the bottom is a sub-tangential cut and has numerous knots.

The vertical planks are assembled with butt-joins with a simple gluing and without using internal connecting elements. These form a whole that is united to the horizontal plank with a half-lap join carried out with a rather unusual method: the vertical planks have been carved out on the back to yield a straight cut, while on the front, the border of the join is irregular. The area of the half-lap join has been reinforced with nails inserted alternating from the front and back.

The support has been finished on the front with rectangular pilasters with rounded corners that separate the individual scenes; these pieces have been nailed to the panel. On the upper and lower border, a simple frame has been attached with glue and thin metal nails. These are flattened and without heads, typical for this use. The frame circles around the ends of the pilasters and follows the mixtilinear forms of the arches. In the upper part of the pilasters, in holes made for the purpose, the points of pinnacles were inserted. The lateral pilasters leave uncovered a strip of the panel onto which were probably applied pilasters that laterally closed the composition.

*The 18th century addition*

In formulating hypotheses on the original structure of the polyptych, we have to keep in mind the added portion in eighteenth-century style that attached to the top and formed the frame. This element appears in old documents as still together with the painting and was likely removed during the restoration of 1983 (Fig. 11). After about twenty years during which it was left in storage and thought lost, it has been recently rediscovered and brought to the laboratory for study and comparison with the *Polyptych* (Fig. 12).

Some very meaningful findings have emerged. The support of the addition is made of poplar wood and its main body is composed of two planks joined along their lengths, oriented horizontally, and continuous with the plank of the support. (Fig. 13). These planks have been shaped so as to fit the mixtilinear profile of the upper border of the painting. In particular, the edge corresponding to the central section and that adjacent on the right have a profile that does not complete the cusps of the inscribed arch and this is seen on the polyptych: in these areas, the apex of the arches are in fact cut, likely just for fitting into this structure (and were then reconstructed in the treatment of 1983 when the structure...
was removed, bringing to light the truncated arches) (Fig. 14). We can imagine that during the operation of filling in and squaring up these modifications were made either because the areas had deteriorated, or perhaps rather that there was a fear that the precise execution of the profile, especially that of the central panel, would cause a decided weakening of the structure. The two added and shaped planks were reinforced and finished architecturally on the front by an overlying frame. Furthermore, on the surface adjacent to the frame of the polyptych in correspondence to the capitals of the pilasters, decorative half-amphorae in poplar have been attached; these elements were glued onto the surface and show signs of having been turned (Fig. 15).

The structure was firmly anchored to the upper border of the polyptych by nails inserted diagonally from the top on the edges of the arches. On the sides, two planks held with a half-lap join to the planks of the addition, extend and are anchored to the lateral parts of the polyptych, probably with nails inserted from the sides into the edges of the panel.

It appears evident that reading the numerous clues present on the panel of the Intercession ought to take into consideration a stratification of signs whose transitory causes makes a secure chronological determination difficult.
Gentile da Fabriano’s *Polyptych of the Intercession*: The conservation treatment of the panel

Ciro Castelli, Mauro Parri, and Andrea Santacesaria


The condition of the panel

The observations made on the structure of the support, as we have described earlier, besides showing the anomalies of the construction, have led to a consideration of the preservation state of the object. For the planks placed vertically, various splits of modest size were found, while in the horizontal plank at the bottom, there were other cracks that were larger in length, width, and depth. These phenomena are due to the unusual construction technique of the support with planks positioned in opposition.

In this panel, the problems of deterioration were accentuated due to an old, widespread wood-boring beetle infestation resulting in extensive galleries that weakened the areas along the joins between the horizontal plank and the vertical ones. Moreover, the plank at the bottom, both due to its aging and its sub-tangential cut, is modestly warped and shows wide cracks along the grain. Especially in this plank, the insects have caused an erosion of the wood material and a general fragility.

Insect damage is also found on part of the frame at the bottom while all the frame elements at the top have been lost.

The previous campaign of restoration on the panel

The last treatment on the panel dates from 1983 and was carried out on the structure without substantially affecting the original assembly; at that time the work was limited to removing the 18th century frame and closing the cracks by inserting poplar wedges; these elements, inserted with a good technique even though using new wood, served not only to reconnect the pieces, but to fill the gaps caused by the contraction of the wood.

To support the panel a new crossbar had been made, placed in the upper portion a good way beneath the bases of the arches. This placement differs from the traditional or prevalent standard, certainly not random, that dictates the crossbar placement directly at the bottom of the arches. This crossbar was made of Masonia walnut and it was fixed to the panel with screws passing through slots cut in the crossbar and screwed into bushings inserted in the panel.

The treatment of the panel and reconstruction of the frame

Considering the condition of the painting and the previous treatment, our project foresaw generally improving the structural integrity of the panel, the removal of the crossbar at the top, and the provision of a new system of restraint that would provide a constant connection and support for the panel. At the bottom, the splits and the deep cracks due to the natural shrinkage of the wood had been reinforced in an effective and traditional way in the earlier treatment, therefore, only the remaining small fissures overlooked in the past were reinforced this time with the technique of inserting aged wedges of poplar wood into thin channels cut with the electric router and glued with a PVA adhesive (Fig. 1).

The limited eroded areas were repaired with small inserts of aged poplar and some areas of the lower frame were also reconstructed (Figs. 2–4).
1. Cutting the channels for repair of the small splits with wedges.

2. Reconstruction of the tip of the arch with aged poplar pieces.

3. A step in the compensation and repair of the lower frame.


5. The placement of the anchorage points for the supporting framework. The attachments are aged walnut and simply glued to the panel.

6. Some areas have been extended to allow for good contact between panel and supporting framework.
7. Detail of a model of the anchorage between crossbar and support. The cutaway shows, from the bottom: panel, walnut foot, conical spring, and regulating nut.

8. The back of the panel after the application of all the attachment points for the supporting framework and crossbars.

9. Paper model of one of the curvilinear frame elements of the arch.

10. Profile of the frame and a straight sample made of poplar wood.
The support on the back was trusted to a chestnut framework with internal crossbars that followed the perimeter of the panel and crossed just under the arches. This was anchored by means of oscillating screws held on small circular wood bases; the screws pass through the framework and attach to an adjustable spring and regulating brass nut (Figs. 5–8). The supporting framework has the functions of restricting the warping deformations of the panel, sustaining the weight of the object in an even way, and protecting the margins; furthermore, it allows the back to be sealed by paneling to reduce the exchange of humidity between the painting and the environment.

The protection can be calibrated according to different needs with the insertion of not only barrier materials but also buffers, for example, Artsorb or silica gel. Furthermore, the framework is furnished with feet that allow the painting to be freed from having to sustain its own weight, especially considering the fact that a critical point in this regard is the lower plank on which the weight of the entire panel rested and which showed a tendency to warp.

The frame elements positioned along the arches were reconstructed following a careful examination of the original parts still present on the capitals and pilasters and whose profile connected the entire upper section of arches. During the reconstruction, the original criteria of workmanship was followed, seeking a geometric regularity, interrupting the elements of
the curved profiles, distinguishing the arched sections from the straight. The sections were firmly joined to each other, resting on the unpainted part of the panel and held by pairs of brass L-brackets on the outer edges (Figs. 9–12).

The panel was protected from xilophagous insect infestation with Permetar dissolved in mineral spirits. On the back, a coating of microcrystalline wax was applied as a protection against sudden fluctuations in the humidity of the environment (Fig. 13).
Niccolò Liberatore called L'Alunno, Coronation of the Virgin, 1495, Church of San Niccolò, Foligno.
Niccolò Liberatore called L’Alunno: Painting methods of an artist who adopted the technical innovations of his time

Ciro Castelli, Mauro Parri, Patrizia Petrone, and Andrea Santacesaria

The altarpiece of the Coronation of the Virgin is located in the church of San Niccolò in Foligno over the altar of a side chapel dedicated to Saint Anthony. Giovanni Antonio Marini and his wife Antonia commissioned it from Niccolò Liberatore. Since the altarpiece was not finished before the death of the couple, it was ultimately delivered to the brother of Antonia, Pierangelo di Gianni di Ser Nuti who was the executor of the will.

The discovery of a document dated September 11, 1495 recording the delivery of a painting on the part of Niccolò Liberatore called l’Alunno (a well-known artist of the Umbrian-Marches territory) to said Ser Nuti for an altarpiece intended for the chapel dedicated to Saint Anthony Abbot in the church of San Niccolò is the substantial reason to attribute this painting to this artist. It is confirmed by the presence in the painting of Saint Anthony and by stylistic observations.

This altarpiece belongs to the late period of the artist in that it adopts the innovation of the Renaissance-style square pala (as already seen in the altarpiece of the church of San Giovanni Battista in Cannara though in a more archaic form for its gold background), while in our example the subject is inserted into an airy and extensive landscape with small vignettes, and the lateral saints accentuate the depth of the view.

The structure of the support of the pala, though clearly not intact due to missing the pinnacle and some restorations, seems to fit with typical fifteenth century constructions. The painting is made of four parts: the predella as a base, the square panel with nailed architrave, and the lateral pilasters.

The painting depicts the Virgin crowned by Christ: these figures are placed in the sky in an ogival cloud framed by a double ring of cherubs of which the inner is on a gold ground and the outer on a painted ground; golden rays surround the figures that stand out against the sky above a hilly landscape carved by a river; in the foreground, to the sides, are two kneeling saints, Saint Bernadino of Siena and Saint Anthony Abbot.

The predella has a gilded frame and a stripe of gold around the painted area; the image of Christ in the center, the Madonna to the left, and Saint John to the right are all enclosed by gold circles; a pair of angels holds a shield at each side of the composition; amphorae with garlands are in the spaces between the circles; and a red ribbon connects the various elements.

The pilasters have Corinthian capitals and are topped by a carved entablature. Each pilaster is painted with floral garlands and, unusually, there is a cut across the upper part; the sides of the pilasters are decorated with imitation marble, typical of the Umbrian-Marches region at the time.

The painting was located in a side chapel over an eighteenth-century altar decorated with white stucco with columns and putti on the sides. It was surmounted by a lunette decorated with leaves and a large eye. At the time the painting was added to the eighteenth-century altar, it was already missing the upper part, and we don't know on what occasion this was lost or removed, perhaps due to damage in an earthquake that had struck the church.

The painting reached our laboratory in September of 2002 in two separate parts: the predella
and the main panel complete with pilasters and upper frame. Various areas had been protected with Japanese tissue adhered with Plexisol to preserve lifting paint and prevent losses (Fig. 1).

The painting, during restoration treatment, was included in the exhibition “Nicolaus Pictor. Niccolò Liberatore detto L’Alunno: artisti e botteghe a Foligno nel Quattrocento” curated by Giordana Benazzi and Elvio Lunghi and held at the Palazzo Trinci in Foligno from May 29 to October 3, 2004. It returned to the Fortezza afterward for the conclusion of the restoration work.

Execution technique

The wood panel

The painting displays innovative elements, both structural and formal (Figs. 2, 21).

The panel is 187 cm high, 156 cm wide, with a thickness of 5 cm throughout most of the central area, while the upper and lower parts are 4 cm thick. The panel is made of four planks of poplar wood arranged with the wood grain running vertically and joined with butt-joins. The quality of the wood is not good. The planks are 19, 60, 56, and 21 cm wide and are sub-tangential cuts. Furthermore, large knots create grain and texture deviations in more than one direction. We don’t know if the carpentry was carried out in the bottega of our painter, one of the best known in the area at that time, or by a “magister lignaminis” at his request.1

The right panel, along the outer edge has extensive wane, while the two central ones have typical signs that indicate, besides belonging to the same trunk, that one came after the other. The panel has two wooden inserts in the right part, patching malformed areas of the wood (Fig. 3). The X-radiograph shows how these were made in different ways: one is composed of two pieces of wood of different sizes nailed together that make up a half-lap join; the other is a single element fitted into a half-lap join. These inserts are fixed to the support with glue and nails inserted under the preparation layers and bent around on the back.

The workmanship of the back of the panel is very uneven, leaving visible the diagonal cuts of the saw, the wide scoop of the adze, and chisel marks. As mentioned, the panel thickness is quite irregular; for the most part it is 5 cm but with two horizontal lengths that are decidedly lower by 1 cm with adze marks and broken wood grain along the upper and lower edges. Furthermore, irregularities are found in the execution of the restraint system for controlling deformations of the panel. This consists of a single crossbar placed at the bottom and held with nails, while on the top, the restraint is trusted to the architrave applied with nails from the front. The lower batten is 15 cm high and 2.2 cm thick in cross-section and furthermore, its position is 4 cm away from the lower margin. This seems quite weak and flexible in relation to the thickness and the dimensions of the support (5 cm): this choice indicates an awareness that the planks could warp over

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1. The painting as it arrived in the laboratory.
2. The back of the wood panel before treatment.
time. This feature is contradicted in the upper part where the restraint is trusted to the architrave which, due to its dimensions, is very rigid. In the past, vertical wood elements connected an overlying structure as seen from two rectangular, smoothed, symmetrical areas, and above these, a series of nail holes (Fig. 4). Two pilasters with capitals complete the architectural structure;

with these elements the dimensions of the painting reach 192 cm high, and 163 cm wide. Each pilaster is made of two elements arranged as an “L”; the upper part ends beneath the carved capital. These elements rest against the support and are held with three large nails each.

The predella

The predella is the step type, 26.5 cm high and 191.5 cm wide. It consists of the front painted panel with a sub-tangential cut, 2.5 cm thick, placed horizontally to which there is, above it, a plank placed as a surface for the painting to rest on; the join between the two planks is reinforced on the sides and originally by a rectangular wood divider placed vertically in the center. The current plank at the bottom is not original. The predella shows other signs of past restorations and the presence of new internal vertical elements (Fig. 5).
The painting

The underdrawing

The process of creating the painting has been analyzed with infrared reflectography using a camera with a filter removed and with a scanner. The latter has provided very precise results, down to showing the smallest detail. The imaging has revealed a brush drawing using a carbon-based ink with soft, confident strokes, and the use of lighter marks when less loaded with pigment. Again with a brush, the artist used washes to create volumes and accentuated shadows with crosshatching. For example, in the mantles the lines go from barely present, to short and strong, determining the depth of the folds. The outlines of the faces are made with light, confident strokes and the

6. Infrared reflectography carried out with a scanner that shows the brush drawing of the face of the Madonna with subtle chiaroscuro washes and more defined lines for the outlines of the hand and face.

7. Infrared reflectography showing the brush drawing of the face of Christ and the emphasis of the chiaroscuro washes.

8. Infrared reflectography showing the brush drawing of the mantle of the Virgin; the chiaroscuro is obtained with crosshatching.

9. Infrared reflectography made with the scanner that shows the pentimenti of the beard and arm of Saint Bernardino.
shadows appear as washes. In some passages of more transparent paint, the underdrawing lines are visible, as in the rocks to the right.

The drawing is well defined and precise in the landscape as well. The painting corresponds perfectly to the underlying marks; the levels of whites, greys, and blacks have been planned completely.

At the compositional level, there are a few, minimal *pentimenti* in the figure of Saint Bernadino of Siena: the flowing beard was wider and the hand and arm up to the elbow were slightly shifted; in the predella, the leg of the cherub at the extreme left has shifted slightly. These variations are also visible to the eye due to the thin application of paint (Figs. 6–10).

**Incisions**

The incision lines follow the traditional rules only in part, as in where they accurately demarcate the boundary between the areas to paint and those to gild. In this painting, the incisions are more precise in the area of the ogive around the outlines of the wings of the angels, in the cloud, etc., and not visible in the folds of the drapery. In the clouds that surround the image of the Coronation, marks are visible that do not correspond to the overlying paint. Perhaps the clouds were initially planned to be thinner. Some angel wings are more pointed at the ends, while other figures have been painted over.
12. The procedure of extracting the crossbar with core cuts around the nails.

13. Reinforcement of the upper cracks with small, aged poplar wedges.

14. Reinforcement of the central join at the top with inlaid, aged poplar.

15. Detail of a cylinder built around a nail shaft.

16. Gluing the original crossbar to the cylinders.

17. Detail of the repair to the original crossbar.

18. Detail of the crossbar, of the nail, and of the cylinder after gluing.
Incisions with the function of marking the position of the pilasters accurately are on the lateral edges of the painting along its whole length; on these are also short marks that correspond to the analogous painted elements on the two sides (marking the position of the clouds, bands of color in the sky, etc.).

The preparatory layers

In this painting, the artist made use of distinctive techniques in various stages:

1) The gesso of the ground. Only coarsely ground gesso applied in three successive layers was found in the areas where samples were taken. From sources, we know that in paintings from the same period, the preparation becomes thinner, some procedures are accelerated, and the use of gesso grosso disappears. Cennini Cennini describes the preparatory layers clearly.

2) The warm tone of the ground. A warm underlying color was found by examination with the microscope and from the cross-sections. We don’t know if the presence of minium, found under some passages, is due to an impurity or to an application of drying oil: in cross-section sample #3 (Figs. 22, 23) rare granules are found, and observing the UV fluorescence, we see the presence of oil.

3) The underpainting or imprimitura. The painter of this altarpiece did not use an imprimitura made of pure lead white, except under a band of pale sky (see sample #4; Figs. 24, 25) where the paint on top is made of lead white with a small amount of azurite. The first layers already provide a thin and opaque ground tone, rich with binder (glue) and with light washes; in the upper part of the sky where the tone is dark, the paint of the underlayer is based on lead white and indigo. In sample #4 the adhesion between the underlayer and the overlying paint is poor, especially where there is a greater presence of lead and tin, causing losses to the paint layer.

4) The gilding. In this painting, the artist uses various gilding techniques. The gold of the central ogive and of various parts of the pala are water-gilded over a very orangey-red bole, darkened in parts by other materials. The metal leaf is so thin as to render visible the areas of overlap; we found a different gold by weight and coloration on the capitals. The bole layer seems more opaque and less bright; due perhaps to a later re-gilding, in fact it is intact with respect to other parts.

The water gilding still follows the fourteenth-century technique, as described by Cennini: demarcated by incisions, avoiding that leaf spills over the line, and with well-cleaned contours. Following his drawing tendencies, the artist demarcated most of the gilded part with a thick, black line. The haloes of the angels and the saints have an elliptical form, giving a sense of depth. From the center of the head, the incisions begin which project as rays and become denser, creating a sense of rotational movement with points of light. The decorations are simple with a double, incised outline with punchmarks in the center. For the figures of the Madonna and Christ, the crowns are on top of the haloes; that of the Madonna is incised around the outline, with graining and drawing, differently from that of Christ which is incised and painted. The cherubs drawn with black lines on the gold have a volume rendered by chiaroscuro drawing and accentuated by toned parts and other parts with graining; they stand out from the dark background made by a cross-hatching black lines and further toning.
Another gilding technique is found in the decorations of the drapery and mantles, in the haloes of the figures in the predella, and in the rays that project from the mandorla. In all of these details we see an amber substance used as a mordant for the gold; only in the rays does the mordant have less thickness. For that applied over the paint of the sky, the red color is from cinnabar, used to mark out their placement. The brightest highlights of the red lake robes of Saint John in the predella are very tiny, almost imperceptible.

The painting

In this painting the artist wanted to exalt the image of the Virgin crowned in the sky through various methods and different painting techniques, effects expressed exhaustively through the golden rays that converge at the center and the double ring of cherubs who with gestures or their gaze point to the vision.

The craquelure typical of all early paintings is lacking in this one due to the glue-based paint medium. We see, however, that in the paint of the mantle of the Madonna and Christ there are
slightly diagonal lines that do not follow the grain of the wood but that suggest the presence of an underlying canvas, not detectable with X-rays.

In terms of painting techniques, the artist shows an awareness of methods of the Northern masters with whom there had been contact both in the early period of the Quattrocento, and in the last decades of the century. The most carefully painted areas of the altarpiece that show these methods most clearly are the predella and the figures in the mandorla.

To identify the pigments used by the presence of specific elements, the analytical method that provided the most thorough results was X-ray fluorescence. A comparison between XRF and false-color infrared reflectography of the blues yielded conclusive evidence of the painting technique. (Figs. 26, 27).

In the sky, in the pale band on the horizon, the painter employed a first layer of lead white mixed with a small amount of indigo which yields a rosy tone with false-color IR. We also found the presence
of lead-tin yellow with a quantity of overlying azurite that progressively increases. The paint of the sky in the very washy, dark tones allows the underlying indigo layer to show through in some areas (confirmed by cross-section). Where the azurite has more covering power, it is more finely ground. The large granules are almost detaching due to lack of binder, though still held together with wax, varnish, and oily substances from the dirt and candle soot, and as mentioned, glazes of glue and carbon black. The depth of the vault of the sky is created with horizontal bands of different tones, shading from light tones to dark blue; the clouds are obtained with striations of full-bodied white over the blue, glazed with lakes to accentuate the volume.

In the central landscape, the hills and rocks to the right contain a first layer of white and indigo with glazes of azurite or copper green, as shown by the false-color infrared. All of the mantles in red lake and azurite are distinctive and emulate Northern painting of an earlier period; the binder is glue. The mantle of the Madonna, along with the underside of the mantle of Christ, is completely in indigo, as seen by false-color infrared which shows the typical response to indigo or lapis lazuli. With black and white infrared, the interpretation is confirmed because the paint appears transparent (whereas copper would appear dark). These pigments are not identifiable with XRF. A high concentration of copper is detected in the diagonal hatched lines, indicating azurite, also suggested by the greater granularity of the pigment. We found that these lines disappear in false-color infrared carried out with the scanner, as if they were another material. The mantle of Christ and of Saint John (in the predella) are in red lake, the darker folds contain indigo. In this drapery the artist doesn’t use lead white. Instead, the light tonality is from the ground layer showing through, and the darker tones are obtained by successive layers of glazes of pure pigment, until a thicker layer is achieved in the deep shadows, accentuated by lines of pure black.

In the flesh tones, the technique borrows from the Flemish masters of the last decades of the fifteenth century. The binder is egg tempera, even though the first layer of the pale green of the angels is dry and much like watercolor, as if it were a glue tempera. Volume is obtained working with successive layers of glazing over the toned ground which is left visible, until arriving at the brightest highlights with touches of white. The flesh tones of the Virgin are more luminous, with blended brush strokes without the green of the preparatory or underlayer; in the other male figures, a base tone with a greater quantity of ochre is used, and the painter works again with glazes, blending the brush strokes. The search for technical simplification also derives from the Flemish masters; the design is enhanced with precise and deliberate marks and the expressions are highlighted with chiaroscuro contrasts.

In other parts of the painting, the technique is similar though the thinly painted areas appear to have more covering power. The violet robes of the saint are obtained without an imprimitura but with paint containing red lake, copper, and lead white, with diagonal lines in the mid-tones.

The habit of Saint Anthony Abbot in pale grey is made with lead white with black and in the warmer tones with earths. In these passages, the mid-tones are pigment-poor, leaving visible the warm tonality of the ground, the shadows and the highlights are more opaque.

The contours of each single shape are highlighted with a neat mark of paint. The figures with an earth, the haloes with a black line, the other elements with lines of variable widths of paint around the subject as if the outline were being drawn.

**Condition**

In order to document the condition and analyze the construction technique, we carried out photography with various light sources, as mentioned, of the paint surface and the reverse, and used X-rays for the support.

**The support**

The painting shows damage typical of its construction technique with cracks that follow the wood grain. The deterioration has been caused by the contraction of the planks encountering resistance from metal restraints in the form of nails from the crossbar and the architrave. The panel is cracked with disjunctions between the edges of the paint; this phenomenon has occurred from the top at the left and at the bottom right and left. The paint surface is nevertheless well-adhered, notwithstanding the significant shrinkage, such that this change can been traced back to the early years in the life of the painting when the paint film was still quite flexible and therefore could fully follow the wood movement. Along the central join, at the top, insect damage has compromised the adhesion between the planks.
The painting

The paint surface has been affected by multiple defects of the support that led to breaks, lifting, and sunken areas, made worse by the insertion of nails.

The joins with the side planks of the altarpiece show on the paint surface as does the outline from the part of the support with added patches; the swollen nails have caused alterations to the surface, especially on the figure of a cherub, causing paint loss (Fig. 11).

The chromatic balance of the painting has been altered by the accumulation of substances added during various treatments, applied in a non-uniform way, and altered by time. The visual effect is of a total flattening of the view (Fig. 28).

The different layers do not always occur in the same order and with the same quantity of material, a result of the innumerable treatment campaigns. The first layer, directly in contact with the paint and detectable across the whole surface is a proteinaceous material (glue) of considerable thickness. This material has been applied more than once, perhaps to create a uniform surface over areas with different binders and pigments with a high granularity; in the outermost application, we find pigments like carbon black over the dark areas of the sky or green on the gold of the pilasters.

The coating of glue is not original, but quite old, given that the painting had already been subject to a rather audacious cleaning that had thinned the paint in several areas where this material had accumulated (for example in the dark blue of the sky where residues of what may have been original varnish were found). The glue, being too strong, created lifting with losses of paint in light parts of the sky and landscape. The paint had peeled away, leaving the imprimitura visible. Over the rest of the surface, micro-losses were visible, due to the detachment of small areas of a brittle material from the next applied layer. This substance was identified with FTIR spectroscopy of sample #8 as a shellac or copal resin, just used pure in this layer.6

Wax spread on the surface was also detected, not on the whole surface, but applied in different campaigns and for different purposes; the outermost layer, quite visible over the imperfections in the surface, is of remarkable thickness and was applied by brush (striations are visible in some areas) with splashes and drips. In other areas, it was applied to prevent the paint from powdering where it was already poorly bound. Furthermore, the filling of the losses was always done with wax but with more care below the layers of glue. This material has absorbed a significant quantity of airborne particulate matter. The gold is covered with the materials already mentioned, which once removed, revealed brush strokes of an amber substance (certainly shellac) with a considerable thickness and density, applied

22. Cross-section #3 from the sky showing indigo.

23. Cross-section #3 in ultraviolet light showing the oil fluorescing.

24. Cross-section #4 from the pale part of the sky: the first layer is lead white with subsequent layers of very thinly applied azurite.

25. Cross-section #4 in ultraviolet light including two layers of gesso with large granules; the outer layer has fluorescence from oil.
evidence, even in the midst of the treatment. Ultimately, it appeared that a large part of the deterioration was related to the construction technique and therefore any repair would impact the original attachments with a high risk of interference.

Given the presence of wood-boring beetle exit holes on the surface, the panel was immediately protected with Permetar insecticide applied by brush.

At the beginning of the treatment, we thought about how to treat the splits caused by transverse shrinkage of the wood strained by the force of the nails of the crossbar and architrave; and furthermore, how to complete the reinforcement and realign the painted edges along the areas with the crossbar at the bottom and covered by the architrave at the top. We therefore had to carry out two separate treatments.

At the bottom, removing the crossbar became inevitable as its presence impeded the proper repair of the splits. This operation in the past was generally carried out by cutting the nails and with the subsequent application of the crossbar after the panel repair with screws passing through it and anchored in the support. Recently, in the cases in which the nails had been inserted from the back and bent around under the preparation layers, making for a completely irreversible attachment. Thanks to our experience acquired on other paintings, a decision was made to make a core cut in the wood of the crossbar around the head of the nail with a special circular bit (Fig. 12). Thus, the crossbar was taken off and the original anchorage remained intact in its place. This procedure made the treatment of the two cracks possible. They

especially in the exposed areas where the bole with a very warm tone stood out.

In the dark blue sky at the top, on both sides, there are two unfilled losses that have been toned with a brown material, applied directly on the gesso ground. These losses correspond to nail holes on the brackets visible on the back. The same oily, brown material was applied over exposed parts (the hand of San Bernardino, stones in the earth, etc.) (Fig. 29). The painting appears worn with very thin paint layers due in part to the drastic previous cleanings, as in the sky where the lack of binder was not enough to hold the large granules of azurite, or in the robes of Saint Nicholas where the paint was powdery and had been saturated with wax. The condition is also due to the technique of the artist who used very watery paint, applied with broad strokes, exploiting the tone of the underlayers through transparency.

Treatment
Reinforcement of the support
The condition of the wood panel, given the deformations assumed by the planks and above all, the open splits, required a reinforcement treatment and general improvement of the crossbar restraint system.

The criteria adopted took into consideration maximizing the legibility of the painting and maintaining the greatest respect for the historical
Ciro Castelli, Mauro Parri, Patrizia Petrone and Andrea Santacesaria, Niccolò Liberatore called L’Alunno: Painting methods ...

were reinforced with thin, aged poplar wedges inserted in very narrow channels. It was possible to limit the extent of the treated area using an electric router, angling the guide to follow the split; the channel was made along short lengths and therefore, followed the path of the damage. The wedges were glued with a strong PVA adhesive (Bindan). At the top, the crack that was generated on the left, due to analogous reasons of strain between the panel and architrave, required a different kind of treatment. The nail that was inserted from the front holding the architrave to the panel was bent back into the support. In this case it was not possible to carry out a core cut into the support, nor extract the nail, therefore a decision was made to cut the nail shaft and free the panel. After this

28. The altarpiece in ultraviolet light: we see various coatings on the gold and over the whole surface.
procedure, the separated edges were immediately re-aligned and it was possible to continue with a proper reinforcement using the same technique as at the bottom (Fig. 13); also at the top, along the central join, the wide gap and the adjacent eroded edges fortunately had not affected the paint and therefore it was reinforced using inlaid pieces of aged poplar glued with Bindan (Fig. 14).

After the reinforcement of the panel, a thorough check of the deformations was carried out. At the top, the cut nail was extracted from the support and substituted with a stainless steel screw passing through the panel and anchored in the architrave. Between the head of the screw and where it rests on the support, special flexible washers were inserted which allow for some gradual movement. Furthermore, the space created between the architrave, which remained planar, and the curved panel was filled with shaped poplar spacers positioned so as to avoid the risk from straightening of the planks and to achieve a uniform contact between architrave and panel.

At the bottom, the nails were wrapped by half-cylindrical poplar pieces, made so as to have an ample internal space in them for the shaft, and thus reproduce the original nail channel; note that the nail would have had a certain freedom of movement given that it was put through a previously prepared hole and that this method essentially avoids the risk of it seizing up. Each cylinder was made with an external diameter equal to the hole made in the crossbar, thus reconstructing the portion of wood lost during the coring. The semi-cylinders were glued around the shaft without jamming it and the crossbar was then attached, threading the cylinders through the cored holes (Figs. 15–19). The anchoring of the crossbar to the support was carried out by gluing the little cylinders to it with a mixture of epoxy resins: Araldite AW 106 + Hardener HV 953 with Araldite SW 427 + HV 427 in a ratio of 2:1. The resulting paste has strong adhesive power and also filling capacity (Fig. 20).

Cleaning

The cleaning faced enormous problems connected to the binder of the painting itself, to the painting technique, and to the previous treatments, carried out at different times and with materials that had altered the color relationships. All of the different parts of the altarpiece had the same kinds of materials, though not always applied in the same sequence and quantity. The main panel was the most complex because the restoration treatments carried out on it were numerous. The cleaning had rendered the paint powdery in some areas, and in others it had been completely impregnated with wax. Documentation on the preceding treatments was totally missing and the historical sources did not provide information earlier than the eighteenth century on what had happened to the painting. The analysis already carried out did not indicate enough information to be able to proceed with confidence; therefore, we made tests directly on the painting until we obtained a precise picture of the added materials.

To give us an idea of the stratigraphy of the added materials, we begin with a description of the cleaning of the predella that was less problematic due to its better condition allowing us to identify these later substances.9

The first stage of cleaning was carried out with a neutral oil-emulsion to remove the superficial grime made of particulates and soot; this treatment was carried out over the whole surface, including the gilded areas.10

The solvents used in the subsequent cleaning were mixtures that worked in different ways on the varied materials added in the treatments from different periods. The various parts of the altarpiece contained the same materials, but not always present with a parallel layer structure. The pala was the most complex because of the waxy materials, the glue, and the different resins had been applied not only as homogenous layers, but also according to color area. The first layer of wax with a considerable thickness was thinned and removed with a solvent gel made of a mixture of three solvents.11

The contact time varied, the rinsing was carried out with hydrocarbons. The solvent gel was tested first on the thicker parts, which softened and were removed leaving minimal traces. In other cases, the drips had corroded the underlying paint, especially along the edges. In a later step, even though a hot spatula tool and absorbent paper were used to remove more wax from the underbound and granular paint, it remained saturated with wax.

The second phase of cleaning served to remove the applications of glue and hard resin. We opted for a slightly acidic oil-emulsion with a percentage of ammonium citrate that softened the glue but that did not soften the resin holding the pigment.

Before choosing a solvent, several were tested, given that the aqueous methods, more suited for removing proteinaceous substances, would have created problems for the depleted binder of the
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The filling phase was especially long, not so much for the losses that were few in number, but for the retouching on the pilasters (the side capitals were reconstructed: one in part, one entirely). We closed the innumerable wood-boring beetle holes that disrupted the image, as additionally, they could be a pathway for depositing eggs. The usual filling with gesso did not work perhaps because the holes had been impregnated with wax or oily substances to which the gesso could not stick. Therefore we inserted a plug of pure cellulose thickened with Klu-cel and then continued with gesso fills.

The cleaning was carried out under magnification though it was not possible to carry it out in a homogenous way due to the different patinations, abrasions, and glazing. The robes of the Dominican saint, impregnated with wax and in part repainted, were cleaned only of superficial deposits. Cleaning the sky was particularly difficult; large particles of pigment came loose with just a pass of cotton wet with mineral spirits. Therefore we used an oil-emulsion on top of Japanese tissue to soften the non-original materials. The rinsing was done by blotting over Japanese tissue; we waited a short period so the paint was not too soft before removing the glue on the surface, working dry with the help of the microscope (Figs. 30, 31).

29. The hand of the saint has been abraded in a previous cleaning and patinated with a bituminous substance.

30. A detail of the cleaning in the light areas of the sky. The losses to the angel correspond to a wood insert.

31. A detail of the cleaning. Many losses that affect just the paint layer are due to the coating of glue and other materials.

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The retouching of the image was carried out entirely with watercolors for the usual reason of wanting to avoid alteration over time but especially to give those areas a degree of absorbency of the varnish similar to the original.

The sides of the pilasters with marbling were also retouched with watercolors, trying to connect the small portions of original and render the two sides uniform. On the ochre areas of the architrave and the capitals, a preliminary, light coating of tempera was applied on which selezione cromatica was carried out. Mastic varnish was applied in multiple coats and rendered uniform by spraying.
In this period, in many regions as in those of Umbria-Marches, there was already substantial legislation governing woodworkers. A commission approved the preliminary drawing, signed in front of a notary on the part of the patron and of the "magister lignaminis." A deposit would have been paid, the work done, and then paid in full after having been subject to the judgment of specialists chosen from the masters of woodworking enrolled in the guild.

By the fifteenth century, in the lands beyond the Alps, the practice of applying a coating of drying oil over glue on a drawing on smooth gesso was in use (the glue served to limit the absorbency of the ground to the oily substances in the binder of the paint). In our painting, there was no glue coating found. For this reason perhaps the preparation had yellowed (keeping in mind that in both glue tempera and in egg tempera a minimal percentage of oil as plasticizer is always present.) The minium is a lead oxide and a good drying agent and its presence is tied to the use of oil cooked at higher temperatures.

The X-rays penetrate through to the level of the ground. The result is interpreted taking into consideration elements that may not visible but could be in the ground, underlayers, or imprimatura. The exam should be carried out by comparing various tonalities of the same color so as to detect the presence of the main element and the percentage of other heavier elements. The lack of precise results implies the presence of low energy elements. A typical example is the presence of indigo or lapis lazuli used to paint robes, containing elements that are not detected.

We considered a metal-gall ink based on copper sulfate though it seems rather unlikely from the color, as these inks tend to turn brown with time.


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6. Manuale del pittore restauratore per Ulisse Forni, Florence, 1866 Vol. II, chapters XX and XXVIII.


9. Bleached wax made up the outermost coating with splashes and drips. Glue applied in a uniform layer (with pigments in some areas). Resin. Bituminous materials, especially on the losses and in the darkest colors. Glue and resin. Dense, thick shellac, often applied by brush over the gilded areas, especially in the areas where the bole was exposed and the gold was missing. A substance with an amber tone applied on the lateral surfaces of the predella and of the pilasters to render uniform the tonality of the wood repairs and the original parts in gold and ochre.

10. Neutral oil-emulsion: Brij 35 (2 gr); Distilled water (10 ml); Tween 20 (2 ml); White spirit (90 ml).

11. Solvent gel: Carbopol 940 (2 gr); Ethomeen C12 (12 ml); Cyclohexane 37.6%; Mineral spirits 32.2%; n-Propanol 30.2%.

12. Solvent gel with acetic acid: Triethanolamine (3 ml); Desionized water (100 ml); Acetic acid (1.5 ml); Coccocolagene (4 ml); Klucel G 4%; Benzyl alcohol (3 ml).

13. Acidic oil-emulsion: Brij 35 (2 g); Distilled water (10 ml); Ammonium citrate (3 ml dissolved in deionized water); Coccocolagene (2 ml); Mineral spirits (150 ml).

14. Solvent gel for gilding: Ethomeen C12 (20 ml); Carbopol 940 (2 g); Distilled water (12 ml); Solution of 10% Dimethyl sulfoxide and 90% Ethyl acetate (20 ml); Ligroin 100–140 (80 ml).
Francesco Salviati, *Deposition*, 1548, Museo di Santa Croce, Florence

Agnolo Bronzino, *Descent of Christ into Limbo*, 1552, Museo di Santa Croce, Florence
Some reflections on treatments of wood panels from the flood

Ciro Castelli, Mauro Parri, and Andrea Santacesaria


The conservation treatment on the wood support of the Deposition by Francesco Salviati

The work carried out in the department of wood panel conservation on Salviati’s great panel, truly a special case, deserves revisiting for more than the single procedures used on the painting or listed in its record.

Just by examining the construction of the support it is possible to recognize a well-planned structural design. Basically, this painting and the Descent into Limbo by Bronzino represent, in all probability, contemporary products of two different workshops. Although dealing with the same destination and equivalent dimensions, these panels illustrate two quite different execution techniques. For the Deposition, continuous vertical planks were chosen, while for the Descent into Limbo the planks have been connected at various heights with expert half-lap joins. This implies, in the first case, the desire to provide more continuity and uniformity to the pictorial plane; in the second case, that of wanting to choose the best parts of each plank. In both, the best techniques were put into action to guarantee the most smooth and even surface for painting. The planks of the Deposition had knotty areas removed through a careful patching on both sides—smaller on the front and larger on the back—a technique guaranteeing

1. Francesco Salviati, Deposition, the panel. 2. Agnolo Bronzino, Descent of Christ into Limbo, the panel.
the inserts stayed firmly attached; moreover, the joins in the planks of the Descent into Limbo have careful half-lap joins with the overlapping edges beveled to 45 degrees to deter the slightest natural warping. Additionally, it should be noted that all the risk zones (joins, patches, and horizontal junctions) have been protected by the application of bands of tow (stoppa).

The current state of both paintings is, unfortunately, heavily affected by the flood damage that dotted the paint surface with marks and scratches that certainly were not present before. The Salviati support appears to be a surface marred by knottiness and other imperfections that are pronounced, moreover, the difficulty of rough-cutting the log into planks led to the use of a plank that has the pith passing through it. All of these elements affected the planarity of the pictorial surface, most likely before the disaster of the flood. Specifically, the plank cut with a slanting grain with respect to the pith of the tree has a different curvature in the upper part (a convex surface) and the lower part (a concave surface). Furthermore, even the panel of the Descent into Limbo is marked on the paint surface by interrupted horizontal lines. This is a sign of the particular difficulty of designing a large panel surface for a painting.

The treatment of the Deposition began in 1990 and was born from the necessity of having to reassemble the six planks of the panel which had been completely separated and had individually received treatment for the consolidation and reattachment of the ground and paint layers over more than twenty years.

On each plank the old crossbar channels were filled with wood inserts in order to provide a more
solid site afterward for the new crossbars, and one that would succeed in compensating for the difference in the curvature, especially in the lower part.

The single planks were independently warped and the problem was that of aligning their various deformations within the general context. For this the planks were positioned vertically and numerous tests arranging them were made that could establish a general curvature that could succeed in absorbing the single deformations, without giving an excessive arc to the whole panel and thus disturbing the effect and creating a difficulty in reinserting it in its frame. The deflection of the curve measured on average 7.5 cm and it is definitely remarkable. Above all it appears very evident when the painting is set on a horizontal surface; vertically it is mitigated and the paint surface can be read with a good continuity without distracting depressions between the joins.

This is an entirely subjective step and in any case, completely reversible, thanks to which the general shape of the panel could be chosen without
any pressure or force on the elements but simply holding them in a position felt to be the most balanced among the various options available. The single planks were assembled anew with wedges placed in the joins and reinforced on the back by crossbars inserted into new channels with a tapering trapezoidal shape. This system is analogous to the original and it makes use of the minute support of the wood grain of the planks and fully reflects the needs of a panel that is extremely deteriorated and sensitive to every small temperature and humidity fluctuation. The difficulties encountered while making the channels for the crossbars were considerable; first of all, it was necessary to adapt the features of a system intended for a flat panel, as it was originally, to a curved one, without having it lose its effectiveness. Furthermore, the lower crossbar has a dangerous counter-tendency with a concave area relative to the aforementioned poor choice of plank. This made it necessary to add thick inserts in the adjacent planks so as to open the new channel only inside the reinforced part without cutting into the wood of the original support and thus weakening the structure in the “axial” direction. The crossbars were built from laminated oak glued with epoxy resin on top of custom-made forms that had a smooth curvature equal to that of the channel in the panel.

Conservation of the panel of the Descent into Limbo of Agnolo Bronzino

Eleven years later, the department took up the conservation of the other large panel, the Descent into Limbo of Agnolo Bronzino. This treatment also deserves a second look: for itself, but also in comparison with the Deposition; it demonstrates a further evolution in the treatment approach.

As mentioned in the corresponding records, both the paintings were freed from their crossbars during their stay at the Limonaia. The panel of the
Deposition as we have seen, was completely separated into six planks and the paint was broken along the joins, while for those in the Descent into Limbo the paint remained together thanks to the underlying presence of the tow. The panel, on the contrary, was warped, separating, and the lower two-thirds had shrunk in the transverse sense; the upper part instead was mostly whole and the curvature remained more even. The circumstances that the painting presented were quite unusual: large areas of paint that were continuous but suspended over nothing and an extreme need to create a supporting surface and reunite the planks in a solid and aligned way. The general treatment plan and the procedures to carry it out were thoroughly discussed in a preceding publication by our Institute.\(^1\) It should be emphasized that the crossbar system, though maintaining some features of the original, was a step ahead in creating an improved relationship between the panel and the back support, using a gradual tension and distributing the single forces of the planks across the entire width of the painting in a smooth way.

The conservation of the large frames

With the reinstallation of these two altarpieces on the horizon, the department was involved in planning a protection that would make use of, in the first place, the associated monumental frame of each painting, and through some appropriate modifications, an enclosure on the back. Using many case-studies, and over nearly twenty years, our Institute has researched the most effective solution for reducing movement of the support and therefore the tensions, through climate control. In the case of paintings on panel with frames, the solution has been that of creating a barrier on the back that is not air tight but that slows the exchange of humidity between the panel and the display environment. It was established that most of the sharp and dangerous environmental fluctuations can be nullified simply by closing off the back of the painting with plywood panels, Forex foam board, Goretex, or some other material capable of making a barrier. Thus, even the conservation treatment in the sense of the work directly affecting the support
can be much less invasive and even the support system for restraining the movement of the panel can function in a much less risky way.

During the planning phase for this type of treatment on the frames, it became apparent that there was a need not only to modify the capacity of the frames, but also to radically change the function for which they had originally been constructed. Both of the frames are made of four independent elements: the horizontal bottom, the two vertical sides, and the arched top. These elements served as an architectonic connection between the painting and the wall structure in the basilica, suggesting that it was possible for the painting and frame to be independently installed in the niche. In our treatment, we thought to make each frame a single whole which could accommodate the painting securely and offer a good protection to the back.

We can outline the treatment of the frame in four steps:

- The restoration of the single elements with the consolidation of the ground layers and the gilding and the reinforcement of the wood structure.
- The construction of the connecting elements that make assembling the individual pieces into a solid whole possible.
- Building up a new internal rebate to create a custom support for the perimeter of the painting due to the warping that occurred after the flood.
- Constructing a build-up on the back that would increase the depth of the frame and allow the use of a backboard.

The conservation of the frame of the Deposition

Our Institute delegated a large part of the treatment of the frame of the Deposition to outside companies who followed this plan. Thus all the consolidation of the ground and gilding, and the reinforcement of the wood structure was carried out by the company C. e S. Martelli; the construction of the back was executed by Restaurarte di Renzo e Nemo Niccoli. Our department took on the construction of the connecting elements and the attachments to the original and the execution of the supporting rebate for the painting.

The elements that make up this frame have a smooth surface on the back, without a rebate or
supporting ledge of any kind. This means, therefore, our task was to create a way of holding the painting from scratch incorporating observations from old archive photographs. Along the bottom, a shelf was placed made of a plank of fir that sustains the painting and discharges the weight on the lower border of the perimeter through vertical fir wood elements that are “section breakers.” After the conservation of the support, the new curvature of the panel drew back away from the frame increasingly toward the sides. It was necessary then to create a rebate for the panel that would connect the original frame with the support so as to supply a precise and continuous base. In order to do this the painting was temporarily inserted into the frame, resting on the shelf, and it was adjusted so as to distribute the gap between it and the frame in a regular way. Therefore the connecting elements were made by shaping fir planks in a mold and anchoring them to the frame. These elements were toned so as to also serve as a chromatic bridge between frame and painting, additionally the areas in contact with the painting were cushioned with strips of Neoprene. This support along the perimeter was anchored using wood brackets that were given flexibility thanks to the placement of springs inside which could absorb, where necessary, the movements of the panel.

The backing was made with a 25 cm wide band around the edges made of woodcore board, matched and attached with brackets to the frame; as we mentioned, this band covered the space occupied by the warped painting and crossbars; in this cavity remaining, some containers of buffering material were placed as a further protection for the artwork. The backboard was screwed to the bands on the perimeter with openings able to accommodate, in the future, adjustments to the climate monitoring system.

The conservation of the frame of the Descent into Limbo

The great frame of the Descent into Limbo was entirely treated at our Institute and has involved the wood sculpture division and the panel conservation department in the paintings division.

The elements of the frame had a type of construction that makes use of two poplar planks...
joined together with poplar, oak, and coniferous members placed against the grain in a triangular shape. This means the frame members make a triangular section with the narrowest part toward the painting and the external part left without a cover because it is hidden by the architecture. Among the planks that make up the frame, the flat ones on the back that have a larger girth and therefore a structural function can be distinguished from the diagonal ones that are thinner and serve to hold the carved parts. The connections between the various elements are mostly made by nails from the main plank, overlapping the triangles, the oblique plank, and the carved shapes which are also glued.

The condition of the wooden structure is very damaged and therefore our department had to first work on giving back some solidity to the single supports which in turn have different structural failures. In the arched top, the structural part was heavily attacked by fungus which had weakened it mechanically, making it nearly impossible to move. The remaining vertical members of the frame showed a significant curvature along their lengths due to the bowing of the supporting plank.

Repeated consolidations with Paraloid B72 were carried out on the supporting plank of the arched top and wood inserts were added to areas where wood had been lost. These procedures had limited results. Therefore, in order to obtain a more solid structure the planks along the back were temporarily removed, because, though consolidated, they could not provide a structural function. This was done in a reversible way by straightening the ends of the nails and pulling off the various planks; then, an arched, oak plank core was inserted into a channel made on the inside of the triangular elements. This arch carried out a very important structural function in that it compensated for the weakness of the original parts, attaching securely to them. The planks removed earlier were reattached in their places thanks to the original nails re-inserted in the old holes and re-bent.

The vertical elements, as mentioned, were decidedly curved; even though the wood was still suitable and had its mechanical integrity, and the joins between elements were firm, it wasn’t possible to proceed in remounting the whole and therefore the installation of the painting because the deformation was still excessive. This is why both the vertical elements were taken apart, using the same technique as for that of the arch. The treatment was limited to straightening the main unpainted plank which with its deformation had affected the other decorative elements anchored to it.

The procedures were carried out differently for the two planks. The left-hand plank was cut with horizontal notches made to weaken its strength; with the insertion of poplar pieces perfectly calibrated and glued with an epoxy resin to a flat reference, the plank was given a good planarity, adequate to serve as an even surface for the application of the decorative elements. The right-hand plank, in contrast, was reshaped into a flat form with moisture and heat, without affecting its material integrity. It is worth noting that, when the...
front plank, onto which the carved decoration is set, was removed, on its interior surface, therefore hidden from view, there appeared drawings of the decoration; these marks corresponded to the position occupied by the final carving and represent precise directions, probably by the artist, for the compositional design of the frame.

The two planks once again provide planarity for the vertical elements, while maintaining a good solidity. It should be pointed out that the straightening treatment in this case was justified by the fact that the treated components were not painted and therefore the treatment carried out was typical of “traditional” carpentry on simple bowed wood.

After having squared up and anchored the four components of the frame, the wood panel department planned the creation of a framework of fir wood. The four elements of the fir structure were 8 cm wide and 7 cm thick, with interlocking joins, and they contribute to giving a further reinforcement to the whole and can sustain an external perimeter; this has a width of 25 cm, it closes the edges of the frame that were originally not covered, and holds the backing boards. Again in this case, the modifications to the frame offer the opportunity to protect the back of the painting and to control the microclimate within using appropriate buffering materials that can be checked through an opening in the backing.

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The early treatments after the flood and the challenges of the panels

Ciro Castelli and Chiara Rossi Scarzanella

The neighborhood of Santa Croce was one of the hardest hit by the overflowing waters of the Arno on November 4, 1966: in the museum spaces that occupied the monks’ old refectory and which is at a lower level than that of the church, the water rapidly reached its high point of 4.3 meters. After about two or three hours, it began to slowly drain away, leaving artworks covered with mud and fuel oil. It is estimated that the lower parts of the panels were under water for about twelve hours considering the flow and drainage of the floodwaters, and naturally, these were the parts to suffer the most.

The first step, carried out in situ and in the dramatic conditions of those first days after the flood, was that of protecting the paint surfaces with a paper facing so as to prevent the loss of paint flakes through the following months when the first detaching and lifting would start to occur. The stock of Japanese tissue was exhausted before the work was finished and therefore paper tissues (Kleenex) were used as a stop-gap solution for the remaining paintings. Paraloid B72 was used as the adhesive, because using an animal glue on the wet surfaces was unthinkable, and compared with wax-resin, B72 offered a greater guarantee of adhesion and resistance.

The particular multi-material nature of panel paintings sets them apart in a substantial way from many other kinds of art, and required not only that they be moved from the areas made unusable by the fuel oil and mud left by the water, but also be relocated to an appropriately acclimatized environment. It was obvious that stresses from the contraction of the planks, which would have appeared quite early on, would have serious consequences for the layers on top of them, and it was exactly that awareness of what would happen that led to the decision to maintain the panels in a humid environment so as to slow the shrinkage of the wood and better control the lifting, intervening as it developed.

There were 320 panel paintings hit by this disaster: a number so large that we can easily appreciate the difficulties that arose for those in charge, not only to start on the immediate urgent treatments, but to plan first the creation of a “hospital” and then a treatment lab immediately after, that would be able to cope with an emergency of such proportions.

Only ten days after the flood, the Limonaia of Boboli Gardens was freed from the plants that resided there and work began to adapt the building to its new function as a shelter for the flooded panel paintings. The large windows were sealed and structures were built to hold the paintings horizontally, though the most ambitious work was providing machines capable of creating an environment with a very high humidity. Knowing that the wood contraction would begin when the humidity of the material reached about 30 percent, it was decided that the humidity of the environment should be kept very high so as to slow the water loss from the paintings as much as possible, allowing for the supports to dry gradually and permitting monitoring of the lifting of the paint that would inevitably appear. Thus, it was possible to climatize the space bringing it up to a stable humidity that was initially 95 percent.
After a few days, the paintings began to arrive. To avoid promoting the growth of micro-organisms from the high humidity, the paintings had been sprayed with an anti-fungal agent (5% Nistatina), a procedure that was repeated in the early part of 1967. When the paintings were admitted, the panels were still saturated with water, beyond 100 percent, and appeared to have expanded to their largest widths, with the paint perfectly flat.

It is appropriate at this point to try to understand what consequences the shock of the flood could have had on the painted panels.

Wood is a typically anisotropic and heterogeneous material: anisotropic because its characteristics very according to the direction; heterogeneous because even in a single direction, these characteristics are not constant. Furthermore, it is a strongly hygroscopic material and very sensitive to changes in relative humidity; it can shift, warp, expand and shrink volumetrically even after being seasoned for centuries. All it takes is a change in the water content inside the cell walls of the wood for this phenomenon to occur. These characteristics are common to all types of wood. The differences in behavior between species appear in the time it takes to adjust to variations in relative humidity, and this is influenced by the density, porosity, quantity of cellulose present in the cell walls, and the condition.

In the case of paintings on panel, the support is almost always a wood that is soft, or rather, a low-density wood, relatively porous, with cells and vessels with large cavities. The age of these objects should also be taken into consideration in that they often have cracks and splits, and they have often been attacked by wood-boring beetles, and sometimes mold and rot. This is enough to illustrate how immersion in water for a period of hours would suffice for the wooden supports to be completely saturated, and expand to their maximum point over the following twenty-four hours. Considering the fact that the supports are made of planks that have variable cuts of wood from diametral to sub-tangential, we can conservatively estimate that the width could increase by 2–2.5 percent.

As seen from the records of the paintings, the measurements carried out on December 14, 1966 saw a significant drop in the water content of the wood supports despite the high level of humidity in the environment. The realization of what was happening probably led to the drastic decision to remove the crossbars from all the large panels, including some polyptychs, especially where the crossbars were in dovetail channels.

The thought process here can be reconstructed from “Ricerche relative al recupero dei dipinti danneggiati dall’alluvione di Firenze nel 1966 [Research on the recovery of paintings damaged in the Florence flood of 1966]” in the Quaderni della Ricerca Scientifica, number 81, 1972, where Professor Giordano writes, “To avoid more serious problems, first the bonds between pieces of wood whose grain was oriented in different directions had to be undone.” Most likely, considering the amount of expansion of the planks, trying to restrain the components would have caused separations in the joins and splitting along the grain. It was hoped that these phenomena could be prevented from occurring, and that each plank’s warp would give the support a single curvature. All of this would be deterred by the weight of the object itself.

The work to remove the crossbars began in December of 1966. Since this was extremely risky, both during the removal phase and afterward, precautions were taken by reinforcing the joins between the planks with the attachment of rectangular wood brackets. These were placed with the grain running diagonal to that of the support and secured across the join with two screws on each short side. These reinforcements were made of beech wood, spaced regularly in terms of height and in a number proportional to the size of the painting. Crossbar removal was not carried out on all the paintings present in the Limonaia perhaps because some were of modest dimensions and therefore it was not considered necessary to take such a drastic step. The crossbars were destroyed and not extracted, in that extraction was considered more dangerous. The work was done by lifting up the paintings, setting them on a metal framework, putting wooden bars under them, and proceeding with a longitudinal cut entirely through the crossbar. The pieces were then removed by prying them out from within the cut.

After forty years, with our current knowledge and with the experience that we have acquired, we can express serious reservations about this choice. Certainly, the catastrophic event that struck cultural heritage was such that it found everyone unprepared and the timeframe for treatment, by necessity short, did not allow for experimentation; it is therefore unfair to criticize the treatments carried out in those dramatic days. This does not mean that removing the crossbars did not cause the loss of an important part—a loss that deprived the panel of any structural support in the slow and critical journey from humidity values of about 30
percent to stabilization levels between 11 and 12 percent.

Aside from a few exceptions, the fateful threshold of 30 percent internal humidity, i.e. the level under which the contraction of the wood begins, was reached in the spring, and the first warping and twisting deformations of the planks began to show, phenomena that inevitably affected the joins, and caused the characteristic ridge on the paint surface, foreshadowing its detachment.

For many paintings, even after being moved to the laboratory at the Fortezza da Basso in June of 1967, it took more than a year for the relative humidity of the panel and environment to reach equilibrium, and it was then that the damage showed itself in all of its severity. In the following years, an explosion of wood-warping phenomena were recorded with the repercussions on the paint surface in the form of serious lifting and flaking, the extent of which was also related to the condition of the painting before the flood and the level and duration of its immersion in water.

In the new labs in the Fortezza, some paintings already appeared to be in very poor condition, others, finding themselves in an environment climatized to over 70% RH, still had a relatively flat support and cohesion between the individual planks. These cases, though, indicated the persistent humidity inside the artwork. In the following months, even these remaining paintings would have increasing problems with regards to the condition of the support and ground. Besides, a material like wood cannot return to the state prior to such a prolonged attack by water: the planks of the support had warped, separated along the joins, split along the grain, and in some cases they were longitudinally twisted, beyond having contracted differentially, especially those paintings that had had a different length of time and level of immersion in water. All of these deformations made it even more difficult to restore the functionality of the support.

An example of this situation is the altarpiece by Salviati, the Deposition from the Cross: shortly after removing the crossbars, the planks separated due to the failure of the glue, and because of a series of problems it remained in pieces for several years. There were many elements that affected the future of this painting: the humidity of the wood was above the saturation point when it was separated, the planks were of mediocre cut which varied from diametral to sub-tangential, the pith that continued from one side to the other, and the widespread and extensive knots repaired since the beginning. In the time that passed between the separation and the reassembly of the painting, the planks showed all of the negative phenomena derived from the above conditions: dimensional fluctuation, warping, curving, twisting, splits along the grain; plus detachment and deformations of the wood inserts under the preparatory layers that had been placed to remediate the large knots.

Other examples that were especially problematic due to their construction technique, their dimensions, and type were the Descent into Limbo by Bronzino and Saint Bernardino by Rossello di Jacopo Franchi. In the first case, though the original construction of the support was meticulous, the damage was complicated in part due to the planks having been extended in height with a series of deep half-lap joins to confer stability. The difference in time and level of immersion of the painting produced a contraction in the planks in the lower part of about two millimeters per plank, while this phenomenon did not exist in the upper part. In this case, the gaps can be compensated for by filling the support from beneath the preparatory layers, addressing the compatibility problems between materials, and avoiding tensions between the original and the restoration. Unfortunately the half-lap joins between the planks that remained underwater for the longest failed due to the swelling of the wood fibers.

In the cusped altarpiece of Saint Bernardino, there were two kinds of problems: besides differential shrinkage of the planks along the bottom, there was strong warping of the planks, a condition incompatible with the overlying predella which remained flat both in terms of length and width. In this kind of situation, it obviously isn't possible to execute a “straightening” of the support or “curving” of the predella, but we need to find a compromise between the two elements that avoids stresses between the components and provides an aesthetic solution for viewing the painting.

At a distance of some years from the flood, it is possible to draw some useful conclusions, not only for natural disasters, but also in relation to technical aspects and the behavior of materials that make up panel supports. Beyond the irreversible damage, described earlier, we think it is useful to formulate some considerations on the choices made at the Limonaia. Actually, the decision to make a climatized environment could have been a positive factor in that it slowed the loss of moisture from the panels and held the planarity of the supports under control.
as well as the detaching of the ground layers. This choice turned out to be mostly negative, however, for many reasons. Maintaining the humidity high for a long time affected the joins between the planks and surely also the glue in the preparatory layers. Furthermore, it is a given that the humidity value inside each artwork could not be determined with certainty, both because each did not have the same exposure to water, and because each one varied in terms of construction and specific materials. This undifferentiated treatment ensured that the planks, over time, would each stabilize at the maximum level of humidity that each one could possibly have, thus some incurred more damage than what was expected.

These considerations are not made to criticize the past, in that the priorities had to fit the timeframe of the treatment. As already mentioned, the number of paintings involved was such as to not allow for specific technical or scientific attention that each one required: there was even a lack, at the beginning, of an adequate number of technicians prepared to cope with these problems. We think that it would have been impossible to make a more careful selection of panels and treatments or have more spaces for their immediate shelter available, each climatized differently. We hope that our technical considerations can be used as a point of departure in the unlucky event that we again find ourselves having to cope with the consequences of a natural disaster of this scale.

The contraction of the supports began to provoke the first detachments of paint, producing situations of ever-increasing seriousness as time passed. The deterioration incurred by the ground layers after soaking in water was added to these mechanical stresses. The solvent effect of the water weakens the film of glue between the cushioning materials (a textile or tow layer) and the support and sometimes between the layer of gesso and glue and the paint, and has a tendency to cause separation between these layers, as seen in all the flooded paintings. Beyond damaging this glue film, the water immersion also heavily affected the condition of the glue and gesso ground. These are components that even after drying remain susceptible to the action of water, but in normal humidity conditions, protected by the paint film of generally hygroscopic nature, maintain a perfect hold. When instead the water breaks through this barrier and wets the ground, the proteinaceous substances swell and, in the case of prolonged immersion, a leaching process occurs: the mechanical action of the water literally carries the molecules of glue away from their places, making them migrate along with it to the outer edge of the ground and thereby altering the ratio between glue and gesso. To this is added the denaturing action that the substances (fuel oil, gasoline, etc.) in the flood waters may have on the glues. This means, essentially, a loss of the mechanical qualities and cohesion of the ground which tends to separate into its components, becoming powdery and unable to withstand mechanical fluctuations from the wood support. After this happens, different kinds of detachment form over time according to the layers in which the adhesion gives way, and according to the direct mechanical cause. Large but generally soft blisters or detached areas form where there is a separation between support and cushioning layer (canvas or tow); lifting of various amounts, sometimes very jagged and irregular, occurs where the ground has given way; detachment of the paint film with flaking or tenting occurs where the adhesion between ground and paint is lost. Naturally, these types of detachment often coexist. The direct mechanical causes are obviously those correlated to the instability of the support, and therefore the zones most damaged relate to underlying areas of inhomogeneity (for example the joins, butterflies, inserts, plugs, interlocking components, etc.). However, the effects of the contraction stresses should not be entirely underestimated. These are the forces that work from left and right toward the center of each plank, compressing the original surface and leading to the formation of detachment areas. In fact, a large number of the paintings had a concentrated area of lifting of considerable magnitude running along the center of the planks, especially those characterized by a near-radial cut.

Another consequence of the water damage that was seen on almost all the paintings once the facing was removed was a disfiguring oxidation of the surfaces, so much so as to prevent, in many cases, reading the underlying painting. Fortunately, cleaning the paintings showed that this oxidation affected only the layers of varnish and not the paint film.

At the appearance of the first lifting and flaking, animal glue was applied by injection but it was immediately clear that in the most serious cases this technique was not feasible: the injected glue ran out of the breaks in the paint in the form of white mush. Essentially, it had dissolved the ground that was still saturated, and carried it away. Furthermore, the ground layers were still wet.
enough to be very soft; even minimal pressure deformed them. In fact, in paintings in which these consolidations took place, the ground material can be seen to have accumulated in ridges and formed depressions due to the excessive softness of the gesso and glue. This state lasted for many months if not years, (see Bronzino’s Descent of Christ into Limbo) since the ground was sealed between the B72 facing that made the painting impermeable and the support that contained a high level of moisture and therefore did not allow the ground to dry. (We think now that the humidity measurements of the wood indicating about 20 percent after six months were taken from a sample on a superficial zone behind the crossbars and therefore did not reflect the situation in the interior.)

As for the paintings only partially exposed to water or damaged only from the extremely humid environment of the churches after the flood, it was possible to carry out treatments that were not too invasive since the damage that appeared was serious but not exceptional (see the records for Saint Bernardino by Domenico di Michelino), while for paintings that were completely or nearly submerged, we became convinced that the degree of deterioration of the washed-out ground layers made the support irrecoverable. To this was added the finding, made some months later, that in many cases the supports were reduced in size, that is they had become narrower than what they were originally, impeding the repositioning of the paint because there was no longer the same surface area available for its attachment. In a report sent to the ministry of culture on February 27, 1967, twenty-eight paintings were officially declared as requiring immediate transfer to a new support, forty-nine were classified as necessary but able to wait, and for another twenty, special treatments were indicated (and among these was Cimabue’s Christ and the two large panels by Salviati and Bronzino). As Umberto Baldini wrote in the exhibition catalogue Firenze restaura:

An artwork… is a composite organism that we have to consider as indivisible… but if agents of various natures negatively intervene in its preservation to the point where the various parts of which this organism is composed risk damaging in an irreversible way the surface of the painting, it will be this, we think, that has to receive the greatest protection, it will be this that must determine the treatment of the other parts. So if the support (preparation and wood) is no longer able to maintain the right relationship of stability with the painting and acts on it in a negative way or risks deteriorating until it is lost forever, and if there is no other way to prevent this, it is clear that, albeit reluctantly, one should proceed to removing it and substituting that which is causing serious damage to the painting.10

On many artworks, the work began moving in this direction.

The Florentine lab had ample and successful experience in this field,11 experience that had come of age in the nineteenth century, in part following contact with Secco Suardo (1864), and that had included the execution of some important treatments in the 1920s. For the time, the technology was quite advanced, as seen both in the removal of just the support (Nardo di Cione’s triptych, Madonna and Child, Saint Gregory, and Saint Job) as well as the removal of all the layers up to the back of the paint film.

Some of these restorations were completed in those years and in the years immediately after, but the workload was such that other treatments remained unfinished, halted though at a phase in which the paint was stabilized, and still others were not even begun. These last comprised for the most part the paintings that were particularly demanding in terms of size, and for these it was necessary to solve logistical problems and deploy a considerable workforce for years.

Over the forty years since then, the approach to these challenges has in part changed, and the solutions adopted for the last works taken on are in some cases different from those that were chosen in the years immediately following the flood. This depends only in part on the introduction of new techniques and materials, because in reality, in the last few decades in which restoration and conservation have made great strides in the field of technical analysis, and the treatment of canvases and cleaning, there have not been new developments for the problems of consolidating paintings on panel. The approach to the artwork has changed as it is understood not only as an image but also as a heterogeneous combination of materials, each of which must be protected intact as much as possible (on that subject, see the contribution of Marco Ciatti12). This has led to the decision to try, bearing in mind the condition of the artwork, solutions that are always less invasive, even if they are less thorough or definitive. Moreover, the sum of the many experiences undertaken in this field by two generations of restorers has led to a series of considerations, observations, and reflections that have allowed us
to obtain excellent results through the progressive refinement of traditional techniques and a prudent use of some synthetic adhesives for the resolution of specific problems.

Being able to maintain the integrity of two large sixteenth-century panels (the Bronzino and Salviati) that were set aside at the time due to the difficulties that their restoration entailed was however a tremendous result, obtained by putting to good use the experiences of all those who, in those years, were in various ways involved in the restoration of the flooded paintings.
These paintings are made on a wooden support that is composed of one or more planks depending on the dimensions of the artwork; the panel thus assembled has crossbars on its back while on the front side it often has a cushioning layer (usually canvas or tow), and always the preparation or ground layers made of gesso and animal glue, and then the paint. The crossbars are placed at right angles with respect to the wood grain of the support, they have a rectangular shape, are secured in different ways according to the period in which they were made: older paintings use nails that are inserted from both the back of the crossbars and from the front of the panel, respecting specific rules. In the following centuries, various systems of attachment by means of partially-moveable constraints were tried, with brackets of wood or iron; finally a structural support system to restrain deformations was developed with a method that involves the insertion of the crossbar along the back of the support in a channel with angled sides that converge lengthwise. Over time the preparation of the panel surface also changed: the older paintings have a surface covered with pieces of canvas, and the ground was applied on top of these, but over the centuries, the technique was simplified, moving toward a simpler application of canvas strips over the joins and imperfections of the panel and subsequently, in the sixteenth century, the application of coarse vegetable fibers (tow) in the place of canvas strips, or the total elimination of any kind of cushioning material. The gesso and animal glue ground was applied over the cushioning layers, or directly on the wood if these were absent, followed by a priming or imprimatura that could be simply glue, and then the paint.

3 In fact, for the panels made of chestnut or oak, the phenomenon of absorption takes place over longer time periods.
6 Some panels were already showing signs of extreme danger in December; one of these was the Deposition by Allori. The reasons that could have contributed to such accentuated damage are varied but one of them that we believe to be important is that it arrived at the Limonaia with a wood humidity value of 66%, much less than the other panels from the same museum which had a humidity between 80–130%. Moreover, it saw an early shift to levels less than 30% by mid-December.
7 The fact that the painted planks were separated made the consolidation of paint easier, moreover, we had to wait for the humidity of the wood to adjust to the environment. Given the very poor condition of the preparatory layers, it was not possible to treat the wood of the painted panels with coercive methods.

The wood support of the Rosano Crucifix:
Technique and comparative examples

Ciro Castelli, Mauro Parri, and Andrea Santacesaria

The paintings of this type from this period that have been passed down to us are not numerous enough for us to make comparisons on the similarities of construction technique or materials employed. We do not have nearly enough technical data in our collection of knowledge to be able to broadly assess the criteria and methods used in these structures or suggest if these are actually from one region or another. For these reasons, we have taken into consideration only some of the crucifixes that we have had the opportunity to study in greater depth in the course of restoration treatments, or during examinations carried out to determine their condition. The paintings considered come from the area of Central Italy, and specifically Tuscany; the contemporary comparisons for the Rosano Crucifix that we use are: a crucifix from a private collection attributed to the same painter, the Sarzana Crucifix of Master Guillielmus (Maestro Guglielmo) from the Duomo of Sarzana, the Crucifix of Villa Giunigi, Crucifix Number 432 of the Uffizi, and a crucifix by a painter from the end of the 12th century from the Abbey of Sant’Antimo, today in Castelnuovo dell’Abate, Montalcino.¹

Construction technique of the support

The panel of the Crucifix is made from chestnut planks, a timber species characteristic of structures for this kind of painting, especially from this period. The thickness of the panel is 5.5 cm and the overall dimensions of the painting currently extend to a height of 254 cm and a width of 230 cm.

The vertical portion is made of three planks: the main upright plank and the lateral apron panels of the body of the cross; these are aligned side-by-side and glued with butt-joins. The joins use four splines (16 cm wide, 10 cm high, and 2.5 cm thick) held with cylindrical dowels (about 2 cm in diameter) passing through the thickness of the panel. The horizontal section is made of single plank with a small added strip along the top part of the left terminal, again using a butt-join anchored with casein and two nails. The horizontal part overlaps the front of the upright panel with a half lap join; reinforcing this join are seven cylindrical, chestnut dowels (2 cm in diameter) located along the same horizontal line and passing perpendicularly through the support. These are distributed in a symmetrical way: two through the lateral panels, and three through the central one (Figs. 1–2).

For this structure, the two main planks, the vertical and horizontal, were cut out beforehand according to a formal design that defined the terminals of the cross that house the figures of the mourners and the lateral apron panels along the body of Christ so as to take advantage of the full width of the support. It should be stressed that the plan gave priority to the continuity on the front of the horizontal element that fits into the vertical upright plank, defining the pictorial unity of the body and arms; this technique is found, as we will see in the comparative section, also in other crosses from the same period like Number 432 from the Uffizi.

The internal faces of the join were protected with an application of a Sienna earth pigment before being glued (Fig. 3). The adhesive was abundantly applied but only on the vertical element; it

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appears quite dense and is made of gesso and animal glue, the same used to glue the dowels² (Fig. 4).

The cut of the planks is radial and the vertical plank was oriented with the outer surface facing the preparatory layers while the other planks were arranged in the opposite way according to the dominant custom. The wood quality is not the best; there are large knotty areas with erosion and losses of wood on the vertical plank. A large knot at the bottom was removed and the area patched with a chestnut piece 4 cm wide and 9 cm high and of the same thickness as the panel, held with casein.³

To complete the surface of the support, a circular halo was added made of a single piece of chestnut wood with a diameter of 42.5 cm and a sloping thickness from 5.5 cm at the top down to about 1.3 cm at the bottom. This piece has a projecting, carved, circular border with regularly spaced decorative motifs in gesso and an internal carved out surface on which was painted the face; the halo was positioned with the upper part leaning forward, set into the panel in a circular cavity and held with glue and four wood dowels passing through the entire thickness of the support and halo. It should be specified that this piece was applied only after the main support was completed, after having secured the crossbars on the back, and especially after having inserted the
iron hanging ring and hook (*campanella*) through the vertical and horizontal planks and having bent it back down under the cavity for the halo (Fig. 5).

Therefore the subsequent steps in the construction of the support, with the half-lap join as described and with the circular cavity for the halo already carved out, foresaw the application on the back of an extremely simple crossbar system; this is made of five poplar pieces: one vertical on the central plank and two horizontal pairs across the plank of the arms and along the lower border of the lateral apron planks (Fig. 6). The crossbars are anchored with straight nails inserted from the back side in a rather obsolete way—that is, they are not bent back around under the preparation. As already mentioned, the hanging ring is held with
an iron omega-shaped hook that passes through the vertical crossbar and the panel and the two points are separated and bent back under the halo cavity (Fig. 7). The construction of the support is finished with the application of the halo in the prepared cavity and its anchoring with glue and the four wood dowels that pass through it.

On the back, the woodworking marks from an adze used to smoothed the surface are quite visible; furthermore, there was a layer of gesso and glue (ammannitura) applied as a protection. Given the few remaining traces of this material, it was not possible to ascertain if this coating was also pigmented (Fig. 8).

On the surface to be painted, a double layer of fine-weave canvas was applied as a cushioning layer up to the edges. The Crucifix therefore was painted over the entire surface of the panel. Along the perimeter, ovoid relief decorations were placed whose imprints can be seen on top of the canvas (Fig. 9).

Usually, a careful reading of the structure of a panel painting brings to light the wisdom of the maker and his profound awareness of the technology of the materials and their behavior: but not only. It is, in fact, particularly important to underscore how this knowledge is also specifically tied to the particular use of wood as a surface on which to paint. The great Giotto-esque crucifixes, especially that of Santa Maria Novella are examples of structures that reach a quality and an elegance of the highest order, with a series of modifications that highlight a design polished down to the smallest detail.5

In the case of the Rosano Crucifix, it should be noted that the structure includes refined features as well as simpler and more modest ones, especially if compared with the other Florentine and Lucchese crucifixes of the period, as we will see shortly. For example, the central half-lap join is particularly well designed; this was made to accommodate the insertion of the top of the lateral apron panels in the horizontal element along a third of its width. To achieve the inner surfaces and make them smooth and even, a small adze was

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7. The iron hanging hook and ring (campanella).

8. Separation of an almost completely detached section of the vertical crossbar. Traces of the original gesso coating on the back can be seen.

9. Traces of the original frame, covered by the seventeenth-century frame (removed during treatment), can be seen in the X-ray.
used. The desire to bond all the main elements of the structure firmly together without resorting to metal nails but just with wooden dowels and an adhesive made of animal glue and gesso should also be emphasized. However, the execution of the joint was not very careful; in fact, during the restoration treatment we noticed that there had always been a gap between the overlapping surfaces as a result of how it was put together, as seen by the thickness of the glue residue inside.

The crossbar system meant to limit deformations appears to be of decidedly lesser quality. Despite the dimensions and the thickness of the panel, poplar crossbars in a rather reduced size were used. Poplar is a weaker wood species and more prone to deterioration than chestnut. Though, on one hand, the vertical length provides reinforcement across the half-lap join, the two horizontal planks were each made of two segments of crossbar that meet the vertical length and that therefore do not provide continuous restraint but were interrupted in the center. In addition, the nails that hold these to the support do not penetrate and get bent back around but instead provide a relatively precarious bond. However, it should be noted that these have essentially held together the parts until now without causing losses. This is also due to the placement of the painting within the abbey—the locations have not put the joints at excessive risk and have therefore succeeded in limiting damage. As we have seen, the only solid link that ties the crossbar to the body and horizontal arms is the iron hanging hardware under the halo cavity—the double shaft of the hook passes through the crossbar, the half-lap of the vertical element (about 2.7 cm), and the modest thickness of the arm (a little less than 1 cm), finishing with the double-shaft separating and being bent back around in a small notch in the already very thin wood. Most likely, during the insertion of this iron hardware, the wood of the arm would have had some damage from disruption of the wood grain and therefore presumably, the anchorage between vertical and horizontal was compromised from the beginning and became more vulnerable over time. These aspects bring us to consider how the support of the Rosano Crucifix was the likely result of inexperience and naïveté in the construction of the object, more than negligence or shoddy execution.

Comparisons with other paintings

The basic points that characterize the carpentry of the cross of the Master of Rosano as just described are: the solidity of the support, the type of joint between horizontal and vertical, the species of wood, the absence of nails in the structure, the large dowels, and the crossbar system. Regarding the strength of the support, the general sense of solidity that the observer has is from the right proportional relationships between height, width, and thickness. Although the upper part of the cross was cut down, an adjustment due to the painting having been relocated presumably in the 17th century, there emerges a strong construction methodology based on a consistent use of materials. The ample thickness of the wood used proves to be effective for the assembly of the vertical and horizontal sections with the half-lap or rather cross-lap join. This is a simple technique that nevertheless incorporates the advantage that the arms are made from a single plank. Furthermore, thanks to the lateral apron panel planks that overlap for a third of the height of the horizontal, there is a strong bond across the join that has meant that over the centuries the planks have maintained planarity. Deeply overlapping the apron panels in the horizontal plank is a feature also found in Crucifix Number 432 of the Uffizi.

The choice of chestnut, a material widely used in paintings from the twelfth and thirteenth centuries, is certainly motivated by the intent to create an object that would last and be stable over time. In fact, this wood species resists deterioration from aging and wood-boring beetle infestation very well due to its natural characteristics. Furthermore, its stability to environmental fluctuations is better with respect to other wood species. The use of wood dowels and not iron nails to join the vertical to the horizontal makes this structure distinctive and unusual. We find this technique again not only in the Sarzana Crucifix but also in the crucifix in a private collection attributed to the same artist, and in a small crucifix in the museum in Montalcino. In this last example, the dowels were not used in the half-lap join but to secure the lateral planks to the central element. The choice of trusting the anchorage of such an important part of the structure of a cross to wood dowels we will not find again afterwards because the use of dowels was substituted with iron nails with large, quadrangular, pyramidal heads whose protruding shafts were bent back down.

The construction technique of the Rosano Crucifix can be contrasted with that of the Sarzana Crucifix. These two paintings have similar dimensions and were made in roughly the same period using the same species of wood. However, they are substantially different in terms of construction...
The major difference is found in the choice of securing the horizontal element to the vertical: in the Rosano Crucifix as described above, the support and solidity of the horizontal is due to having been made from a single plank with a good thickness. This panel has a further reinforcement in the lower part of the arms thanks to the half-lap joint that supports it across two-thirds of its length. Therefore, the weight of the projecting part of the arms with the terminals with Mourners, is not such as to subject the panel to deformations.

For the Sarzana Crucifix, different assessments can be made for the mortise-and-tenon joins that serve as the connection between horizontal and vertical elements. The use of such a technique in this structure is conditioned by the shape and dimensions of the cross where a choice that allows it to be more graceful and have structural harmony through balanced proportions makes this contextually appropriate. In addition, the choice of inserting the arms reduces cracking on the painted image from joins between planks. Furthermore, this kind of join has prevented, in this particular type of cross, weakening the upper part of the vertical section near the halo. In order to support the arms well at the connection to the body, a series of technical adjustments were put into practice so that the weight of the projecting arms did not impact only on the mortise-and-tenon. In order for the mortise socket that receives the tenon to be durable and stable, it is a third of the thickness of the plank and centered; it stops four centimeters before reaching the shoulder. The tenon was reduced in height in the area corresponding to the un-carved part of the vertical so as to obtain a perfect fit. Additional support is then given to the arms, on the lower side, from the lateral planks attached to the sides of the body of Christ. The precision in the creation of these joins ensures the success of the design.

Of course differences in the structures of the Master of Rosano and Master Guillielmus are also distinguishable in the way the crossbar system is made; in the Rosano Crucifix the vertical element is given priority for structural reinforcement. The system is extremely simple: it is made of a continuous element positioned at the center of the back of the support, the crossbars of the arms are placed on the sides of this and along the lower margin of the apron. In the Sarzana Crucifix, the support for the projecting arms is a single vertical crossbar that unites the horizontal to the vertical; it is secured to the vertical plank, the load-bearing part

11. Crucifix Number 432, Gallerie degli Uffizi, Florence. The use of recycled wood, nails anchoring the horizontal arm to the vertical plank, and the coarse workmanship of the construction are evident on the reverse.
of the structure, with three nails and another three for each arm.

Some Lucchese painted crosses were made following the same criteria, shape, structure, and wood species of the Sarzana Crucifix. Examples are the crucifix of the Museo Nazionale di Villa Guinigi, and the crucifix of the church of San Michele also in Lucca.

Another useful comparison for the Rosano Crucifix is the Crucifix Number 432 of the Uffizi (Fig. 10). In this painting, the materials and techniques used in the structure are exactly the same. Chestnut wood was used, the vertical and horizontal elements were built in the same way, and the same criteria were followed for the join between upright section and arms. As in the Rosano Crucifix the lateral apron panels to the sides of Christ were joined overlapping by one third the lower part of the horizontal section. The differences that emerge in the cross of the Uffizi include a widespread use of iron nails and recycled wood10 (Fig. 11). In fact, in this example, the arms are attached to the body by long quadrangular iron nails, inserted in an alternating way both from the back and front before the application of the ground layers; those that protrude on the back have been bent down with little care, in fact, part of the shaft of the nails sticks out before being bent back into the wood. In addition, there a lack of care in the final finishing of the wood. In the history of making panel supports for paintings, the use of wood recovered from previous objects is found across various centuries. Some examples are the Triptych of San Giovenale by Masaccio, and the Polyptych of the Intercession by Gentile da Fabriano.

It is not possible to compare the crossbars because those present on Crucifix 432 of the Uffizi have been re-made relatively recently. The only thing that we can see is that the current one is in large part positioned over the space of a pre-existing one. As with the Rosano Crucifix the painting of the Uffizi bears the same qualities of stability and general preservation of the object, and in both, the same problem of the separation between horizontal and vertical parts exists. This negative factor that involves the cracking of the painting of the figure of Christ and in the partial detachment of the horizontal section with respect to the body, derives from the kind of structure and in the shrinkage of the wood over the centuries. For Crucifix 432, the most distinctive feature is the likely originality of the gilded perimeter frame with a wide, rounded molding, matching the gold-ground of the painting; this element is not found in the other painted crosses examined and represents a unique example for the period.

The structure of the crucifix attributed to the same painter as that of Rosano is both interesting and unusual. The painting of modest dimensions is well-proportioned. It is very likely made of poplar wood. The arms are made of two elements that join at the body with quite an unusual attachment (Fig. 12). Unfortunately, it is not possible to say what adjustments to size and shape have happened. The cross is made of a vertical element made of a single plank of diametral cut and two other smaller planks for the arms. The area of the body, of the legs and of the upper section, is carved out from a single plank; the arms each join to the body with half-lap join. This type of join is unusual in this kind of panel: it consists of a half-lap tenon carved out on part of the back, as long as a third of the total length of the arm, with a slightly trapezoidal shape with sloping sides and off-center toward the bottom. However, they have been inserted by force into the body with anchorage in the form of four dowels similar to those of the Rosano Crucifix. The nails that are present we think are not original but added in a period after it was made.
The presence of large wooden dowels is also found in a crucifix of a painter from the end of the twelfth century—a panel made for the Abbey of Sant’Antimo in Castelnuovo dell’Abate, Montalcino. Even though later and of much smaller dimensions, it is made according to the parameters of the Rosano Crucifix. It is differentiated by the kind of wood, but it is very similar in terms of proportion and workmanship, for example the wood dowels that hold the lateral panels to the body of Christ. The main difference is in the use of a different species of wood.

Some considerations on the techniques of these artworks

Analyzing the measures put into effect in the making of these crosses, the differences that we find indicate an interweaving of technical solutions aimed at determining an ideal wooden structure—ideal not only for itself, but capable of receiving and preserving the painting that would be applied. For example, in this period, we see how it was already considered necessary to select wood planks that would ensure durability, good stability, and suitability to receive the preparatory layers that characterize painting on panel.

We also encounter even more detailed features that distinguish wood structures meant for furniture from those meant for a painting. The care taken in the choice of wood, the kind of cut, and the face that was destined to be painted are elements that show an awareness of the properties of wood, its natural adaptations to environmental fluctuations, and to the deformations caused by aging. It should also be added that the back of the painting was treated with an application of material with the same characteristics as the preparatory layers of the painting. This material certainly had the function of balancing the forces between front and back and protecting the wood from insect attack and environmental factors. A lot of care, as Cennino Cennini would write in his Libro dell’arte two centuries later, is also given to the application of the preparatory layers on the panel before painting. In this period, precisely because of the awareness of wood properties, the panel was no longer painted on directly, but there were pieces of canvases, sometimes double-thick, applied to reduce and cushion the negative actions of the wood on the layers of gesso. Despite this, the gesso, due to its glue component, was sensitive to environmental fluctuations with an expansion similar to that of wood though certainly the degree of movement of the support is not comparable to that of the ground.

As we see through the analysis conducted on these paintings, there are different techniques used and variations in the expertise of the carpentry workshops that worked for different artists, also symptomatic of the intellectual richness of the region. Furthermore, some considerations derive from the fact that the choices of certain rules were dictated by scale or shape of the paintings that needed to be made. But precisely because of the adoption of these adjustments, it is easy to see how nothing happened by chance and the choices did not arise out of a void but rather traced their origins from the context that drew on a longstanding knowledge.

All of this knowledge seems to have become perfected gradually over time through the observations and experiences that the artists had directly with the existing artworks and objects.

1 Currently the painting is at the Museo di Montalcino.
2 The presence of Sienna earths with gesso and glue was detected by analysis carried out by the Laboratorio Scientifico of the Opificio delle Pietre Dure, record number 0959.3.
3 The presence of casein was detected by analysis carried out by the Laboratorio Scientifico of the Opificio delle Pietre Dure, record number 0959.2.
4 This particular aspect has been discussed in the contribution by Roberto Bellucci on the restoration treatment.
7 See the text by Roberto Bellucci on the restoration.
9 For the Rosano Crucifix the current dimensions are: 254 cm high x 230 cm wide, with a thickness of 5.5 cm. For the Sarzana Crucifix: 297 cm high, 214 cm wide, with a maximum thickness of 5 cm, minimum of 4.2 cm.
10 On the back, there were channels cut horizontally in the lateral panels that served no technical function for this kind of object.
The wood support of the Rosano Crucifix: Conservation and restoration

Ciro Castelli, Mauro Parri, and Andrea Santacesaria

Condition and treatment plan

The Rosano Crucifix arrived in the Laboratory with essentially two apparent alterations that been carried out in the past.

The vertical panel had been cut down just above the halo and was therefore missing the entire cartouche at the top. The cut edge had a conical hole made in it with an opening of about 2.2 cm and a depth of 7 cm in which a relic had been inserted which was still present at the time of our treatment. Most likely, this small object was originally in another location in the part that was cut off and therefore the current hole was made immediately after the cut to rehouse the relic in the support. In fact, the upper edge has a gouge that is evidence of its original location. The other modification that the painting was subjected to was the application of a carved frame applied to the perimeter; it was attached directly on top of the paint with carpenter’s hide glue and nails. These alterations were carried out at the same time and came about from a change in the location of the crucifix within the abbey church which occurred in the 17th century.

The support does not bear any signs of previous structural treatments but only deterioration related to the original construction technique. Therefore it can be thought of as an exceptional finding in that it has preserved its material integrity almost completely intact for a millennium despite this combination of elements that theoretically would lead us to think of preservation difficulties since the beginning (Fig. 1).

Even when the Crucifix was being moved to the laboratory, it was possible to recognize a series of phenomena of detachment and structural failure of the assembly.

First of all, the poplar crossbars had suffered from significant wood-boring beetle infestation; some nails that held them to the panel had come loose from their holes making the connection between panel and crossbar quite weak. This condition was most visible where the horizontal element was shifted about 1 cm forward, such as to make for a step in the surface, horizontally across the picture plane, along the join line between the planks and resulting in the fracturing of canvas and paint. Furthermore, the joins between the main vertical and the planks that formed the lateral apron panels had given way; on the left in a linear way, on the right causing cracking of the lateral plank at the height of the spline. This fact is accounted for by the natural transverse contraction of the vertical planks that strain against the wood dowels, causing fracturing along the join lines or in weaker grain area (Figs. 2–3).

The panel had widespread wood-boring beetle damage concentrated around a knotty area of the central plank, causing deep erosion.

The analysis of the condition reveals the painting caught in a dangerous and precarious state. Clear detachment and progressive structural failure could be ascertained to which solutions were proposed both for preservation reasons and for the physical security of the object (Fig. 6, p. 159).

A treatment methodology was needed that had as its main scope that of providing a stronger bond between all the parts.
During the development of the treatment plan, evaluating the construction technique of the *Crucifix* and considering the importance of it as exceptional historical evidence, a decision was made to work to preserve exactly this original technique, taking advantage of its characteristics and giving new functionality to the hold of the materials and structure. Given the extreme vulnerability of the connections between the parts (the nails and dowels had loosened) it seemed possible and relatively easy to dismantle the support without causing losses or damage to the original materials. The nails could be extracted by pulling them out of their holes in which the adhesion was in certain cases minimal, and in others entirely nonexistent. It was, in fact, possible to ascertain that the glue of the dowels had given way and the wood element on which the
face of Christ was painted could be extracted without danger; furthermore, the shaft of the hook was made of soft iron and could be easily straightened and removed. All these steps would make the next phase of consolidation of the panel and rejoining of the original assembly possible allowing for firm connections. From our point of view, in the early planning, this series of operations would enable the reinforcement of the deep detachments between the central vertical plank and the lateral apron panels: in this case the procedure would have caused a slight loss of original wood material in order to permit the execution of narrow channels for wedges, but this is a loss that is perfectly compensated for by the results in terms of returning the wholeness of the image and the aim of preservation. Finally, according to this same preservation principle, the reconstruction of all the eroded wood areas could be executed, like those in proximity to the knots attacked by insects or along the edges; this operation would give greater solidity and a protection from dust and subsequent biological attack.

However, the assessment of the painting developed over time with a series of considerations. As is typical, the various working options for paintings being restored in our laboratory are questioned and discussed in a collegial way by the work team and even if these are purely technical choices, they are subject to critical reflection. In this case, it is important to recognize how pursuing this in depth brought about a substantial and important modification to some parts of the treatment plan. While the necessity of structural dismantling and a new and more solid re-assembly remained, corrections to the plan regarding especially excluding the wedge-reinforcements for the separations of the joins were made in light of new, clearer ideas about the treatment methodology, the execution technique, and the condition of the entire painting. This was an important marker that allowed us to see how the ideal set up of different phases of critical and technical development ought to proceed in step as so often one illuminates the other.

It is essential, therefore to be able to rethink decisions that seem already definitive just based on practicalities: technical abilities should never be the guiding criteria for restoration choices, but only add support to the critical process.

It was possible, on the basis of what was expressed earlier, to better recognize the cause of the joins opening up along the lateral panels as due to a shrinkage of the wood that was restricted or jammed by the dowels. We know from experience that the wood panels are subject to a series of forces due to various factors in their first years of life. The single elements connected to each other seek an equilibrium across the whole; the overlying layers of gesso, glue, and paint introduce a quantity of humidity that provokes further settling movements. Finally, the finished painting adapts to the display environment in which it is installed, the different types of wood complete their adjustments, and the various materials begin to react to the new environmental conditions. In this step, it is possible to see large contractions of the panel.
imposing stresses and separation along joins and cracks, presumably due to the forces exerted by rigid connecting elements like dowels or nails. These phenomena can amount to some millimeters of transverse contraction of the paint surface, even some centimeters as was seen in the most striking case of Duccio’s Maestà in the Uffizi. This means that the surface on which the paint was applied contracted and was reduced in size. In this situation it might be thought that occurrences of paint lifting are likely but the surfaces of the paintings that show this kind of problem to different degrees do not have flaking or lifting, except for a tendency to crack along with the panel. If the same phenomenon of contraction occurred centuries later as in the case of the supports struck by the flood, the paint layer would obviously detach, not only because of loss of adherence, but because of the volumetric shrinkage of the panel.

Therefore, in the case of the Rosano Crucifix, as with innumerable early cases, the flexibility of the materials applied in layers has allowed the ground and paint to follow the contraction of the support without damage. From this analysis of behavior of materials derives the possibility of locating the deterioration factors in time; this serves to clarify many unknowns in relation to the condition, and above all regarding the development of a treatment plan aimed at the actual needs of the painting and therefore limited in impact. These factors indicate that some of the heavy-handed treatments of the past on wood supports were due to a superficial reading of deterioration factors. In fact, if we chronologically contextualize the deterioration of the Crucifix to the earliest years of its history, we can read the marks of time with a new perspective.

The cracks, the separations, the deformations, even the wood-boring beetle damage can be associated with its beginnings and therefore their preservation impact can be put in perspective. Thus, a panel, even though eroded and riddled with beetle tunnels, can be considered, paradoxically, strong and clear evidence of an excellent state of preservation. It illustrates, in fact, better than any list, that which the passage of time has marked on its substance, thanks to its exceptional duration in the same location and to the environmental stability.

Faced with these considerations, our treatment of the support followed a very different approach from that which we had originally decided, especially with regard to the reinforcement of the separating joins of the lateral panels and their connection to the vertical plank. Though aware that using thin wedges to re-attach the joins would have assured a strong bond, we decided for a path that would be more respectful of the original material, exceptionally preserved over time.

The treatment of the support

Obstacles were not encountered in carrying out the steps of the treatment nor were changes from the treatment plan required.

Almost all the elements of the frame were detaching and were therefore removed by extracting the nails; the work was carried out with extreme caution because some portions of paint remained attached to the underside of the frame. The segments of frame that were firmly adhered to the surface were reduced in thickness until the paint was exposed. Subsequently, all the areas of paint stuck to the detached pieces of frame were recovered and repositioned in their original locations with a technique that is described in the contribution on the treatment of the painted surface.

The upper horizontal crossbars were practically free and the nails came out without any resistance. Then the painting was positioned on its side to enable it to be dismantled with full control and a view of the whole (Fig. 4). The piece with the

4. The painting was positioned on its side in order to be dismantled. The discontinuity between horizontal and vertical is visible.
head was extracted with much care because the friction of the dowels in their cavities could have caused damage to the paint where they contacted it at their ends (Figs. 5–6). The removal process was carried out with constant observation of the paint surface in raking light. Three dowels remained inserted in the wood of the halo while the fourth remained embedded in the vertical plank because its tip had naturally detached from the ground and canvas on the area of the head. After the piece was removed, the iron hanging hook (campanella) was drawn out and the wood fragments remaining under this were saved. Then the horizontal element with the arms was detached from the body of the cross, a procedure enabled by the complete separation along the join lines of the canvas and paint. This was a simpler operation from the previous one in that the dowels had given way more definitively and were attached only to the arm (Figs. 7–8). Inside the join there was a great quantity of material that had accumulated over time and that was carefully removed, with care to not remove fragments of original material (gesso with animal glue and Sienna earth) still present as a coating but not well adhered to the support. The part of the arm that was cracked and eroded in proximity to the iron of the hanging hook was reinforced; the fragments that had been saved were repositioned and the losses were filled with aged chestnut wood (Fig. 9). During this operation, it was noted that the reconstruction of the wood need not be limited in depth to follow the thin original layer of about 1 cm in that, since the beginning, there had been a gap between the surface of the arm and the body. This probably caused the thinner wood to give way, especially because in dividing and bending back down the arms of the iron hook, there was no adequate resistance in the underlying wood. Therefore, the reconstruction made during the treatment goes deeper in the wood than the original and it rests, without being glued, on the surface of the body of the cross.
This allows, on one hand, the reconstruction to be more solid and on the other, the entire layered structure including the thicknesses of the vertical and horizontal of the cross can offer a better and more secure brace for the iron hanging hook at the moment in which it will be re-installed and take on its traditional function of support once again (Fig. 10).

On the dismantled panel, some procedures were carried out to adjust and reinforce it in a limited, localized way. The small piece held with nails at the top of the left terminal showed signs of the adhesive giving way and it was re-attached; in the open gap of the join a thin spacer of chestnut was glued with PVA Bindan P. The deep, eroded knot was reconstructed with a series of small pieces of aged chestnut glued with Bindan P. The end of the lower crossbar that was extremely eroded was reconstructed with pieces of old poplar (Fig. 11). On the vertical crossbar, the separation of an area at the top was consolidated with glue (Figs. 12–13). At the bottom, erosion from insects reduced the wood around the shaft and under the head of the nail; the area was reconstructed with small pieces of aged poplar so as to fill the gaps. The dismantled elements were subjected to a micro-vacuuming and wood consolidation. The wood of the panel was treated with Regalrez 1126 as a consolidant while the poplar of the crossbars was treated with Paraloid B72. These products were chosen based on the role that they should fulfill—for the different types of wood and according to

8. The main body of the cross after dismantling.

9. Reconstruction of the horizontal plank near the hole for the hanging hook (a detail from the top). The dowels embedded in the body were isolated during the gluing.

10. Reinsertion of the iron hanging hook (campanella) and bending of the shafts.
tests carried out on samples. The wood of the crossbars needed to regain strength in order to carry out its structural function and therefore they underwent a treatment of strong consolidation with a material that is usually solid, that is Paraloid B72. The panel was treated with Regalrez 1126 because it only needed a light consolidation on the surface which has the function of holding the fragile parts of the external wood surface together and especially of protecting it from temperature and humidity fluctuations. With the aim of finding the right relationship between quantity of product and depth of absorbance, tests were carried out on samples of aged wood having similar characteristics to the wood of the Crucifix. Afterward, the samples underwent a further test of humidification to verify the protective effect of the various applications of the consolidant. At the end of the tests, the best mixture was determined to be the Regalrez 1126 dissolved to 20% in ligroin 100°/140° and applied in two coats by brush.

Before proceeding to remount the horizontal section, the dowels and their corresponding holes were completely cleaned so as to avoid blockage or obstruction. The horizontal was positioned in its original location, finally achieving surface continuity with the vertical element (Fig. 14). The adhesion of the elements was achieved through the wood dowels; in the thin circular spaces around them small chips of chestnut wood held with hide glue were inserted (Fig. 15). This step allowed for

11. Reconstruction of an end of the horizontal crossbar with small pieces of aged poplar.
12. Separation of an almost entirely detached part of the vertical crossbar. Traces of an original gesso coating can be seen on the back.
14. Re-attachment of the horizontal part achieved planarity between the elements of the support.
15. Adhering the dowels with the insertion of small pieces held with hide glue in the gaps.
filling of the narrow spaces around the shaft of the wood dowel with an technique that could be reversed; in case of necessity, the added wood could be removed and the join freed.

The iron hanging hook was reinserted and bent into its original position with a secured anchorage in the wood such as to allow it to reassume its function of supporting the entire painting. Then the wood element with the head was re-positioned and the dowels secured with the same procedure described earlier. On the back, the crossbars for the arms were anchored to the panel using the original nails; these were reinserted into their holes and held with a mixture of epoxy resins (Araldite AW106/HV953U and Araldite SV427/HV427 in a ratio of 1:1). This combination yields a gap-filling material with good adhesion and less rigidity with respect to only using Araldite AW106/HV953U. The nails of the lower crossbars were inserted with the same technique. During the work of inserting the nails, a lot of care was taken to limit the application
of the resin only to lengths of nail within the support itself, using the hole of the crossbar only as a passageway.

The reconstructed part of the lower crossbar on the left had two nails; in the existing holes in the support double-threaded brass bushings were inserted that could anchor stainless steel screws inserted deep into the wood of the reconstructed area; these were then covered externally with the old nail heads to grant an aesthetic unity also to the support.

With this treatment, the painting acquired a sufficient solidity and a good planarity of the surfaces. Even the separations and cracks, on which it was decided not to intervene, seemed well connected, thanks to the anchorage of the dowels. As gaps remained open in these areas and along the borders of the join through which deterioration agents like air currents, dirt, and insects could have infiltrated, these areas were closed with deeply inserted strips of balsa fitted into the spaces thanks to their extreme softness (Fig. 16).

Before re-adhering the canvas to the panel, a careful review of the perimeter border was carried out that included a partial reconstruction of the eroded areas. This treatment is described in more detail in the contribution of Salvatore Meccio and Linda Lucarelli.

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**Raphael’s Madonna with a Goldfinch: The construction, deterioration, and conservation treatment of the wood panel**

Ciro Castelli

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1. **Introduction: preventive measures to protect the painting when it entered the laboratory**

   When the painting arrived in the laboratory, monitoring of its environmental conditions was begun with sensors placed in the area where it was located. To improve the stability of the relative humidity, the painting was enclosed in a wooden container to protect it from even minor variations caused by the daily presence of the personnel (Fig. 1). The data on the environmental conditions and the behavior of the painting itself were checked daily to verify the eventual presence of micro-dimensional changes taking place in the wood panel or the paint layers following the work’s transit from the room in the Uffizi where it was exhibited to the laboratory. While a similar observation procedure is followed for every painted wooden object entering the laboratory, here it was considered even more essential due to the particular conditions of the panel defined by numerous existing fractures. Also during this initial observation period, the analysis and documentation was planned, so as to reduce to a minimum the risks of moving the work to other areas of the laboratory.

   The materials applied to the back of the panel in the past were also carefully observed, and were judged to be still contributing positively to stabilizing the wood. For this reason we decided to avoid interfering with the layers of waxy substances on the back of the panel and on the heads and side edges of the boards. However, since their presence did not permit a well-defined inspection of the wood species and its features, and thus impeded their identification and in-depth study, the principal means to investigate the support material and its condition became X-radiography and CAT-scan analysis. However, the size of the painting made CAT scanning extremely difficult to perform in this preliminary stage; in fact this form of analysis became possible only several years later thanks to a new method developed by the University of Bologna. For these reasons a complete treatment plan was not prepared initially, and consequently the decisions regarding the support were dependent on the results of cleaning the painted surface and the analyses that could be done in the meantime.

2. **The technique of construction of the panel**

   The panel measures 107 cm high by 77 cm wide, and varies in thickness from 3 to 3.5 cm. It is composed of two poplar wood boards placed vertically: one 53 cm wide and the other 24 cm (Figs. 1).
The flat edges of the boards have been butt-joined without any internal dowels or rectangular inserts, and a strip of canvas has been applied over the joins, as described in more detail by Patrizia Riitano in this same volume.¹

Most of the information concerning the technique of construction and the choice of wood was derived from X-radiography. The widespread although not completely uniform presence of gesso allowed us to discern the wood’s relatively straight grain and rather homogeneous consistency, and to observe that it was also free of knots or other defects.

While the material itself was good quality, the cut of the boards was less carefully selected; in fact, the wider plank shows a sub-tangential cut visible centrally in the board head and progressively less towards the edges; the smaller board is instead fully tangential.

The wider board has been mounted with the inner side (the one facing the center of the tree trunk when cut) towards the preparatory layers, as was customary, while the other board is reversed; therefore their assembly does not follow what may be considered a practically constant rule.² Two dovetail-shape crossbars sustain the panel on the rear and counteract its tendency to warp and curve. They are 2.4 cm thick and are inserted into the wood for an average depth of 1.2 cm. These crossbars are trapezoidal in cross-section and taper from one end to the other, again as usual, and have been inserted into their tracks tapering in opposite directions. Both crossbars are situated at a certain distance from the board heads, the upper one, 8.5 cm, and the lower one, 10 cm.³ However, differently from other examples of this period, the crossbars are entirely trapezoidal in shape and therefore fit precisely into their housings without having a widened upper part that extends beyond and covers the edges of the opening.

3. Damage caused by the collapse of the building

As is known, this panel painting, dating from 1505–06, suffered severe damage in 1547 in the collapse of the house where it was located. As may be seen in the X-radiograph (Fig. 4), the panel broke into three separate pieces, therefore more than just the two boards that composed it originally. Other fractures are visible in each of the three parts: one in the left hand piece, four in the central one, and five on the right. These separations and fractures follow the vertical direction of the grain and fibers of the wood, almost always for

2. Drawing of the painting from the rear showing the technique of construction.

3. Drawing of the front side of the panel with canvas applied over the join.

4. The X-radiograph shows the damage incurred in the house collapse despite the repair made in 1548.
practically the full height of the panel and through its entire thickness. Other cracks are visible perpendicular to the grain, which however have not produced further complete separations since they proceed in sections from one growth ring to another, which provides some sort of albeit weak connection between the parts.4

The wooden fibers in the lower left corner must have been so severely fragmented that it was necessary to “gouge” out most of the wood and replace it with two new wooden pieces to regain the original shape. Another piece of new wood was inserted from the lower edge into the part corresponding to the right foot of the Christ Child. Several millimeters of paint loss occurred all along the edges of the fractured parts.

4. The sixteenth-century panel reconstruction after the building’s collapse

The three broken pieces of the panel had been reunited gluing them together side to side with carpenter’s glue, without previously rectifying the edges of the separated parts (Fig. 5). Nails had been inserted obliquely into the upper heads of the boards in correspondence to the breaks in order to improve the contact between sides so as to allow for better adhesion and strength of the joins.

5. After cleaning, the damage to the paint layer incurred during the sixteenth-century house collapse is evident.

6. The reverse in raking light showing deformations of the panel from the 1548 repair of the fractures.

The repair of the other fractures followed the same criteria: glue had been put into the openings and pressure was applied on either side to achieve adhesion. This was certainly more difficult where the parts were not completely separated because of the limited penetration of the glue and the need to keep the pieces together long enough for the glue to dry (Figs. 6–7, 9–10). The difficulties faced during the sixteenth century treatment were shown by the discovery during the preliminary examination of several gaps inside the joins and the instability of many of the fractured parts of the panel.5 Two long nails, together with two shorter ones, and five
join, carved out of one side of the new piece and from the matching area on the rear of the paint-
ing. There is a loss in the wood at the center of the lower edge, near the reconstructed part, about 1.2 cm deep, 15 cm wide, and extending 10 cm above the crossbar. Such damage must have been the result of the painting hitting the ground, splintering the wood to pieces by combining the effects of the height of the fall, the weight of the work, its angle at the moment it struck the ground, the point of impact, and the resistance of the crossbar in its seat.

smaller nails had been inserted into the left edge of the panel, again for the purpose of keeping the break together and reinforcing the join. For the rightmost fracture, nails had been inserted from the rear of the panel, as it was impossible to do so from the side edges of the boards. These rather small, short nails had been inserted very obliquely to avoid the risk of having them come out through the paint surface. Two nails had also been introduced from the front in the upper portion of this split, in this case through the paint. The fracture had a semicircular shape in this area, and the grain had separated horizontally within the thickness of the wood (Fig. 8) creating a gap in the paint. The sixteenth century restorers evidently found it very difficult to keep the painted edges of this break level during fixing.

The lower left corner and part of the left side of the panel had been reconstructed by adding two pieces of poplar wood, oriented with the grain parallel to the rest, held with glue and two long nails. The part corresponding to the right foot of the Christ Child had also been replaced, with a strip of wood 27 cm long by 5 cm wide and as thick as the support itself. The flat side edges of this piece had been glued to the adjacent wood of the support; its upper edge was joined in a 6 cm long half-lap

8. The holes in the paint after removal of the nails; cleaning of the split in the upper right portion of the painting.

9. Detail of the X-radiograph, upper central portion, showing the fractures.

10. Detail of the painting corresponding to the preceding X-radiograph.
The resulting missing portions of wood had been filled with a mixture of gesso and animal glue. All the separated and reconstructed areas had been joined leaving their margins on the painted side noticeably out of plane, and with paint losses along their margins. The crossbars had been put back without any sort of correction to their channels, and since they did not adhere well to the panel, a nail had been inserted into the upper one to hold it to the panel. The very irregular warp of the panel may be related to this episode.

5. Condition of the panel before our treatment
The wood of the panel and the crossbars was in generally good condition, with only a few old exit holes from wood-boring insects and without any other biological attack.

The panel had extensive areas of detachment around all the fractures and separations where there was breakage within the grain of the wood. As previously mentioned, ample portions of the margins along the breaks remained out of plane on the painted side, and the crossbars did not adhere well to the tracks in the panel.

6. Planning the treatment for the wood panel
An innovative treatment approach was formulated in the light of the very delicate state of the work, in particular the variety of fractures, the paint losses along all the edges of these, and the layer of beeswax on the rear. Although a good norm in wood conservation has been and still is to correct, adjust, and strive to perfect the alignment of a break using traditional adhesives, in this case the extent and nature of the fractures would have resulted in substantial and heavily invasive intervention if treated this way. Following evaluation of the results of repairing the fractures on a specially prepared test model using an epoxy resin rather than traditional adhesives, a decision was made to adopt this material and to limit operations to reuniting the fissures without sacrificing any of the original wood. The original batten system was also maintained, since it was considered an important part of the work historically and still functioned well to preserve the support and the stability of the paint layers. The plan also permitted preserving the wax on the rear, with the exception of the areas on the lower part of the panel that required reconstruction.

7. Treatment
The painting was placed vertically, resting on one side within a “cage” (Fig. 13) formed from two rectangular frames (Fig. 14). The structure was equipped with adjustable screws, making it possible to change the position of the panel as needed during treatment and apply varying pressure at different heights. Since the frame furnished the panel with the necessary support in the direction perpendicular to its grain, we were able to remove the crossbars safely from their channels. The system allowed working safely and with precision on the repair of the fractures on the back while keeping the painted side under constant observation. The first procedures to align and adhere the breaks began with the one farthest to the right, whose upper part showed marked curvature and which penetrated obliquely into the thickness of the wood. After removal of the nails inserted to strengthen the union during the 1548 restoration, the two separate sides of the break were cleaned using a slim, toothed blade (Fig. 15). Having checked that the two sides of the split met and were level
Of course any adhesive is always attentively assessed in relation to the problems posed by the specific treatment, and it is also possible to affirm that a perfect adhesive for every instance does not exist. In the present case the eventual negative effects of using a resin were held to be practically non-existent, and even basically irrelevant. In fact the resin would be applied within the thickness of the support, in a very thin layer on the surface of wood to deform in reaction to variations of humidity.

(Fig. 16), they were glued together with a two-component epoxy resin inserted into the opening (Figs. 17–18). Given the function expected from the adhesive, the type chosen had to be viscous enough to permit application with a thin palette knife, as well as offer the necessary adhesion. It is useful to say a few words about the choice of the epoxy, a material both rigid and stable. The use of this adhesive on wood may prove problematic, as with all resins, especially because of the tendency of wood to deform in reaction to variations of humidity.
positive effects of such intervention were considerable: solid adhesion of the fissures, no removal of original wood or alteration of the aesthetic appearance of the support as it appears to us today.

The other fractures were repaired following the same criteria: the breaks were sealed after cleaning the internal parts with a thin, toothed blade, in many cases also leveling the painted edges. When the space inside the fissures reached about half a millimeter, small pieces of aged poplar wood wide enough to fill the gap were inserted together with the resin (Fig. 19). The old portion of wood added to reconstruct the right foot of the Christ Child was unstable, with the painted surface incorrectly connected to the adjacent original. The insert was therefore removed (Figs. 20–21) without demolishing any wood; one of the faces of its half-lap joint was slightly reinforced and the parts coming into contact with the original support cleaned. The piece was then reinserted in place, keeping the painted side level with the original color (Figs. 22–24).

The gesso fill in the loss of wood in the lower part of the support was removed, and then the base and sides of this area were smoothed gradually step by step in depth. Small pieces of aged poplar wood were used to reinforce the area, inserted in layers like a parquet, with their growth rings aligned to those of the panel (Figs. 25–28).

Following the removal of the crossbars, the slanted sides of their tracks were adjusted, and the same was done slightly to the bases and sides of the crossbars themselves. A small strip of wood was added to the oblique sides of the crosspieces to achieve the best fit between the parts (Figs. 28–31).
21. In order to adjust the position of the fragment of the foot, it was removed.

22. The insert with the foot was removed because it was detached and had shifted position.

23. The area adjacent to the foot was aligned and re-adhered.

24. The foot insert was repositioned, aligned, and then glued in place.
25. Lower central area of the reverse of the panel showing 1548 restoration fills made of poplar wood and gilder’s gesso.

26. With the crossbar removed, the gesso was cleaned out and the reconstruction of the area was begun with strips of aged poplar.

27. Reconstruction of the lower part of the panel.

28. Reconstruction of the lower margin with strips of aged poplar.

29. The channel of the upper crossbar.

30. The crossbar was inserted back in its channel after being adjusted.
31. The reverse of the panel, after treatment.
8. Comparison with the supports of several other paintings by Raphael

Various works by Raphael have been brought to our Laboratory for study or restoration purposes since the early 1980s. As Umberto Baldini informs us in Indagini su Raffaello, his contribution to the catalog of the exhibition Raffaello a Firenze, eleven works were treated at the Opificio delle Pietre Dure on that occasion and another five paintings had been previously restored. These works are all panel paintings, with the exception of La Velata on canvas; the portrait of Cardinal Bernardino Dovizi da Bobbiana is also a canvas painting, however it was not among the works the Opificio studied thoroughly. Numerous paintings have been further investigated during the research carried out for the conservation of the Madonna of the Goldfinch: the painted surface and the supports have been examined in normal and raking-light conditions, and through single-film X-radiography and IR reflectography. The results have been combined with those done previously at the time of the 1984 exhibition.

Most of the information derived from analysis regards the techniques of construction and the choice of wood. The panels are either composed of a single board or more than one; this is related of course to the dimensions of the work, which in turn is connected to the type of image depicted. The number of crossbars and their mode of attachment also varies according to size: a single one has been placed centrally on the panel of the Madonna del Granduca; two are found on most of the others, including the Madonna del Baldacchino even though it is larger. The crosspieces are all trapezoidal in cross-section and shaped to fit into dovetail tracks carved in the wood, with their width tapering in opposite directions. This system is exactly the same as that found on the Madonna of the Goldfinch.

The portraits of Agnolo Doni and Maddalena Doni have lime wood supports, each consisting of a single board about one centimeter thick. They retain the original frames which hold the panels in a channel extending along their internal perimeters. Both sides of the board structures are painted, using their inner faces for the portraits.9

The panel of the Portrait of a Woman (La Gravida) is also made of the same wood species, and has a main board with a 3.9 cm wide strip of wood added to the side, fixed with four sturdy, quadrangular and pyramidal nails. La Muta is structured differently: it is composed of two planks, one 33 cm wide and the other 15 cm. The first board is subradially cut with its outer face in the direction of the ground, therefore different from the other cases cited.11 As on the Madonna del Granduca, the rear of the panel has been coated with beeswax. These last two paintings are also framed similarly to the Doni portraits, so that the frame fulfills both a functional and aesthetic purpose. This framing method is somewhat similar to that used on several portraits by Antonello da Messina, although these are constructed with the planks set horizontally. Such a system was designed to combine structural restraint and a pleasing presentation of the works, and is often used on Flemish paintings.

Analysis of the wood species reveals that poplar was the main type used, although several smaller panels, such as the portraits mentioned above, are made with lime wood. The portraits are on relatively thin panels, averaging about 10–12 mm; instead the larger paintings generally have thicker panels, even more than was usual at the time. The wood grain runs vertically on all of Raphael’s Florentine works, except for the panel with Ezekiel’s Vision.12 The wood chosen for the portraits is of very good quality: the boards show straight grain and are generally cut rather centrally, with few defects that could affect the painted surface. In fact, even when without a frame, the cut and quality of the wood, even more than the species chosen, has contributed to maintaining the portraits basically flat. The choice of lime wood has resulted in a greater contraction of the wood grain that we can detect on the paint by careful examination. The effect on the paint surface is due to an intrinsic characteristic of the wood species itself: since lime wood’s density is about 20% greater than poplar, the wood is more prone to contraction with aging. Despite these undesirable tensions, the paint does not seem unstable, and the craquelure visible on the painted surface can be considered typical of Raphael’s works.

The entire painted surface of the other works by Raphael extends out to the edges of the panel, since as usual in this period, the frame was constructed separately and put on the painting only after both were finished. Several paintings showed a very careful choice of wood both for the cut and the lack of defects; the relationship between the size of the support and its thickness was also appropriate. The Madonna del Baldacchino represents this very well: it is composed of four poplar wood boards, cut sub-tangentially, with scarce presence of defects and good homogeneity. Particular attention has been given to the size of the planks, which are large enough to reduce negative effects due to the joins. The full width has been achieved adding two strips of wood to the
sides; also pieces of canvas have been placed over the joins and over the few defects present. The channels left by the crosspieces, removed when the entire support was thinned down for cradling in 1830, reveal that they were placed at the same distance from the heads of the boards, thus also supplying control in the central area. Each of the three main joins also had three double-dovetail insertions.

The wood for the Madonna dell’Impannata was less well chosen than that described above. The panel is formed of three boards, one of which is decidedly poor in quality, having three large knots that create a very wavy area of wood grain. The other two boards, although without knots, have a sub-tangential cut and the grain appears slightly curved. This painting also has two dovetail-shaped crosspieces in a coniferous wood, specifically fir. The rear of the panel has been smoothed down, not so much to reduce the thickness but probably to remove an oil-based grey paint applied sometime in the past over the entire support, including the crossbars.

The Portrait of Tommaso Inghirami called Fe-dra Inghirami, is painted on a poplar wood panel made of two butt-joined boards, supported by two crossbars, which have substituted the originals in a past restoration. Unlike in other the other panels where care in the construction avoids negative repercussions for the image, here the join between the two boards passes through the center of the figure’s face. The presence of large knots in the wood lowers its quality; one of these has been “gouged” out on the front of the board and plugged with a piece of wood before applying the ground; also the grain and fibers of both boards are somewhat curved. The planks have been arranged following the general rule of using the inner side for the preparatory and paint layers. The rear has been coated with a primer; although this layer is not original, it probably replaces a previous one.

The Madonna della Seggiola is an example instead of excellent support construction: made with three poplar wood planks, which although not very wide are of well-selected wood, are sub-radial cut and placed vertically; they are also of appropriate thickness (2.8 cm) in proportion to the painting’s 71 cm full diameter. The boards are arranged with their inner faces towards the preparatory layers; the crossbars are of walnut wood. The rear of the panel has been carefully smoothed after connecting the planks. Although no precise, fixed rules appear to exist for placing the boards of round panels, as there are for rectangular ones, we believe that in this case the choice of arranging them vertically is intentional.

The Madonna del Granduca is an exception because its support consists of a single wide, diametrically cut board, 55.9 x 84.4 cm and about 3 cm thick. The material used is of very high quality, a factor that may have determined the unusual decision to use only a single crosspiece placed centrally. The woodworker perhaps judged that given the excellent quality of wood, the crossbar would have to function only as a structural reinforcement without needing to control warp.

The presence of a strip of canvas along the joins of the Madonna del Cardellino, identified by Patrizia Ritanò, should be recalled since it represents a provision taken to increase the stability of the paint layers. Such care has also been taken on the Madonna del Baldacchino, where canvas is present along all the joins as well as in small pieces that cover several knots and irregularities in the wood. The habit of applying strips of canvas on the joins and defects in the wood is one of the changes taking place from the more careful medieval construction of supports and preparatory layers, to the simpler and less complicated techniques that emerged during the fifteenth century.

The Marriage of the Virgin panel leads us to make another comment on Raphael’s techniques of panel construction. The altarpiece was made in 1504, commissioned by the Albizzini family for the Saint Joseph chapel in the Church of San Francesco at Città di Castello. Examination of the painting and its X-radiograph revealed that the panel is poplar wood, and is 174 x 120 cm and 4.5 cm thick. The structure is composed of seven butt-joined boards, placed horizontally. The three crosspieces now on the rear are not original, having been mounted during intervention by Molteni in 1857; the restorer tells us in his report dated 1858 that the battens were originally two, and since they had been thinned down until level with the panel in a previous restoration, they had lost their effectiveness. Therefore another crossbar was added, following a lengthy process aimed at flattening the wood. Any further features of the panel useful for comparison with other works by Raphael are concealed by the grey oil paint covering the entire wood surface. Another detail that distinguishes this work is the unpainted border 3.5 cm wide, uniformly covered with a black color, which is now being investigated by the restorers of the Pinacoteca di Brera. Of course this area painted black was not visible since it would have been covered by the frame edge. As was customary in the territory around Urbino and
along the Adriatic coast, the planks were often arranged horizontally; the Bufi Altarpiece by Giovanni Santi, Raphael's father, is made this way, as is the Sacred Conversation by Piero della Francesca. Wooden bridges connect the crosspieces to the Bufi panel, a technique found in the mid-fifteenth century in and around Siena and then in Florence. Molteni’s report also informs us that the Marriage of the Virgin had dovetail-shaped crosspieces, a technique which replaced the former methods of application used by painters such as Piero della Francesca and others working in Urbino in the second half of the fifteenth century. The presence of an unpainted portion around the perimeter of the painted surface makes us think that the original frame was not mounted at the same time as the making of the board structure, but was rather an autonomous, free-standing construction designed to enclose the painting afterwards.

Considering the influence of Piero della Francesca in this area, we might think that there was a frame united to the painted edge similar to those found on his Brera Altarpiece, on the Flagellation and on the Ideal City from the Galleria Nazionale delle Marche in Urbino. However this seems unlikely given the lack of nail holes in the panel, and of even the slightest upward curvature of the ground at the edge of the painted area.

In conclusion, we may say that all of wood panels of the Raphael paintings examined have a similar crossbar system. Instead the quality of the wood chosen is not always uniform, as certain works reveal the use of excellent materials while others show scarcer attention to this. Another feature noted on all of the works (except for the Marriage of the Virgin where such information is lacking) is the particular dovetail shape of the crosspieces. This is important to mention since the crossbars on the works examined dating from this period are prevalently dovetail shaped, however with the upper portion above the housing widened by adding a rectangular section that covers the edges of the track. The main wood species used was poplar, except for the three portraits cited.

The criteria for support construction seem derived more from the traditions in the territory the works came from, rather than depending on the painters’ personal choices. In fact, the support boards in panel paintings from the area of Urbino tend to be arranged horizontally, while around Florence they are more often vertical. Strips of canvas on the joins are present in some but not the majority of cases, even where their inclusion would have been opportune: for example in the Fedra Inghirami panel in which the join between the boards passes precisely through the center of the sitter’s face with the obvious risk of it becoming visible in such an important part of the portrait. This leads us to think that the preparation of the panel for painting might not have been the work of Raphael himself, but perhaps assigned to collaborators or specialists.

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1. Putting canvas on the joints is a practice seen on other sixteenth-century paintings by Raphael, and will be treated in the section comparing this work with others by the artist.

2. Another Raphael work with support boards assembled this way is the Madonna and Child with the Young St. John (Distafallei Madonna), from the Bode Museum in Berlin. Its poplar wood support measures 69 x 52.5 cm and is 2 cm thick, made with two boards positioned with the side to prepare reversed, one 30.2 cm wide and the other 22 cm [P. Klein-]. Bauch, "Analyses of Wood from Italian Paintings with Special Reference to Raphael," in The Princeton Raphael Symposium, J. Shearman-M. B. Hall eds., Princeton, 1990, pp. 88–89.

3. The upper crossbar tapers from right to left, from a maximum width of 7.5 cm to 5 cm; the lower one left to right from 6 cm to 4.5 cm.

4. Wood tends typically to fracture along the line of the grain; instead this type of fissuring is closely linked to the growth rings whose consistency differs according to seasonal changes during the yearly growth of the tree: these differences in density and compactness cause reactions to stress that can produce lines of fracture or separations.

5. Most of the joins had an empty space of about one millimeter between the sides.

6. This method of uniting the wooden piece with the painted part was certainly planned, considering the effort needed to execute it. This leads us to suppose that while the paint and part of the wood beneath it were irreversible, a certain amount of the innermost portion of wood was still in good condition.

7. The epoxy resin chosen was Araldite AV 1253, Hardener HV 1253, Epoxy Paste Adhesive.


9. See the entry by R. Nardi Berti, in Raffaello...cit., pp. 252, 254. The two supports for the Doni portraits have been cut sub-radially from the same board, one after the other.

10. The main board of the support of the so-called “Gravida” has a sub-radial cut, and a smaller strip of wood added to the side.

11. Macroscopic inspection of what little is visible at the edges of the frame indicates that the wood is poplar, deduced also on the basis of the porosity of the board heads. Microscopic analysis was not carried out because of the layer of beeswax on the rear, therefore these deductions cannot be confirmed with certainty.

12. The boards of the Brera altarpiece of the Marriage of the Virgin are arranged horizontally.

13. As described in Raffaello a Pitti, “La Madonna del Baldacchino”: Storia e restauro, Florence, 1991, the painting has been prepared very carefully, with strips of canvas attached not only over the main joints but also along the strips of wood added to the sides. Another feature to note is that none of the painted figures coincide with the joins between the planks.
TECHNICAL INNOVATION IN THE CONSTRUCTION OF FRA ANGELICO’S SAN MARCO ALTARPIECE

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Construction technique
The San Marco Altarpiece represents a clear example of a structure that would have required a precise and detailed construction plan. This would have involved both general features and more specific ones and the impression created is that the numerous innovations found in the examination of the support served specific requirements and were not the result of casual choices or adaptations of older techniques.

First of all, there is the shape. The square altarpiece or pala was inserted into a classical architectural framework made of wood assembled from independent components. The painted panel would have rested on a predella and have been flanked by pilasters and topped by an architrave. This makes for an entire structure that is practically self-supporting where the predella carries the weight of the panel. The pilasters fit into the predella at the bottom and at the top they bear the weight of the upper element. In similar examples, the panel has longer crossbars than its own width and the projecting parts of these attach to pilasters.

Even the very first findings indicate that this is an innovative structure for the period and for this artist who up to this point had his supports built with typically medieval techniques. It is notable that in this altarpiece the support of the main panel has a ground layer covering the entire surface and the frame is not attached to the perimeter of the panel but was meant to be an independent structure designed to hold the painting inside of it. Furthermore, the crossbars are attached with a system never seen before. Though in some ways this is still essentially a system of spot-attachments for the crossbars along the margins of the individual planks, it is perfectly evident that this allows for relatively independent linear movements of the panel under the restraint of the crossbar. Furthermore, the location of the anchor points along the margins of the planks also permits movements from warping. As we will see in more detail, the technical changes in the object are also found in the preparation layers. Comparing the San Marco Altarpiece to the Linaioli Tabernacle, made a decade earlier, reveals a rather profound change in approach and above all in technique with respect to the short period of time that passed between the two paintings. We don’t know if this altarpiece was actually the first panel made with these innovations, but from this point on, we find a distinct development of this structural technique.

Below we will describe separately the panel, the predella, and the pilasters, according to features analyzed in our Laboratory.

The Panel
The wood support is made of a poplar panel reinforced on the back by three sturdy fir wood crossbars. It is 233.5 cm wide and 227 cm high with a thickness of about 3.8 cm. In cross-section, the crossbars are 9 cm high and 12 cm deep, and are located at the center, 21.5 cm from the bottom edge, and 24.5 cm from the top (Figs. 1–2).

The panel is made of seven poplar planks of varying widths: the central one appears widest at 42 cm. Looking at the back, it is joined to three on the right of 33.7, 34, and 30.5 cm and three on the left of 35.6, 26.7, and 31 cm.
The panel has a quite homogeneous texture and there is only one knot on the second plank from the right. Almost all the planks derive from non-central, rather intermediate cuts with clear tangential areas at the center (the so-called flame figure). The second panel on the left is distinct from these though in that it has a very close and regular growth ring pattern, typical of a central cut.

The planks were arranged to be glued together with butt-joins with their internal sides facing the preparatory layers. Before proceeding with the assembly, the locations of the anchorage mechanisms for the crossbars were prepared along each join. Circular channels were made with a diameter of 8 mm into the join-edges of all the panels while on the back, rectangular notches were carved out that correspond to these channels, measuring about 7 mm wide and 4 cm high with a depth of more than 2.5 cm. All the channels and notches were made at the same heights, at the same distances from the upper and lower edges, and are perfectly aligned. Cylindrical metal pins (spinotti) about 12 cm long and 8 mm in diameter were inserted into the channels. Upon assembly, the perfectly aligned notches on the adjacent edges of the planks matched up and the sum of their widths created a cavity of about 1.5 cm. On the most outer planks, the crossbar anchorage was made by cutting an 8 mm hole as usual though less deep (about 8.5 cm), and again over this, a full 1.5 cm wide by 4 cm high notch was cut at 2.2 cm from the edge. As we can see, the attachment points for this particular crossbar system were made before the panel was assembled. After this, the panels were put together and firmly glued with casein. The back of the panel was finished by planing it down, the last steps of this were horizontal passes with a smoothing plane (pialletto); on some planks, at the center where the cut of the trunk yielded a less thick plank, the surface was smoothed locally with a small adze (ascia). The back of the panel is therefore quite clean and elegant looking, despite the use of two distinct types of tools (Figs. 3–4).

Behind each crossbar, three horizontal lines were scored with a metal point; one corresponding to the center of the notch and therefore of the metal pin and the other two aligning with the upper and lower edges of the notches, probably to allow for adjusting their shapes after assembly. The pins, inserted midway through the edges of the panels, were quite visible in the center of each notch in which they were housed without touching the surrounding wood. Three crossbars with a rectangular cross-section and prepared slots measuring 2.5 cm wide and 1.5 cm high were applied to the panel so as to match up with the notches. These slots were protected and reinforced on the outer surface with metal plates about 7 cm wide, 6 cm high, and 1 mm thick, with an analogous eyehole to that found in the crossbar, of 2.5 cm wide and 1.5 cm high; the plates were attached to the crossbar at the level of the outside surface and each held with four nails. (Figs. 5–9). The element that carries out the real work of anchoring the crossbars to the panel is a square, metal, harpoon-like shaft with a curled end that hooks around the metal pin; the external shaft passes through the slot of the crossbar; in the last section, the harpoon shaft exits the crossbar and a metal key or wedge fits through a slot in the shaft, securing the crossbar and allowing for the gradual tightening of its contact...
with the panel. The metal plate applied where the hook and wedge are evidently serves to protect the wood of the crossbar from the friction of the metal and to make the anchorage mechanism more solid and stable. The panel was then planed on the front side with the pialletto passed horizontally in the final finishing step, as is quite visible in the X-ray. The carpenter did this probably with the intent

3. The back of the panel in normal light.

4. Raking light shows the woodworking marks of plane and adze.

5. Detail of the lower crossbar and its attachment. The metal wedge ensures the crossbar is held against the support.

7. Detail without the harpoon.

6. Temporary dismantling of the crossbar. Detail of the harpoon inserted in the notch in the support.

8. Detail of the harpoon and pin in the notch.
of roughening the fibers of the wood grain and consequently increasing porosity and providing a better grip for the subsequent layers of ground and paint.

The *San Marco Altarpiece* therefore demonstrates interesting innovations in the construction of the wood support and becomes a meaningful example within the category of early Renaissance structures. The transition from the medieval era to the Renaissance affects the entire Quattrocento in a radical way, including the introduction of new panel painting formats. This transformation also includes the creation of these new “square” panels, making for evident and important changes to the specifics of working and using wood.

In sum, the elements that stand out in this period, besides the new shape of the paintings, the changing patronage, and the proliferating production, are the use of poplar planks that are no longer primarily central cuts, nor of consistent thickness; the reduction in the use of the canvas under the preparation layers (*incamottatura*); and the progressive separation of the architectural elements from the panel. Numerous studies on the subject indicate the time period of the construction of the *San Marco Altarpiece* as a turning point in the transition between medieval techniques and the multifaceted and experimental Renaissance style. Examining these “new” fifteen-century panels provides further evidence of the high quality of craftsmen employed in the construction of wood supports. The necessity of fabricating square panels with wood planks that were more subject to deformation (with respect to the central cuts of the Middle Ages that were more consistent and stable), imposed new working methods that reveal an excellent understanding of wood and its properties. The woodworking artisan proved himself to be capable and flexible, and above all, ready to build wood panels destined to last over time.

There is a fundamental relationship between the panel and the crossbar system that decisively determines the preservation and the lifespan of an artwork. In the Middle Ages, metal nails firmly anchored the crossbar on panel paintings; they were driven into holes passing through these panels and then bent back and pounded back in. The nail provides a tightening force between the panel and the crossbar which is held between the head and the bent nail point, without creating diverging stresses on the wood grain and therefore without instilling an initial strain in the plank. In fact, the hole prepared to hold the nail, even though not large, permitted the passage of the shaft of the nail so that the wood grain was not disturbed. For structural success, and also to reduce risks connected to the introduction of excessive strain and consequent join separation or splitting, the quality of the wood was important; the planks were primarily radial cut and therefore less subject to transverse contraction. Furthermore, the considerable thickness of the panels guaranteed a significant inertia to counter fluctuations in the humidity of the environment.

The *San Marco Altarpiece* presents us with a structure made of excellent wood in terms of the quality and thickness of the planks (as we have seen, the grain is regular, the texture homogeneous, and the thickness is 3.8 cm—good in relation to the surface area of the painting.) The cut of all the planks, except one, however tends to be external and intermediate, thus more subject to curvature and contraction in the transverse sense. Quite likely anchoring the crossbars with traditional nails would invite a risk of cracking and separating joins in the panel; in fact, the planks, having a tendency to contract and warp, would have caused the nails to jam inside the channels and, after having allowed some initial movement, would have strained the entire structure.
Currently, the triptych from the museum in Asciano by Ambrogio Lorenzetti depicting St. Michael Archangel killing the dragon with Saints Benedict and Bartholomew is in our laboratory. Though it is a much older painting, the main panel is made of a large sub-tangential plank to which have been added two planks with three dowels on each side, plus two further strips. The two crossbars are attached with nails, in keeping with the tradition of the period. Currently, you can discern a decisive transverse shrinkage of the main plank and a separation of the side planks, quantifiable to a total distance of 8 to 12 mm.

Aware of this possibility, the workshop undertaking the construction of the San Marco Altarpiece developed an attachment for the crossbars that was more flexible than traditional nails. The mechanism appears well-suited to its function, thanks undoubtedly to the ability of the harpoons to shift and especially to the slot carved in the crossbar—these allow the iron parts to slide sideways internally, effectively reducing the risk of cracking. In any case, this is an innovation and shows an advanced thought-process in which transverse constraint is exercised but there is also a certain freedom given to the central parts of each plank for warping movements.

This system can be considered a valid prototype and beginning at this time many panels were given an identical or quite similar system, or in any case, addressed the same preservation problems for the support. For example, the Altarpiece of Bosco ai Frati and the Annalena Altarpiece have an entirely identical system, though incomplete, perhaps carried out by the same workshop; there is a parallel but slightly differently made mechanism in the Annunciation of Montecarlo. The Altarpiece of the Noviziato of Santa Croce by Filippo Lippi is such a close match to ours except for lacking the detail of the metal plates protecting the crossbars from the tightening force of the metal wedge.

During the Quattrocento, new systems for anchoring crossbars are created that anticipate the adoption of flexible metal mechanisms or semi-sliding ones, like those cited, or other experimental forms like the system present on the paintings in Pienza of Sano di Pietro or Vecchieta where trapezoidal channels are made in the surface of the support for fully-sliding crossbars. Again in Pienza, and in any case from the Sienese territory of the mid-Quattrocento, a system using little bridges (ponticelli) takes the stage. Thus, the crossbars slide freely held by wooden bridges, or alternatively, primarily around Florence, iron bridges, attached to the support with nails.3

The Predella

The two paintings examined depict the Burial of Saints Cosmas and Damian and the Dream of the Deacon Justinian. Both are made with horizontal poplar planks and retain their original thickness.

The panel of the Burial is 45.6 cm wide with a variable height of 38.5 cm on the left and 38.1 on the right (as seen from the back), and a thickness of 3.5 cm. It is made of two planks, the lower one varies from 30.4 to 30.1 cm high and the other is has parallel edges and is 8 cm high. These were painted on the side which would have faced the center of the tree trunk. In raking light, the fine finish of the back made with very close strokes of an adze can be seen. On the back, a metal point was used to score a vertical line 4.8 cm from the left side. Between this line and the edge of the panel, at the top, there is a remnant of a nail inserted from the front, having a T-shaped head, not a rounded head, but rather formed from two wings typical of Quattrocento polyptych construction.4 The choice of this kind of nail could be due to having to insert the head completely in the wood without causing breakage of the fibers especially near the end of the plank (Figs. 10–11).

The panel of the Dream of the Deacon Justinian is 46.5 cm wide, 37.7 cm high, and 3.5 cm thick. It is made of three pieces: at the bottom, the main plank has a width that varies from 29.9 cm on the right to 31.7 cm on the left (as seen from the back);
the middle piece measures 6 cm and 4.2 cm respectively; and the upper has parallel long edges and measures 1.8 cm. Unlike the previous panel, the painted side is the one that would have been facing the outside of the tree. Examining the panel in raking light reveals a finishing of the back carried out with a smoothing plane or fore plane (pialletto or sbozzino) that is nearly flat perpendicular to the grain in a similar way to that found on the front and back of the main panel of the altarpiece. At the top along the right and left edges of the panel there are heads and parts of the shafts of two nails like those found on the other panel. Near the left side, the residue of a wood piece—it seems that the grain is that of a conifer from the few remaining traces—glued vertically and then detached, seems to relate to the left nail though it is not entirely clear (Figs. 12–13).

By direct examination of the panels, of the paint surfaces, and by reading previous studies,\(^5\) it can be inferred that the predella could have had a front side with single scenes that were separated by painted framing (probably columns) and not attached vertical elements. Therefore it is plausible that the front panel was a completely painted flat surface and that the two painted panels on the sides were simply attached at a ninety-degree angle. The analysis and examination of the predella panels from the Museo di San Marco confirmed the observations of Umberto Baldini: the two planks of the *Burial* and the three of the *Dream* make for an incompatibility if proposing the two scenes were part of the same frontal. Besides this, there is also the different arrangement of the growth rings of the main plank. Furthermore, other important details like the location of the nails, the scored marks, and the traces of the vertical elements can contribute to enrich our understanding of the structure, putting the panels with the elements that strengthened the predella into context and that, after the separation of the scenes, were lost. From their regular placement, these dividing elements or “section-breakers” may have been part of the original wood structure. For example, the nails are only present at the top, but it is likely that there were other matching ones at the bottom; therefore there may have been an unpainted

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11. The panel of the *Burial* seen from the side. The visible warping is the result of a past treatment and the arrangement of the tree rings shows that the paint surface, facing up here, was oriented toward the inside of the tree.

12. The back of the panel of the *Dream of the Deacon Justinian* in raking light. The planing with a *pialletto* can be seen and on the left border there is a trace of a former glued vertical element.

13. The panel of the *Dream of the Deacon Justinian* seen from the side. The tree rings indicate that the paint surface, facing up here, was oriented toward the outside of the tree.
part of the panel that extended toward the bottom. A more detailed, comparative study would include scientific analysis of all the existing panels and the use of focused and complementary diagnostic techniques without which these findings can only be tentative.

The Pilasters
There is no definite information about the structure and the appearance of the elements that would have closed the sides of the panel painting. These were most likely pilasters or columns that would have connected to the other parts of the Renaissance pala. These would have rested on the predella and held up the architrave; thus carrying out not only an aesthetic function, but a structural one as well. The structure of the pilasters or columns would have differed depending on the circumstances; for example, in some cases, solid wood may have been used when the total thickness of the element was just a few centimeters; or, in the case of structures with a greater thickness, box-like columns could be made of three vertical planks, one face (on which were painted the scenes), and two sides, strengthened internally by horizontal elements that provided an armature.

The reconstruction that is proposed here is based on some clues found on the small panels depicting the beatified Dominicans (Beati Domenicani). Each of these has, on one of the two sides at the edge of the painted part, the telltale raised lip of ground which connected the plane of the panel with the stepped part of the frame, defining a definite limit of the painted surface and furthermore, suggesting that part of the panel remained plain wood and bore an engaged frame. The remaining three sides were, conversely, perfectly trimmed, therefore any trace of this lip or burr was lost and we don’t know how much is missing except for estimating the distance between the figure and edge. On the back of the panels there are marks from the old nail holes in which the nail heads were sunk under the preparatory layers.

These observations are further enhanced by the information regarding the thickness of the other elements of the pala; the main support reached a thickness of almost 20 cm (if we add the 3.8 cm of the panel to the 12 cm of the crossbar with the harpoon shaft); furthermore, the predella has a painted side of almost 50 cm (with the scene of the Dream measuring 46.5 cm and certainly also missing part of its borders). All of this suggests that the columns would have been made with a box-construction.

The two small panels, probably belonging to the painted scenes on the lateral pilasters, show two full-length blessed Dominicans, each composition on a single poplar plank with a vertical grain. From examining the end grain of the wood, it is possible to see that both planks are sub-radial from quarter-sawn lumber.

The panel called the Blessed Dominican measures 12.9 cm at the bottom and is 13.1 cm wide, while its height is 39.1 cm with a thickness that varies from 8 to 9 mm. The panel has two nail holes, placed diagonally in the upper half.

The panel of Saint Vincent Ferrer measures 12.9 cm wide and 39.2 cm high with a thickness of 8 to 9 mm. The panel has a hole along the lower margin. At the time, the reason for the two panels having been cut down to their current dimensions was not known and it did not seem likely that the explanation was connected to them having been inserted in the frame that came with the altarpiece to our laboratory. The weight-bearing columns of the pala, placed vertically, had been taken apart and the paintings cut down and thinned. The thinning, quite evident from the extensive insect tunneling exposed on the back, was done with a scrub plane (sgrossino).

The same limitations for the considerations made for the predella panels apply in this case as well. Furthermore, on these two panels, given the significant loss of material, the features that can provide plausible explanations are few. However, good starting points are the footprint of the frame, the width of the panels, the specific cut of the planks, and some of the nail holes. The scenes should be considered in relation to the original dimensions of the columns and with the width of the end panels on the front of the predella. In addition, the kind of cut excludes that our two Dominicans could be obtained in a vertical continuum from the same plank. Another element to consider is the presence and the position of the nail holes which, in relation to the other paintings from the same San Marco Altarpiece can provide some indication of the elements that made up the original structure.

Condition and Treatment
The two small painted panels were each inserted and glued with hide glue into frames that enclosed them on the back and covered their perimeters. This solution, not very sophisticated in its execution, used a fir panel and a frame. The panel, oriented with the wood grain vertically, was deliberately carved out to receive the full thickness of the supports while
along the perimeter, the carved frame, applied as the front of the container, enclosed the paintings along the edges. The frame-box can be seen to be visibly warped and so the painted panels seem to be have a greater degree of deformation. Even though it is not possible to fully see the paintings in that they are closed within the containing structure, it is perfectly understandable that this effect is due to the compression of the box along the sides of the paintings. The reasons for these extremely poor preservation circumstances are certainly due to the transverse restriction of the wood of the frame-box and therefore it was decided to extract the paintings from this kind of framing (Figs. 14–15).

It was then possible to see that the two panels were of poplar wood with a vertical grain and extensively altered in dimensions and thickness, as described earlier. The wood, though having suffered an extensive wood-boring beetle attack, was still in good enough condition to support the ground and paint layers.

The quality of the wood, or what can been determined from the reduced dimensions, is good. On the side edges of both the paintings, strips of fir wood had been attached on which rest the frame and that allow for the entire painted surface to be visible. The ends of both panels had been planed smooth to the point of clearly showing the thickness of the gesso of the ground; the back surface is slightly undulating due to the thickness having been reduced repeatedly with a scrub plane along the whole panel. Because of this, the panels have a mechanical fragility that could result in fractures along the grain of the wood from careless handling.

A further consideration is that the limited thickness of the wood, the open insect channels, and the tear-out of the grain considerably add to the exposure of the paintings to environmental fluctuations.

All of these factors brought us to plan and carry out a treatment that would act as structural reinforcement, restraint on the warping deformations, and general protection from the display environment. At the same time the plan foresaw the maximum respect for original materials and the elimination of improper stresses on the panel, reducing to a minimum the restraint and maintenance needed (Figs. 16–17).

For each panel, therefore, a small perimeter framework of chestnut wood was created for the back with a single crossbar in the center, shaped to fit the support and attached with seven springs. These springs were anchored into small chestnut blocks measuring 0.9 x 0.9 x 0.3 cm, glued on the back with a mixture of adhesive in a 1:1 ratio of Araldite AW 106/HV 953U (1:0.8) and Araldite SV 427/HV 427 (1:1). The back of the framework was closed with a 4 mm chestnut panel to protect the support and improve the environmental stability.

3. In the Cinquecento, this system of restraint on the panel was then used alongside the more widely found type employing sliding crossbars inserted in channels in the panel that were tapered so as to be trapezoidal in cross-section.
4. The same type of nail has been seen in some fragments belonging to the Sassetta polyptych of Sansepolcro.
16. The back of the *Blessed Vincent Ferrer*. A nail hole appears at the bottom.

17. The back of the *Blessed Dominican* after treatment. A framework on the back is anchored with adjustable springs. The back of the panel is closed with a chestnut panel. In the upper part, two diagonally-placed nail holes can be seen.
A simple description of the construction technique of such a complex artwork as our altarpiece can hardly do justice to all the details encountered during the study to which it was subjected. An examination of the construction of the single components is further enriched by finding a series of quite specific clues that reveal aspects of the overall project and shed light on the operations carried out at the time by the workshop that did the carpentry. In fact, studying the kind of crossbar system and the choice and treatment of the wood confirms what we know of the skills and various working methods of the woodworker’s bottega, and shows what their level of expertise was. Moreover, it appears evident that the whole project followed a plan that was defined from the outset. After making the individual components, these were assembled in order to check and adjust small but important final details.

We can easily imagine a large space inside a workshop in which the whole altarpiece, gessoed but not yet painted, would have been put together, evaluated, and perhaps adjusted. Once the spatial arrangement of the entire assembly was verified, the pictorial areas within each panel could have been defined. This was done by incising the outlines of the columns and thus the divisions of the painting with a metal point on the gesso. Clearly, this step prior to painting, highlights a significant aspect in the practices of an important workshop in terms of space and labor.

Construction technique

Information about the original construction of the individual panels, that is, their dimensions, composition, the thickness of the planks, and the crossbar system, has been determined by pursuing different pathways and comparing the evidence. First of all, this means examining the panels, or at least the parts that have survived. Additionally, the reports written in 1915 by Antonio Avena and by Mauro Pellicioli after the treatment in 1934 were evaluated. Furthermore, recently we have had the chance to see photographs taken in 1915 by Attilio Motta which provided a lot of information about the supports of the Saint Peter panel and the central panel with the Madonna and Child.1

The San Zeno altarpiece is composed of three panels that depict three different parts of the Sacra Conversazione. This arrangement demands quite a precise working method. A large polyptych, a dosal, or a pala each illustrate a different structural approach depending on the period and geographic area in which the altarpiece was made. Large surfaces such as those of our altarpiece (approximately 4.50 x 4.50 m) in other contexts would not have been planned to have inserted panels, but would have been made of side-by-side panels connected with continuous battens inside an assembly resting on a large predella and held up on the sides by pilasters. Many examples with these structural features are found in Tuscan painting. In other cases, for example in the Valle Romita Polyptych by Gentile da Fabriano, a load-bearing architectural structure encompasses the whole space and is then completed with individual painted panels. Our altarpiece therefore fits into the category that includes, among others, the Polyptych of Olera by Cima da Conegliano, and the Polyptych of Saint James in Peghera by...
plane with a slightly curved blade was used, making an approximately horizontal motion. (Fig. 1) There are areas where the tool has changed direction, but it seems that this is due to an contorted wood grain that required being worked differently. In the X-ray, though, these areas do not show particular marks or disruption to the fibers of the wood. The presence of these areas could explain some difficulty in planing the support due to poor wood quality. The backs of the panels were also finished with a certain care; the planks, once assembled, were planed working in a horizontal direction.

The crossbar system applied to the panels was not typical in part because of the enormous size of its components and its shape, and furthermore, even the method in which it was anchored to the panel was rather unusual. This strong supporting framework used 30 cm wide horizontal members and 10 cm wide vertical members (Figs. 2–4).  

1. Detail of the X-ray image showing the support of the Madonna and Child. The slanting striations are from planing the panel before it was gessoed.
2. Photograph by Attilio Motta from 1915 of the back of the panel with Saint Peter. The sturdy original crossbars, the tool marks from finishing the back surface of the panel, and the two large splits that cut through the panel can be seen.

3. Photograph by Attilio Motta from 1915. The back of the panel with the Madonna and Child. The central crossbar is missing.

4. Diagram of the construction of the original crossbar support system.
In the corners, the planks were held by what was probably a mortise-and-tenon join, though the possibility of a half-lap join cannot be excluded; the central crossbar, positioned horizontally half-way up, intersected the vertical ones with dovetail joins though its full thickness. Pellicioli wrote that the crossbars were poplar and 30 cm wide, not specifying the difference between the vertical and horizontal members or their 4 cm thickness.

The crossbar system was anchored to the panel with metal nails. Those in the upper and lower crossbars were inserted from the front and bent around on the back, two per panel. To recreate an even surface for the preparation layers and prevent the nail heads from creating marks, the nails were sunk into the planks to a depth of 5 mm and sealed with poplar wood inserts. However, in the central crossbar, the nails were inserted from the back without penetrating all the way through. Evidence of these different ways of inserting nails is also seen on the support where the channels of nails passing through have been filled with poplar inserts whereas the holes of recessed nails have instead been filled with cylindrical wood plugs. The different ways of using nails is also confirmed by the 1915 photo where, in the case of the Madonna and Child, the central batten is missing, due, in fact, to the poor grip of the nails inserted from the reverse that pass only partially through the panel. The logic of this method is difficult to guess and we cannot exclude that the central crossbar was added after the support was already gessoed.

To complete the description of the crossbars on the panels of Saint Peter and the Madonna and Child, we can add that the same type of finishing and smoothing of the panel was present on the surfaces of the crossbars as well. Furthermore, on Saint Peter, the crossbars were moderately warped outward; they were sub-tangential cuts and the central element had more curvature than the others. The upper crossbar and the central one were positioned with the internal face against the panel, while the crossbar at the bottom faced out. Analyzing each panel based only on the dimensions recorded by Avena and Pellicioli in the records, it immediately appears that they were exceptionally oversized at 5 cm thick, as was the width of the crossbars (30 cm). This is notable especially taking into account the limited dimensions of the panels and their insertion into a solid framing structure like the great monumental frame. Before being able to see the photographs, we were able to determine that the three panels could have been the massive and exaggeratedly robust product of a workshop that had tried to make up for poor quality wood by using increased thicknesses and widths. Actually, the exact measurements are those derived by scaling up Attilio Motta’s photos and they show an orderly, sturdy kind of construction, carried out with the criteria of medieval carpentry. In particular, seeing the appearance that the artwork originally had allowed us to evaluate the proportional relationships between the support, crossbars, the side strips, and the workmanship. Essentially, the appearance of the back of the panels brought to mind the sturdy construction of household doors, not of traditional painting supports; this unusual quality was evoked especially by the three high, thick horizontal crossbars supporting the panels. Even the type of dovetail join that connected the central crossbar to the vertical ones betrays the signs of generic carpentry craftsmanship. All of this deliberate sturdiness appears even odder when conceived in the territory where the works were created and remembering how they are set inside a large architectonic frame.

Considering the three panels in detail, let us describe them by associating the right one with the figure of Saint John the Baptist, the central with the Madonna and Child, and the left one with Saint Peter, and for brevity, maintaining these names.

The support of Saint John the Baptist is 135.1 cm wide and 213.1 cm high. It is now 2 cm thick and made of four poplar planks of average quality. The two central are quite wide, while the side ones are narrower: beginning on the right side of the reverse, the first is a radial cut and 24.7 cm wide; the second is sub-radial and 41.3 cm wide; the third is radial and 41.3 cm wide; and the fourth is sub-radial and 27.8 cm wide. The grain is on average relatively straight, the rings moderately prominent, and the texture is not very fine. Analogously to the planks of the other panels, these have been finished independently, the edges to be joined have been straightened, and the holes for the circular splines have been prepared. Each join has four of these and their distribution is not perfectly even, but well-distributed in such a way as to hold the planks in a single plane. The panel was finished on the back and front with a plane working in a horizontal direction. The joins of the panel are further reinforced on the front by a series of butterfly inserts.

The panel of the Madonna and Child is 127.5 cm wide and 213 cm high. Currently, it is 2 cm thick and composed of one narrow strip and three planks, all of poplar wood. Looking at the back, beginning
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Tapered dowels and butterflies. For the dowels especially, their number and position in terms of height distribution and distance from front surface has been recorded for each panel. On the Saint Peter panel, the two joins use four dowels each. These rough dowels, called cavicchi, have a faceted surface and are tapered at each end with a diameter of 1 cm and an average length of 8 cm (Fig. 5). The holes were made with an auger with a helical screw bit, a type called a trivellino. The dowels were not glued and are shorter than their cavities. The distribution of dowels along the joins is regular but not entirely strict; essentially they were placed as a guide to help line up the planks. This slight, but noticeable irregularity shows that the craftsmen in the workshop were not rigorously following the plan, but allowing a certain approximation in measurements to prevail, perhaps also due to the mundane nature of the work (Fig. 6). This quality was also found in the other two panels. For example, in the Madonna and Child panel, as seen from the back, the dowel at the bottom between the second and third plank seems to be missing; in the Saint John the Baptist panel, the dowels at the top and bottom are lined
Returning to the study of the records, looking for more information on the thickness of the panels, one might conclude that the three supports had a total thickness of 9 cm, given the sum of 5 cm of the panels (0.05 m according to Avena) and 4 cm of the crossbars (according to Pellicioli). Along with this, it is important to note what Pellicioli wrote explaining the reduction of the thickness of the panels, “Then the thickness of the panels was measured, and all the wood that was greater than that measure was removed, that is, to the thinnest point of the panels [È stato poi registrato lo spessore delle tavole asportando tutto il legno che era di spessore superiore al registro e cioè al punto più sottile delle tavole].” It seems appropriate to pose some questions connected to that statement: did the planks vary in thickness within each panel? And also, was the variation in thickness of the planks linked to each panel?

Just as for the dowels, the placement of the butterflies on the side destined for the preparation layers was not strictly systematic. Specifically, for the Madonna and Child, which was the most regular, there was the same casual imprecision encountered with the dowels and, almost always, there was care taken to avoid lining up their positions and risk breaking through the plank. In the Saint John the Baptist panel, we find four butterflies inserted across the central join and two on the side joins and the general position of the inserts seems decisively moved upward, while the panel of Saint Peter has only two butterflies at the bottom on the right join where there was a major gap between the planks, almost like a preventive reinforcement of an area judged to be weak from the outset.

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From the photographs, the first possibility can be eliminated in that the panel of the Madonna and Child retains the same thickness even under the missing central crossbar. Based on data that emerged during our conservation treatment, another hypothesis can be formulated about the dowels and their current placement inside the planks. This supposes an underlying assumption that the dowels, according to standard practice, would be inserted at the halfway point in edge of the plank. By the carpenter’s rules of craftsmanship, the distribution of dowels along the joins was determined
using a division of space that incorporated symmetry. For example, in general, the same distance from the upper and lower edges and the intermediate intervals were measured off with a certain regularity. Moreover, the function of the dowels was that of guiding the planks during the gluing step, so that they remained aligned and keeping this in mind, it is reasonable to think that each dowel was precisely positioned as close as possible to the center of the side edge of the panel to be joined. The remaining dowels have a diameter of 1 cm and the curious aspect is that their current position is not always the same distance from the paint surface, but varies by panel. In Saint Peter, the dowels were removed when the panel was thinned and the empty channels were filled with wood inserts. In the Madonna and Child, the dowels are still present but have been cut down to nearly half their width. In the Saint John panel, the dowels are completely enclosed and not visible from the back (Fig. 7). Thus we identified that the center of the dowels of the three panels were at different distances from the front surface; in the panel of Saint Peter, the center of the dowel is at 1.9 cm from the paint layer; in the Madonna and Child, 1.5 cm; while in Saint John, it is at 1 cm. Doubling these measurements, that is using the value determined from the center of the dowel channel as a measurement of half the thickness of the panel, the three thicknesses are: for Saint Peter, 3.8 cm; for the Madonna and Child, 3 cm; and for Saint John, 2 cm. This last measurement is about the thickness that all the panels currently have and may explain what Pellicioli described regarding the registro, or set value that he wanted to maintain during the thinning operation. It is hard to accept that the bottega charged with constructing the supports would have used panels of such different thicknesses and in this case, as noted for the placement of the dowels, it could be the result of an irregular procedure that is, however, surprising and unusual.

**Condition**

When examining the condition of the painted panels, it is important to distinguish between two different aspects:
- the deterioration caused by a natural aging of the materials
- the effects of the treatment by Pellicioli.
caused by a nail, begins in the lower part and runs along the robe of Saint Benedict. Furthermore, again on the robe of Saint Benedict, the head of a nail attaching the crossbar is quite visible; this means that the wooden plug that concealed it, along with the painted surface, has fallen out. At the time in which the photographs were taken, the three panels still had their original crossbars and therefore the panels were at their full thickness. In 1915, Avena described the condition of the individual panels, implying that the force of the crossbars and the restraint exercised by the nails caused the splits. Pellicioli (after 1934) provides a better description of the condition of the paint and above all the procedures carried out on the support.

Natural deterioration

This information leads us to believe that there has been a strong transverse contraction of the planks especially in the Saint Peter panel, and to an apparently lesser degree, in that of Saint John. The planks have moved against the metal anchorage points of the crossbars and have cracked. Most likely, the nails were inserted in pre-drilled holes that allowed for some initial shifting; as has

When the altarpiece was looked at by the Opificio team, the effects of the twentieth-century treatment were dominant. To go back to what could have been the condition before this treatment, it was necessary to examine the archive photographs, the documents that traced the story of the artwork and its having been moved as a result of the Napoleonic requisition, and later, relocations inside the basilica. From the archive images, two extensive cracks can be seen on the panel of Saint Peter; one crack starts at the bottom along the join between planks and stops by the head of Saint John the Evangelist, the other descends until reaching the book of Saint Paul. From an image of the detail of the lower part, the join appears held together by two butterflies; the lower one has come out of its cavity on the left though remains anchored in the right plank while the upper butterfly has fallen out and is entirely lost (Figs. 8 and 9). The other split is a separation along the grain inside the central plank and the gap allows a clear view of the torn wood and the canvas under the preparation layers. The archive photographs also show two splits in the Saint John panel: one through the body of the saint, the other, probably

8. Photograph from 1915. Detail from the Saint Peter panel. The split at the bottom has opened and a butterfly spline has fallen out.

9. Photograph from 1915. Detail from Saint Peter panel. Detail of crack.
happened in the central panel. But when the shrinkage surpassed a certain degree, the nails encountered a forceful restraint. If we try to read the state of the paint in relation to the contraction of the panel, we can infer from the records cited earlier that there were localized areas of lifting and minor cracking. The panel of Saint Peter, despite the strong contraction and the wide splits, has a paint surface with a stability similar to that of the other two panels. The condition of the support of Saint Peter reflects, to a greater degree, the effects of the natural behavior of a painted wood support. When a panel is prepared as a support for a painting, the wood is not always perfectly seasoned, or in any case, may have been alive not long before. Even if the wood were fully seasoned and stable, applying the gesso and glue along with the possible adhesion of a canvas under the preparation layers, and even the application of the paint itself, all carry a large amount of moisture that is absorbed and released in a relatively short period of time. During the initial period, a series of settling movements occur that often determine the permanent condition of the artwork, and already cause the first cracks to appear. For example, the support of the Descent from the Cross by Agnolo Bronzino in the Museo dell’Opera di Santa Croce has, up high, along a join, two butterfly inserts carried out with the same technique as the others under the preparation, indicating an early gap needing reinforcement. During the settling phase, the paint and preparatory layers are flexible enough that they can move with the contracting wood without losing adhesion. One exemplary case is definitely Duccio’s Maestà in the Uffizi in which a transverse contraction of large proportions is seen, though the paint is perfectly flat and well-adhered. This elastic capacity is lost over time and the chance that the paint will later be able to withstand a contraction from sideways compression of the wood grain is enormously reduced. Other factors obviously come into play here such as the stability of the display environment, and above all, the quality of the preparation layers. This leads us to believe that the damages visible in the historic photographs and described in the documentation were probably, in large part, very old and derived from the initial period in the life of the artwork. Contributing to the problem are the environmental conditions and the movements that the altarpiece has been subjected to over time.

**Pellicioli’s treatment**

As we mentioned, Mauro Pellicioli documented the treatment he did in the years 1933–34. This record is of great value for many reasons. First of all, it describes the procedures in chronological order very carefully and furthermore confirms the work carried out on the wood support. This wealth of details is quite rare in records related to conservation treatments of the time. Often hasty descriptions are encountered and only of the painted part; rarely is there a mention or analysis of the wooden support. Often, moreover, the justification of certain procedures is missing, and the phases of work are summarized without a proper analysis of the condition. In general, the essential connection between the visible effects of deterioration and their underlying causes is usually missing and, in fact, this has become a relatively recent accomplishment.

Here, the treatment is described in a clear way and the wealth of details shows the restorer’s openness to sharing—an extremely rare feature in the restoration landscape of that time. This all should be said though it was undoubtedly a radical treatment that had among its various objectives that of reuniting the separated planks and straightening the supports. In Pellicioli’s report and in that of 1915, the high mechanical tension and thus the splitting was ascribed to the sturdiness of the nailed-on crossbar system. The first step for working on the reinforcement was that of removing the original crossbars. This practice was standard at the time, and continued up until recently when, fortunately, original—or at least old—carpentry has taken on the value of important historical evidence, prompting specialized conservators to consider all possible solutions that would allow for functional preservation.

Pellicioli describes proceeding with the removal of the crossbars and the nails, some of which were pulled out from the back, others from the front, with the dislodging of paint in correspondence to the nail heads. The cavities were filled with poplar wood cut from the old crossbars. The panel, freed from the crossbars, probably reacted to the residual tensions that had been under restraint until then, and deformed in different ways: by warping, curving, and twisting. Later, the cracks were mended with poplar wedges and oak butterfly inserts for more reinforcement. In some passages, the two elements were used together. After the reinforcements were carried out, the planks were straightened;
deep grooves were made which went through to within 5 mm of the paint surface, and a narrow slice or sliver (sverze) of oak wood was used to fill them. The grooves were made vertically, horizontally, and diagonally so as to weaken the wood according to the various kinds of deformation affecting it. The long wood slices, triangular in cross-section, were pounded with force into the channels (rectangular in cross-section due to having been made with a saw blade) and the planks were straightened according to plan. In particular, since the shape of the support before the oak filling was warped, the convex paint surface had a wider transverse measurement with respect to the concave back. Now, having been planed down and flattened, the back surface increased, reaching the dimensions of the front. This movement of forced twisting has compressed the fibers of the wood under the paint surface, causing a predictable contraction with lifting and flaking. Moreover, the longitudinal cuts show up on the surface. Especially in raking light, the parallel vertical lines from the invasive restoration treatment carried out by Pellicioli are quite apparent.

This step was followed by thinning the panel to further reduce the force of the wood. During this phase, as we have described, the dowels were exposed in the panel of the Madonna and Child and that of Saint Peter. On Saint Peter, the butterflies inserted by Pellicioli himself were thinned down to a mere 1–2 mm, again indicating that the panels had originally had a different thickness. Reducing the thickness also had the function of offering a perfectly even surface for the new cradle restraint system. In fact, the mechanism of the rigid cradle composed of glued vertical elements with movable horizontal elements inserted through them represents a geometric system of force transformation and requires the utmost precision for the anchorage points. This system is supposed to counter the tendency to warp with a stronger force, and guide the movement of the support toward a flat, transverse expansion.

This intervention on the support is considered, in general, extremely invasive; the operations carried out on the very old cracks have irreparably changed the mechanics of the panel. Important original elements have been destroyed like the wood removed during the thinning process (that would have increased the inertia of the panels in relation to environmental fluctuations), and the crossbars that provided an important support function. The wood fibers have been irreversibly weakened by the deep cuts and new tensions have been introduced opposing the natural ones. The application of a rigid cradle on the thinned and filled support, in the overwhelming majority of cases, causes large tensions in the panel with strong sideways contraction of the support surface with lifting and flaking of the preparation layers and paint. In this specific case, there is such a contraction, without, fortunately significant damage to the paint because of the high quality of the preparation layers. One positive effect of the treatment has been that the splits are closed and stabilized.

Conclusions regarding condition

As previously described, the three panels present a state that is heavily affected by Pellicioli’s treatment. To define this more precisely, we can say that a horizontal cross-section of the panels would have been flat, but a vertical one would have been concave.

This phenomenon is often seen in a more or less pronounced way in panels restrained with a rigid cradle; the vertical members glued along the wood grain exert a non-uniform, asymmetric pull on the surface due the channels made for the horizontal members. The vertical degree of deflection can be measured by the centimeter in terms of its order of magnitude. Many of the chip fills have contracted and the glue putty used as an adhesive shows signs of giving way. Some of the grooves, due to the tensions between the planks and the rigid restraint system, had started splits in the wood all the way down to the paint. This is a clear sign of malfunction in the support system in addition to the presence of friction between the horizontal crossbars—meant to slide—and the back of the panel. On the large frame, there are very visible signs of wood-boring beetle attack with deposits of frass. It was not clear if the infestation was active when the painting was brought in for examination by the Opificio specialists, however; there were signs that the display environment could provide favorable conditions for a new infestation that could affect the panel paintings.

The conservation treatment of the structure and wood support

From the examination of the structure and the condition of the panels it was possible to outline a treatment plan that would respond to multiple problems. For the individual panels, the objective
was that of providing a functional mechanism for supporting the deformations of the panels, lightening the force of the crossbars, and allowing the horizontal members to slide. To obtain that result in a truly effective way, the panels needed to be reinforced, the grooves checked, and the splits rejoined. Furthermore, the panels had to be fit into the vertical architectonic frame structure and suitably protected from rapid changes in temperature and humidity.

The treatment of the panels

Our treatment had to directly address Pellcioli’s work: his grooves, his reinforcements, and his restraint system. It was necessary to evaluate how far to carry the treatment, that is, whether or not to completely eliminate the elements applied in the previous treatment or rather to limit ourselves to adjusting and correcting critical areas. Therefore, the paintings were studied in detail including from the point of view of stability of the paint and preparatory layers. The condition was generally stable with good adherence of the layers, though there was a series of scattered minor losses. This is a clear indication of the ground layers holding on well and preventing the paint from flaking over a wide area and together with this was the feeling that the paintings should not be subjected to particularly traumatic or invasive procedures. If on one hand, removing the crossbars was necessary to reduce the friction and tensions, on the other, proceeding to completely remove the elements glued along the grain would have subjected the panels to a series of extremely dangerous vibrations that would have increased the detachment of the applied materials. Therefore, our treatment was limited to improving the integrity of the panels and adjusting the existing crossbar system.

The paintings and the architectonic frame elements were given an immediate anoxic de-infestation treatment. The fourteen parts that make up the San Zeno altarpiece were put into as many oxygen-barrier bags with a modified atmosphere nitrogen environment. In this way, any insects inside the structure were eliminated by asphyxia. After three weeks of treatment, the single pieces were given a brush application of Permetar insecticide. This provides some protection to the wood and deters new infestations (Figs. 10 and 11).

There was an awareness that our treatment of the wood supports would change the structural mechanics of the paintings. The panels would be gradually freed from the restraint of the rigid crossbars and the release of tension would result in a slight warping. That curvature would be a positive factor in the preservation of the painting in that the paint surface would become slightly convex, and its surface area gently increased. The paint would be in a more stable, favorable state. The degree of deformation was expected to be within a limited range that would be perceptible only looking at the artwork from the side, not the front. The panels therefore underwent laser beam profilometry measurements with a scanning system.
before and after the procedure. The measurements were compared to derive an exact value for the deformation that occurred during the treatment (Figs. 12 and 13).

The panels were gradually freed from Pellicioli’s crossbars. In place of these, pairs of flexible crossbars were inserted that allowed each panel, ideally when oriented vertically, to assume a slight warp. The procedures were carried out in an environment with a stable temperature and humidity so that the moment could be determined in which the internal forces in the panel were relaxed, without any new fluctuations inducing changes (Fig. 14).

The supports were stabilized with an average deflection distance (sagitta) of about 1.2 cm. It was therefore necessary to provide the panels with curved crossbars. These elements were made to respect the new parameters; pairs of curved crossbars were inserted into the channels for the old crossbars. In each 2 cm deep space, two 1 cm thick, chestnut-laminate crossbars were inserted. The new crossbars were designed to fit the old channels and therefore did not require new anchorage points on the panel; furthermore, they conform to the movement in a more flexible way than before. The crossbars were assembled on a curved form having an curvature deflection of 0.8 cm so that they would immediately provide some resistance to the 1.2 cm curvature of the panel. Determining the thickness and curvature of the new elements also took into account the number of crossbars for each panel (11), the weakening that each panel had suffered from the grooves, as well as the arrangement that each panel would have in the final architectonic structure and eventual protective backing. The

12. Removing the pre-existing crossbars. The crossbars were substituted with more flexible elements.

13. The panels were placed vertically, free from the old crossbars and restrained by flexible supports so as to gradually release the accumulated tension.

14. After the release of tension, the panels assumed a convex curvature.
crossbars, taken individually, might seem too weak and overly flexible, but all the conditions mentioned before made us opt for this solution which should be evaluated in its entirety.

With the insertion of the new crossbars, the panel assumed an average deflection of 1 cm. This showed that the new crossbars were restricting the amount of warp, giving the supports an intermediate curvature between the free position of 1.2 cm and that of the crossbars of 0.8 cm. Taking into consideration the width of the supports, their thickness, and the increase in deflection, which from a flat position had increased to 1 cm, it is possible to approximately calculate that the surface of the paint has been increased by about 0.6 mm (Fig. 15). This is a considerable increase that enhances the stability of the paint surface. As previously specified, after applying the new crossbars, the panels were again measured with the profilometry laser (Figs. 16 and 17).

After determining the curvature of the panels, the paintings were set up on customized supports, the new crossbars were removed, and the panels were reinforced. An examination of all the

15. Calculation sheet for determining the amount of expansion of the painting surface based on the curvature of the panel.

16. The paintings undergo laser profilometry before and after the removal of the crossbars.

17. A comparison of the paint surface before removing the crossbars (on the bottom with a lighter tone) and after (above, with a darker tone). There is a visible increase in curvature.
grooves and areas filled with oak slices provided an even better understanding of the damage that the artwork had suffered from that former treatment. Most of the channels showed signs of poor cohesion with evident shrinking of the adhesive; in some areas, especially along the lower border of the Madonna panel, the tensions between panel and crossbar had caused splitting extending down from the grooves (Fig. 18).

Our treatment consisted of a first step of identifying the failing wood fills for removal and substitution with poplar wedges, and secondly, in reinforcing the areas with splits. These procedures were carried out by clearing the affected grooves using an electric router with a conical point with a very narrow angle (15°). All of the areas with grooves near the top and bottom edges were reinforced for a distance of 20 cm. Thus, the edges of the panels were made secure and the risk of new cracks was reduced. Removing the old oak fills was limited to cutting down to the depth to which they were inserted in the panel; furthermore, the limited width of the opening of the new grooves means the removal of original material was minimal. It was, however, necessary to create perfectly even triangular channels into which the seasoned poplar wedges would fit precisely. This kind of treatment guarantees greater strength and reinforcement of the wood fibers. The adhesive used, a PVA called Bindan, was applied in minimal quantities.
The same type of operation was carried out in the grooves that showed signs of the old glue failing, limiting the treatment to only the areas heavily at risk, avoiding subjecting the artwork to further vibrations. As already emphasized, the procedure of reinforcing the grooves was carried out to a greater depth in the cracked areas, so as to obtain a perfect bond between the sides and the best alignment of paint edges (Figs. 19–21). On the central panel, a local treatment was also done where a wooden insert had been positioned to cover the head of an original nail. This element had been anchored below the level of surrounding paint during what was probably the extraction of the nail, creating a visible step between the paint surfaces. In order to bring the small insert up to the surface plane, it was necessary to access it from the back. The patch made by Pellicioli was partially cleared away and slight pressure on the insert moved it to the right level. Then the area was filled, as always with aged poplar glued with Bindan (Figs. 22 and 23). After the complete reinforcement of the panels, the crossbars were lubricated with paraffin wax and inserted anew into the channels.
Our belief is that we were able to carry out a treatment that removed the principal sources of tension and also structural weakness of the panels while respecting the conditions for the preservation of the paint. An important role was played by the protection that the paintings received once they were installed in the frame. The three panels were each protected by a sheet of plywood that serves as a barrier (Fig. 24); all the framework elements were closed from behind by wood paneling that creates a kind of buffer of air that slows the effects of fluctuations in humidity and temperature from the display environment. Thus, these indispensible strategies for the protection of such fragile and delicate paintings were assigned to the by now proven system for slowing the exchange with the external environment that alternately would have involved the execution of a much more extensive treatment on the paintings and therefore would have been riskier for the stability of the paint layers. It would have required the use of isolating materials applied in direct contact with the support which would have heavily conditioned their correct reading and preservation in the future.

Reinstalling the altarpiece on the altar

At the end of the treatment, an installation plan was researched and developed for all the components of the altarpiece through which it was possible to achieve several goals.

- First of all it was necessary to rediscover the original installation, even improving if possible on the system adopted for temporary exhibitions. The paintings had to be accessible from the back without risk.
- The containing structure had to offer protection to the back and top of the panels from environmental fluctuations, dust, and insects.
- The paneling on the back had to provide convenient access to the supports so that they could be reached without hindrance as well as allowing for monitoring of the microclimate within the space.
- The structure applied to the frame had to be easy to transport and mount, light but also strong.

The project included freeing the altar from all wood elements added in the 1934 treatment and relied instead on the attachment points and bearing capacity of the vertical wooden posts inserted into the designated sockets already in the marble floor. These elements required an appropriate reinforcement in order to securely hold up the altarpiece. They especially needed to be stable with regards to tipping toward the back and front. Therefore they were provided with sturdy flanking supports that screwed to the existing shafts extending them toward the back; these increased their footprint and prevented flexing (Fig. 25). These elements are made of 3 cm woodcore board, and extended to the edge of the altar and are secured at the bottom with...
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metal brackets that are screwed to the back of the altar (Fig. 26). Another important piece is the high horizontal wood bar behind the architrave which is screwed to the posts; this has a double function: holding the posts parallel and in plumb, and offering a continuous support to the back of the architrave (Fig. 27). The side supports and the horizontal bar are sufficient to allow for mounting the frame elements. At the top, the architrave is held by steel brackets at the top of the vertical shafts and rests against the horizontal wood bar at the back; the predella sits on the pre-existing wooden box painted with Verona marbling (which is, in turn, resting on the altar); the columns are inserted into the architrave and rest on the top of the predella; and finally, the volutes are attached high up on top of the pediment (Figs. 28–32).

The paintings are inserted in their places and each is secured centrally at the top with a strip of chestnut wood screwed into the architrave and at the bottom by a block screwed into the top of the predella. The placement of only one anchor point in the center top and bottom for each panel avoids the risk of blocking the movements of the supports and ensures that it is the crossbars that
28. The paintings were secured in the frame with wood pieces placed at the center of each panel.

29. The large framework is anchored to the new side pillars.

30. Application of the cover on the top and attachment of the volutes.

31. Installing the doors enclosing the back.
provide the restraining function. Moreover, the surfaces of the frame that are in contact with the panels were lined with Teflon adhesive tape so as to reduce friction and avoid scratches.

The structure designed to protect the paintings from environmental fluctuations was made of a large fir wood framework placed in the back, resting on the altar, connecting to the sides with screws. The framework holds a series of panels that completely enclose the back of the altarpiece. The 2 cm woodcore panels that enclose the spaces behind the predella, the columns, and the architrave, are secured on the sides; at the top a cover is positioned and screwed on, again in 2 cm woodcore board, that rests on the top of the architrave; finally, on the back, the wide spaces left by the geometry of the framework receive six doors at the bottom, corresponding to the scenes in the predella, and four doors above where the three main painted panels are. These doors are simply held in by wooden strips and can be removed with a simple upward movement, freeing the bottom, allowing for quick and easy access to the backs of the painting, and, additionally, permitting access to the climate monitoring system inside the enclosure.

1 The images are in L. Puppi, Il trittico di Andrea Mantegna per la Basilica di San Zeno Maggiore in Verona, Verona, 1972.
2 The approximate measurements were obtained by scaling photographs up to the actual dimensions.
3 The treatment was carried out by Ivano Francavilla.
4 The equipment was developed by the engineering faculty of the University of Florence for our wood panel conservation department and has been, in recent years, a significant method of technical analysis with repeatable and comparable measurements. For our purposes, the profilometry is obtained with a laser ray emitter moved by a scanner according to orthogonal Cartesian axes x and y. The laser meets the surface being measured and determines the distance from the source (z) over all the points measured. The surface can be measured in both the horizontal and vertical direction with a precision of 0.4 mm; the minimal distance of each step is 0.4 mm; the values are recorded every third step (1.2 mm). Thanks to the detection of the reference points on the surface, the measurements were repeated and compared so as to evaluate in a quantitative way the new curvature assumed by the paint surface.
5 Each element of the pair of crossbars is made of three laminated strips of 3 mm glued together with epoxy resin Araldite AW 106/HV 953U in a ratio of 1:0.8.
6 The mathematical calculation, developed by Matteo Santacesaria, is based on the following assumptions: the section of the plank of wood (initially rectangular with sides l and 2s, where l is the width of the panel and s is half the thickness) curves so that the two lengths l become arc lengths of two concentric circumferences (where the difference between the two radii is 2s), and the intermediate arc length is l. If we call x the deflection or sagitta, we can use the following formula for the difference d of the arc of the external circumference of the curved section and the initial value l (approximate formula for a small angle of curvature): 
\[ d = \frac{1}{2} \times \left( l - \sqrt{l^2 - 32 \times x \times s} \right) \]
Note: The above formula is a corrected and revised version of the one in the Italian version of this work.
Giotto, Crucifix, c. 1320, Church of Ognissanti, Florence.
Giotto’s Crucifix of Ognissanti: Construction Technique, Condition, and Treatment of the Wood Panel

Ciro Castelli, Mauro Parri, and Andrea Santacesaria

The wood support of the crucifix of the Church of Ognissanti painted by Giotto (presently 467 cm high and 356 cm wide) represents a typical medieval panel structure: it is a good quality, essentially sturdy construction, conceived and perfected aesthetically as a whole1 (Figs. 1–2).

This last attribute mostly concerns the delicate carving of the perimeter frame that elegantly encloses the quatrefoil spaces of the Mourners (where diagonals and arcs alternate), the four quarter-circles bridging the corners of the intersection between arms and body, and the two semicircles at the base of the lateral apron panels. In addition, the standard working characteristics of medieval craftsmanship can be seen: robust planks for the panel with solid vertical and horizontal crossbars placed on the back to form a well-distributed, reinforcing lattice attached to the panel with quadrangular nails with large, faceted heads.

Ours belongs to the ranks of the great painted crosses of the Duecento and Trecento. (To cite a few, that of Santa Maria Novella and of Rimini by Giotto, the earlier ones of Arezzo and of Santa Croce by Cimabue, that of Santa Croce and of San Cresci by Lippo di Benveni, that of Santa Croce by the Master of Figline, and the one after Giotto of San Marco.) These are the result of not only an iconographic development but also a technical evolution, achieved over the course of the construction of the older crosses. The qualities that the paintings of this period share are dimensions that are decidedly larger with respect to preceding examples (let us recall that the crucifix of Santa Maria Novella and that of the Master of Figline measure more than 5 meters in height and 4 in width and even the crucifix of San Marco measures 6.30 m by 4.08 m) and their installation and suspension up on the tramezzo of the churches with heavy iron

rings and a slight tilt forward. The construction of this kind of painting can be defined as the most complex among painted wooden objects, in fact, in order to obtain this shape the panel must reconcile the difficult coexistence of vertical and horizontal planks that make up the body and arms. This kind of structural problem was resolved in early examples of the twelfth century, like the so-called Lucchese crosses (for example, Sarzana, the one of Villa Guinigi, of San Michele in Foro, and others) with independent arms inserted with a tenon into the upright portion of the cross. In the same period, in different geographical areas, other craftsmen
built crosses that instead had continuous arms, crossing the body with a half-lap join (the Crucifix of “Alberto Sotio” in the Duomo of Spoleto, the Crucifix of Rosano, and Number 432 of the Uffizi, among early examples.) The technique of using continuous arms with a half-lap join became more frequent and widespread from the second half of the Duecento and the first half of the Trecento. During the period in question, with the birth of the mendicant orders and the consequent move to bring the liturgy closer to the faithful, we see a transformation that brings about the construction of larger churches and a new function for the artworks inside; these become larger compared with previous ones and are located more centrally so as to be seen from all areas of the church. This change favors the construction of crosses with the single horizontal panel joined to the vertical with a half-lap join, providing greater structural stability. All of these construction characteristics we find in the Crucifix of Ognissanti.

When examining the construction, the high quality and the skill of the medieval carpenter who designed and created the cogent structure is evident. He was extremely precise in his execution and prudent in selecting the varieties and quality of wood. On the other hand, the support has been exposed to environmental fluctuations, vulnerable to wood-boring beetle attack and deposits of dust, though overall the conditions, its behavior over time, and the structural method most suitable to maintain a strong and light-enough structure for a monumental work of art suspended at an angle at a considerable height. Based on our experience, the craftsman charged with planning a construction of this type had not only carpentry ability and precision, but also remarkable awareness of mechanical engineering and construction technology, as well as benefitting from the accumulated experience of the past. We must take into account that specialization in the construction of objects destined to be painted is a very specific subdivision of general woodworking. Making this kind of structure poses a series of challenges for various reasons. The shape is essentially two dimensional in that its height and width outweigh the depth; there is a major asymmetry between the front side (where generally the side of the plank that faced the interior of the trunk is the painted side) and the back (which is opposite to the former, rarely painted, but sometimes protected with gesso or minium, and most importantly, the location of the panel restraint system); and finally, the support must provide stability for the paint surface (for this the wood is chosen from those with a greater inertia in terms of temperature and humidity like the right cut of poplar wood). Furthermore, it is useful to remember that around 1100 the widespread production of panel paintings began, and therefore at the moment in which wood was chosen as a material for paintings, the Italian carpentry craftsmen were surely in possession of excellent knowledge of the techniques of woodworking and construction and employed them with extreme refinement. Consequently, by examining the support of the Crucifix of Ognissanti we can verify the degree of technical development reached by these medieval craftsmen.

Usually the supports of the great crosses are described by listing the planks, their dimensions, and the various assembly techniques used. In reality, analyzing the support of the painted crosses from Giotto’s time more in depth, what emerges has been truly high-quality planning in which all the planks have a quite precise shape and placement that is by no means random. The solidity that this artwork has maintained until today is the result of the carpenter’s cognizance and the methods put into effect at the beginning.

The support of a monumental cross, as for all the artworks of this kind, incorporates a difficult challenge: the coexistence of planks oriented vertically and horizontally joined in the same plane. This feature required, in this case, the creation of a half-lap join between the body and arms, with the removal of wood and therefore the weakening of the planks with the consequent necessity of having to find an adequate reinforcement. The reduction of half the thickness of the vertical section and the horizontal so as to be able to unite them on the same plane weakened both and therefore the whole structure in a substantial way. Because of this, a series of measures were put in place to improve its robustness. In the case of our Crucifix (as with most of the others of the period), the vertical is carved out on the back to house the
join with the arms; therefore, the vertical side is presented to the viewer as a continuous surface from the bottom to the top without interruption. In contrast, the horizontal arm is carved out on the top side and therefore appears interrupted. The join lines between arms and body form an “L” whose horizontal border is the head of the apron panel that widens the vertical body on each side. This method is repeated in a symmetrical way on the back in the structure of the crossbar lattice. Again, this assembly uses vertical and horizontal lengths that intersect with half-lap joins. The vertical lengths also have a cut-away part on the side closest to the panel to house the horizontal crossbars (and these in turn are cut away on the back or exterior face). Therefore, even the crossbar system maintains a continuity of the vertical elements facing outward. This consistency in continuity (for the vertical elements) of the outer surfaces and the interruptions of the internal surfaces, together with the extensive nailing, provides strength and a remarkable solidity to the whole—a quality established only by respecting the described structural symmetry with precision. Furthermore, the long crossbars on the arms, weakened at the point of intersection with the verticals, are given strength from their attachment to the lateral panels of the body. This contributes in a substantial way to sustaining the projecting arms and opposing their twisting. We are aware, furthermore, that the elements taken individually (planks and horizontal and vertical crossbars) show a natural tendency to flex. For example, the main plank that makes the vertical backbone—48.5 cm wide, 7 cm thick, and currently 463 cm long, and that has been cut down to 3.5 cm thick in the area of the half-lap join—is by itself is not particularly rigid. Similarly, the vertical crossbars of the lattice measure about 4.5 m long, with an average thickness and width of 8.5 cm by 7 cm and have a series of cut-out notches corresponding to half-lap joins with the horizontal crossbars. These also certainly could flex to a significant degree and bear the risk of breaking when subjected to minimal stresses.

Basically, we can conclude that the construction of a monumental cross relies at its heart on the use of “weak” elements but that these are united wisely following precise rules that confer strength to the whole. In the specific case of our Crucifix, the panel has a thickness that is already very robust (7 cm) while the support of the Crucifix of Santa Maria Novella has a 5 cm thick panel but is equally strong and solid. (It is 530 cm high, 400 cm wide, and therefore slightly bigger.) This brings us to consider the example of Santa Maria Novella as one of the greatest expressions of medieval carpentry craftsmanship where an extremely detailed project is indulged with the best cuts of wood and given a meticulous execution even down to the smallest details including aesthetic aspects. This example also illustrates how the structural criteria prevail over the strength of single elements and contribute to create strong structures, while still allowing for them to be refined and elegant and not excessively heavy.

The Structure of the Wood Support

The support of the Crucifix of Ognissanti is composed of a poplar panel, an auxiliary support system made of a lattice of crossbars in chestnut and fir, and a carved frame applied to the perimeter of the front. The panel is 7 cm thick and is essentially made up of a vertical and a horizontal section that are joined with a half-lap join. The vertical element is made of a main plank, now measuring 463.5 cm in length with a width at its widest point at the bottom of 48.5 cm. It has a roughly 2 cm deep notch cut into it where it joins the plank on the left; moving up along the vertical plank, it narrows considerably until it reaches a width of about 44 cm. In order to square up the vertical element and to make up for the irregularities due to its slight tapering, lateral additions were attached. These lateral planks are about 26.2 cm wide and serve as the support for the painting of the lower half of Christ’s body (Figs. 3–4). At the bottom they form a lobate shape and at the top they rest in the half-lap join with the main horizontal, overlapping for about 10 cm or a fifth of the total width of the plank. This amount is important because it determines the size of the join and its strength. In the Crucifix of Santa Maria Novella, the planks are fitted into the join for a distance of 6 cm (less than one-ninth of the total 52 cm), and we find the same relationship in Cimabue’s Crucifix of Santa Croce; however, in contrast, in the Crucifix of San Marco from the school of Giotto these planks completely overlap the entire join (52 cm), while in the Crucifix of Rimini the planks stop at the horizontal element and do not overlap it at all. These differences that we also see in
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The plank and two forming the top and bottom points.

The panel displays the distinctive feature of wood joins made according to the compositional needs of the painting. Usually, in other structures, (for example, the Crucifix of Santa Maria Novella, the Crucifix of Rimini and many others) the panels are aligned together in a geometric way with perfectly smooth and straight surfaces of contact made with tools of the period. In this case, the main planks are cut to a specific shape: in the case of the main horizontal plank, the central part is narrower and contributes to the half-lap join; the vertical plank, meanwhile, is reduced to house one of the lateral planks that widens the surface for the body of Christ, offering a contact surface that is not perfectly smoothed with a plane, but quite likely, finished along the last section at the bottom with a rasp. We know how important the precision of the joins was because of the glue used: calcium caseinate, like all water-based adhesives, requires even surfaces that match up perfectly. What we have described is, though, a rather unique feature of this kind of panel.

To take advantage of the best characteristics of wood, the planks used are generally a radial or sub-radial cut; the texture is, overall, essentially good. The vertical panel has a mostly straight grain with few knots and with a flame figure at the bottom. In general, the principle of placing the planks with the internal side facing the ground layers has been respected. The horizontal panel meanwhile has major knots in the central portion with a change in direction of the grain. This panel has growth ring separations on the left side behind the Madonna and in the center; the phenomenon affects the surface of the panel and dates from its construction as seen from embedded traces of red originally used to mark out the geometric shape of the painting, a feature described more later.

The planks that form the panel of the Crucifix have been worked independently, aligned
with butt-joins and glued. Along the join between the vertical plank and the left apron panel, (the one overlapping by about 2 cm as seen from the painted side), but only along this join, two 18 cm tapered dowels (cavicchi) were inserted. This is probably to give a more solid attachment compensating for the planks that are not perfectly in contact.

Two semicircular elements that complete the lobes at the bottom of the cross are attached with glue and nails to the two lateral planks that extend the width for the body of Christ. These two additions have some features which deserve a brief aside. Their anchorage with nails indicates that when they were applied they already had a rounded form and their present dimensions. The X-ray shows the remains of two nails inserted in the support and located under the bottom of these semicircular elements; these could indicate that in these points there were other wood pieces attached but then removed, probably due to second thoughts while the work was in progress. Furthermore, their thickness is greater than that of the adjacent plank and the attachment on the sides of the support seems to have been done after the application of the crossbar lattice; in fact, the crossbars do not overlap but stop before the uneven, stepped edge of the two additions. From the X-ray of this area of the support, besides the remains of nails next to the lobes, channels left by old nails that were extracted can be seen. These are present on both sides, slightly angled inward and appear to have been removed not long after having been inserted because of the lack of oxidation. It was also noted that the distance between the nails present on the lower margin of the lobes and the nail remnant in the support, as well as the distance between this and the holes left by extracted nails have an identical interval of 14 cm. From this we can imagine some information about the original placement of the lobe. It was at the same distance from the lower margin as the current piece (about 11 cm), it had a semicircular shape with a radius of 16 cm (now it is 19 cm), and projected a maximum amount from the border of the panel of 9 cm (14 cm now). This last observation leads us to think that the decorative element projected a relatively small amount (9 cm) and that it was held by three nails: one at the bottom where the others are now, one at the top that was extracted, and a central one of which the tip has remained embedded. The semicircle does not have a central nail now, probably exactly because it projects more (Figs. 7–8).

Once the vertical and horizontal panels were assembled from their various pieces (with the exception of the two additions just mentioned), the two panels were carefully planed before being joined. The side that was to receive the ground layers was smoothed with such care so as to present a very uniform radiopacity in the X-ray; with effort it is possible to see that the planing was done with a small plane with a fairly flat blade that was worked perpendicularly to the grain of the wood. The back is also planed with the same technique, but not with the same degree of finish; in fact, the areas where the crossbar members are attached have been further smoothed with a plane so as to create an even contact surface.

After these procedures, the vertical and horizontal panels were connected with a half-lap
join anchored with glue and nails inserted from the front; the X-ray shows six nails aligned in the lower part of the join holding the top edges of the side planks and the vertical panel with the horizontal and three nails at the top in just the central plank.

In the same area, on the front of the painting, the element that forms the halo was set in. It is made of a single piece of semicircular wood with a thickness that increases toward the top. A carved frame runs along the outer border with inlaid glass pieces. The frame is attached at the base with glue and six nails and the inset element is attached the same way. The X-ray allows us to recognize this is a change in the original plan that probably would have used a higher placement and a slightly wider shape for the halo. In fact, even using raking light allows for the detection of a slightly larger semicircular cavity (Fig. 9). It is curious to see that this change came about after the application of the canvas to the support by cutting away the halo element that was already attached until it reached its current shape. In the X-ray, the area occupied by the first version of the halo appears to have variable densities: at the left edge of the current halo the remains of the inset wood can be seen after the piece was reduced to the level of the adjacent canvas on the panel, leaving therefore, less space for the ground which is thinner. Meanwhile, in the area at the top, the wood is completely missing and was filled with a thicker layer of gesso; to the right the cavity in the panel was filled with a wood insert, arranged with the grain horizontal and held with seven small nails; it is not clear if this filling was carried out with part of the wood prepared previously or with another insert. The frame attached to the border is longer than the raised half-circumference and the ends rest on the surface of the panel in a different way with respect to the other crosses where the frame is only applied to the sloped part of the inset halo element.

In the four corners formed by the half-lap join, there are four metal L-brackets attached with nails driven into the edge of the panel;
these probably have the function of reinforcement and holding together the planks near the join, providing greater solidity at a crucial point in the support. There are also additional quarter-circle elements attached with two large metal nails each at these four corners, covering the metal brackets; of these, three are positioned with the grain running vertically, while the upper right one (when facing the painting) has a horizontal grain (Fig. 10).

The panel is certainly the result of a geometrically designed plan. The shape of the panels, their lengths, the relationships in proportions between the vertical and horizontal have been determined previously in a drawing to scale and then faithfully transferred to the back of the Crucifix. There are, in fact, quite visible marks that delineate the geometric construction of the shape of the painting. Particularly on the horizontal arm, a red line, probably made with a snap-line, runs along the middle plank. At the center of the quatrefoil terminals, other red lines, intersecting diagonally, determine the center of the arcs of the rounded lobes or run parallel to the borders of the points at a distance of about 6 cm toward the interior. Furthermore, arcs are scored with a metal point, again at the same distance from the border, almost as if to divide the area occupied on the front by the frame from the area destined to be painted (Figs. 11–13). Other incisions, again using a metal point, define the height of the
side semicircles on the bottom of the vertical panel. These marks therefore served to define the cut-out shape of the painting after the panel was constructed. As mentioned earlier, in some areas with growth ring separations, these marks run over the disrupted surface revealing that at the time of construction, the wood already had this defect of ring shake. On the back of the panel we also found marks incised with a metal point that determine the position of the crossbars and that measure out the divisions of the lattice placed to reinforce the panel, signs that were regularly respected in the moment of attaching these crossbars. From examining the panel we can therefore determine this planning stage is an intermediate moment after the assembly of the panel and before the application of the ground layers and the attachment of the crossbar lattice with the relative holes for the insertion of nails; undoubtedly this was an important phase during which the craftsman defined the shape of the painting in detail before proceeding to complete the structure with the reinforcing lattice (Fig. 14).

On many paintings restored or examined by our Laboratory in the past, traces of marks that indicated the geometry of the construction have been found, for example on the Coronation of the Virgin by Lorenzo Monaco in the Uffizi. In that case, red marks were found on the front side under the frame that defined a division of parts of the painting. Additionally, on the back of Fra Angelico’s San Marco Altarpiece there are quite visible incisions and red lines that define the position of the crossbars and the anchorage rings inserted into the panel. The back of Bronzino’s Descent into Limbo in Santa Croce has visible traces of red rectangular shapes that mark the position on the outside surface of numerous rectangular splines (ranghette) inserted inside the planks, and therefore no longer visible. This allowed the carpenter to insert wooden pins (anchoring the splines) perpendicularly into the panel. Recently, on the back of the Giottesque Crucifix of San Marco, similar marks were found to those on the Crucifix of Ognissanti with red from a snap-line and incisions made to determine the shape and height of the arcs, median lines for the principle planks, and incisions to define the positions of the crossbars, so much so as to imply a “family relationship” between these two structures, at least in terms of this characteristic.

The stylistic analogies with the Giottesque Crucifix of San Marco and also with that of Padua (though much smaller in size), leads us to think that our cross also ended at the bottom with a trapezoidal base meant to have a representation of Golgotha. Quite likely this element was made of a panel positioned horizontally connected with a tenon join and reinforced with the crossbar system so as to be quite secure because it made up the base on which the painting rested. Furthermore, the shape of this terminal part follows a mixtilinear canon that could have included two semicircles on the sides like the Crucifix of Padua, at the join between the vertical part and Golgotha or, more likely, along the diagonal sides of the trapezoid as in the Crucifix of San Marco. The likelihood of the second possibility is based on the very probable (given the scale of the painting) structural independence of the main part of the cross from the Golgotha part and, that is, the very real possibility that the trapezoid was simply attached to the rest of the panel, as for the examples of the Santa Maria Novella Crucifix and that of San Marco but not tightly incorporated into it as instead is seen in the Crucifix of Padua (on a much more contained scale). The Crucifix of Ognissanti therefore represents the first example with a mixtilinear contour in Florence, previously used by Giotto in Rimini and Padua.

On the back of the panel a restraint and reinforcement system was attached in the form of a lattice of nailed crossbars. Before proceeding to prepare the various lengths, their positions were determined on the surface of the panel and marked with metal point incisions. The assembly is made of two verticals and two horizontals placed along the upright section and the horizontal element of the cross along the sides.
of the load-bearing planks. The long crossbars were cut to size and finished with a bevel on the outer corners in preparation for overlapping with half-lap joins. As mentioned previously, the vertical members were carved out on the back while the horizontals, in turn, were carved out on the front (Figs. 15–17).

A series of ten, short horizontal crossbars attached at various heights and joined, as always, with half-lap joins to the main vertical lengths contribute to provide support for the panel. There are also six short vertical crossbars positioned on the arms, again with the same method. The crossbars are made of different species of wood. The main vertical and horizontal lengths are fir while the others are fir, chestnut, or poplar. Considering the placement of the individual segments, it is not possible to identify a clear guideline governing the choice of wood. On some, signs of previous workmanship can be seen, for example large cylindrical holes are signs that the material is recycled from older objects. These have variable sizes in cross-section: the long crossbars are about 9 cm wide and 7 deep; the short crossbars are on average 7 cm wide with a height of 6 cm. The outer corners of these elements are beveled giving a lighter, elegant quality to the whole. Furthermore, when looking at an angle at the painting, the bulky intrusiveness of the crossbar lattice is reduced. The system was designed so as to be able to support and restrain the panel in terms of accommodating the large dimensions and the co-existence of perpendicular wood grains, while also allowing the structure to be displayed resting on the tramezzo of the church, tilting forward at a slight angle. The reinforcement lattice had to therefore sustain the forces of the projecting elements and maintain the panel surface perfectly in plane. The particular technique of arranging the half-lap joins between verticals and horizontals, which we mentioned earlier, is essential for the integrity of the entire painting, accompanied by a scrupulous nailing of the crossbars to the panel. The nails were inserted from the back in holes made in the long and short crossbars, and then bent back around on the front. Generally, these were placed at each intersection and the centers of the crossbars that joined with the vertical lengths so as to support the vertical weight-bearing planks of the central section. On the terminals with the Mourners and Christ Blessing, or the apron panels of the body, the crossbars had nails inserted along the margins, corresponding to the frame on the front so that the bent points would have been covered. Probably for this reason, among the marks on the back of the panel, lines of demarcation were made between the painted parts and the areas covered by the frame, transferring on the back this important information from the front.

The distribution of the nails is similar to that present in other crosses cited above, different though in Giotto’s Crucifix in Santa
Maria Novella which did not have the series at the center of the crossbars that support the vertical weight-bearing portion, because that area is along the vertical join between the two planks that form the upright part of the cross.

The support is held up by five iron rings (campanelle): along the arms, under the halo, and high at the center of the terminal with Christ Blessing. These elements were each anchored in different ways according to the function that they would carry out. The rings are threaded through a metal collar shaped like a long strip of iron folded completely in half. The three rings connected to the vertical planks (the two at the top and the one under the halo) are inserted into a hole that passes through the crossbars and the panel; the points of the iron attachments were bent and beaten down below the surface of the side destined to be painted (Figs. 18–19). The one that corresponding to the halo passes through the vertical upright panel and the horizontal arms; the points emerge, separate and are bent back on the surface of the halo cavity, then the whole area is covered by the semicircular inset piece of wood (Figs. 20–21). A different technique is chosen for the two rings attached to the arms; these are only connected to the
crossbar: the iron prongs pass through it with the points separating and being bent back into the crossbar itself without coming into contact with the panel. The vertical crossbars are in a dense wood (chestnut) and are firmly anchored to the panel, each with a pair of nails, placed above and below the hanging hardware.

It can be thought that the painting was intended to be displayed on the tramezzo of the church on which it rested with a slight tilt forward as it appears from the Giottesque frescoes of Assisi. The rings contribute to reinforcing the painting in the upper and central parts, while the rings on the arms serve as stabilizers, like a counterbrace. In this position the elements of the support receive planar deformation stresses that are very strong, especially in the areas of the half-lap join and therefore the crossbar system and the metal tie-points serves to strengthen the whole and oppose these tendencies, serving, in turn, to absorb and distribute the stresses from being pulled and suspended at an angle across the surfaces of the panel.

An elegant frame carved with a foliate pattern and gilded was applied with glue and nails around the perimeter of the painting for a width of about 6 cm. It has a primarily aesthetic function of finishing the edges of the painting without contributing a structural function or protecting the edges of the panel, except as a cover for the numerous nails that anchor the crossbars. The border of the support was protected and finished with a ground layer of gesso and glue followed by a layer of red ochre that also extends to the underside of the carved leaves of the frame. This material is also found on the edges of the panel and on along the crossbar that flanks it. This feature also contributes to the decoration of the border and supports they idea that this was located in the center of the church. There is no trace on the back of the support of any protective application of gesso and glue, or minium.

The crossbar system, as mentioned previously, is well-distributed across the surface of the panel respecting fairly regular intervals, for instance the horizontal crossbars have a space of about 30 cm between them. Consequently, the dimensions that the cross had before the bottom was cut can be extrapolated. The last horizontal crossbar is about 20 cm from the cut edge; using this measurement we can add 10 cm to complete the interval and about 8 cm for the width of the missing crossbar. Beyond this point which we find about 18 cm lower than the current end, the trapezoidal element with Golgotha would have been located. It is difficult to imagine precisely what the size of this element was. In the Crucifix of Santa Maria Novella it is 70 cm high, while in the Crucifix of San Marco, though its full height is more than a meter higher, it is only 75 cm. If we add the amount of 70 cm to the roughly 18 cm from the cropping of the bottom to the current height of our cross (467 cm) we derive a total measurement of 550 cm high and 376 cm wide.

As emphasized at the beginning, the construction of the cross is high quality. Comparisons can still be made to the other great Crucifix of Santa Maria Novella as an example of an elegant, refined, and solid construction. Aside from the general shape and category of panel painting, there are very few common aspects between the two structures, or rather we think it is difficult to see them as products of the same carpentry workshops. The Crucifix of Santa Maria Novella appears more refined with careful finishing on the back and the protection of minium; even the crossbar system has an elegant carved shape in cross-section, difficult to achieve over the half-lap joins, instead of a nearly rectangular shape which is easier to intersect. Furthermore, the frame has not only an aesthetic value, but seals the edges of the panel, protecting the sides and the plank ends from environmental fluctuations in temperature and humidity, contributing to an improved stability of the whole. The two parts that make up the panel are the body and the arms and these are in turn formed from two radial planks each from which the heartwood has been removed to make them more homogenous and stable. These measures, combined with the choice of using thinner planks (5 cm instead of 7) for the main planks, give the Crucifix of Santa Maria Novella a kind of superior quality almost never achieved in other structures. On these findings, we base the idea, as mentioned, that the workshop that made the first of Giotto’s crosses also made or designed the support for the Maestà of Ognissanti (which demonstrates a similarly quite refined technique, both in the shape of the carved elm crossbars, and in the protection provided with minium on the back); but that the cross made for this same Church of Ognissanti was made by another workshop, probably close in terms of technique though separated by time, to the one that later made the Crucifix of San Marco.
**Condition of the support**

In general, almost all the original elements of the wood support display a good state of preservation in keeping with the characteristics of the materials, the timespan of aging, and the kind of structure. There are two important moments that affected the integrity of the painting as well as its mechanical solidity.

As we mentioned earlier, the *Crucifix* is lacking the scene of Golgotha at its foot (Figs. 22–23). Observing the lower part, a cut can be seen that marks the panel and crossbar, though above the hypothetical line of contact with what was probably a trapezoidal base. Currently, the lower part of the support appears to have been cut along an arbitrary line that does not respect the intervals of the crossbar system. The cut leaves the ends of the vertical lengths practically free without an anchorage to the panel near enough to provide reinforcement to what is now the base, nor is there a connecting crossbar between the two verticals. In fact, the lowest original crossbar is at 21 cm from the bottom edge and the nails that join the panel and crossbars are about 23 cm from the edge. Moreover, the lower portion of the support shows that the distribution of the original crossbars were placed at relatively regular intervals of about 30 cm on average. The cut at 20 cm from the last crossbar has essentially interrupted this system and taken away strength from the whole area. The effects of this can be seen by observing the ends of the vertical lengths on the back: on the left the vertical length is completely cut at the height of the horizontal crossbar while on the right it is cracked and very deteriorated with losses of wood material. We can suppose that this damage is due to stresses and vibrations that occurred at a time while the painting was moved. Furthermore, even the panel has a crack in the center about 50 cm long, reinforced along the first 20 cm in a previous treatment.

Another important event negatively affected the condition of the painting and its integrity: in examining the support on the back of the left arm, it is evident that one part of the lower horizontal length is missing for about 37 cm; furthermore, in the same area the surface of the panel is very deteriorated with deep erosion from wood-boring beetles (Figs. 24–25). Even on the front, the corresponding area has many losses of paint. Probably an infiltration of moisture caused a severe expansion of the panel in this area causing the loss of paint on the front and deterioration of the wood material on the back. In particular, the moisture triggered mold and insect activity so as to cause the loss of surface material of the panel and of all the reinforcement crossbars around the area affected. This damage, though localized and limited, is very important also because it undermined an important reinforcement point of the half-lap join of the panels. In fact, just looking on the painting at the line of the join between the vertical body and the horizontal arm, before the restoration, a greater distance between the elements is seen specifically in this weakened area. The support therefore has less rigidity and a greater tendency to flex horizontally over the span of the arm. Therefore, any movement of the *Crucifix* can cause the structure to undergo excessive stresses and deformations.

The panel has some limited cracking due to the natural contraction of the wood. One
of these is present in the center of the vertical section, probably favored by the insertion of the nails of the crossbars. This crack passes through the paint surface beginning under the halo and extends about 85 cm. Furthermore, even the piece that makes up the halo has cracking along the grain. The contraction phenomenon of the wood is also concentrated along the boundaries of the half-lap join of the panel where the wood sections are oriented with the grain perpendicular. As mentioned previously, on the right when facing the painting, the gap was more evident due to the lack of crossbar on the back. Overall, the support shows mild evidence of attack by wood-boring beetles, both from the Anobid and the Cerambycid families, with a modest number of exit holes on the border and the back.

As a whole, aside from the factors mentioned, the support has held up admirably over time. Other phenomena can also be noted that have marked the appearance of the work of art, fortunately localized and not affecting the stability of the structure. For example, at the ends of the arms, the terminal panels with the Mourners have had the points trimmed with the removal of the edge of the panel and gilded frame for about 10 cm on each side; the points were rebuilt and attached in a previously restoration which fixed them directly to the main support, each with a pair of screws.

Another feature relates to the perimeter frame which is already, in itself a fragile and delicate element subject to wear. Over the course of time, many of the foliate parts that project beyond the external contour of the crucifix have been lost or eroded by wood-boring beetles. In the area struck by moisture infiltration (in the right arm as seen front the front), the water-damaged leaves have lost their gilding and preparation. Other lengths of frame have been substituted, in particular two large areas of repair can be cited: in the lower right we find a vertical segment of frame about 40 cm long that is completely redone and in part fitted into a rectangular slot in the support; on the arm with Saint John the entire upper length was substituted, corresponding to the area damaged by moisture. New parts of the frame were found also along the two quarter circles that link the body to the arms on the underside; in this case it is possible that the cause of the deterioration and the loss of original materials is due to wear and damage from ropes or braces used to move the painting in the past. Most likely the repair of the frame and the substitution of some parts goes back to the Mostra Giottesca of 1937.

The Conservation Treatment of the Support
The conservation treatment of a work of art, in terms of the support and the painted surfaces, follows criteria and a sequence of procedures established over many years in our Laboratory according to which it is not possible to treat an object without first understanding its materials and techniques. Naturally, a careful examination of the condition is necessary in order to completely verify if the general state of solidity and stability of the structure puts at risk the integrity of the object, both in the short and long term. The analyses in this regard have been described previously and they have highlighted the major needs of the painting for its best future preservation. We therefore embarked on a treatment aimed at
removing the factors that could aggravate the natural aging phenomena of the painting, being quite careful to avoid procedures that were oversized in proportion to the actual needs of the artwork. The excessive addition of materials not only makes the restoration more exposed to deterioration, but affects in a more significant way the materials and the evidence of the original technique, causing serious damage to the artwork understood as a document of time period, of a region, or of a workshop.

The treatment on the wood support of the Crucifix of Ognissanti was carried out in the spring of 2009. In the summer of 2004, there was a prelude to the treatment in the form of a de-infestation carried out by R.G.I. of Genoa. The Crucifix was placed inside a large oxygen-barrier enclosure where the internal atmosphere was modified to be anoxic (about 0.2% oxygen). The temperature and the humidity were stabilized and monitored at values of 20°C and 55%RH. After four weeks the enclosure was opened and the painting was protected with the insecticide Permetar applied by brush with the aim of deterring future attacks by wood-boring beetles. During the almost five years from the de-infestation to the treatment of the support itself, no new insect damage was seen; in any case, the effects of the active agent of permethrin would have dissipated allowing for work to proceed on the support without risk of exposure.

Given the general condition of the support, in order to turn the crucifix and position it in a way that permitted work on the back, a structure was created with fir wood posts in contact with the front and back of the horizontal arm so as to create an effective reinforcement that would prevent the possible and dangerous flexing due to the absence of that portion of crossbar (Fig. 26).

On the panel, the eroded areas on the arm in correspondence with the missing crossbar have a significantly weakened surface and heavy deterioration, and like the areas affected by the tree-ring separations, they required proper consolidation. In the same areas, and in general across the entire back of the support, a large quantity of dust and dirt had filled the various surface recesses, among them the crevices between panel and crossbar, small cracks, and gaps in the tree ring separations of the planks. The particulate matter had formed a thick layer on the eroded areas and would have been an obstacle to any consolidation procedures. Therefore, the back of the support underwent a careful cleaning to remove these superficial deposits. The cleaning was carried out in stages starting with the bulk of the matter removed by brush, surgical pick, and vacuum suction. Then a Wishab sponge was used, and finally, to obtain a cleaner surface, the remaining grime was wiped away with slightly damp sponges. During the cleaning, the original markings appeared (Figs. 27–33).

The support was consolidated with a 7.5% solution of Paraloid B72 diluted in ethyl acetate and applied by brush to the entire surface, especially thoroughly in the eroded areas to obtain a better effect (Fig. 34). In fact, in the areas affected by moisture, the wood of the panel also needed a surface reconstruction that was carried out with small, very thin pieces of aged poplar, glued with the PVA adhesive Bindan to create a new, more compact surface that would be more resistant to future deterioration. In other areas, the panel showed
signs of localized erosion and these areas were in turn reconstructed with the same technique (Figs. 35–37). The deep, central crack that runs vertically through the center of the plank with the body of Christ was cleaned thoroughly and reinforced by inserting a series of thin slivers of aged poplar glued with Bindan (Fig. 38). With the same technique, the crack up high in the center of the panel with Christ Blessing was mended (Fig. 39).

The parts of the support affected by ring separations were consolidated and integrated so as to re-connect the separated areas and prevent dust and other external agents from...
infiltrating and further aggravating the condition. The treatment was carried out by cleaning and slightly clearing out the gaps between the separated and deformed rings. Then the areas were filled with balsa wood glued with Bindan. This choice was deemed the most appropriate way to close the openings without resorting to removing portions of original wood, nor needing extensive repairs with new wood (Fig. 40).

Along the crossbars, numerous small cracks had opened up from the natural contraction of
is toward the interior of the structure, would attach to the part that crosses over the junction between vertical and horizontal, while in the other direction, toward the end of the arm, it joins the end portion, and rests parallel to the grain of the plank of the panel. The section of crossbar on the right, furthermore, besides
being very eroded, is not well-anchored to the panel because it ends far from the nail holding it. It was therefore necessary to anchor the new piece beyond the nail, creating a more extended bond with the adjacent portion of crossbar. This is why the point of contact was extended along the whole length of the crossbar on the right and not limited to a local and superficial adhesion in the area of contact.

Consequently, the right crossbar was cut halfway through with a longitudinal cut parallel to the surface of the panel, (Figs. 53–54) and two parallel channels 2 cm wide and deep were made in the part remaining in place into which were inserted...
two chestnut lengths (Figs. 55–58). These strips, about 2 cm thick, are about 70 cm long and skirt the central part where the nail is inserted; they extend along the edge of the vertical crossbar on the left until they touch the remains of the crossbar at the end of the arm (Figs. 59–62). The two lengths are joined firmly to the crossbar and provide a connection to the most external part with which they are attached in the simplest way, with a pair of wooden dowels each. The whole is glued with a mixture of epoxy resins Araldite AW 106/HV 953U (1:0.8) and Araldite SV 427/HV 427.
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(1:1) in a ratio of 1:1. The operation of reinforcement and bridging also uses pieces of chestnut that fill the spaces between the strips and together hold and surround the shaft of the nail that in this way returns to perform its function of anchorage with the large head resting on the new insert. In our system of connecting the eroded crossbars, the chestnut elements make for a strong core that fits inside the original fir crossbar; this core was then covered externally by aged fir. For the part on the right, the surface portion of the cut crossbar (temporarily set aside) was excavated in such a...
way as to house the interlocking core of chestnut and was then repositioned and adhered with the same adhesive used previously. The area needing reconstruction was repaired with inserts of aged fir glued with Bindan (Figs. 63–67).

For the conservation treatment of the frame, a choice was made not to substitute the carved parts inserted in 1937 because the wood seemed to be stable, but rather to adjust the carving where necessary.14

The support was again protected with Permat insecticide applied by brush. Subsequently, the painting was again turned around with the help of the structure used before, now with a purely precautionary scope, because the whole, thanks to our treatment, had regained a great part of its lost solidity.

The Crucifix of Ognissanti required further attention, above all in view of the transportation to and re-installation in the Church of Ognissanti. In its last months at the Laboratory, the Crucifix was raised and positioned vertically to allow for the final phases of conservation and the final photographic documentation. For this series of movements, some procedures were carried out for the safety of the painting. Specifically, the lower weight-bearing surface was given an oak strip anchored to the reconstructed part of the vertical crossbars. Thus the painting would not rest directly on the ground but on a base;
furthermore, this element serves as a grip at the bottom when the painting is positioned on the metal structure built for its display in the church, avoiding contact between the metal brackets and the painting surface (Fig. 68). Furthermore, in order to position the Crucifix vertically (especially thinking of transport to the church), and foreseeing a series of both major and minor movements, a large structure was readied that enclosed the entire vertical section of the painting from the bottom to the top and offered a base for lifting it without risk from the ground, and firm anchorage points for the hoisting ropes that allow for it to be raised from the floor of the Church up to the metal bracket in the upper chapel. Furthermore, the specific assembly technique of the framework allowed for it to be smoothly dismantled right next to the metal structure that would then support the painting in its final position, allowing for a swift transition for the Crucifix between structures and reducing the risks that could arise in the final phases of installation (Fig. 69).

1 The painting, as we will see later, has had the base with Golgotha removed. There are also losses to a section of the bottom of the panel and of the two outer points of the terminal panels with the Mourners; consequently the current vertical and horizontal dimensions do not correspond to the original.

2 Poplar wood is quite suitable, in addition, there is good homogeneity in the wood grain and the weight is less which has allowed for the creation of artworks of large dimensions.

3 It is important to remember that there is evidence of paintings on panel before the 12th century such as the Madonna della Clemenza from the 8th century or even the small archeological tablets from Fayum representing expressions of a private use.

4 Evidence of the high quality reached by Italian carpentry around the year 1000 is found in R. W. Symonds, “Il mobilio nell’epoca postromana,” in Storia della tecnologia, Turin 1981.


6 As described earlier, the panel has suffered the loss of the last portion at the bottom and the join with the panel with Golgotha.

7 See the record S. 1233.3 at the Laboratorio Scientifico of the Opificio

8 A defect due to freezing that is found largely in chestnut timber but can also be found in poplar.

9 Most likely, this structure also respects the criteria of inserting nails into holes made with a carpenter’s brace (menarola or girabacchino).

10 Specifically, these are the crosses of Cimabue, of Lippo di Benivieni, and the Master of Fignole in Santa Croce, that of Giotto in Rimini, and that of the Giottesque school in the church of San Marco.

11 The identification was possible with XRF and FORS analysis.

12 The treatment was carried out by Ercole Gialdi, Federica Di Sanno, and Simone Orecchia.

13 It is our conviction that a de-infestation and the subsequent application of Permetar insecticide should take place at the end of the treatment on the panel so as to not send the material into circulation and inhale the insecticide when working. It is true though that some objects that have an evident insect attack underway need a de-infestation treatment immediately. In this case we could choose an anoxic treatment and then proceed with the structural treatment and finally apply the permethrin insecticide. Otherwise we would have had to use appropriate respiratory protection.

14 For a complete description of the restoration of the frame, see the separate chapter on this subject by P. Bracco, O. Ciappi, and A. M. Hilling (in L’officina di Giotto: Il restauro della Croce di Ognissanti).
The restoration of the Linaioli Tabernacle represented an important occasion for the study of a panel structure with a very unusual shape that belongs, as we will see, to a transitional period between traditional medieval construction methods and subsequent Renaissance production. This special quality, that most likely makes this painting by Fra Angelico the last exemplar of the old construction practices, has resulted in some visible damage to the object. Thus, the study undertaken here has allowed for the planning and creation of a restoration treatment that is tightly linked to the deterioration factors present that also heavily influence the reading of the iconography. These conditions derive from its very construction technique and are common to many large-scale paintings of the early Quattrocento. As we have had a chance to analyze, the paintings made between the thirteenth and fifteenth centuries are in general very solid, well-made, and resistant to the passage of time. The structure of the Tabernacle is typical of a large wooden construction, both from the point of view of the technique used and from that of the historic use of the object. Considering the kind of painting, it incorporates within itself both a monumental scale and a refined execution.

The great Tabernacle closes with two hinged doors, in part still functional, demonstrating the level of specialization and quality of the artisans who worked in this discipline in the fourth decade of the Quattrocento. But it is also true that its unusual characteristics rely on a very rigid panel restraint system and a large frame that is integral to the panel and contributes to restrict the forces of the wood. While these are mostly positive factors for the preservation of the artifact, in large-scale paintings, tensions are created that can cause cracking in the support as the wood ages. The study of the structure, down to the smallest detail, revealed important evidence that the workmanship still maintained the construction criteria of the thirteenth and fourteenth centuries, found similarly in the great arched altarpieces of Cimabue, Duccio, and Giotto, made more than thirteen decades earlier.

Before and during this study of the Tabernacle, other paintings by Fra Angelico were examined. These assessments brought to light the reality of a painter who created a wide variety of objects, among them: triptychs, polyptychs, small panels, rectangular altarpieces (like the Cortona Altarpiece and the Coronation of the Virgin of the Galerie degli Uffizi), and arched ones, (like the Coronation of the Virgin of the Louvre). Fra Angelico is thus a painter who, through his art, demonstrates a pathway that traces a dividing line between late Gothic culture on one side, and on the other side, the development of a momentum for renewal. Such characteristics are evident on the pictorial surface where there is a greater command of the use of perspective, but above all, stand out in the construction of the wood support. In fact, all of his paintings until the middle of the third decade of the Quattrocento are made in a so-called medieval way. With the Annalena Altarpiece, there is a complete shift that affects all the paintings that Fra Angelico makes subsequently. These innovations involve the panels at all levels: from their shape, to...
the innovative attachment of the partially-sliding crossbars, to the frames that are no longer integral to the panel. Examples are the San Marco Altarpiece, and that of Bosco ai Frati, and the ones that followed. The innovations infected his closest collaborators, Filippo Lippi, and the students Zanobi Strozzi, Benozzo Gozzoli, and Domenico di Michelino, and spread to other Florentine painters who in turn added their own adjustments. These changes around the middle of the fifteenth century also affected the Sienese painters who worked on the panels for the Duomo of Pienza. The innovations infected his closest collaborators, Filippo Lippi, and the students Zanobi Strozzi, Benozzo Gozzoli, and Domenico di Michelino, and spread to other Florentine painters who in turn added their own adjustments. These changes around the middle of the fifteenth century also affected the Sienese painters who worked on the panels for the Duomo of Pienza.3

The Construction of the Wood Support

The monumental arched structure is made of various elements that are closely connected: the main altarpiece panel support with its crossbar reinforcement system and the precious frame; the two doors that close, each painted on both sides; and the three painted scenes that form the front panel of the predella at the base.

The main part of the altarpiece with the Madonna and Child is definitely the most complex and carefully defined element, consisting of the weight-bearing structure that allows for the insertion of the hinges that secure the doors through the frame and the support. Considering the notable thickness of the sides of the structure and the lack of finish on these parts, it is reasonable to imagine that the painting was planned to be inserted within a stone frame in a wall. The installation attachments probably included two iron pieces that extended from the sides of the painting and anchored laterally in the wall. Since these were eliminated in the past, what remains of this early plan are two cylindrical holes on the sides halfway up. An additional attachment was present at the top of the arch, halfway through the edge of the panel and that allowed the painting to be safely held upright inside the niche. It was composed of the combination of two soldered metal lengths, inserted in a hole made diagonally from the top, inside of the splayed frame, and emerging on the reverse; this element has a forked shape in the upper part and, secured with a kind of wing-nut, found a solid grip on a threaded iron piece in the wall; at the other end, the two points that are not soldered diverge and are inserted in the crossbar lengths assuring an excellent grip for the anchorage system (Fig. 1).

The panel is composed of five vertical planks of poplar, each 3 cm thick (Fig. 2). Wood is a typically anisotropic and heterogeneous material and therefore to understand the characteristics of the structure, it is useful to describe each plank. The first from the left, as seen from the back, is 26 cm wide, with a sub-radial cut with a relatively straight grain, an average and relatively regular texture without knots or particular defects. The internal surface is facing toward the preparatory layers. The second is 36 cm wide with an intermediate cut close to sub-radial with tangential parts in the center, a curvilinear grain, a medium, relatively homogeneous texture, except for the central part of the plank. The tree rings are relatively pronounced and have a distance between them that varies from 5 to 11 mm. The third is 36.5 cm wide with a diametrical cut, shows some knots, and has a medium texture with irregularities in the areas around the knots, and a moderately curvilinear grain. The fourth plank is 35.5 cm wide with a cut near sub-tangential (with two wide flame figures), a slightly curved grain, and a more or less homogeneous wood consistency depending on the area. The fifth is 43 cm wide, the cut is quite close to the diameter, the grain is nearly straight, slightly pronounced, and the consistency is not very homogeneous. Worth noting is a small horizontal fracture in the grain of the wood.

The planks are butt-joined, the joins are perfectly aligned, and there are no internal connecting elements. The panel, once assembled, was planed smooth both on the side that would receive the ground layers and on the back. This was carried out with a small plane working horizontally. The planing of the front face can be described as flawless in that the difference in the thickness in the gesso of the ground is barely seen and no disruption of the wood grain is visible. The back of
the support was carefully planed with the same tool and working criteria but somewhat less care, yielding a more or less extensive disruption of the wood grain. On the back of the panel, four planks have been attached in a kind of wide crossbar system; the lowest is 36.5 cm wide, that in the center (starting 1 meter from the bottom) is 36 cm wide, while at the top two planks together (the lower measuring 51 cm and the other of 36.5 cm) cover the entire arched portion totaling 87.5 cm. These three elements are 3.5 cm thick, of a medium grade, using cuts of wood that are relatively central within the trunk with knots of various sizes (Fig. 3). The grain is quite non-homogeneous and finishing has been done with a plane. They are attached to the panel with a calcium caseinate glue and with several nails inserted from the front, with the heads well recessed under the surface of the panel and isolated with small plugs of poplar so as not to affect the preparatory layers (Fig. 4). This measure calls for a longer working time with respect to a simple fill or the application of layers of canvas or parchment over the heads of the nails and shows a sophisticated technique characteristic of some elegant medieval structures like the Crucifix of Santa Croce by Cimabue, or Renaissance panels, like the San Zeno Altarpiece by Andrea Mantegna.

On three sides of the perimeter of the front surface (on the vertical sides and on the upper arch) the robust splayed frame pieces have been applied. These overlap the panel with a width at the base of 14.5 cm and are 19.5 cm thick. The two straight vertical sides are each made of a single element of poplar carved from the middle of a trunk with the shape in cross-section of a right trapezoid. The arched part is made by overlapping, in six layers, numerous sections of poplar, custom-cut and carved to obtain together the matching trapezoidal profile. The curved part is made with a laminated system with the various pieces nailed and glued to each other in a staggered way so as to create a very tight and solid structure (Fig. 5). The areas of contact between the curved and the vertical parts of the frame do not meet with a flush surface: in fact, the two upper layers interlock in matching sites on the vertical strips in a way that provides a strong connection between the elements of the frame and together reduces the risk that the intersection between arch and straight portion becomes conspicuous on the paint surface. The frame is secured to the panel with glue and nails inserted from the back. To make the panel more rigid and resistant, additional strips were applied around the perimeter of the back, fitting in between the horizontal crossbars precisely. Triangular-shaped pieces of poplar were inserted in the corners to complete the structure on the back of the panel (Fig. 6). Looking at the structure of the back, the reinforcement is impressive and
the overlapping of several elements make the whole extremely solid. The reason for this can be found in the specific function that this structure had to carry out in order to allow the doors to open. The central altarpiece had to provide a solid anchor point to support the weight of the projecting doors and to allow for their swinging motion. This is why, for each door, three hinges with deep iron straps (gangherelle) were inserted fully into the frame, emerging on the back in a double-forked trunk (Fig. 7). Of this hardware, only the central elements currently remain, and these, in any case, no longer carry out their original function because the connecting dowels have been cut out. The four other iron straps were removed and substituted with hinges screwed on the sides in a relatively modern period. Additionally, three metal elements were inserted from the top and halfway up the sides (of these only the one at the top is still present) that serve to firmly anchor the altarpiece to the wall and hold the entire weight of the structure which could be subjected to a major weight shift forward at the moment when the doors are opened. On the front side, another frame serves to connect the large splayed frame and the panel surface. It is 8 cm wide, with a 3 cm flat portion and a carved portion of 5 cm. The arched part of the frame is made of three curved segments; all of the elements are secured to the panel with glue and nails. The join between the vertical sides of the frame and the lower element is made with two cuts: square in the flat part with the verticals extending through, and at a 45 degree angle in the carved part. This technique, widely used in woodworking for furnishings of churches and civil palaces, is usually applied in the construction of large doors and windows in that it also provides a greater stability to the whole join.

The altarpiece is closed on the bottom by a simple plank of poplar 177 cm long, 26 cm wide, and 3 cm thick that covers the entire depth of the altarpiece including the frame and crossbars. It gives a certain strength and integrity to the splayed frame, the panel, and the crossbar on the back, elements to which it is still secured by an old series of long nails. This plank does not belong to the original structure of the Tabernacle but comes from an adjustment carried out during an old repair to the painting or at the time in which the predella was taken apart and divided into what is now three pieces.

We can conclude with confidence that originally there was a plank placed at the base and secured to these parts of the altarpiece; in fact a different color of wood clearly appears where contact protected the wood from exposure, maintaining a lighter, clean area. This area is furthermore perfectly smooth, above all, where the two ends of the great frame and of the frame applied to the main support are (Fig. 8). On the ends of the main frame there are visible traces of glue that serve as evidence of the attachment to the bottom plank. The
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The base, different from that which is currently present, was slightly larger and extended forward another eight centimeters; it is not possible to determine if the front side was smooth or carved to match the frame of the lost predella box. The loss of this plank can be ascribed to different causes, among them wear over time and abrasions caused by friction with the doors, or damage from dismantling during various moves of the altarpiece over the centuries, especially during the eighteenth and nineteenth centuries. On the back of the altarpiece, there are numerous areas of grey fill made of sparry calcite in a protein binder, probably applied originally on areas considered delicate and therefore to be protected as was a typical way of treating the finishing of these artworks. These areas correspond to the metal hardware, the knots, defects in the wood, areas along the joins, and between the crossbars and the panel. The same kind of fill material is found on the three small panels of the predella as we will see later (Fig. 9).

The two doors are similar in structure to each other. They are painted on both sides and are made of a panel with a surrounding perimeter frame. The door on the left has a figure of Saint Mark on a dark background on one side and Saint John the Baptist on a gold ground on the other. It is the one made to close first against the altarpiece, while the other door, with Saint Peter on a dark background and Saint Mark on a gold ground, completes the closure of the tabernacle resting against the other door and having, on its inside, a latching mechanism with an internal bolt catch seen by X-radiography. The two doors are edged with the same system used commonly for double doors: that is, in the area where they make contact on closing, they have a shape with three stepped levels that perfectly align so as to isolate the inside area from eventual deterioration factors (such as excessive humidity or dust) present in the surrounding environment.

The right door has a panel 90 cm wide made of two poplar planks, both with a radial cut. Measuring from the hinge side, the first plank is 53.5 cm and the second 36.5 cm wide, both with a thickness of 3 cm. The planks are butt-joined without internal connecting elements and they have traces of wood-boring beetle damage that occurred before the ground was applied. Thanks to the X-ray and from the application of the ground, it is possible to see that the wood planks, once assembled, were planed with a small plane with the final passes carried out, as usual, horizontally (Fig. 10). On the front and back, the panel is edged by a perimeter engaged frame carved similarly to that of the central altarpiece. On the vertical sides and in the upper quarter-circle

8. Detail of the underside of the altarpiece. Note the structure of the splayed frame created with a single poplar piece. Furthermore, traces of glue from a plank that closed this area originally can be seen.

9. A detail of the back surface in which numerous fills are seen, and on the sides, marks remain from old hardware for securing the altarpiece in the niche, now removed.

10. X-radiography detail of the left door in which traces of the diagonal planing of the panel are clearly visible.
doors (three per door), of which four still function, allowing the doors to swing. The metal elements consist of a flat iron piece inserted into the panel of the doors within a cavity carved from the internal surface (that which shows the saints on a gold ground.) The hinges of each door have three different shapes according to their position. At the top, the hinge strap is 3.5 cm wide and curved; it is set within the panel and covered by the curved part of the frame. At the center, the hinge strap is 3 cm wide and positioned vertically, again under the frame. At the bottom, the iron piece is again 3 cm wide and positioned horizontally under the lower frame at a distance of about 18 cm from the bottom. All of the hardware has been inserted into fitted cavities with nails passing through holes that were previously made in the hinge strap. It is notable that the majority of the nails have almost always been inserted diagonally and in slightly different ways as seen in the X-ray film. The nails that hold the hinge straps at the bottom on the right are pointing upward while on the left they point down; those used in the center at the right are pointing out, while on the left they appear to be straight (rarely the point emerges from beyond the edges of the hinge strap); at the top on the right the nails were applied from the bottom up, initially toward the inside and then, moving toward the outside, while on the left only the lowest nails appear to be present and some holes in the hinge strap clearly appear empty and unused.

At the base, the tabernacle has a predella with three painted scenes. Currently, these are three separate panels set within a single gilded frame of recent construction. Originally, the predella would have had the traditional box-construction with a plank placed horizontally in the front bearing the
Ciro Castelli, Mauro Parri, and Andrea Santacesaria, The Linaioli Tabernacle: The wood support

outside, giving an obvious asymmetry to the panels. There are, however, other very clear marks that may have been used during the assembly of the predella. These are vertical incisions made with a metal point and vertical red marks carried out on top of the fill. These last marks serve to establish the current structure because their spacing appears to follow a true symmetry which places the three scenes in an appropriate sequence. The panels were positioned so as to respect the space required by the iconography and in relation to the marks made in a horizontally aligned and vertically equidistant
way. Furthermore, examining the upper and lower edges allows us to see that, at the top, the panels may not have touched, while at the bottom they may have been cut down somewhat. This is then supported by the decidedly downward shift in the original position of the flame figure from the center of the plank. As far as regards the distance that the three scenes should have between them, it is useful to note that though on one hand the vertical incised lines help us to find parameters, on the other, determining this with precision is made difficult by the thick application of wax on the back of the *Saint Peter Preaching*; this layer does not accurately allow us to see marks on the back, except for the shape of the gesso fills. We can, however, imagine that the missing part of panel between the scenes would have covered 3 to 3.5 cm and it is along these areas that we find vertical dividers inside the predella box, held, as is traditionally done, by nails inserted from the front and therefore covered by the frames that border the scenes (Fig. 16).

In summarizing all the hypotheses about the original structure of the predella formulated up to now, it is useful to consider the original marble frame that holds the tabernacle in the Museum of San Marco and the measurements that have become an important reference. The niche that holds the painting has a total height of 361.5 cm and a width of 192 cm. The altarpiece is 289.5 cm high, the upper hook for securing it extends 4 cm; if we subtract the height of the altarpiece (289.5), the space of the lost marble frame (18), and the upper hook distance (4), there remains a gap of 50 cm. The width of the predella could have been wider with respect to the altarpiece to completely fill the width of 192 cm following a precise aesthetic plan that would tie into the width of the upper part when the doors were open. In fact, the mounting of the whole tabernacle foresees, as a rule, first the placement of the base which could occupy nearly the full width inside the marble frame, and then the installation of the altarpiece that would have to be narrower to give space for the doors to open with a rotation of greater than 90° without being impeded by the marble frame on either side. From this reconstruction we deduce that currently, the front panel is missing 31.5 cm. If we consider that the painted margins of the predella scenes are complete and define the original dimensions of the scenes, the missing parts were wood and were covered by the frames. The predella had very strong sides with a thickness of over 10 cm so as to sustain the weight of the overlying structure and in particular the wide splayed frame that is found sitting in line with these. The front plank was attached to these elements with nails inserted from the front, some of which are visible in the X-ray in the two side panels. There were probably only two internal dividers and they were found aligned with the unpainted parts between the scenes; these elements could have had a width of about 3 to 3.5 cm and were nailed to the front. On the painted panel, the scenes were completely surrounded by frames applied on the front and held with glue and small nails (Fig. 17).
**Condition**

The Tabernacle is in excellent condition due to wise choices in materials and excellent construction technique. In general, there are two macroscopic phenomena that can be seen. The first is due to natural movement and the settling of materials and the second to a change made in the lower part of the altarpiece, especially the predella.

All the components of the large structure show good planarity and integrity of the planks with little insect damage. The panel of the altarpiece is marked by three cracks along joins and a split by the head of the Child that is quite visible on the painting surface. Looking from the right side, we see that the first three join lines of the planks show clear signs of giving way. Especially in the first join (between the first and second plank), though not appearing as visible as the others, a crack begins from the bottom and extends for about 80 cm. The second join (between the second and third plank) has a crack that begins at the bottom along the join and then at about 110 cm of height bends toward the interior, following the direction of the grain of the third plank, continuing practically for the entire height of the altarpiece. The third join separation (between the third and fourth plank) begins at about 80 cm from the bottom and extends for 160 cm up to a height of about 240 cm. As we have described, the two more central fissures are more apparent, on average exposing a separation between the edges of about 2–3 mm and an evident disjunction in level between the margins of paint; the outer join appears like a crack that is slightly out of plane but the edges are in any case very close. The separated joints and cracks of the panel are due to the natural movement of the contraction of the wood that encountered, during a period of adjustment, a strong restraint from the metal nails and glue that held the crossbars to the panel. The cut of wood of the planks, three of which are radial and two intermediate as we have seen, has obviously contributed to this phenomenon. This becomes very important for several reasons: primarily it is related to the technology of woodworking and therefore connected to the original structure; another factor is that the condition of the painting provides interesting keys for deciphering the deterioration factors at work on the wood support; and finally, the information goes toward creating a frame of reference in which treatment on the wood structure of the painting can be planned.

The planks that make up the panel are subjected to a series of contraction forces tied to the type of cut that they have. This phenomenon was well known by the carpentry workshops specialized in the construction of wood supports for painting and made up an important criterion during the long period of panel painting production from the twelfth to sixteenth centuries, guiding the appropriate technical choices during the development of different kinds of supports. In fact, there is a very close relationship between the kind of panel, with its different cut and thickness of plank, and the system of securing the crossbars. In the so-called medieval period, which concludes right about with our Tabernacle, the prevailing choice of plank was a radial cut which results as very stable with minor transverse contraction movements with respect to the tangential cuts and therefore is more suited to being supported by strong crossbars anchored with nails. In later periods, therefore beginning shortly after or around 1433, a complete change is seen both in the format of the paintings, and in the choice of their component parts, above all in the cut, the quality, and the thickness of the wood used (but not the wood species!). In parallel, the crossbar systems and their method of attachment changed. The use of nails was rapidly set aside for mechanisms that foresaw movable or sliding crossbars and offered a more flexible restraint and were therefore suited to the innovations of the panel. The choice of sub-radial or intermediate planks brought with it a new kind of restraint, commensurate with the forces that develop in the plank in different directions from in the past. The new panels could warp, or contract in width and it was clear that the restraint couldn’t come from nearly fixed points without certainly causing tensions, friction, and consequent cracking (Fig. 18). With this premise, we want to approach the central issue of the specific problem tied to the cracking present on the panel of the tabernacle. As we have seen earlier, the structure is markedly medieval in the strongest sense of the term, but the panel has two planks that are not completely radial that have had a natural transverse contraction losing about 3–4 mm of width total. To this issue we can add that the period of construction of the tabernacle became in a tangible way, a moment of transition between one construction method and another quite different. The transition, as is obvious, didn’t appear completely in one precise moment but evolved through stages, true moments of transformation and, probably, technical experiences that directed subsequent structural choices toward more suitable solutions.
The structure of our Tabernacle shows signs of this development; there are however other factors that can help in deciphering the phenomena, locating it within a significant timeframe. As we know, the wood support, before being painted, undergoes a series of processes that determine the early interactions of the component materials. The application of the preparatory layers on the support includes a first coat of only glue, followed by adhering pieces of canvas to the support and then the various layers of gesso that will form the foundation for the paint. Therefore the panel, for a brief period, absorbs and loses moisture and follows a natural process of adjustment that depends, besides this, on proper seasoning of the wood. It can be said that the wood of our Tabernacle was certainly well seasoned because some of the planks used in the doors show signs of old insect damage; in other cases, as for the wood of the predella, the presence of recycled wood is a possibility. These details show how important having stable wood was for the carpenter.
and also how planks with no insect damage were chosen with the same criteria. Beyond this, the evident contraction of the planks is due to characteristics of the wood material, that is therefore the cut of the planks and the migration of moisture caused further movement and settling. The contraction is evident and it is calculated to be an average of 3–4 mm of substance total. Observing the effects on the paint surface, we can confirm that, faced with this kind of contraction, it has remained perfectly planar and the ground and paint are well-adhered to the support: we appreciate that the greater part of the movement must have happened immediately in the early period of the life of the painting, when the layered materials were new and still flexible, still able to follow sudden movements and significant contractions of the supporting surface. Over the course of the following centuries, this quality was lost as the materials became ever more brittle. In normal environmental conditions, with generally limited extremes of relative humidity, the wood continues to move and contract even though it is by a much more limited degree, and still accompanied by the limited flexibility of the overlying materials.

Conservation Treatment History

The Tabernacle bears signs of previous conservation treatments, which as we will see, were related to the different installations of the painting and different preservation requirements. As mentioned above, four of the six original hinge straps that supported the doors were replaced with new brackets and hinges. This hardware was partially sunk into the external side of the large, projecting frame and fixed with large screws that seem to have nineteenth-century characteristics. The two metal forks of the original hinge straps positioned halfway up are still in the frame and the support, while the other four have been extracted and the cavities are quite visible in the X-ray. In addition, two of the join separations present on the panel were closed with small strips of wood extending through the support; on the painted side these were retouched to imitate the surrounding surface. On the back, the gaps were glued in segments and “bridged” with pieces of paper. These treatments over time were not able to hold the separate pieces together; when the painting arrived in the Laboratory, the strips were completely separated along the cracks and it was even possible to see light through the gaps.

The Conservation Treatment

The treatment plan took into consideration a series of factors that had emerged during the research phase. First of all, the quite solid and well-held together type of structure on one hand still clearly showed natural settling fluctuations and on the other, incorporated materials that had lost most of their original flexibility.

The considerations expressed during the research phase on the technique and deterioration allowed us to delineate quite a thorough treatment plan while limiting it only to the areas where the panel of the altarpiece showed visible discontinuities due to separating joins and deep and extensive cracks that marked the painting visibly and disturbed its correct reading. The structure in general is well preserved, though it was given some general treatments which we will address later, carried out in subsequent periods at suitable times so as not to interfere with the more localized treatments that were performed.

As we mentioned earlier, the most apparent structural problem of the Tabernacle guided our procedural choices for the panel treatment.

The phenomenon of cracking and separating joins of a panel is common to many panel paintings of every period; aside from the various original causes, the solution is not always the same. The cracks indicate where the structure is interrupted: the failure of joins between planks or splitting inside the same plank that leads to the separation of broken edges and a discontinuity of the paint along these margins. The reinforcement of the affected areas is normally done with a technique using wedges (incuneatura). This method relies on opening a narrow channel in the wood into which aged poplar segments, triangular in cross-section, are inserted precisely. This technique of reinforcement can accommodate various adjustments such as that of inserting and gluing thin strips of aged poplar into very narrow openings (about 1 mm), or using only glue without wood. However executed, these procedures have the scope of recreating the lost continuity, interrupting the process of separation and consolidating the panel. These procedures are absolutely recommended and can be carried out without risk where the support has sliding crossbars and does not have major counter indications, except in unusual cases to be evaluated individually. For paintings with a medieval structure, for example our Tabernacle, the reinforcement could trigger dangerous consequences. In fact, for panels held
with metal anchor points, the gaps can even provide a kind of release valve for the movements of the support and closing these areas with the wedges can be risky. The movements of the panel might find new outlets and therefore cause more damage to the structure; in some cases we have seen failures of old treatments with the detachment of glued wedges but it can be imagined that the new damages could even affect the grain of the panels and trigger failures and splitting in areas that were previously intact.

For this reason the gaps present on the panel of the altarpiece were subjected to a measuring campaign which had the purpose of establishing the degree of movement occurring on the panel in these areas. The investigation was carried out in collaboration with the Istituto di Fisica Applicata “Nello Carrara” of the CNR (National Research Council) through the application of a distributed Bragg reflector using optical fibers. The measurements were made in April of 2003 and established with absolute precision that along the gaps in the panel movements developed to a degree consistent with and in any case always strictly correlated to the fluctuations in relative humidity of the environment; and at the time, a series of possibilities were formulated that concerned the stabilization of the display environment and provided new solutions for the reinforcement of the support.

After this preliminary work, in the years following 2003 and in the months that preceded the treatment of the support, some convictions matured which provided a base for experimentation to find a suitable solution. First of all, our treatment aimed to clean and then close the gaps so as to eliminate the deposits of dirt present and the passage of air, both deterioration factors. In order to do this, a good solution was determined to be the use of balsa wood. Previously, with this particular wood species the gaps present in the Rosano Crucifix were closed by inserting strips of this material into the gaps without glue. In this way the passage of air was effectively blocked as well as the resulting deposits of dirt, often linked to wood-boring insect damage. The balsa wood has different properties which makes it preferable to other types of wood or other fill materials. It is easily workable, light, compressible, and expandable, especially suited to fill narrow spaces without creating tension or obstruction. Based on these considerations, some experiments to check the hold of the balsa wood were initiated in order to improve our understanding of its characteristics and to understand if it could perform other functions in the reinforcement work on our altarpiece. For this, models in poplar wood were prepared with separating joins and cracks similar to those being addressed. These were reinforced with balsa pieces glued with Bindan PVA adhesive into precise channels. The results of this study were truly encouraging. In fact, the balsa wood is suitable for many reasons: it carries out the function of perfectly sealing the gaps, it connects to the edges of the panel in a solid way, and at the same time allows for re-aligning and maintaining the adjacent edges of the gap in the panel at the same level. Furthermore, the small panels joined with balsa were put under tension forces with traction and compression measured locally with a centesimal dial gauge during which the material proved flexible and yielded without losing adherence or disrupting the alignment with metal anchor points, the gaps can even provide a kind of release valve for the movements of the support and closing these areas with the wedges can be risky. The movements of the panel might find new outlets and therefore cause more damage to the structure; in some cases we have seen failures of old treatments with the detachment of glued wedges but it can be imagined that the new damages could even affect the grain of the panels and trigger failures and splitting in areas that were previously intact.

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between the sides. Therefore, thanks to this research, a truly solid and flexible joint was developed that has the necessary characteristics to function in our particular case (Fig. 19).

The reinforcement was then carried out in 2009, initially by removing the strips and glue inserted in the past, and proceeding with lightly shaving down the edges to be joined. This preparation was done only in the channels where the panel was not covered by the crossbar system. The channels were opened in some areas with a router with a cylindrical bit, in others using a conical bit with a very narrow angle so as to eliminate the deposits of dust and provide a good surface for adhering the new wood pieces; the treatment was limited in scope to only the open gaps (Fig. 20). The edges of the gaps were brought into alignment with gentle pressure from tie rods and the balsa pieces were inserted and glued in place with Bindan PVA adhesive. The closing of the separated joints by inserting balsa strips was mostly done from the back though completed from the front in the areas covered by the crossbars. The filling was further completed on the front with a row of balsa pieces inserted to fill the gaps, positioned slightly below the paint surface, as a foundation for the later filling. The panel was freed from the tie rods and maintained the correct level, confirming what had been seen experimentally (Fig. 21).

We conclude that with the simple use of balsa wood, a viable solution to a specific problem was found, common to many wood supports with a typically medieval structure. The flexible joint allows for a durable connection and also maintains the possibility of accommodating the natural movements of the panel over those areas without creating additional stresses. Furthermore, the work was confined to areas where access was possible and therefore limited in terms of invasiveness and the use of extraneous materials therefore avoiding damaging the integrity of the work or altering the original constituent values of the painting.

Additional reinforcements were made on the outside surface of the large frame of the altarpiece where there were deep cavities that held the old iron pieces that anchored the painting laterally in its initial installation. These areas were filled with wood inserts: small pieces of aged poplar glued with Bindan. The holes left on the back of the painting from the original hinge straps (substituted by a modern screwed-on hinge system) were closed with elements in balsa, suitably carved and adhered with a light application of Bindan.

Subsequently, the painting was carefully cleaned on the back, vacuuming away the dust deposits. Then all the parts were given an anoxic de-infestation treatment and protected with Permethrin insecticide applied by brush. The back of the altarpiece and two of the three predella panels were protected with microcrystalline Multiwax 445 dissolved to 4% in ligroin (Fig. 22).
22. Reverse of the central panel, after treatment.
el was constructed and then the crossbar system used by the carpenter. First the panel, anchored the large frame on the front. Inserted from the back, in passing through the panel, it was surrounded by crossbars and back of the panel; its thickness of the planks (3 cm), on the other hand, tied on one side to the relative thickness of the planks (3 cm), on the other side to the pyramidal form of the nails and the impossibility of bending them; finally the substantial weight of the doors has to be taken into account. These are the factors that led to the insertion of diagonal nails so as to secure better the iron straps of the panel.

15 The planks with a radial cut develop minimal shrinkage in width and the most in thickness.

16 It is useful to remember that even the way in which the nails are inserted contributes to reduce risks from restriction that can be caused by their presence.

17 As noted at the beginning, Fra Angelico is the painter who over the course of his production, and in particular at the end of the 1430s, first showed tangible technical innovations in the supports of his paintings, in the frames, and in painting. These changes, which in particular involved the crossbar systems, were copied by his collaborators and then by other painters of this period who were working in and around Florence. It is reasonable to think that the novelty that is found in the construction techniques in the later decades in Urbino and surrounding territories is attributable to the experiences begun with the Annalena Altarpiece and that of Bosco ai Frati.


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1 Dipinti su tavola: La tecnica e la conservazione dei supporti, edited by M. Ciatti, C. Castelli, A. Santacesaria, Florence 1999.

2 This evolution of Fra Angelico is given a detailed treatment by Mario Salmi in the foreword of the 1955 catalogue of the Fra Angelico exhibition. He cites, among many paintings, the Triptych of San Domenico transformed into a pala and the scene of the Death of St. Nicholas, in the predella of the Triptych of Perugia.

3 The subject has been extensively addressed in the article of C. Castelli, M. Ciatti, M. Parri, A. Santacesaria, “Considerazione e novità sulla costruzione dei supporti lignei nel Quattrocento,” OPD Restauro 9, 1997, pp. 162–74.

4 As stated on several occasions, the practice of arranging the planks with the internal part facing the preparatory layers can be truly considered a rule, in existence since the first examples of the twelfth century until the last ones of the sixteenth century. The reason is linked to the characteristics of the wood in that as it ages the planarity is maintained as much as possible, or rather, the risk of deformation is reduced the most.

5 It was not possible to verify with certainty the presence of an adhesive between the crossbars and the back of the panel; its application was detected in some small stains between the crossbars and panel but there is reason to infer its use analyzing the criteria adopted in general in the construction of this altarpiece. It is a strong structure, well held together with planks, crossbars, and frame forming a solid unit. Furthermore, we find evidence of glue used to secure the original planks on the bottom of the tabernacle.

6 Reconstructing the stages of putting together the support of the altarpiece allows us to establish, thanks to the nailing pattern, the sequence used by the carpenter. First the panel was constructed and then the crossbar system was applied with nails inserted from the front. Then the splayed frame and the vertical elements on the back were attached; these contributed to strengthen the panel as nails inserted from the back, in passing through the panel, anchored the large frame on the front.


8 Technical examination record no. 1471 in the Laboratorio Scientifico of the Officium delle Pietre Dure.

9 Working the wood in the horizontal direction opens the pores of the wood more, so as to favor better adhesion with the first application of glue.

10 The presence of exit holes from wood-boring beetles when the ground was applied is unusual, though possible. This condition generally leads us to think that the wood was much older than a typical seasoning or it may be a re-used piece from another object, or from a tree that died standing, or finally, from a trunk that was felled and remained too long on the ground before being reduced to planks. It is hard to say at this point if this was used knowingly thinking that it was a more stable material, or rather from simple thriftiness.

11 The diagonal insertion of the nails is not random, but tied on one side to the relative thickness of the planks (3 cm), on the other to the pyramidal form of the nails and the impossibility of bending them; finally the substantial weight of the doors has to be taken into account. These are the factors that led to the insertion of diagonal nails so as to secure better the iron straps of the panel.

12 It is good to remember that it is not rare to find fills like this on painted panels even if in this case the treatment is quite extensive.
When our Laboratory became involved with the project of the *Triptych of the Badia of Rofeno*, we immediately found ourselves confronted by quite a complicated artwork. The sixteenth-century stylistic remodeling had added a large quantity of new material and contributed, on one hand, to a change in the original appearance of the painting, and on the other, to compromising the preservation of the paint. Other related issues were the integrity and condition of the surviving fourteenth-century parts which had endured both the sixteenth-century transformation and the restoration treatments of 1910, 1950, and 1996.

Finally, we evaluated our assessments in the context of the environmental conditions of the museum where the triptych has been displayed. This is all essential for being able to plan a systematic treatment for the consolidation of paint as well as making the support and the other attached architectural parts as functional as possible.

Other important questions to resolve related to the altarpiece's historical origins. In fact, the sixteenth-century modifications had led some scholars to believe that the triptych was the result of an assemblage of paintings by different Sienese masters. However, a preliminary examination of the object shows the structure to have been created following a single, coherent plan in terms of the technique but also the materials used. The color and morphological properties of the wood of the panels and crossbars, the extreme similarities in the way they have been worked, the presence of dowels (*cavicchi*) in the joins, the dimensions, the thickness, and proportions of the panels indicate that this was created in a single time period and by one maker. The crossbars, divided up panel-by-panel in the sixteenth-century treatment, used to match perfectly—in terms of shape, dimensions, the way they were nailed, in addition to being made of the same materials. Furthermore, the crossbars are positioned on the support in a way that is typical of triptych tradition and Sienese polyptychs. As we will discuss further, the Trecento parts unequivocally belong to the original triptych design.

As we will later see in detail during the different phases of research and treatment, the artwork was approached with great care, testing techniques and subjecting the results to an ongoing critique, determining the best treatment strategy as work progressed. The final result was reached while working with the artwork under constant observation, carefully checking the behavior of the painted panels.

The treatment carried out on the painting by Ambrogio Lorenzetti was essentially approached from two directions: first the triptych was freed from the sixteenth-century frame and after that, the conservation work was carried out on the fourteenth-century parts as well as the sixteenth-century additions. The dismantling work undoubtedly served to clarify and make more apparent the structural methods of the original, bringing to light a series of elements that serve as evidence of a clear, well-defined design. Analyzing the support allows us to appreciate the quality of the carpenter’s workshop that was chosen and the procedural decisions made during construction.
The construction technique of the triptych

After removing the sixteenth-century frame, the painting appeared essentially whole in terms of its central core and with its frame almost intact. Observing it, we were able to appreciate the way the painted scenes were divided; these different parts, though by themselves adequately clear, were missing some original architectonic ornamentation which would have geometrically and architecturally completed the whole, like, for example, the predella box at the base of the whole altarpiece and the two lateral pilasters. These framing elements would have given the painting better compositional and spatial proportions.

The current predella and pilasters are from the sixteenth-century reconstruction.

In addition to these considerations, while studying the artwork, we were able to confirm that despite the various incidents and alterations over time, the elements that have come down to us are essentially complete and the losses limited to some of the internal attachments, therefore it is possible to define the original structure precisely.

The triptych is on two tiers: the lower part contains the central rectangular panel with Saint Michael and the side panels with Saint Bartholomew and Saint Benedict; the upper order is contained within the triangular gables. The center contains the Madonna and Child which is an independent panel with its own crossbar and a way of fastening to the lower part that is reversible; to the sides are Saint Louis of Toulouse and Saint John the Evangelist. The structure of the triptych is based on a main section that incorporates Saint Michael and the two lateral saints with pointed arches, connected together with three dowels inserted in the sides of the flanking panels and on the back by two continuous, nailed crossbars; the panel of the Madonna, as mentioned, is an element apart that fits into two brackets on the upper border of the panel of Saint Michael.

During the dismantling of the altarpiece, very important evidence about the two triangular gabled tops with Saint Louis of Toulouse and Saint John the Evangelist came to light: from a careful examination, in addition to studying the pattern of growth rings of the wood in the X-ray, as well as traces of paint, it was possible to determine with certainty that these had been cut off and made independent though they had once been continuous with the support of the lateral saints, making for a single gabled panel on each side. Moreover, by looking at the corresponding edges along the cut, corresponding marks with a matching form can be seen, as if the tops were unevenly sawed off, without later being smoothed. When the pieces are put next to each other, the only missing material seems to be the “path” that the saw opened through the wood.

The structure of the panel

The Triptych of the Badia of Rofeno has a support made entirely of poplar wood, meaning both the panel and crossbars.

The panel of Saint Michael is 102.1 cm wide, 123.5 cm high, with a thickness of 3 cm. It is made of a central plank that is 61.1 cm wide to which two narrower lateral planks have been butt-joined and glued with casein (Fig. 1). There are also three dowels (cavicchi) in each join. The panel has then been enlarged again with two 5 cm strips, again butt-joined and glued with casein and furthermore, nailed with four metal nails each. The central plank which by itself makes up the majority of the panel has a sub-tangential cut with a broad, central, cathedral grain or flame pattern while the four side pieces are more central cuts, perhaps taken from trees of smaller dimensions, which for some sections, show slab-cut areas. The dowels seem to be chestnut because the X-ray image shows a density similar to that of the dowels connecting the central panel of Saint Michael and the two lateral saints which were extracted and therefore examined. These are on average 11 cm long with a diameter of about 1 cm and are loosely placed into holes that are deeper than the dowel; in the X-ray, the empty space between the end of...
the dowel and the end of its channel measures more than 2 cm on each side.

The panel of Saint Bartholomew is 43.5 cm wide and 146.8 cm tall. It is 3 cm thick like the panel of Saint Michael. The shape of this panel is composed of a rectangle measuring 43.5 cm wide and 103.8 cm high, topped by a triangular gable with a base that is 35 cm wide and a height of 43 cm. The panel is composed of a main plank 40.5 cm wide enlarged on the side toward the center by a 3 cm strip, butt-joined, glued with casein, and held with three nails. The main plank is an intermediate cut close to tangential with quite an irregular grain; furthermore, there is a compromised area with ring shake and a bark pocket, now friable and deeply eroded.

The panel of Saint Benedict is however made of a single plank that has the same measurements as Saint Bartholomew. The cut is also an intermediate cut close to tangential with a broad, central cathedral grain. The quality of the wood is slightly better with respect to the plank of Saint Bartholomew, the grain is slightly curved and the knots are quite few.

The three panels are connected with three dowels along each line of contact; they are simply held in position side-by-side, without additional constraints or gluing, creating a combined width of about 192 cm (Figs. 2–4). On the reverse, two poplar crossbars (7 cm high, 4 cm thick, and about 190 cm long) were applied. One is positioned about 10 cm from the bottom, the other is directly under the base of the gables. The crossbars were anchored with metal nails inserted from the back and clinched back down from the front, under where the ground layers were later applied. Two nails for each lateral panel and four for the central panel were inserted. An important characteristic of this anchorage is the presence of a horizontal slot made in the underside of the crossbar corresponding to the passage of the nail shaft. Let us
remember that in the medieval period, putting in nails required that the panel and crossbars would be prepared first with holes using an auger and then the shaft of the nail would be inserted; therefore the nail was housed in a channel that allowed for some movement of the panel but the elements that found themselves pressed between the nail head and the bent back point would still be held together. In this quite special case—to date not seen elsewhere in panels with nailed crossbars—the medieval method is carried out with an interesting twist: a slot increases the space the nail can move in the crossbar and therefore allows for a little more movement in the panel (Figs. 5–6). This feature is unique and is justified by the cut of wood used in the planks of the panel which, as we described, is mostly intermediate and sub-tangential. This cut can cause, over time, a large transverse contraction. However, the nails have room that allows for greater movement of the panel, diminishing the risk of cracking or the joins separating. The planks of this type have greater instability with respect to radial planks commonly used in this same time period. In fact, until the first decades of the Quattrocento, there was a perfect and virtuous symbiosis between radial planks and crossbars anchored with nails; in our case, the planks were subject to tangential shrinkage that can provoke warping and linear contraction in the transverse sense. The carpenter building the triptych made slots in the crossbars to reduce the risk that a transverse contraction of the panel would jam against the nails and cause cracking of the picture plane. Let us say that these craftsmen put into effect, with great foresight, an adaptation that would be developed more than a century later. From this detail we may conclude that, although over time the movement of the plank has in any case been restricted by the nails and resulted in cracks, the carpenter understood the behavior of the available materials quite well, a further sign that there was a solid workshop tradition specialized in building panels for paintings.

The gable with the Madonna and Child measures 91.8 cm at the base, is 88.5 cm high, and is 2.5 cm thick. Is made of three planks; the central one is 49.1 cm wide and the two sides measure 21.7 and 21 cm. The planks are butt-joined with casein glue and have one dowel per join, centered in the face of the join, 23 cm from the base. Observing the shape, the size, and density in the X-ray, we see similarities with the dowels inserted in the panel of Saint Michael. The central plank is a sub-tangential cut with a broad cathedral grain in the center. The quality of the wood is not homogeneous and the grain is curved in part by the presence of a large knot at the bottom which is similar in terms of deterioration to that in the panel of Saint Bartholomew. The two lateral additions meanwhile are mostly radial. The panel is reinforced on the back by a single crossbar, placed about 15 cm from the bottom and attached with three nails, one in each plank, with the same anchorage technique used in the central section.

During the construction of the two tiers, a system that allowed them to be reversibly connected was incorporated. In order to do this, under the crossbar of the gable of the Madonna, two wood pieces (3.3 cm by 1.8 and 30 cm long)
were applied. These were inserted in channels that were a little more than 1 cm deep, carved in the lower border of the crossbar. Each piece was anchored with a nail about 3 cm from the lower edge of the panel. These elements, though held by a single nail, were nevertheless quite firmly held thanks to the channel in the crossbar that prevented any rotation (Figs. 7–10). These created a convenient and solid connection as they precisely fit into brackets secured on the upper edge of the back of the main panel of Saint Michael. The brackets are made of poplar wood, 15 cm wide, 8 cm high, and 3.5 cm thick. They are held by a pair of nails inserted from the back, bent around from the front and covered by the frame border that overlaps the edges of the painted scenes. To ease the insertion and alignment of the panels, two shallow reductions were made in the back of Saint Michael to accommodate the connecting elements precisely. The panels of Saint Michael and the two lateral saints were completed by frames around the perimeter. Specifically, the panel of Saint Michael has a flat frame about 5 cm wide and about 6 cm thick with an internal molding along the entire perimeter. The saints have a similar frame on the
outer vertical edge and at the bottom (Fig. 11). A simple frame molding, about 1.5 cm wide, was applied to the internal vertical borders, leaving space for the columns that separate the paintings. This molding was applied along the gabled edges, including those of the Madonna and Child, and along the boundary separating the rectangular zones from the two lateral saints in the gables. It was probably also applied above the wider frame along the horizontal lower borders of the three scenes and upper part of the panel of Saint Michael. The diagonal sides of the gables certainly originally had carved frames attached with glue and nails, though today these are totally lost. From the X-rays, it can clearly be seen how the front surface of the panel was worked with a plane, in a slightly diagonal, mostly horizontal direction. This planing would have smoothed the surface and broken up the wood grain slightly, giving it tooth for the glue to grip for adhering the canvas to the panels (Fig. 12).

**The sixteenth-century transformation**

The altarpiece has undergone a major transformation, dictated probably by aesthetic and cultural needs which profoundly marked some fundamental aspects of its original structure. Above all, the new presentation disturbed the reading of the artwork so much so as to cast doubt on the consistency of the panels and their belonging to the same original group (Fig. 13).

In order to be arranged in the sixteenth-century configuration, the triptych had been dismantled. The first step was removing the gable with the Madonna and Child; the next step would have been to cut through the two crossbars of the main
register along the join between the central panel of Saint Michael and the saints. These lateral panels would have been subject to other alterations: first the remaining parts of the upper crossbar were removed (the lower one was left), by cutting the nails that held it on, leaving their tips embedded. After removing the sections of the crossbars, the gables with Saint Louis of Toulouse and Saint John the Evangelist were separated from the rectangular parts with Saint Benedict and Saint Bartholomew. The panels were cut apart with a saw, the borders were not straightened, and with this we can consider the procedures for taking apart the triptych concluded (Fig. 14).

The sixteenth-century re-assembly required first of all a re-alignment between the Saint Michael panel and the saints without their gables; the three panels were reconnected and reinforced on the back with quite crude wood lengths, nailed into the panels. Thus, in order to lengthen the lateral panels with saints up to the height of the Saint Michael panel, two rectangles of wood about 23 cm high and made of two planks (the lower one of about 14 cm and upper one of 9 cm) were positioned with their grain running horizontally. These were reinforced on the back by two blocks that connect to the lower side panels and to the central one and by the two battens that are attached on the external borders that unite the extensions with the lower panels. These reinforcing additions are in poplar wood held on with nails and they are essentially coarse in terms of shape.

13. Archive photograph taken prior to the treatment of 1996 in which the gaps in the central panel appear filled with wood strips.

14. The back of the lower part of the triptych before our treatment.
and workmanship. With this addition the two lateral scenes reached the same height as the panel of Saint Michael, creating a single horizontal onto which the three gables could rest. Saints Louis of Toulouse and John the Evangelist were attached using wooden brackets similar to those that hold the Madonna onto the panel of Saint Michael, with a vertical batten placed in the center of the gables.

After the re-assembly of the triptych, the carved frames were prepared along with the predella and the lateral pilasters. The central area was decorated with a frame that extended along the perimeter of the pictorial surfaces, with a rectangular structure using two internal attachments. The frame elements are about 6.5 cm wide and 1.5 cm thick; at the corners these outer elements meet with mitered joins while the inside vertical strips are fitted into the horizontal without interruption at a ninety-degree angle (Fig. 15). The components of the frame are attached directly with glue and nails onto the original frames, hiding them completely (Fig. 16). In the corners, rosettes carved from poplar conceal the joins (Fig. 17). The two rectangular areas above the figures of saints were covered with two carved panels using matching motifs to those present on the frame. The three gables are decorated with carved pieces that extend their surface area to the sides. The triptych was therefore re-assembled in the new sixteenth-century arrangement with the three gables aligned at the same level with a new and richer frame. On the outer sides, two vertical strips have been attached to conceal those edges of the support. The triptych was completed with a predella at the base and two lateral pilasters. The predella is made in the usual way and the materials are evidently recycled. For instance, the box is made of a carved front face with an upper plank made of two elements running lengthwise, and one at the base, in addition to the sides. Within the structure, two wooden pieces at the ends and two section dividers inside reinforce the predella. These last are placed with the grain running horizontally, however the whole has a good solidity and therefore is ideal for holding the weight of the triptych elements and pilasters. The predella is 242 cm long, 30 cm high, and about 20 cm deep. The two lateral pilasters have a simple structure with three planks forming a box in which the front is 12 cm wide and the depth is about 18 cm. At the bottom and top, wooden pieces are attached that hold and strengthen the structure. The pilasters are furthermore topped by carved candelabras. The pilasters and predella are richly decorated with gilded carving. From the
radiography and by examining the artwork itself, as well as from the carbon-14 testing, the wooden components of the predella and pilasters do not seem to belong to the original fourteenth-century structure (Figs. 18–19).

Analyzing the new frame, we can see that in contrast to the refinement and high quality of the carving, the wood employed for a structural function seems to be rather poor. For example, the elements that connect the panels of the triptych are certainly recycled planks attached without any adjusting. Furthermore, one of the two planks used to close the sides has a series of very clear, regular gouge marks; it is very likely that the plank was the surface on which the rosettes applied in the corners of the frame were glued and carved (Fig. 20). Also, the predella and pilasters have internal parts that are very deteriorated or modified and recycled from other objects.

**Condition**

The painted panels arrived in our Laboratory with serious structural problems. The deterioration of the artwork has undoubtedly a series of causes that are overlapping, deriving both from the original technique of construction and from the problems introduced by the sixteenth-century frame, as well as the display environment. We can confirm that the deterioration that has occurred recently due to a lack of climate control in the Palazzo Corboli moved forward the schedule for a major treatment which the artwork would have needed anyway.

As previously described, the carpenter used planks with a sub-tangential cut when assembling the panel, above all in the center of the panel of
Saint Michael and in the gable of the Madonna and Child. The planks have suffered a clear transverse contraction, (above all in Saint Michael) that has caused wide splits along the joins with the lateral planks. We have already said that the nails that hold the crossbars are in enlarged channels that allow a good degree of movement for the panel. However, the degree of shrinkage is seen to be quite a bit higher than foreseen and consequently, the nails are impeding movement and causing the planks to separate. Moreover, this tendency for transverse contraction typical of sub-tangential panels has undoubtedly reduced the underlying surface area for the preparatory and paint layers. In the early life of the painting these movements could have happened without damage to the ground and paint thanks to the flexibility of the materials. The same contractions, taking place more recently when the materials had become brittle, have instead caused losses and lifting of the paint. These assessments apply to nearly all the planks of the panels that are from similar cuts of wood. Wherever the wood has contracted transversely, lifting and flaking has occurred. Additionally, in the panel of Saint Michael, this has also caused quite evident cracks and opened wide gaps.

The sixteenth-century modifications also explain damage like the loss of original parts including the upper crossbars of the lateral saints and some portions of the frame over the perimeter of the painted surfaces which probably projected and prevented setting down the new, carved frame members. Furthermore, the nails and the glue used to attach the new frame on top of the original have instead caused losses and lifting of the paint. These assessments apply to nearly all the planks of the panels that are from similar cuts of wood. Wherever the wood has contracted transversely, lifting and flaking has occurred. Additionally, in the panel of Saint Michael, this has also caused quite evident cracks and opened wide gaps.

The conservation treatment history

The support shows signs of a series of treatments which have occurred over time. From an old archive photograph, the joins of the central panel with Saint Michael were closed with the insertion of wooden strips to fill the gaps; the same technique has been used to reinforce the joins in the gable with the Madonna (Fig. 13). From the same photograph, the three gables appear edged on the back by simple strips probably attached with screws. The wood grain of the planks is not discernable as if it were covered by a ground or by a heavy layer of dust; it seems as though the same layer has settled on the sixteenth-century sections, thus it cannot be clearly identified as an original layer. Though the back of the gable of Saint Louis is not clear, it appears now to have a fill at the top and has a horizontal cut, while in the image the surface is homogenous and appears to be covered by two smaller, vertical, side-by-side panels.

At the time in which the photograph was taken, the two side gables did not have the fitted connection that we found and which must have been made during the last treatment of the 1990s, copying the system used for the central gable. This mechanism employs two brackets attached under the border of the Saint Michael panel, positioned horizontally and anchored with two nails each. At the time of the photograph, the two brackets were still the original ones; the one on the right appears cracked in two places corresponding to the nail holes. Currently, the right bracket appears newly made, it is held with two screws and shaped very similarly to the original. It was probably added during the last restoration treatment.

During the last treatment, the planks of Saint Michael were put back together with wide wedges and the same system was used to reinforce a crack high up in the center. In the gable of the Madonna, an area affected by a large knot has been removed and filled with a single poplar insert. Probably during the same period, the point of the gable with Saint Louis of Toulouse was repaired; the area had suffered heavy deterioration and therefore had been substituted by a single patch using a half-lap join; under this was another deteriorated area in the shape of a rectangle that had been carved out and filled with an insert of the same shape.

The preliminary conservation treatment of the support

The first procedures carried out on the support were done so as to try to free the Saint Michael panel from the accumulated tensions that had
Ciro Castelli, Mauro Parri, and Andrea Santacesaria, *The Triptych of the Badia a Rofeno by Ambrogio Lorenzetti*...

connected the central plank of Saint Michael to the two crossbars were disengaged by making a core cut around the nail (Figs. 21–22). Using a cylindrical router, the wood of the crossbars was cut through and the panel was freed. This procedure, according to our plan, would have allowed for the plank to warp (keeping in mind that it is a sub-tangential cut) and therefore greater convexity and an increase of the surface for the paint to adhere to. In reality, the plank did not warp according to the typical tendency that we expected for wood held flat by rigid crossbars. Quite probably we were facing an essentially stabilized, total volumetric shrinkage of the wood with a tangential cut, exposed for a long time to a dry climate and with crossbars that imposed flatness on the support; wood that is under restraint for a long time can be thought to have collapsed and its force of reaction over time is reduced to a minimum.

This step was, in any case, essential later on as slight pressure was able to be put on the center of the plank which caused a small shift and convexity of the paint surface.

**Dismantling the triptych**

The procedures described so far contributed to the development of a general conservation treatment plan for the painting and, in detail, for its wooden support. The objectives that were defined covered different aspects for the preservation of the painting:

- Allow for a thorough and effective consolidation of the paint for which dismantling the triptych became necessary, also freeing it from the non-original overlying frame.
- Carry out the restoration of the single supports, removing overlapping elements from the front and the rough additions on the back.

caused numerous losses and lifting areas of paint. It was therefore necessary to create the conditions to allow the raised paint to find adequate space to lie back down on the panel. Generally, forcing panels flat that have a tendency to warp puts the paint surface under compression. Therefore, freeing them of this restraint and releasing these tensions increases the convexity of the panel and enlarges the surface where the paint needs to adhere. In this case though, the phenomenon affecting the support of the triptych is much more complex. The painting had at one time absorbed a significant quantity of humidity and then subsequently been placed in a very dry environment. It seems that the wood swelled and increased in width and then shrank dramatically. Probably these movements contributed to damage further the cohesion between layers that were already fragile from the accumulated tensions developed over time and due to the intrinsic lack of flexibility in the ground. The shrinkage of the wood was concentrated in the central areas of the panels where the tree rings are tangential and caused mostly transverse contraction and warping. This indicates that the wood was subjected to a general volumetric contraction, developed along tangential lines that created substantially different tensions than those caused by the rigid crossbars and nails through the planks that had warping tendencies. In these panels, the shrinkage was complete, and very close, in type but not degree, to the deterioration caused by the flood of 1966 and therefore irreversible.

To better clarify the concept, it is worthwhile explaining the first treatment that was carried out on the painting on its arrival in the laboratory. As mentioned earlier, the paint needed to have a chance to find, somehow, space enough for adhering to the panel. For this, the four nails that caused numerous losses and lifting areas of paint.
The treatment of the support of the triptych

The panel of Saint Michael also had old gaps along the joins between the central plank and the sides that had been filled by large poplar wedges leaving some disturbing, poorly aligned paint edges. Furthermore, the areas in proximity to the paint were filled with a very hard fill material of the type used in auto body repair shops. The old wedges were completely removed and the losses were freed from their fills (Figs. 24–25). The channels were reinforced by repairing the borders of each plank and then cutting a narrow channel for the definitive connecting wedges. The repair of the old channels was carried out with small sections of old poplar in order to break up the strength of the added wood. The last step of the wedge reinforcement process was to correctly align the

Provide a clear view of the Trecento triptych, allowing for the assessment of which parts were missing and verify the original assembly method.

In the course of work, a further objective determined was that of allowing for the triptych to been seen both in its fourteenth-century and in its sixteenth-century forms, developing a series of simple mechanisms to allow for a quick and safe change of installation depending on the version chosen.

After the preliminary procedures described above, work was begun by removing the sixteenth-century frame from the fourteenth-century painting. The work started with the central portion including Saint Michael and the lateral saints. First of all the rosettes in the corners of the sixteenth-century frame were removed followed by the frame elements that had been attached with nails and glue. This work, carried out with the painting lying horizontally, brought to light the hidden original frame bordering the scenes and along with its importance, it became evident also how the deterioration caused by the nail holes and glue tore portions of the paint itself. After having secured the paint, the artwork was positioned vertically on an easel and was freed from the connecting elements on the back that had been attached with nails. The lateral saints were therefore separated from Saint Michael, pulling out the dowels inserted into the edges, and the small panels on the upper edge were detached (Fig. 23).

Seeing the individual components revealed the majority of the information that we described for the technique of the structure, like the way that the lateral saints and the gables had originally been continuous, and the precise spatial location of all the parts.
broken edges of paint, creating a continuous surface (Fig. 26). The inserted pieces were glued with Bindan, a PVA. On the back, the areas that were not filled from behind by wedges were filled with small wood pieces placed under the level of the preparatory layers in order to provide a continuous and homogenous surface for the paint layers.

A similar operation of substituting large wedges was also carried out in the upper part of the same Saint Michael panel where there was an old repaired crack. The gable with the Madonna was reinforced along the joins, substituting the small strips inserted imprecisely in an early period with new strips with a rectangular cross-section. These elements were chosen specifically and adjusted with great precision; they were attached and the parts rejoined with PVA adhesive. Again, in this case, the edges of paint were properly re-aligned and strips of aged poplar wood were attached with Bindan. In the lower part of the panel of the gable, one area that was previously repaired with a single wood insert had become precarious. Therefore, this element was substituted with a wood fill made in three layers, using small pieces of aged poplar glued with Bindan. The panel of Saint Bartholomew also had a deteriorated area caused by ring shake and it was reinforced, again with aged poplar inserts (Fig. 27). After reinforcing the panels, the new system for supporting the curvature of the panels was prepared. The central panel was reconnected to the original crossbars by filling in the space that was opened during the coring cuts around the nails with poplar wood and a mixture of the epoxy resin Araldite AW 106 / HV 953U (1:0.8) and Araldite SV 427 / HV 427 (1:1) in a 1:1 ratio. The crossbars were therefore given back their old function thanks to the original nails being newly secured. The lateral saints no longer had any panel restraint in the upper portions and therefore new crossbars were planned that could serve a series of functions: along with that of responding to movement of the panels, they would allow for an easy attachment of the upper gables, and a stable connection to the portion of the original upper crossbar of the central panel. Two aged-poplar crossbars were prepared, quite similar in appearance to the wood of the surviving crossbar on Saint Michael and with matching dimensions of depth and height. The crossbars were anchored by means of a sliding, flexible system based on three points of attachment per crossbar. Each connection point uses a double-threaded sleeve inserted in the holes of the old nails. The mechanism, completely hidden inside the crossbar, allows the panel transverse movement while a spiral, cylindrical spring, appropriately adjusted, exerts restraint on warping tendencies. A thin, vertical channel has been made on the inside of the new crossbars to accommodate a metal piece anchored to the gable as a reversible connector between the parts. Furthermore, a metal “L” bracket firmly connects the parts of the crossbars of the single scenes restoring the lost unity of the triptych (Figs. 28–31).

The predella was reinforced in the areas that had been eroded by wood-boring beetles, especially the upper plank. The areas were consolidated with applications of Paraloid B72, applied by brush as a 5% solution in ethyl acetate, and then
filled with small pieces of aged poplar wood glued with Bindan. The internal reinforcing elements were also attached with Bindan and, where necessary, with a mixture of epoxy resins Araldite AW 106/HV 953U (1:0.8) and Araldite SV 427/HV 427 (1:1) in a ratio of 1:1.

All the wooden parts of the triptych were de-infested in an anoxic environment and protected with Permetar insecticide applied by brush (Fig. 32).

The restoration of the sixteenth-century frame

The conservation treatment for the frame had to include, besides the strengthening of its components, a general plan for exhibition. The treatment also had to include making the sixteenth-century portion self-sustaining so it could be viewed separately from Ambrogio Lorenzetti’s triptych, though also incorporating the possibility of housing the painted scenes in an easily reversible way. Therefore, the frames that surrounded the perimeter of the gables were separated from the original supports. The elements that were detached from the front surface of the triptych were reconnectedin a stable way so as to form a solid and independent structure on which to attach the three frames of the gables. The elements of the frames were glued again in the corners with a mixture of epoxy resins Araldite AW 106 / HV 953U (1:0.8) and Araldite SV 427 / HV 427 (1:1) in a ratio of 1:1. The rectangular plaques with carved decorations that occupied the spaces above the lateral saints were re-attached to these. The brackets that served to anchor the lateral gables were adjusted to accommodate the sixteenth-century version of the
Ciro Castelli, Mauro Parri, and Andrea Santacesaria, The Triptych of the Badia a Rofeno by Ambrogio Lorenzetti...

The triptych frame so as to still be able to anchor the painted scenes. On the sides edges of the frame, the pieces were attached that made up the old sides that were previously connected to the supports of the lateral saints and closed off the area connected to the pilasters. The sixteenth-century structure was re-assembled resting the lateral pilasters and the central carved frame with the ornamented gables and intermediate pinnacles on the predella. These were all attached in a reversible way with glued and screwed elements.

The predella platform was consolidated with Paraloid B72, reinforced along the upper and lower surfaces, and the supports on the sides which would receive the connections to the pilasters. All the fills were made using small pieces of aged wood, arranged in layers and overlapping lengths, then glued with Bindan (Fig. 33).

1 De Nicola noted a difference in stylistic period between the gable of the Madonna and Child and the other parts of the triptych. Brogi, in 1865, also saw a substantial formal variety in the altarpiece of St Michael stemming from the work of different hands, noted as a generic “Anonymous artists of the Sienese school [Ignoti artisti di Scuola senese]” in the museum guide. Palazzo Corboli Museo dell’Arte Sacra, edited by Cecilia Alessi, pp. 114–15, Siena, 2002.
Panel paintings: Some updates
Marco Ciatti

The activity of the Laboratory and some reflections on theory
Since the publication in 1999 of the volume Dipinti su tavola. La tecnica e la conservazione dei supporti, entirely dedicated to panel paintings and their techniques of construction, deterioration, and conservation, many projects then in progress have been concluded and new ones begun. As always, facing the specific difficulties of each painting during treatment has stimulated reflection on both the theoretical and technical aspects of intervention. This attention is typical of our approach, since we are convinced that conservation ought never be limited to mere operational practice, but should always involve a research project that will require constant review in order to reach conclusion, even if this means questioning our own certainties. Only in this way will we be truly of aid to the artworks.

The year 2001 marked the conclusion of treatment on Giotto’s Crucifix from Santa Maria Novella. Very important observations emerged during this delicate work, especially during separation of the trapezoidal footboard from the main wooden structure to repair it and improve its connection to the rest of the Cross. On this occasion we identified two different episodes of modification to the painting: the first during its actual construction, resulting from the artist’s decision to incorporate an element that was initially intended only as a means of support into the main structure. This provision provided the space necessary to paint the detail of Adam’s skull on Golgotha, thus also amplifying the iconographic scheme in a way which actually changes our perception of the Crucifixion, seen as a narrative, more naturalistic representation in place of a basically iconic image focused on its symbolic significance. Of course this evolution was only partial, as Giotto continued to pay tribute to tradition: while the body of the crucified Christ is shown in a truly revolutionary, physically tangible form, the cross itself is still represented emblematically, since it is painted uniformly blue with ultramarine rather than depicted as if made of wood. Yet as if it were indeed a piece of wood, the Cross is driven into the rock of Golgotha, similar to the way it appears in Crucifixion scenes inserted in narrative sequences of the Passion of Christ. The second structural modification identified dates from a later moment, and was evidently undertaken to reinforce a particularly delicate part of the structure, perhaps to resolve problems deriving from the frequent moving of such a large, heavy object, certainly not easily accomplished without risking damage.

Again in 2001, the results following the completion of the conservation of the Sarzana Crucifix were published. The painting, which bears the signature of Master Guglielmo and the date 1138, represents a veritable archetype of Central Italian panel painting, whose unusual structural features were previously discussed in our volume of 1999. The following year, 2002, work on the extraordinary Madonna and Child from Santa Maria Maggiore was concluded, and became the subject of a special monographic volume. A new proposal for dating this panel was advanced, together with the attribution to an artist perhaps from southern
Italy, but in any case part of the Byzantine cultural environment, active in Florence in the last quarter of the 12th century. This proposal was supported by archeometric analysis that included dendrochronology and radiocarbon dating, together with a lengthy series of observations and reflections on the painting’s typology and iconography, and even more so on the analysis of its technical characteristics. The details presented in our publica
tion highlighted the choice of chestnut wood for making the support, according to a custom that seems more and more typical of the century proposed. Examination of the panel’s construction led to identifying other features that could be hypoth-
ized as typical of the 12th century: crossbars nailed to the upper and lower extremities on the rear of the wooden panel; joining using “cheese” glue (calcium caseinate); reinforcement of the joints with biscuits secured with pairs of wooden pins. Summing our knowledge of the methods used to build this panel, with those gathered on the Sarzana Crucifix and on the contemporary Rosano Crucifix, then under restoration in the laboratory, we began to assemble a certain amount of significant data on the techniques in a period about which very little was previously known.

I would like to repeat here once more a concept that has guided me over the last twenty years which justifies our plans for intervention on such ancient works: Giotto does indeed represent a di-
viding point, not only in stylistic terms but also from a technical point of view. The origin of the great renovation in painting taking place during the 13th century, so rich in new aspects, was ini-
tially Byzantine, then diffused throughout Tuscany through the mediation of the artistic culture of Pisa; carried on by Cimabue, and finally exploding with revolutionary impact with Giotto. It is therefore totally misleading to consider the entire field of medieval techniques only in the light of the otherwise more than instructive Libro dell’Arte by Cennino Cennini and instead we can appreciate that the technical methods of constructing and painting wooden panels in the 13th century were fundamentally different; meanwhile the information contained in several earlier trea-
tises, such as those by Heraclius or Theophilus, is unfortunately only partial. The paintings them-
selves will therefore perform a function, not only as art, but as documents that permit us to recon-
struct this history.

The collaboration with the Soprintendenza of Pisa for the “Cimabue a Pisa” exhibition held in 2005 represented an exceptionally important op-
portunity in this sense. Although there was only a limited amount of time available, the works to be exhibited were examined using various ana-
lytical methods (X-radiography, high-resolution IR reflectography and other infrared techniques). The results obtained from this fundamental docu-
mentary material were summarized in the exhibition catalog, and then divulged in extended form in the subsequent technical bulletin issued by our Institute. The transition from chestnut to poplar wood for making the support was con-
firmed, the former being more frequently iden-
tified on works of the 12th century, while the second was preferred during the 13th century. Examination of the refined construction of these panel paintings revealed how completely each problem had been understood, and also pointed out certain features connected to local peculiarities: though all the boards were butt-joined with casein glue, the use of dowels (cavicchi) prevailed and these were larger than those for Florentine panels; and the battens are narrower although somewhat deeper. It is interesting to observe that certain similar features have been observed on works made by Florentine artists for churches in Pisa, including Giotto’s Stigmata of St. Francis, therefore possibly constructed and painted in that city. Thirteenth-century Pisa was especially noticeable for the great variety of technical prac-
tices apparently existing simultaneously. For ex-
ample, the crosses built between the 12th and the early 13th century present either two separate arm pieces attached by means of a tenon inserted into a mortise on the central body, or a continu-
uous arm board united to the main body by means of a central cross-lap joint.

In 2004, the delightful, tiny processional Cross painted on both sides by Bernardo Daddi, now in the Poldi Pezzoli Museum in Milan provided a very interesting experience: both because it drew our attention to this special kind of small artifact, especially in comparison with the great crosses made for church partitions on which we are usually more accustomed to work; and because of a surprising finding from an innovative imaging technique. The principles behind this painting’s methods of construction were basically similar to those guiding the making of full-sized objects; however, rather than being surprising, this may actually be inherent to the very concept of the arts during the Middle Ages. In fact, as already mentioned, whatever material
was used to create an artwork in this period, and of whatever size it might be, from the small, precious artifacts fashioned by goldsmiths to the vast stone cathedrals, all was considered suitable to convey an analogous vision of the world, thus revealing a substantial unification of the arts. In this case, examination of the cross through an advanced system of tomography, made possible thanks to the collaboration of Siemens Italia and Maurizio Seracini, also provided fundamental information about the exact position inside the object of several screws added during a preceding restoration. The extraordinary three-dimensional rendering of the work not only exactly defined this situation and the related technical problems, it also showed the presence of a hidden cavity intended to hold a relic, not easily distinguishable in an ordinary X-radiograph. The detection of this element was particularly important for a better interpretation of the artwork’s meaning within a medieval context and in light of the function of the cross to prepare those condemned to death for execution.

During the year 2005, the lengthy and complex treatment of the Pala Dei by Rosso Fiorentino was completed and presented to the public in a small exhibition organized in the Sala Bianca in Palazzo Pitti. The complexity of this panel’s condition from a practical point of view—the work, dating from 1522, had been enlarged at the end of the 17th century when it entered the Medici collections—posed quite specific challenges for the specialists engaged in the structural reinforcement: separation of the various parts, the repair of each damage caused by the enlargement, and the subsequent re-assembly of the entire painting, however implementing a new and more appropriate support system.

In November of 2006, forty years after the 1996 flood in Florence, the treatment of eight severely water-damaged panel paintings was concluded in the Laboratory and their return to the refectory in the Museum of Santa Croce was marked by a new installation designed by Contemporanea Progetti, also intended as a permanent exhibition of their conservation. Although the solutions the department applied to these challenges have already been published, we may add here that the difficulties encountered were especially pronounced due to transfer operations begun previously, or when it was necessary to repair the wood panels and regain satisfactory adhesion of the paint layers, as was the case for the two enormous 16th-century altarpieces by Francesco Salviati and Agnolo Bronzino. The Bronzino treatment, including several technical innovations, had already been in part reported during the symposium organized to celebrate seventy years of the Laboratory’s activity since its founding (1932–2002), and whose proceedings were published the following year. Another volume in the same series as the present one was specifically dedicated to the entire group of paintings, on occasion of their new exhibition in the Museum of Santa Croce. Reflecting after a certain length of time on this last event, at the time usefully seen as a terminating-point for the lengthy operations still underway in the laboratory, we may affirm that the occasion itself was quite important, especially for those interested in reconstructing a history of restoration in Italy. The eight panels required different treatment methods, depending on what stage of work had been reached on each one previously. In several cases the first phases of a traditional transfer of the paint layers had already been started, with demolition of the wood and the degraded preparatory layers. Various more modern solutions were sought in resuming the restoration of these paintings, including efforts to remedy the effects of the long interruption of work. In other cases, the entire panel was able to be salvaged, in particular those that had proved more resistant to the effects of the flood, sometimes also thanks to their more robust construction. Both theoretically and technically, the most complex treatments were on the two monumental altarpieces: Salviati’s Descent of Christ into Limbo and Bronzino’s Deposition, a subject rarely represented in Western art. Repair of the two wooden panels, which had suffered from various decay factors, was particularly problematic, as was regaining sufficient adhesion of the paint layers. Although the numerous technical innovations for treatment were undoubtedly important, the most noteworthy aspect may be considered the general project planning: treatment was not the only element on which we relied to ensure the integrity of the panels. This was combined with successive preventive conservation. As is known, the effects of the flood on the most heavily damaged works, such as those in the Museum of Santa Croce, were so profound that it became impossible to completely reconstitute stable conditions without sacrificing part of the constituent materials, as was the case, in fact, with paint transfer operations. Analysis of the behavior of
Structural Conservation of Panel Paintings at the OPD in Florence: Method, Theory, and Practice

the panels showed that even micro-movements of the wood, sometimes the result of small environmental variations, could produce detachment due to the extreme deterioration of the preparatory layers and the resulting loss of adhesion of the paint layers. We therefore decided to proceed in two different directions: both by recuperating the greatest degree of cohesion possible through application of the most sophisticated techniques developed by our restorers, and by introducing preventive conservation measures to limit the movements of the wood through the enclosure of the exposed wood of the sides and rear of the panel in a specially designed container. By uniting restoration and preventive conservation we were thus able to noticeably reduce the invasiveness of intervention, especially by avoiding transfer operations, and then were able to replace the works in the refectory, itself without climate control, without any evident problems arising since then. In the same period as the Santa Croce initiative, intervention on the Rosano Crucifix was also completed. This fundamental example of the earliest moment of panel painting in Florence was ascribed to the early decades of the 12th century on the basis of the most recent studies carried out during its restoration. Similar to many other works of the period, the painted cross was made of chestnut wood, and since it had never suffered substantial modifications it represented an exceptional document for research into the artistic techniques of the time. The wood structure was the subject of in-depth investigation, in part because of the deterioration and failure of the main joint uniting the horizontal arm pieces to the central vertical body. This led to performing an operation, at first apparently quite invasive, but which in reality proved to be the most respectful and effective option: the main support elements were disassembled, obviously recognizing this procedure as feasible only after having ascertained that the joining method did not rely on clinched nails but only on the insertion of wooden pins. Treatment achieved the goal of totally reestablishing the original structure, as well as allowing for a thorough study of the technique. Again in 2006, the results of conservation and research on the Polypych of the Intercession by Gentile da Fabriano were also the subject of a publication. This panel was long considered a publication. 10

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The extremely delicate intervention on Raphael’s Madonna with a Goldfinch posed even more complex problems and uncertainties about how to resolve them. The panel had been broken into pieces in 1547, when the home of the Nasi family, where it was kept, collapsed in a landslide, according to Vasari’s well-known account. The repair work to remedy this had itself undergone inevitable alterations, resulting in the opening of fissures in the panel and noticeable surface irregularities. Intervention to obtain the maximum strength when re-attaching the edges of the open cracks and the total elimination of the differences in level would inevitably be quite invasive. Following the present guiding philosophy, the aim was to define the degree of solidity necessary, in relation to the work’s future exposure to stress factors, and for this the Gallerie degli Uffizi conservators were involved in the question of how to exhibit it after restoration. The group decided to avoid replacing the work directly in contact with the surrounding atmosphere by enclosing it in a monitored, environmentally stable container. A climate-frame solution was chosen, inserted into the painting’s regular Gallery frame adapted for the purpose, which also reduced to a minimum any negative visual effects also thanks to the use of non-reflective glass. This permitted considerably limiting our planned repair operations, which our restorers carried out in an almost micro-surgical way only in those areas presenting the most accentuated and dangerous alterations. The principle was therefore once again affirmed that intervention methods must be logically connected to the environmental conditions of the exhibition site. In the same year the results of research on the predella scene now in the Ingres Museum of Montauban, originally part of Masolino’s Carnesecchi Triptych, were published. 11 Despite the panel’s small size, this experience was significant because of the need to create a specifically designed supporting framework, shaped

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to fit the rear and connected to it by means of an elastic system. The remaining empty spaces were filled with slips of wood inserted without fastening them to the original panel. This provision increases the overall mass of the object, and thus naturally contributes to stabilizing the microclimate and therefore also the behavior of the wood. The results of such research have also been extended to other cases of panel control and stabilization, taking advantage of the existing frame for both purposes, successfully employing the system to noticeably reduce the invasiveness of intervention. An excellent example of this practice was the beautiful Madonna Trivulzio by Antonello da Messina from the Museo Civico d’Arte Antica in Palazzo Madama in Turin.  

A much more extensive and equally complex project was carried out on the wood support of Mantegna’s San Zeno Altarpiece.  

The conservation problems requiring treatment in this case derived from various factors, primarily the drastic restoration of the 1930s aimed at flattening the panel, done according to Mauro Pellicioli’s instructions, which entailed reducing the panel’s thickness accompanied by wedge insertion and followed by cradling. Further damage had been caused by repeatedly moving the very intricately built painting, whose problems of stability were worsened in such instances by the loss of the original features of its construction. Treatment, after the initial phase of study and analysis, therefore encompassed every possible aspect: anoxic disinestation, repair of the single boards, revision of the support system on the rear, and improving of the structure in general. The painting was then returned to its altar in the Basilica di San Zeno, with a new protective panel applied to the rear to stabilize the wood’s behavior. Since then, both the panel and the environment are being monitored and for now this indicates satisfying results.

The treatment of the panels of other monumental works were also particularly complex, such as those on the Ognissanti Cross, mutilated as a result of a relocation and damaged by water infiltrations, and with the loss of one of the rear crossbars; and on the Linaioli Tabernacle. The study of the principles determining the method of construction used for the Cross not only served to plan the treatment, but also to supply the designers of the new support devices with the parameters of the distribution of the forces in play, in order to base the control system on the original concepts. Thanks to the collaboration of various professional figures, the approval of the institutions involved and the generosity of the sponsor Arteria, it was possible to return the work to the Church of Ognissanti, placing the monumental Cross in the elevated chapel in the left transept, thus permitting a viewpoint analogous to that of its original position on the partition wall. The restoration, which also included preventive conservation measures to keep constantly under control, not only preserved the ancient artistic materials, but also permitted the recovery of the meaning and religious functions of the artwork.

The conservation of the Linaioli Tabernacle, a work characterized by quite unusual methods of construction, permitted study and advanced understanding of the state of the fissures produced in the panel by movements of the wood over time, also through a new and very interesting method for measuring micro-movements devised by colleagues from IFAC-CNR. Special technical features were also observed on the San Zanobi Dossal attributed to the Bigallo Master: despite its considerable dimensions this panel demonstrated the use of the hollowed-out method to obtain the flat board structure in a single piece with the frame, as was usual for much smaller icons of the East. Although much is still to be said on the implications of this technique, which was the object of detailed investigation by our restorers and the subject of a thesis for the diploma of our School, we will limit our comments here to the related conservation problems. These were in part intrinsic to the technique itself, as well as being the result in this case of the invasive restoration of the 1930s, when the thickness of the panel was reduced, followed by cradling and then reconstruction of the original dimensions. Very complex procedures were needed to rectify the support and control system, and reinforce it by fastening a specially shaped framework to the rear with the, by now well-known, elastic system. Future publications on the conservation of Vasari’s enormous Last Supper from the Museum of Santa Croce are also planned. Initially financed by a special contribution from the Protezione Civile at the time of the events for the 40th anniversary of the flood in Florence, it was subsequently inserted in the extensive Panel Painting Initiative promoted by the Getty Conservation Institute and the Getty Foundation. It is important to mention that this difficult conservation project
has served as a case study on which many young colleagues from museums around the world have focused to acquire experience, thus sharing widely the excellence of our Institute’s practices.

The laboratory has also participated in recent years (1999–2006) in several other particularly stimulating research projects. Independently from actual treatment, our involvement was determined by a recognized capacity to understand the characteristics of support construction, to the point of being able to propose—but also certain times to refute—hypotheses on questions of a strictly art-historical nature. As far as method is concerned, it is particularly important to note that a significant number of scholars have recognized the importance of such technical studies, including those related to panels, for the overall comprehension of works of art. Perhaps the most important example of this activity has been the research on the panels by Masaccio and Masolino. These results were presented in the volume edited by Carl Brandon Strehlke and Cecilia Frosinini in 2002, sponsored jointly by the National Gallery of London, the Philadelphia Museum of Art, and our Institute, and generously financed by the Samuel H. Kress Foundation, and the materials also appeared in the proceedings of the conference held on the occasion of an exhibition organized in 2002 by Victor M. Schmidt, whose proceedings have been published by the Center for Advanced Study in the Visual Arts. Then in 2004, we collaborated with several other institutions in investigative research aimed at enriching the appreciation of the works in a Fra’ Carnevale exhibition with technical contents. More recently, in 2009, we took part in an important research project, promoted by the Harvard University Berenson Foundation and coordinated by Machtelt Israëls, which focused on reconstructing Sassetta’s double-faced altarpiece from Borgo Sansepolcro.

The often-requested consulting role of the Opificio has always offered our institution the opportunity to investigate works and problems of noticeable interest. Among the numerous cases that may be cited, I would like to mention only two particularly important ones. The first is the restoration of the Castelfranco altarpiece by Giorgione, presented in a specifically dedicated volume in 2003; the innovative intervention on the support was carried out by Pier Paolo Malfarini, among the young colleagues who have interpreted intelligently the approach absorbed during internship in our department. Another interesting case was the Verucchio Cross, restored in the best possible way after suffering a disastrous accident, carried out by a group under the guidance of Marisa Caprara, implementing an intrepid but substantially respectful project devised by our sector. Lastly, the treatment of the wood support of the Pala Bottigella by Vincenzo Foppa from the Museo Civico in Pavia was executed under the guidance of our Institute.

Nor have these years passed in vain from the point of view of theoretical reflections, which have confirmed and even reinforced various methodological principles, capable in the past and also for the future of producing direct consequences on the choice and elaboration of procedures for intervention.

In my opinion the most important concept is considering restoration not to be just a series of more or less refined practical operations carried out to treat a work at any given moment, but rather as a project specifically formulated according to the characteristics and requirements of each single piece. We will not go into great detail here on this matter, as it has been the subject of a recent, specifically focused contribution, but it is important to indicate several especially meaningful points. The initial phase of a project must consist in research into the constituent materials and the immaterial significance conveyed by them; having understood this, it will be possible to establish the theoretical goals and consequently the priorities which will be the basis of the guidelines for the entire intervention, including work on the wood. All of this will be carried out, of course, in relation to the environmental conditions of the future exhibition site, which must be fully understood in order to plan treatment correctly.

The concept of the need to reduce the invasiveness of support intervention to a minimum, already illustrated in 1999, has been further strengthened through diffusion of the concept of so-called “minimal intervention,” promoted in particular through the ingenious insights of Vishwa Mehra. This methodology has been developed in Italy especially thanks to the members of the CESMAR7 association, who opportunistically dedicated one of their conferences to the matter
in 2004. It was particularly meaningful for us that the expert invited on this occasion to speak on the subject of wood panels was Ciro Castelli. It is our firm conviction that the importance of this approach lies in the renewed affirmation of the basic principle of respect for the artwork, while always encouraging continuous and prudent verification of the methods employed. This is connected to what has already been said, in the sense that determining any minimum or maximum degree of intervention is obviously related to the results one intends to obtain, which in turn may be clearly and correctly defined only after having followed a conceptual planning method as described above. In this way the valid outlining of an overall project for conservation may prove useful to really try to minimize intervention. Other theoreticians of restoration have accompanied the concept of “minimal intervention” with that of “sustainable conservation,” evidently borrowing the term from other aspects of human life. For us this means conceiving the reduction of invasiveness of restoration as a necessary requisite, not only as a form of respect for the material integrity of the work of art, but also to succeed in transmitting the document to future generations together with its entire content of meaning, avoiding the selective elimination of certain elements. This will allow the appreciation of aspects which perhaps we find less interesting today, but which in the future can acquire just such importance: in the end this means not entirely deciding at the present moment the future appearance of the work. However in this prospect we cannot and must not remain paralyzed about intervention, but rather strive to correctly understand the influence the operations should assume, choosing among those not heavily selective among the constituent materials and the various historical phases, evaluating them without referring only to the minor and often rather petty needs of the present moment. Whoever does restoration will determine the way in which a work of art may be appreciated in its future lifetime, and therefore, without wanting to be rhetorical, he/she actually assumes a responsibility of a historical nature.

A final theoretical consideration whose importance has steadily increased in recent years, invests the relationship between restoration and the subsequent conservation of the work of art, moments and aspects which must be considered as part of a general plan for conservation, and not as distinct and even antagonistic disciplines. We must be aware that if restoration is a means, conservation is the finality, as Stella Casiello has written, and it is also true that restoration is not the only instrument that we can and must use to reach our goals: maintenance, preventive conservation, and restoration are the three arms we have available. Once again adequate and informed project-planning will permit us to select which instruments and how many of these to use each time. Certainly maintenance and preventive conservation ought to come first, if just because they aim at avoiding the damage that makes restoration necessary; but since we live in an imperfect reality, we must also keep our third weapon perfectly effective, well-oiled, and up to date, to avoid finding ourselves having to face extremely serious problems without adequate means. It ought to be rather obvious, although in Italy this is absolutely not so, that if everyone is so concerned about the maintenance of such a fundamentally insignificant object as an automobile, there is no reason for not considering this absolutely necessary for a precious and delicate artwork. Even common sense tells us that it will be useless to take the trouble to restore a work of art with sophisticated methods and employing substantial resources (and perhaps even following the precepts of “minimal intervention”), if no one cares to provide for subsequent preventive conservation, the only way to assure the lasting nature of whatever positive results are achieved. Otherwise even the most limited degree of invasiveness will prove to be negative, rendered useless due to rapid reproduction of the decay factors. There is still another and more profound meaning of the need for relating the moment dedicated to restoration to provisions for preventive conservation: if we attempt to obtain the desired result from the sum of their combined actions, then it may be possible to really reduce the invasiveness of intervention, since restoration alone is not asked to take on the entire task of conservation. This appears evident in the case of works where the adhesion of the paint layers has been seriously weakened because of problems of partial de-cohesion of the preparatory layers, such as on the flood damaged panels in the final phases of restoration in the laboratory. If we had wished to reach a sufficiently solid state only through “restoration,” in fact, it would have been necessary to carry out much more invasive operations, even to the point of transferring the painted surfaces to a new support. The strength of the adhesion of the paint layers re-established
on Bronzino’s *Descent to Limbo* and Salviati’s *Deposition from the Cross* is certainly not exceptional, and may be considered sufficient only if we add the partial stabilization of the behavior of the wood achieved by enclosing the rear and sides of the support in a specially designed container, to considerably slow down its tendency to move and therefore transmit stress to the preparatory-paint layer complex. In restoration, evaluations on the finalities of the various phases are often expressed very superficially: for example, what exactly does it mean to say that the support or the paint layers have been “consolidated”? Evidently, beyond the impossibility of quantifying the data in relation to what would pertain to a “healthy” object, the degree of solidity an object has obtained through intervention is connected to the negative stimuli the work may encounter in the future. For this reason, initiating restoration without knowing what the future environmental conditions of the work will be, and in any case not reflecting on this aspect and perhaps acting to improve these conditions, is today frankly irresponsible and hopefully belongs to a past era of restoration. Our work and this volume aim at going in the desired direction.
6 La “Pala Dei” del Rosso Fiorentino a Pitti: Storia e restauro, ed. by M. Ciatti, and S. Padovani, Florence, 2005.
23 Il restauro della Pala Bottigella di Vincenzo Foppa, ed. by D. Tolomelli, Pavia 2011.
1. Introduction

The main purpose of this contribution is to share the results of over forty years’ work in the Department of Panel Painting Restoration at the Fortezza da Basso Laboratory in Florence. The main themes treated are the techniques of construction of wooden supports for painting; the conservation problems caused by the physical decay of the material components; and the various types of restoration treatments that have been carried out on these objects. Starting our discussion of panel painting with the methods used for construction may appear rather didactic or perhaps even somewhat tangential, especially since the most urgent problems these works face today concern their preservation. So why shouldn’t we dedicate immediate attention to the factors causing accelerated aging and deterioration, or to the appropriate methods for conservation? In reality, some very important reasons lie behind this, first of all the conviction that it is not possible to address any specific case of deterioration and the related conservation problems without first formulating a precise, comprehensive idea of all of the work’s components. Only by gaining in-depth knowledge about the techniques and materials underlying the artworks’ design and construction will it be possible to analyze the reasons for deterioration and to recognize the signs that indicate past interference with the objects. It is equally important to relate this knowledge to understanding the environmental conditions of the artwork’s exhibition site: in fact the severe effects of unsuitable parameters are known to be among the primary causes of accelerated aging and decay of the material components. The study of the various categories of artisans that collaborated in producing the objects will also be useful, since understanding their work procedures and specific fields of expertise will help us to distinguish problems which might derive from original features, from those induced by episodes of past restoration (in reality the greatest cause of the aggravation of decay factors). Useful information on this subject may be found in various manuals such as those authored by Secco Suardo and Forni, as well as in various nineteenth-century restoration reports.¹

These brief preliminary remarks are not to be interpreted as wanting to contribute in any way to certain sterile polemics, such as those which have sometimes arisen from the contrasting opinions of various groups practicing this sort of restoration. In fact, we wish to contribute usefully to understanding the problematic history of these objects’ conservation over the centuries. It is certainly true that the structural conservation of panels has always been relegated to the margins of the conservation field, and those who have done this work were often borrowed from generic carpentry, and moreover, usually directed by persons whose expertise focused more on the pictorial aspects rather than on the composite structures typical of panel paintings and other wooden objects. Analysis of this kind helps us to understand just how incorrect certain evaluations of conservation problems may be, the result of systematically privileging the works’ aesthetic appearance, and from considering the objects as a set of separate materials rather than

as a single entity whose very existence depends on the delicate balance of its multiple components. Studying past restorations helps us to verify that this has indeed often been the case.

The general approach to wooden objects has evolved considerably in recent decades, becoming increasingly self-critical. There seems to be a growing sensitivity already evident during professional training, which in turn leads to a greater awareness of the limits of customary restoration techniques, and to realizing that the best way to respond to conservation problems, according to the general principles of due respect for the artwork, entails attention to every single part of it and avoiding any incautious, invasive, or even worse, destructive actions.

The previous observations thus serve to introduce our discussion of the construction of panel paintings from the early twelfth through the sixteenth centuries. While the main material components of the artifacts remained basically the same throughout the entire time span, the most significant changes apparently took place in the development of the techniques for constructing wooden supports, together with those regarding the paint layers, and the design and execution of frames.

The subject of wood as a material emerges as one of the most innovative, or shall we say newly re-discovered components of our discussion. The choice of the materials for wooden objects and the modes of their assembly and protection were based on excellent knowledge, as in fact emerges from their direct observation. Such ability certainly did not come out of nowhere, being undeniably the fruit of a highly refined workshop tradition passed on over the centuries. Wood itself may be considered a material perfectly suitable for making supports for painting: typically easy to tool and work, resistant and long lasting, it was able to supply an excellent surface to receive the preparatory layers; another advantage was its suitability for making both large and small works. These positive aspects definitely contributed to the diffusion of wood-based artifacts from the Middle Ages through the Renaissance and beyond, and were further enhanced by combining the use of wood as a support for painting with the application of a gypsum and glue ground, itself able to confer special qualities to the polychrome surface.

We may identify several broad periods in the five centuries taken into consideration here, when the main developments of wood support construction occurred. These periods also correspond to the moments of the greatest technical and cultural evolutions taking place in general: the thirteenth and fourteenth centuries, part of the fifteenth, and the sixteenth century. The basic configuration of the panels examined here is essentially a wooden board structure designed to receive the preparatory layers, and a supporting system attached to the rear. The latter could consist simply in straight horizontal crossbeams, or be arranged in a more complex form, such as a perimeter framework into which the crossbars were inserted, or a grid such as those used for painted crosses or particularly large panels. These support mechanisms were designed to ensure general structural reinforcement and to resist the tendency of the wood to warp and curve, and as we will later see were the components that conceptually changed the most over the centuries.

The board assembly would be completed by adding a frame, either placed frontally and united to the boards around their perimeter, thus acting as a counterpart to the battens on the rear; or in certain periods also fashioned to enclose the panel’s outer edges. This latter solution had the advantage of protecting the wood from variations of relative humidity, while also playing a structural role helping to keep the panel flat. While the relationship of the frame components to the rest of the object evolved in the course of time, their basic aesthetic and mechanical functions remained constant. The supports examined, although apparently assembled in a basically elementary form, in reality involved applying precise technological principles. These criteria respond not only to the artworks’ specific typologies, but also to the essential functional qualities of the materials themselves, designed and employed to assure the efficiency of the ground layers and the overall strength of the structure, and to protect the panel from external environmental factors.

2. Medieval panel paintings

The panel paintings dating from the earliest period examined here are characterized by their particularly solid and stable construction coming from the excellent choice of materials and the rigorous application of the various technical procedures. This is true of both the methods used to construct the panel and to prepare it for painting, both of which followed the technical precepts of the “workshop” tradition, meaning by this the wealth of empirical knowledge inherited, developed, and improved over the centuries. The study of the surviving works
the supports examined reveal a generally scarce reality producing perfectly radial-cut boards. In fact, the boards chosen for making the object were prevalently those cut straight through the central part of the diameter of the tree trunk, including several that incorporated its entire width. In this case, however, care would be taken to eliminate the central part or pith, therefore in reality producing perfectly radial-cut boards. In fact, the supports examined reveal a generally scarce presence of complete tangential boards. Furthermore, the side edges of the sawn planks were planed down to eliminate any remnants of sapwood, prone to decay and the attack of wood-boring insects. The boards chosen to compose the panels usually had straight-running grain, homogenous consistency, and a limited presence of large knots or other defects, which in any case would be repaired by covering them with appropriate plugs. Besides this careful choice of materials, we may also observe that most supports are rather thick in proportion to the overall dimensions of the paintings. This was certainly not accidental but rather a calculated choice aimed at assuring adequate stability, meaning the panel would resist adverse climate fluctuations and thus be as durable as possible, positive qualities that would translate to the preparatory layers. The various phases of workmanship were carried out to the highest degree of perfection: the sawn boards were joined perfectly; choice materials were selected for the crossbeams which were then tooled to perfection; the frame was fashioned and applied in order to fulfill its various aesthetic, structural, and protective functions; cloth was applied to the wood to buffer its movements, as well as to connect the various frame pieces to the rest of the panel.

Coating the rear with materials similar to those used to prepare the front for painting concluded the construction of the wooden support. An example of this procedure may be seen on a Jacopo Franchi triptych now in the Galleria dell’Accademia (Florence): the wood on the rear has been covered with multiple layers of gesso grosso composed of gypsum and glue, then painted in a tempera medium with a decorative motif that imitates squares of marble. In other cases, such as Giotto’s Crucifix from Santa Maria Novella, his Maestà now in the Uffizi, the altarpiece from San Giorgio alla Costa, the Stigmata of Saint Francis in the Louvre, and the Madonna and Child from the Oratorio di Sant’Omobono in Borgo San Lorenzo (whose original dimensions have been drastically reduced), the rear was finished with coats of minium in a glue medium. Applying these materials to the bare wood aimed at balancing the effects on the two sides of the panel deriving from exposure to the surrounding environment, acting as a barrier against wood-boring pests and climatic fluctuations, while also conferring aesthetic values to the work.

2.1. Typology of the artworks

We will now examine several typical categories of painted wooden panels dating from the thirteenth to the end of the sixteenth century, to analyze how they were built and how the materials and technical developments evolved over the centuries. We can begin by examining several specific typologies: altar frontals or dossals (antependia); carved-out panels with integral frames; rectangular panels with or without haloes carved in relief; painted crosses; altarpieces with cusped arches or gables; the triptych and polyptych composed of single or double registers; colmi (small paintings for private devotion, often in the form of tabernacles with or without closable doors); and birth plates (deschi da parto). We will conclude with a few remarks on Flemish panel paintings, although these constitute a subject of their own which makes it impossible to treat them completely here.

2.2. The construction plan

The making of a wooden object, as simple or complex as it might be, clearly arose from precise preliminary agreements with the patron, establishing the shape and dimensions of the work, what type of wood to use, and the criteria for choice of the materials. Working methods and the degree of the object’s finish would be defined, together with the length of time needed to complete it and the terms for consigning the finished piece. Documentary evidence provides us with precise information about the prices of a woodworking bottega: for example, the convent of Santa Felicita paid the considerable sum of eighty gold florins in 1395, for the wood support of a polyptych for the high altar of the church. The expense for carpentry usually represented about 15–20% of the total cost of the artwork. The project certainly included precise obligations for the patron, the painter, and the woodworker. Payment could be divided into various installments, especially for such complicated panels as a polyptych: at the moment of signing the contract, during its making, and upon
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consignment. According to the contract for the Sassetta altarpiece for the high altar of the Church of San Francesco in Sansepolcro, stipulated on September 5, 1437, the term for consigning the panel was four years, although it was actually finished only after seven. The amount agreed upon was rather high, 510 florins, and included the carpentry work the master from Siena was obligated to redo completely, since Antonio from Anghiari, to whom the work had been first assigned, retained what he had already prepared. The contract also fixed the payment schedule in three portions of 170 florins apiece. Other documents have been discovered: those for Filippo Lippi’s Mariinghi altarpiece for the altar of Sant’Ambrogio (1439–1447), which cost 35 florins for the woodwork and another 426 florins for painting; or those for the Masaccio’s polyptych for the Church of the Carmine in Pisa (1426), whose panel cost 18 florins and the painting 80. The amounts varied according to the patron’s capacity for investment and how important the artists involved were.

We have seen evidence on various works that the panel’s construction plan continued to be developed and adapted during production, as seen by full-scale marks made directly on the wood. This procedure has been observed in each period and for every type of panel.

Once all the materials for building the support were ready, bringing each section to the size decided, and leveling the edges of the boards to perfection for joining, the normal procedure foresaw marking where biscuits (ranghette) and dowels (cavicchi) were to be inserted. The position of the biscuits and the dimensions and final shape of the entire panel—rectangular, arched, or circular—would be marked on the boards after their assembly. The final step would be to define the position of the crosspieces. These were certainly complicated operations when planning a triptych or a polyptych: the space had to be divided and the form of the panels traced, the outlines marked together with the dimensions of the cusps, and the placement of the surmounting parts indicated. The final operation consisted in marking the position of the painted architectural and figurative elements. Similar procedures were followed for crosses after completion of the vertical body and arm pieces, a generally more complicated operation in comparison to marking rectangular pieces given their often non-linear perimeters.

An example of this form of preliminary marking was found on the central panel of the Madonna and Child triptych from the Church in Romena attributed to Giovanni del Biondo, heavily damaged by the flood of 1966: after removal of the pointed arch, three red lines, still sharp, were found that had been used to indicate the base and the point of the gable. Similar signs have also been observed on the wooden panel of Lorenzo Monaco’s Coronation of the Virgin altarpiece, today in the Uffizi: red lines were drawn to mark the areas where the battens would be placed on the rear, while others on the front traced the shapes of the gables, the arcs of the framing elements, and the overlying aedicules. Similar features have been observed on works by Fra Angelico, such as the altarpieces from San Marco, Annalena, and Bosco ai Frati, in the form of continuous straight red lines where the battens were to be fastened to the rear. The position of several biscuits appeared on the rear of Bronzino’s great panel of the Descent into Limbo from the Santa Croce Museum, to indicate where holes should be driven into the wood to insert the pins which would fasten the biscuits in their position midway inside the thickness of the support. Tracing the design on the rear when preparing the support of monumental crosses was of fundamental importance, done to mark the central point of the main body and arm panels, the contours of the terminals with the Mourners, and the spaces where the other parts should go. This procedure has been followed in Giotto’s Ognissanti Crucifix and in the great San Marco Crucifix attributed to his school (Figs. 1–2). Such planning permitted the woodworker to organize and construct the support in a rational way, following a sequence which foresaw preparing and finishing the necessary boards, assembling them, then preparing the battens and whatever inserts the format might call for, and lastly drilling the holes to receive the nails. The same rules were followed for the frame components, which were prepared in the required form prior to their attachment to the panel. If the object were a polyptych, all the various architectural elements, gables, pinnacles, predella, pilasters, etc., would be prepared according to the plan. Once the board structure was completed, it could be adjusted to size if necessary, and the other elements mounted according to the design: arches, the predella below, and any other structural components such as columns, pinnacles or whatever was required to finish the product.

2.3. Types of wood and their characteristics

Choosing a certain type of wood for making painted objects was certainly never haphazard, although to a certain extent the sources of
supply typical of a certain geographical area might influence the choice. A useful source of information about the species of wood used for making painting supports in antiquity is Pliny the Elder: he mentions lime (linden), acacia, fig, cedar, and sycamore trees as sources of wood, used for paintings ranging in date from the first through the fourth century A.D. It should be remembered, however, that the rare works surviving from this period are confined to a single type, that is funerary portraits. Cennino Cennini’s *Libro dell’Arte* cites the use of wood from fig trees.
and from what he calls albero (which in modern Italian simply means tree), as well as from lime and willow trees. These indications correspond to the following species: white poplar (Populus alba L.), lime or linden (Tilia cordata L.), and willow (Salix alba). Although these authors do not cite cypress as a source of wood for making panels, its use has been verified for the so-called Madonna della Clemenza, an early medieval work conserved in the Roman church of Santa Maria in Trastevere. Cypress wood was also used for the Virtue panels that Piero Benci, called Pollaiolo, was commissioned to paint to decorate the stalls in the hall of the Florentine Tribunale della Mecanzia (Merchants’ Tribune), the first to be finished being Charity (August 18, 1469). These ogival panels are painted on cypress wood (with the exception of Botticelli’s Fortitude which is poplar) and were made without battens.

Pear tree wood has also been used for making panels for painting, although it was more frequently used for furniture. The types of supports made of pear require further investigation, since the known examples are very rare: the only one we have encountered up to now is an oil painting representing The Daughters of King Ferdinand I by Jacob Seisenegger, c. 1534, in the Museum of the Castello del Buon Consiglio in Trent (204 x 113 cm and 1.5 cm thick). Olive trees were also used, although this wood’s features differ greatly from those of poplar, being very fine grained and with a surface that seems oily. Olive wood has been used for the support of the Baptism of Christ by Pietro Vannucci called Perugino (1490–1500, 30 x 23.3 cm), now in the Kunsthistorisches Museum in Vienna.

The most frequently occurring species of wood used for the works we have had the opportunity to examine directly are rather limited in number: chestnut, poplar, lime, spruce, silver fir, walnut, cypress, and cherry wood; while wood of the oak tree was preferred by Flemish artists. The choice of the wood for crossbars does not seem to follow the precise rules typical for supports: while for the earlier works chestnut and elm wood were preferred, in later centuries we find an abundance of battens made of wood from poplar and fir trees. In the area in and around Siena, the use of chestnut for constructing crossbeams persisted over the centuries, to the point where it may be said that this species dominates throughout the course of the fifteenth and sixteenth centuries.

Fundamental research aimed at identifying the wood used for making supports for painting is that done by Jacqueline Marette, who identified the wood species of over 1,000 panel paintings dating from the twelfth to the sixteenth centuries. Her study reports that in Italy poplar wood was the species used in 90% of the cases examined, while

2. The marks on the rear of the panel allowed reconstruction of the design used to cut the contour of the cross after its assembly.
the rest of the total is divided among 2% lime, 3% silver fir, 1% spruce, 3% walnut, and 1% oak. Leonardo da Vinci painted both the Lady with an Ermine from the Czartoryski Museum in Kraków, and the Musician in the Pinactoeca Ambrosiana in Milan on walnut.

The wood of chestnut trees was used rather frequently during the twelfth and thirteenth centuries, less so in those to follow. Chestnut has been used for the panels of several very important works, such as the Crucifix in the Duomo of Sarzana, painted by Master Guglielmo in 1138, and many other works dated not long after. This species was widely diffused in the areas around Lucca, and Pisa, but also extended to Florence, where we find it in the Rosano Crucifix, in the carved bas-relief panel from the Church of Santa Maria Maggiore, and in the Crucifix no. 432 from the Gallerie degli Uffizi. Poplar wood (Populus alba) was also used during this early period, although it may be affirmed that its systematic use began only in the second half of the thirteenth century, in particular for the monumental painted crucifixes, gabled altarpieces, and other types of objects.

As for lime wood, we have found relatively few panels made of this material, although several are the works of such important painters as Dürer, Cranach, and Raphael. Coniferous wood is mostly present in northern Italy, in particular in the Venetian region, although important thirteenth century panels made of this material may also be found also in southern Italy.

Cypress has been determined in only a few cases, such as the previously mentioned Virtues by Pietro del Pollaiolo painted for the Merchants’ Tribune. The restoration of their supports has revealed the methods of construction: three boards of which the central is the widest have been butt-joined edge to edge; no battens have been fastened to the rear; instead “dovetail” elements have been set into the joins, with shaped rather than straight edges forming a decorative motif. The Madonna della Clemenza is also made of cypress wood with three vertically arranged boards, also joined by uniting their flat edges, and with a linen cloth laid down over the wood. This painting conserves its original chestnut wood frame, characterized by the groove carved into its inner edge that allows it to be fitted onto and enclose the panel’s perimeter.

Beyond what strictly involves the technology of the materials, the use of the various species of wood may be logically connected to the works’ intended function. Its choice was certainly guided by the desire to find a material suitable for obtaining the greatest degree of stability and durability of the objects, as well as uniformity, fineness of grain, and correct surface porosity, qualities capable of offering an optimum surface for the preparatory layers. Chestnut trees, which belong to the deciduous category, provide wood that possesses most of these qualities, especially a good stability in the presence of ambient variations in humidity and resistance to wood-boring insects. These are combined, however, with certain negative aspects, mainly due to the presence of tannins and to the wood’s irregular texture. In fact, tannin may become soluble during the application of gesso, with the risk of staining the ground, while the irregularities may affect the adherence of the ground layers to the surface. In any case, coating the wood first with glue and adhering cloth to it before applying the gesso could efficiently counteract such negative factors.

Poplar wood also has various positive qualities, being lightweight, easy to season and work, relatively uniform, with an appropriate degree of porosity and good chromatic appearance. Furthermore, thanks to the relatively low specific gravity of this type of wood, RH variations do not engender any particularly accentuated phenomena of dilation and warp, considered among the most dangerous factors for polychrome artifacts. On the other hand, poplar wood also presents certain negative characteristics, in particular its vulnerability to attack by hylophagous insects. In comparison to the other species taken into consideration, the wood from coniferous trees has certain features that render it the least suitable for support construction, such as its marked irregularity, greater tendency to react to RH variations, and scarce resistance to mold.

2.4. The woodworker’s workshop
The descriptions contained in various manuscripts provide us with an idea of how a Quattrocento craftsman’s workshop was organized; other documents transcribe the actual laws and statutes regulating the practice of this craftsmen’s trade in the Florentine Republic of the period. “As is well-known, in 1314, painters in Florence had the opportunity (and obligation) to register in one of the most important major guilds, that of the Medici e Speziali. The members of the woodworkers’ guild were those meant for structural tasks but they were also authorized to paint, letting us deduce that the relationship between painters and craftsmen was becoming increasingly closer. The types of tools...
used to construct the objects have been illustrated in various ways, supplying useful information about them: for instance, woodworking utensils were sometimes represented in the inlays of fifteenth-century wooden choir stalls; or, as they appear in another important example, carved on the pilasters of the Badia di Rofena triptych. A scene in a 1470 miniature by Jean Bourdichon is an especially meaningful painted example, showing the woodworking tools and the objects made with them. Another example is one of the three sections of the Mérode triptych painted by the Flémalle Master (Robert Campin) in 1427, depicting St. Joseph in his very tidy carpentry workshop with the tools of his trade.

However, it is mainly through direct examination of paintings dating from the various periods and the study of the techniques used for to construct them, that we are able to gather useful information for understanding the way these artisan workshops were organized and how work proceeded during the late Middle Ages and the Renaissance. The construction of works of such large dimensions as Giotto’s Crucifix from Santa Maria Novella (whose height is 530 cm by 400 cm in width at the extremities of the arms, and which weighs about 300 kg), or Duccio’s Rucellai Madonna now in the Gallerie degli Uffizi (450 x 290 cm, surely weighing around 450 kg), or his gabled Maestà in the Opera del Duomo in Siena would certainly have been impossible without having ample work space and many differently specialized craftsmen available. We also know of very large panels fabricated in the ample spaces of churches, for example Bronzino’s Deposition made for the Zoccolanti friars of Cosmopolis (Portoferraio) on the Island of Elba, but crafted in the precincts of the Church of Santa Croce in Florence.

Documents referring to the construction of choir stalls often cite the name of the workshop headmaster, who was responsible for the most delicate and important tasks, although it is obvious that many other persons would also labor under his guidance. The woodworkers assigned to the heaviest building tasks were surely among these, despite the fact that they were certainly not also intarsia inlayers or carvers. These observations may be useful compared with what happens today, for example the fact that in the past the manual toil of constructing wooden objects basically involved the same techniques as those dedicated to the rest of the work, requiring identical criteria for choosing the materials and organizing labor in the workshop.

2.5. Construction of the panel

The most commonly used method for cutting boards from the tree trunk was to cut parallel planks of various thicknesses from the trunk, slicing through it from one side to the other. In this way it was possible to obtain the greatest quantity of material from the trunk, in the form of boards each having a different type of cut: diametrical, sub-radial, sub-tangential, and tangential (Fig. 3). This method of board cutting has been used for all of the works made in Italy, and we may also say in general in Europe. Several Flemish paintings are an exception to this, being made with boards cut from tree trunks divided into quarters. After selecting the wood of the desired plant species and having the appropriate properties, the boards would be selected for assembly, privileging the ones obtained from the area nearest to the center of the trunk. The boards would then be readied to receive the preparatory layers, preferably the side facing inwards towards the center of the trunk because this position provided greater stability. Stability was such an important aspect that it was also sought after by choosing very thick boards in proportion to their width and height, since the increase in mass was able to slow down certain potentially harmful physical reactions.

Each board was worked separately, dedicating more attention to the front side to be painted, smoothing it down with care; the rear was usually finished less accurately, often leaving it just as it was after sawing, or only partially smoothing the surface.

3. Drawing illustrating the way in which a tree trunk was sawn into boards.
with a roughing plane or adze (Fig. 4). The boards were then joined together to form the full panel, usually positioning the widest and naturally also the best quality planks centrally, leaving the others for the side portions. Any smaller sections of wood to reach the desired dimensions would be joined laterally. Cavities, circular for insertion of wooden dowels (cavicchi) and rectangular when biscuits (ranghette) were planned, were carved in the thickness of the boards from their side edges. Dowels and biscuits were fashioned out of wood harder than that used for the support itself; most dowels were made of oak or chestnut wood, while biscuits were usually walnut. These elements, distributed uniformly along the joins, were positioned cross-grain in relation to the board structure; they would also be slightly shorter than their housings and were generally not glued in. Their main function was to hold the edges of the planks level as they were glued together, and to a lesser degree to strengthen the joins. After having perfectly adjusted the surface of the boards’ edges, they would be scored diagonally to assure good grip for the adhesive, followed by gluing with calcium caseinate. The boards were usually butt-joined side to side, although there are cases of continuous tongue and groove connections along their entire length. The choice of “cheese” or lime-casein glue was intentional since it could be used cold, or rather at room temperature, and had a relatively slow drying time; it was therefore particularly suitable for large-scale objects composed of various pieces. Furthermore, this type of glue also furnished a particularly strong hold and was quite resistant to dampness. The boards glued together to form the support were held firmly united during this operation, either clamping them (Figs. 5, 6), or holding them together with other devices such as...
as a pair of parallel bars, whose ends were clamped to form a vice whose force was increased by inserting wedges. Typically, the panels made in central Italy are composed of vertically arranged boards, although works whose boards are connected horizontally (beyond the many altar dossals whose function suggested constructing them this way in any case) certainly do not lack. Niccolò di Pietro Gerini’s Deposition from the Church of San Carlo in Florence, recently restored at the Opificio delle Pietre Dure, is an example of this type of support structure: gabled and very large in size (its maximum height is 408 cm, and width is 286 cm), the support is formed of butt-joined poplar boards mounted horizontally. An unusual feature in this case is the fact that several planks have been mounted with their “external” side (meaning the side of the board facing outwards towards the bark when the tree trunk is sectioned, rather than inwards towards the center) placed facing frontwards to receive the preparatory and paint layers. Similar characteristics have been noted on another painting by Niccolò di Pietro Gerini, a triptych with the Madonna and Child Enthroned and the Saints Nicholas of Bari, Lawrence, Bartholomew and a Bishop in the lateral parts, from the Church of San Martino at Ponte a Mensola in Florence, recently acquired by the Gallerie degli Uffizi. In this case the support consists of a single horizontal board assembly measuring 164 x 139 cm overall, with the outer face of the uppermost board facing the front, and the crossbars on the rear nailed at the center of each portion in correspondence to its pointed arch. However, these are not the only examples from Florence: a similar system may be seen on another triptych, the Madonna with Child and Angels by Bernardo Daddi from the Church of Santa Croce, composed of horizontal boards and battens which are still the original ones nailed to the panel in correspondence to the gables. Other examples are: the central part with the Madonna and Child, originally part of a now dismembered polyptych by the school of Bernardo Daddi (Museum of Santa Croce, Florence); the triptych with the Madonna and Saints Matthew and Nicholas in the Gallerie degli Uffizi (144 x 194 cm, with original crossbars); the panels with Saints Catherine, Jacob and John attributed to Jacopo del Casentino (Castelfiorentino, Museum of Santa Verdiana). Among the works by Duccio di Boninsegna with horizontally placed boards, we may cite the two Maestà panels, each painted on both sides, the one from Massa Marittima on a single panel, and the one in Siena formed of two board structures.

The application of crossbars to the rear of the support was the next step, aimed at reinforcing the structure and countering the tendency of the boards to warp. Whether this consisted of simple crossbars or was more complex, it always involved nailing down the battens. The nail was an essential element of this type of supporting restraint, and its characteristics—the metal from which it was made and the way the nail functioned—are certainly worth a moment of attention. The nails used to fasten crosspieces had a flat-sided, pyramid-shaped Shank terminating in a large faceted head on one end and tapered to a sharply pointed tip on the other; they were usually made of impure and sufficiently ductile scrap iron. Nailing furnished point-by-point attachment of the battens to the support, usually entailing insertion of two nails per board, positioned several centimeters inside their outer edges, although wider panels might require three nails per board. The way in which these nails carried out their function of fastening the crossbars to the support was certainly different from what we are accustomed to today: the nail’s grip, rather than being provided by the pointed shaft penetrating and creating its own space in the wood, was the result of the hold assured by the large nail head on one side, and the tip bent back and clinched into the wood on the other. For this type of anchorage, holes were pre-bored in the battens to allow the nails to pass through their entire thickness, while the tip coming out on the front of the support was clinched back into the wood, in a space carved for this purpose in correspondence to where the nail emerged. The more accurate constructions foresaw covering the protruding parts of these iron elements with plugs of the same wood as the rest of the support, in order to isolate the metal from the preparatory layers (as in the case of Cimabue’s Crucifix from the Museum of Santa Croce, Fra Angelico’s Linaioli Tabernacle, and many other works). In numerous other examples, the metal elements were covered with gesso, on top of which a piece of cloth or a parchment patch would be applied to grant further isolation. Heating of the metal and subsequent insertion of the iron nail at high temperatures was also sometimes practiced, although rarely, to facilitate the passage of the nail through the wood, as has been observed in the assembly of the components forming the predella of the Annunciation by Lorenzo Monaco from the Church of Santa Trinita (Florence).

The frame was the final part of the construction to be mounted. It could consist of two or more pieces, depending on the shape and dimensions.
desired, although the rules normally prescribed that one section would be placed on the front perimeter, while another would complete the profile by enclosing the panel along its side edges, covering their entire thickness (Fig. 7). The two parts were fastened point by point to the rest of the construction with glue and nails; the tips of the nails were clinched back into the wood, and would thus remain underneath the portion of the frame placed on the front of the painting. The nails used to fasten ornamental parts differed from those described previously, having a flatter shaft and practically no head. Wooden pins could replace nails in paintings that demonstrated a particularly high level of attention to the quality of workmanship, as was the case of the Giotto Crucifix from Santa Maria Novella. A work from an earlier period in the Bargello Museum attributed to Enrico di Tedice also has frame elements fastened with wooden pins. The nails used for attaching frames, architectural elements, and above all crossbar systems (whether simple or in the form of a lattice, were in any case all victims of the great scorn of restorers practicing during the nineteenth and for that matter even for most of the twentieth century) but were able to create quite effective bonds on many works of this period, and often still functional well. The excellent choice of materials, the type of nails, their shape and flexibility, the criteria for insertion, and the adaptive ability of the wood surrounding the nails all contributed to this.

An important and unusual example of a technique to nail the battens to the panel is that on Ambrogio Lorenzetti’s Badia di Rofena Polyptych. The system is quite simple yet functional, allowing the support to adapt to the movements of expansion and shrinkage, as well as to natural changes due to aging. The technique consisted of carving a V-shaped slot in the inner face of the batten in correspondence to the nail (Figs. 8–10), horizontal in relation to its seat; the slot penetrates to about two-thirds of the batten’s thickness, and measures about 1.5 cm on each side from the center of the nail hole. The purpose of this mechanism was to allow at least to a certain extent the movement of the panel in relation to the point of anchorage of the nails in the batten.

Even the format of the paintings from this period seems to adapt at least partially to how wood tends to behave: in fact, many works were not particularly large in width. Conversely, the limits of using this iron-bound method of applying battens and frames were reached with the great—and typically very wide—gabled altarpieces at
the end of the thirteenth and beginning of the fourteenth centuries: for example, the *Maestà* panels painted by Duccio and Giotto (the latter 325 cm high by 204 cm wide), both now in the Uffizi, have suffered enough dimensional shrinkage of the boards during their lengthy process of stabilization that the ability of the wood to adapt to the nails has been exceeded. This has provoked cracking which has found its way to the painted surface. Such phenomena are instead relatively limited on the other works, and without consequences for the preservation of the paint layers. On even very large painted crosses, for example, the dimensional modifications of the wood components subject to this type of reaction have remained well within tolerated margins despite the passage of time.

As for preparation of the wood panel for painting, all the rules described by Cennino Cennini in his *Libro dell’Arte* seem to have been actually put into practice. We may observe, in fact, that a layer of cloth has indeed been glued to the support, extended to also encase the frame, followed by various coats of gesso (calcium sulfate dihydrate or gypsum) in a glue medium laid down over the cloth. Finishing of the back could include a coating of minium or gesso grosso with glue that was sometimes also decorated. These technical features have without doubt ensured greater stability for the artworks by reducing deformations from movements due to the exchange of moisture with the surrounding air, and by acting as a protection against wood-boring insect attack.

2.6. Altar frontals

Among the many painted objects made of wood throughout the centuries, altar frontals (otherwise called “dossals” or “antependia”) are among the simplest structures; their peculiarity lies in the recurring format and sometimes in the absence of crossbars placed on the rear as a reinforcement. Established practice in fact prescribed that even a small size composite group of boards would require structural devices capable of stabilizing the ensemble. When these are lacking, their function was probably substituted by some aspect of the placement of the object in its site, and of course also by the presence of engaged frames, united with the support on the front and sometimes also enclosing the edges. The rectangular shape of dossal panels certainly reflects the space they were intended to occupy, whether positioned in front of the altar or on the wall above the altar-table. The wood support is composed of horizontally arranged boards, while control of deformation and structural support relies on the presence of the frame elements attached to the front and sometimes also to the sides; in certain cases such panels do have battens nailed to the rear. Meliore’s dossal with the *Madonna and Child* and Saints (Florence, Gallerie degli Uffizi, 85 x 210 cm) is an interesting example of a type of dossal construction without battens: while the shape of the poplar wood support is basically horizontal, the central part of the upper edge incorporates a
gable containing the halo and part of the Savior’s head. The flat upper portion of the original frame is decorated with a double row of pastiglia hemispheres in relief, and the inner strip of the frame around the perimeter is sloped and decorated. In this case it has not been possible to verify whether the frame pieces have been carved out of the actual support boards or applied separately. An example of a different shape of dossal is the one by the Tressa Master in the Pinactoeca Nazionale in Siena: the frame that separates the scenes internally has been carved out of the wood of the support itself, while the parts on the edges have been applied separately; three crossbars were originally nailed to the rear. A similar structure has also been used for the Bigallo Master dossal now in the Opera del Duomo in Florence. This large panel has a sizable frame on the front carved out of the thickness of the support wood, while the frame originally around the edges, now lost, was applied and fastened with nails. Unfortunately, the panel was thinned down during restoration in the 1930s, making it impossible to ascertain whether battens originally existed on the rear. Further technical details regarding these two works are included in the chapter on carved-out supports.

Restoration of the St. Michael Archangel dossal by the Vico l’Abate Master and that by Meliore from the Church of San Leolino at Panzano has provided further knowledge on this type of construction. The support of the St. Michael panel is rectangular, formed of three nearly sub-radial boards of poplar wood, characterized by their straight grain, rather homogeneous consistency, and scarcity of knots. After trimming the edges, the sides of the boards were perfectly matched together and butt-joined, glued one to another; a poplar wood frame, 6 cm wide and 1.5 cm thick, with an inner edge sloped at an angle of about 45°, was glued and nailed to the front of the support. A single piece of cloth was then glued over the entire support, extending up and over the outermost edge of the frame. The well-chosen boards certainly contributed to this painting’s excellent state of conservation, although the wood does show some signs of an antique attack of wood-boring insects, in any case compatible with what might be expected given the type of wood and the age of the panel. The good general conditions may be principally attributed, in any case, to the high quality and consequently fine state of the preparatory layers, as confirmed by the X-radiograph. Preparation for painting included the gluing down of a very densely woven piece of cloth over the entire support and the frame, the application of a generous coat of gypsum and glue gesso, followed by priming of the entire surface. A layer of gesso grosso was also applied to the rear of the panel.

The dossal by Meliore (Fig. 11) is similar in form and dimensions. The panel is composed of three boards made of not particularly choice poplar wood, cut sub-tangentially. The boards have two large knots and the porosity of the wood is irregular; furthermore the finishing of the edges of the planks has not entirely eliminated the sapwood. The boards, whose “inner” faces constitute the side used to prepare and paint, have been assembled uniting each join with the aid of four dowels, uniformly distributed along their length. As usual, the dowels are spindle-shaped to adapt better to the cavities, which were pre-bored using a conical spiral drill (the maximum diameter of the cylindrical part of these openings measures about one centimeter). The hardwood dowels have been inserted in the pre-prepared openings cross-grain to the fiber of the boards; they have not been glued in, and fit without forcing lengthwise (Fig. 12). As in the case of the former painting, strips
of wood measuring 5.5 cm in width and 1.5 thick have been fastened to the front margins of the support to frame it, gluing the portions at intervals to the support, and nailing them down with nails inserted front to back, with the tips clinched back into the wood on the rear. A tightly woven canvas has been glued to the support flats and the frame, therefore covering all the parts before application of the preparation. The ground is a complex combination of seven layers: first gesso grosso, followed by fine-grained gesso, all with an animal glue medium.

2.7. Examining a special technique of construction: carved-out supports

This chapter does not intend to be a study of Byzantine icons and their genesis, a subject matter whose scope and complexity is even greater than usually thought, and therefore requires extensive historical and technical research. Since my personal knowledge of this type of painting is limited to several works conserved in various Tuscan museums, my observations will be reserved to describing the construction of different types of twelfth and thirteenth century wooden panels, made according to similar criteria.35

We refer to panels as carved-out or hollowed-out when their frame or architectural elements have been carved from the wooden panel itself, and therefore lie on a different plane from the rest. Various typologies of panel paintings could be made this way, such as the altar dossal, the “alterolo,” the polyptych, certain painted crosses, small pointed arched panels with hinged doors, or even simpler types. Usually these works were painted only on one side, although there are also cases painted on both.

This special mode of construction was typical of traditional Byzantine panels, generally limited in size and quite simply fashioned without elaborate architectural or shaped frame elements. As we will see, numerous twelfth and thirteenth century panels made in central Italy were fashioned by hollowing out the support, generally made of popular or chestnut wood. Carving certain parts such as flat or shaped frames elements directly from the support material may seem a way to simplify construction; in reality working this way was actually more complicated, and more time was spent to produce a flat plane on a lower level and prepare it to receive the ground layers for painting.

The technique of carving out the painting plane from the full thickness of the wood is alternative to that usually preferred in our regional areas, which foresaw preparing a flat board surface on which to attach separate frame ornaments. However, in this period the specialized carpentry workshops were perfectly capable of producing very high quality objects with a variety of special techniques, testimony to their knowledge and competence. We may therefore say that the hollowed-out support was among the numerous choices available, all belonging to a workshop tradition of great quality and proficiency.

As already said, the technique of preparing a support with borders raised above the level for painting without adding any other wooden pieces, was the method used principally to make icons, strictly linked to the Byzantine tradition.36 Many examples of this type of panel exist in countries of mainly Orthodox religious traditions, and are documented well before the Middle Ages and up to the present day, although the period of greatest development goes from the second half of the thirteenth century through the middle of the sixteenth. Of course the artistic qualities of these objects is also embodied in other details besides the carpentry and painting techniques; often the sacred images are surrounded by finely embossed silver revetments, textile strips, and other elements applied to contain relics. These features are certainly not secondary, and distinguish these objects from those of a prevalently Western cultural tradition. The innovations introduced in the late Middle Ages by artists such as Cimabue and Giotto (said to have transformed painting from “Greek to Latin”37) brought fundamental changes both in panel construction and the actual painting technique. One interpretation emerging from studies on Byzantine works motivates making the support with the main painted surface on a lowered level, in the symbolic significance this assumes from a religious point of view. None the less, the shape and size of many panels also concurs in rendering them suitable for hollowing out the wood to prepare the support.38

Our observations on this matter are not in contrast with motives based on devotional sentiments; they simply refer to what was perfectly understood by the artisans crafting these objects. Master woodworkers understood from experience the various aspects of the behavior of wood, its seasoning, warp, and aging; they were therefore certainly capable of making supports from single board structures that succeeded in reducing tensions within that might reflect on the preparatory
layers. Thus the panel structure was made to receive the sacred image in the best possible way, protecting it and assuring its long-lasting preservation, so that its intrinsic devotional and religious values would be fully sustained.

As mentioned before, the Byzantine icon is characterized by a simple and essential technique of construction: the wood was carefully selected and seasoned, and might also be submerged in water at about 50° C to eliminate any residual extractives in order to increase its resistance to wood-boring insect attack. The wood species used were rather limited: among these we may cite wood from such deciduous trees as poplar, lime, and alder, and depending on provenance, also oak and birch; coniferous species such as cypress and fir were also used (although the latter was not considered particularly suitable because of its non-homogeneous grain and the presence of resin in the wood).

The pieces examined have not revealed any specific rules regulating board placement, since both vertical and horizontal arrangements have been observed, undoubtedly in relation to the panel’s final shape and dimensions.

Assembly generally entailed butt-joining the side edges of the boards and inserting dowels or biscuits in the joins, placing the “inner” face of the cut boards on the side destined to receive the preparatory layers. These criteria are therefore similar to those followed for most panel paintings in Italy from the twelfth to the fifteenth century.

Carving out the flat surface for painting was certainly the most complex operation. Since the presence of the raised edges obstructed the general use of carpenter’s planes, it was necessary to resort to other tools: chisels, gouges, and two-handed draw blades were needed to finish the internal flat portion. The front face of the frame was planed flat, while the inner edge was chiseled sloping downwards towards the painted surface. Icons formed of more than one board probably involved preparing each plank separately before assembly, finishing the edges before joining and scoring the surface to improve adhesion. The flat plane usually appears appropriately smoothed to receive the ground layers, worked following the grain of the wood; cloth could also be applied as a buffer layer between the wood and the gesso.

The raised edge portions were simply realized, creating a flat surface on the front, with a straight external edge and the inner edge slanting towards the painted surface. The depth of the internal plane in relation to the raised elements varied, from about five to six millimeters to a centimeter. The varying dimensions of the frame parts were probably in proportion to the overall size of the works, although this cannot be intended as a precise rule. Lastly, several of the panels observed, especially those in the form of a polyptych, also presented molded or flat elements added to the side edges or to the frame on the front, or on the outer edges of the gables.

Again, the fact that such a procedure for support construction allowed the boards to adjust physiologically according to their cut, without encountering any contrasting cross grain elements, contributed to the good preservation of the preparatory layers and the entire artifact. It is well known that even after a long period of seasoning, wood continues to react to variations of RH in the surrounding environment, producing movements and warp in the material; even after centuries these reactions continue to reduce the wood’s dimensions, although in a limited way. Therefore carving the framework out of the entire thickness of the wood support without applying any elements with fibers running cross-grain favored the uniform behavior of the entire object. By discussing several examples of paintings with similar constructive features made in central Italy in the twelfth, thirteenth, and fourteenth centuries, we hope to improve understanding of this particular structural category. The contacts which existed between Byzantium and Pisa, and from there with other cities, certainly played an important role by diffusing new models to imitate, although formal and technical distinctions between the two support methods remained.

Various thirteenth and fourteenth century panels have been made with the painting surface recessed below the frame, including important examples in the Museo di San Matteo in Pisa (Fig. 13), and others from areas in and around Florence and Siena; however, the earliest known example is the Madonna Advocata icon in Santa Maria in Aracoeli in Rome.

Pisa underwent a great period of economic development during the Middle Ages thanks to its geographical position and the trade this offered inland, but more so by sea with cities along the coast and in the East. Pisa’s commerce extended along the shores of the Mediterranean, while in the twelfth and thirteenth centuries the city also acquired military force as well as being an important meeting point for international trade.
It is particularly difficult to understand the origins of this influence: certain icons famous for devotional reasons must have played a decisive role through imitation of their technical features. However, workshop know-how would have been difficult to transmit only in this way, and usually required a more direct relationship; therefore we cannot exclude the actual presence of some painters or woodworkers from the Byzantine realm who could have diffused the technical procedures among local artisans. The inherent symbolic values were so forceful that they would have been maintained in any case, even after the advent of conspicuous changes: unquestionably the increased size of the works destined to be placed on the partitions and altars of Western churches became unsuitable for icons. This regarded not only the method of construction used to make them, but even more so the expressive intentions. In this case, after all, technique and style did not always proceed together.

Manufacturing centers developed in Pisa, together with activities for artistic production arising from important cultural contacts.

Besides the works from Pisa, several other interesting examples may be mentioned: the San Zanobi Dossal by the Bigallo Master now in the Museo dell’Opera del Duomo in Florence; two works by the Tressa Master in Siena, the Madonna and Child called the Madonna of the Large Eyes in the Museo dell’Opera del Duomo, and the Savior Dossal in the Pinacoteca Nazionale; two works by Giotto, the Badia Altarpiece now in the Uffizi and the Polyptych in the Pinacoteca of Bologna. These works show that the technique of hollowing out the support existed over a rather wide time span, from the end of the eleventh until the first half of the fourteenth century.

The methods for constructing Byzantine icons thus continued to influence Tuscan medieval painting until the fourteenth century, including the technical aspects, at a time when the new Giottesque version of the Gothic style had already achieved the highest expressive effects. Furthermore, this influence continued even when panel paintings had reached sizeable dimensions well beyond those of traditional icons, and were set in monumental positions on the rood screens and altars of Western churches.

The following table lists the hollowed-out works ascertained up to now in Italy.43
<table>
<thead>
<tr>
<th>WORK</th>
<th>AUTHOR</th>
<th>PERIOD</th>
<th>DIMENSIONS (heightxwidth)</th>
<th>LOCATION</th>
<th>TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Madonna Advocata</td>
<td>Ciro Castelli</td>
<td>third quarter of 11th cent.</td>
<td>82.5 x 51.5 cm</td>
<td>Rome, Santa Maria in Aracoeli</td>
<td>icon</td>
</tr>
<tr>
<td>San Pietro all'Orto Cross</td>
<td>artist from Pisa</td>
<td>beginning of 12th cent.</td>
<td>295 x 210 cm</td>
<td>Pisa, Museo Nazionale di San Matteo</td>
<td>painted cross</td>
</tr>
<tr>
<td>Madonna and Child</td>
<td>artist from Pisa</td>
<td>1140–1160</td>
<td>68 x 50 cm</td>
<td>Pisa, Museo Nazionale di San Matteo</td>
<td>altarpiece</td>
</tr>
<tr>
<td>Madonna “Kardiotissa”</td>
<td></td>
<td>second half of 12th cent.</td>
<td>115 x 71.5 cm</td>
<td>Athens, Christian and Byzantine Museum</td>
<td>Byzantine icon</td>
</tr>
<tr>
<td>Madonna and Child “INELLUS”</td>
<td></td>
<td>beginning of 13th cent.</td>
<td>80.2 x 59.7 cm</td>
<td>Pisa, Museo Nazionale di San matteo</td>
<td>altarpiece</td>
</tr>
<tr>
<td>Madonna del Casale</td>
<td>Tuscan master</td>
<td>1212 ?</td>
<td>180 x 79 cm</td>
<td>Florence, Gallerie degli Uffizi</td>
<td>altarpiece</td>
</tr>
<tr>
<td>Savior Dossal</td>
<td>Tressa Master</td>
<td>first half 13th cent.</td>
<td>98 x 198 cm</td>
<td>Siena, Pinacoteca Nazionale</td>
<td>dossal</td>
</tr>
<tr>
<td>Madonna of the Large Eyes</td>
<td>Tressa Master</td>
<td>first half 13th cent.</td>
<td></td>
<td>Museum of the Opera del Duomo di Siena</td>
<td>icon</td>
</tr>
<tr>
<td>San Zanobi Dossal</td>
<td>Bigallo Master</td>
<td>1220–1230</td>
<td>112 x 278 cm</td>
<td>Florence, Museum of the Opera del Duomo</td>
<td>antependium</td>
</tr>
<tr>
<td>Madonna “de Ambro”</td>
<td>attr. “Alberto Sotio”</td>
<td>first half 13th cent.</td>
<td>173 x 66</td>
<td>L'Aquila, Museo Nazionale d'Abruzzo</td>
<td>altarpiece</td>
</tr>
<tr>
<td>Saint Francis</td>
<td>attr. Giunta Pisano</td>
<td>first half 13th cent.</td>
<td>163 x 129</td>
<td>Pisa, Museo Nazionale di San Matteo</td>
<td>altarpiece</td>
</tr>
<tr>
<td>Christus triumphans and Stories of the Passion</td>
<td>Enrico di Tedice</td>
<td>first half 13th cent.</td>
<td>257 x 155 cm</td>
<td>Vicopisano, Church of San Giovanni alla Vena</td>
<td>painted cross</td>
</tr>
<tr>
<td>Standing Madonna with Child and two angels</td>
<td>Enrico di Tedice</td>
<td>first half 13th cent.</td>
<td>105 x 73.5</td>
<td>Peccioli, Prepositura di San Verano</td>
<td>icon</td>
</tr>
<tr>
<td>Deposition</td>
<td>Enrico di Tedice</td>
<td>mid 13th cent.</td>
<td>57 x 35 cm</td>
<td>Pisa, Museo Nazionale di San Matteo</td>
<td>altarpiece</td>
</tr>
<tr>
<td>Saint Catherine</td>
<td>Attr. Maestro di Calci</td>
<td>mid 13th cent.</td>
<td>107 x 115 cm</td>
<td>Pisa, Museo Nazionale di San Matteo</td>
<td>altarpiece</td>
</tr>
<tr>
<td>Madonna Enthroned with Child</td>
<td>Roman Master</td>
<td>mid 13th cent.</td>
<td></td>
<td>Viterbo, Museo Civico</td>
<td>altarpiece</td>
</tr>
<tr>
<td>Madonna with Child and Angels</td>
<td>Master of Saints Cosmas and Damian</td>
<td>1260–1275</td>
<td>85.4 x 56 cm</td>
<td>Pisa, Museo Nazionale di San Matteo</td>
<td>altarpiece (triptych?)</td>
</tr>
<tr>
<td>Saints Nicola, John and Procolo</td>
<td>Pacino di Buonaguida</td>
<td>1305–1310</td>
<td>75 x 52 (each panel)</td>
<td>Florence, Galleria dell'Accademia</td>
<td>polyptych (three surviving parts)</td>
</tr>
<tr>
<td>Madonna and Child</td>
<td>Madonna Altieri Master</td>
<td>1310</td>
<td>121.5 x 73.5</td>
<td>private collection</td>
<td>altarpiece</td>
</tr>
<tr>
<td>Madonna and Child</td>
<td>School of Bernardo Daddi</td>
<td>mid 1300s</td>
<td>98 x 55 cm</td>
<td>Florence, Museum of Santa Croce</td>
<td>polyptych (only surviving panel)</td>
</tr>
<tr>
<td>Pantocrator with Saints Peter and Paul</td>
<td></td>
<td>first half of 14th century</td>
<td>76 x 60</td>
<td>Pisa, Museo Nazionale di San Matteo</td>
<td>icon</td>
</tr>
<tr>
<td>Badia Polyptych</td>
<td>Giotto</td>
<td>1303</td>
<td>142 x 337 cm</td>
<td>Florence, Gallerie degli Uffizi</td>
<td>polyptych</td>
</tr>
<tr>
<td>Bologna Polyptych</td>
<td>Giotto</td>
<td>c. 1330</td>
<td>147 x 217</td>
<td>Pinacoteca Nazionale of Bologna</td>
<td>polyptych</td>
</tr>
<tr>
<td>Madonna and Child Enthroned with Saints and angels</td>
<td>Jacopo Landi, called Jacopo del Casentino</td>
<td>1340</td>
<td>39 x 42 cm</td>
<td>Florence, Gallerie degli Uffizi</td>
<td>portable tabernacle</td>
</tr>
<tr>
<td>Christ deposed with the Virgin and Saints</td>
<td>Vitale da Bologna</td>
<td>1350–1360</td>
<td>60 x 39 cm</td>
<td>Florence, Fondazione Longhi</td>
<td>altarolo</td>
</tr>
</tbody>
</table>
2.8. Construction of the wood support of Master Guglielmo’s Cross

The painted Crucifix by Master Guglielmo from the Duomo of Sarzana (Fig. 14), dated 1138, is the earliest work among those studied to reveal such a significantly complex and articulated structure, showing an excellent understanding of wood as a material and of the techniques of assembly. While its structural aspects may seem relatively simple at a first glance, the work is actually evidence that these woodworking techniques could not have originated in the period of its creation, but must have been the fruit of an already consistent past tradition. The chestnut wood support measures 297 cm in height and has a maximum width of 214 cm at the extremities of the arm boards; the main board placed vertically is quite wide (63 cm), and its height is that of the cross itself. The wood, very well chosen, has been cut almost diametrically, and has straight-running grain and homogeneous consistency; the material for the arm and two side apron boards also corresponds to these criteria. The boards have been placed so that their inner faces would receive the preparation; the proportions among height, width and thickness is correct, and the arms and body parts of the structure have been perfectly united with mortise and tenon joints. The two strips of wood added to each side of the cross, flanking the Christ figure, have been fastened with casein glue and four nails each. The arms have been tightly secured in their housings with bone glue, and each piece has been further fixed passing three wood pins through them (Figs. 15, 16). Keeping in mind that these joins represent the major area of structural weakness, we may identify three different solutions excogitated to make the arm junctions more solid. First, the thickness of the arm pieces has been slightly tapered outwards towards the extremities to reduce the weight of these projecting parts, a feature that also conveys the sensation that the body of Christ is advancing slightly towards us. The second provision was to carve out the mortise openings in the side edges of the main vertical board a few centimeters below its upper edge; this assured that all four sides of the arm tenon housings would remain intact, therefore increasing the stability of the join and its ability to resist the tensions during insertion of the tenons themselves. Lastly, the third technical detail that contributed to supporting the arms and avoiding dangerous “twisting” of the contrasting parts, was the way in which the two lateral aprons flanking the body of the cross have been joined to the arm boards above: the vertical and horizontal pieces were united by means of a tenon on the upper edge of each apron board, inserted into a mortise opened in the thickness of the horizontal arm board above. The halo was made of a separate piece of chestnut wood, carved sloping downwards, set into a cavity opened for it in the main panel, and nailed and glued similarly to the other components. The outer perimeter of the circular halo was finely carved with a simulated intertwining thorn motif meeting at four points. A crosspiece was originally fixed to the rear at the height of the arms: placed centrally on the horizontal boards, this batten was fastened to the vertical board (with the body of Christ) with three nails, and to each arm piece with another two. This crossbar kept the warp of the central panel under control and helped to support the jutting arms, thus reducing their weight on the joints and distributing the forces among the various parts. Old nail holes in the lower part of the foot tablet may suggest the presence of another crosspiece which might have also served as a base for the cross, inserted into an opening to receive it. A fine, close-woven cloth was applied to the
front of the wood support, as was customary at the time. The rear of the wood support was carefully coated with a layer of gesso grosso in glue, which balanced the forces acting on the two faces and protected the painting.54

Other painted crosses from the area of Lucca, such as the Crucifixes in the museum of Villa Guinigi and in the church of San Michele in Foro, were constructed with the same type of wood and technical criteria as Master Guglielmo’s Sarzana Crucifix.

2.9. Method of construction of the wood support of two twelfth-century crosses

As we will see, the structural features of this type of wood artifact evolved technically, varying according to the object’s geographical origin and the period of its making. In Florence, changes in the techniques of construction may be already perceived at the beginning of the thirteenth century, as exemplified by the Crucifix painted by the Rosano Master, or by the Uffizi Crucifix no. 432. Although these structures are of chestnut wood, as were the crucifixes by Guglielmo and the others from Lucca, the criteria for assembly of the various parts of the cross structure appear to be substantially different. These two crosses have a single board placed vertically and two aprons added to each side to create the final body shape; the arms are composed of a single plank, fitted into a cross-lap joint. This was made by thinning down the wood in the area corresponding to the joint to half its original thickness, on the front face of the vertical board with the Christ figure and on the rear of the arm board. The upper part of the aprons were connected to the under part of the arm board using a similar cross-lap joint.

The cross-lap joints which unite the body, arms, and lateral portions of the Rosano Crucifix were glued together and fixed with passing wood dowels, six inserted through the lower part and another two through the upper part of the arm board. The halo, which consists of a circular, diagonal-cut piece of chestnut wood, was also fixed by means of glue and wooden pins (Figs. 17, 18). The side aprons were united to the body of the cross with the aid of four biscuits inserted into their edges, each fixed with a pair of pins. The cross-lap joints carved out of both the body and arm boards were executed in a very refined way, using a small adze to fashion the surfaces, leaving almost no marks visible. As for the construction of the Crucifix no. 432 from the Uffizi, the cross-lap joint uniting the
parts is fastened with glue and nails, inserted from the front of the support and bent back on the rear, while no dowels reinforce the join. A series of traces and holes observed on the wood of this Cross suggest the possibility that the wood corresponds to a previously used material.

Original battens survive only on the rear of the Rosano Crucifix, in the form of a quite simple support structure, apparently of not great strength. This certainly should not be considered an error of construction, however, since its choice was based on the awareness of the robust nature of the support itself, and therefore could permit assigning less control function than usual to the crossbar system (Fig. 19). The aim was to reinforce the joining of the vertical and arm boards, and keep under
control any tendency of the different sections to deform especially in the lower area of the main part. The vertical board was also left thicker to increase the hold of the iron ring inserted into it for hanging the work. The “batten system” consists in a vertical bar and two horizontal sections divided into four separate pieces, all in poplar wood and tapered at the ends. The vertical piece was applied first, nailed from the rear but without passing the nails through to the front of the support; the other crosspieces were then fixed, two to form the batten placed centrally across the arm board, and the others at the base of the area composed of the body and lateral boards. The heads of these pieces fit perfectly against the vertical batten where they meet it; all of them have been nailed from the rear without the nails going through to the front.

The Uffizi Crucifix no. 432 no longer has its original crossbeams, but rather replacements, although these are similar to the simple batten systems traditionally used for crosses. The horizontal bars, one placed centrally in the arm piece and the other across the base of the body board, have been inserted in a cross-lap joint carved into the inner face of the vertical bar.

2.10 Two late twelfth-century crosses from the area of Siena

Two important twelfth-century painted crosses, made of choice materials and with very fine pictorial and technical execution, are as follows: the Cross painted by an anonymous master from Siena, measuring 176.5 x 117.5 cm and 5 cm thick, from the Church of San Pietro in Villore in San Giovanni d’Asso (Siena), now in the Museo Diocesano in Pienza; and the Cross in the Museo Civico e Diocesano d’Arte Sacra in Montalcino. These works may be considered among the earliest examples of painting and of panel-making of this type from the area around Siena.

As we will see, the structural features regarding the union of the arm and body of these two examples differ from those of both the Rosano and the Uffizi 432 Cross. Although we are still speaking of a cross-lap joint, here the entire width of the arm piece has been inserted into the vertical body board. On the first cross, the arm board has been inserted from the rear, an important detail since it shows that the craftsmen were aware of the problems connected to the reactions of the wood support and its eventual dimensional changes that could also affect the paint layers. For this reason the wooden structure of the San Pietro in Villore Cross, now in the Pienza museum, was designed to make the joints coincide with the painted forearms rather than with the chest of the Christ figure (Fig. 20). The same criteria was followed for another cross, painted by a master from Siena in the first years of the thirteenth century, from the Convent of Santa Chiara and now in the Pinacoteca Nazionale, both in Siena.

The San Pietro in Villore Cross appears very solidly constructed of chestnut wood in six wooden parts including the halo, and has never had crosspieces on the rear. The main weight-bearing section is the central board, 43.3 cm wide and 176.6 high. Two lateral strips each 8.5 cm wide have been added to form the complete body area, therefore making its width 60 cm overall. The flat edges of these strips have been glued to the main board, with the aid of four dowel insertions each. A biscuit has also been inserted in each of the two joins within the thickness of the board, at the height of the figure’s lower portion, and has been blocked by an oak wood pin passing through the entire thickness of the panel. All of the dowels measure 2 cm in diameter and are glued in. The arm board is a single plank, 117.7 cm long by 21.5 cm high,
whose entire width has been placed cross-grain in the cross-lap joint which unites it with the vertical part, inserted from the rear. The union of the two opposing parts has been obtained gluing them together and inserting 12 pins, each 2 cm in diameter, front to back through both the arm and body wood. A tablet 60 cm long by 21.8 cm high tops the cross, made of a single board whose fibers run opposite to those of the vertical section. This part has been inserted into the top of the main body from the front, in a cross-lap joint with inclined edges. The rear shows no signs of the existence of an original crossbeam system, nor of previous restoration. The absence of crossbars, although rare even for small crosses, has been compensated for by the solid, conspicuous consistency of the arm and body portions themselves. On the other hand, application of battens would have proved difficult since the arm piece protrudes from the rear of the vertical part.

The other cross, attributed to a late twelfth century master from Siena, comes from the Abbey of Sant’Antimo and is now in the Museo Civico in Montalcino; it measures 155 x 117 cm, and is also egg tempera painted on cloth glued to the poplar wood panel. The two parts have different thickness: 4 cm for the vertical part, and 3 cm for the arm piece. Two other sections have been added laterally, butt-joined as usual: the left one is 14 cm wide, the one on the right is 14.5 cm. Direct observation alone does not permit verifying whether any elements have been inserted internally in the joins. The arm board is a single piece of wood, 20 cm in width; the tablet and the halo are also single boards, the first 18.5 cm in width, and the latter 25 cm in diameter. The halo, whose thickness diminishes downwards, is basically circular, except for the lower edge that terminates in a straight line. A cross-lap joint unites the body and arm boards, with the arm piece placed in front of the body; the tablet is also fitted cross-grain in a similar join, from the front in the upper part of the cross. Lastly, the halo is inserted into the upper edge of the arm board for about one centimeter. The present position of the cross on the wall did not permit viewing the rear, making it impossible for now to describe the crossbar system or comment on its originality. Neither are we able to say what function or placement the cross had originally.

2.11. Some comparisons with the Cross by “Alberto Sotio”

The description of the Cross by “Alberto Sotio” dated 1187, now in the Duomo of Spoleto, brings us to mention a very peculiar structural feature, consisting in the fact that two different wood species have been used: walnut for the arm board and poplar for the body. We are unable to associate this choice with any plausible reasons related to the technology of such materials; perhaps it is possible to hypothesize other motives, such as economical ones, the re-use of already existing portions of wood, or simply that the woodworker was resorting to what was on hand at the moment in the workshop. Careful observation of the carpentry has revealed that each side of the vertical part, a board 57 cm wide, has been shaped by adding a strip of wood, which however differ in size. The construction is unbalanced, in fact, as if the object had been assembled in a hurry, further supporting the idea that the wood may have been recuperated.

Another work attributed to the same master, the Maria Regina panel now in the Pinacoteca di Brera, is a fragment of an originally larger work, again showing the use of walnut wood. One hypothesis is that the artist responsible for this panel utilized the same workshop as the one engaged for the Spoleto Cross, which probably produced other wooden objects besides those for painting. It should be noted however that this piece is a single panel which, differently from the disharmonious cross described above, has been finely crafted by chiseling both the slanted plane meant to fit it into the main board structure, and to finish the wood on the rear.

Considering the types of wood used for other crosses from the Spoleto area, especially the so-called Croce Azzurra attributed to a master called “Alberto Sotio,” the hypothesis of the unintentional use of two different species for the Cross in the Duomo of Spoleto seems to find confirmation, since all of the others examples are made of poplar wood. Furthermore, the “Croce Azzurra” has been constructed symmetrically, which also contributes to supporting the idea that the use of different support materials was indeed unintentional. The use of two different species has proved negative for conservation over time since wood-boring insects have attacked the walnut parts, although the interaction of the various parts with aging has not been the source of particular problems deriving from contrasting movements of the two different types of wood.

As for structural reinforcements, crosspieces were not necessarily made of the same species of wood as the panel painting’s board structure. The
choice of one type of wood or another was con-
ected to the need for finding material with ade-
quate strength and durability in relation to the
size of the work, the method of application, and
the overall methods of construction, also in my
opinion to how the panel was to be exhibited, as
these were often destined to be hung suspended
or inserted into a stone base.

Twelfth-century crosses, usually of reduced
size, relied essentially on the cross-lap junction
of the arm and body boards in order to achieve
the desired strength of the support structure. This
situation was destined to change, however, during
the century to follow, as the increased dimensions
of crosses demanded application of more stable,
solid structural features such as batten systems.60

2.12 Monumental Crucifixes

Important technical developments in making
painted crosses took place during the thir-
teenth century, as clearly appears in works such
as those painted by Cimabue for San Domenico
in Arezzo and for the Church of Santa Croce in
Florence, and by Giotto for Santa Maria Novella
again in Florence. As we will see, given the size
and shape of these works, the wood craftsmen be-
gan to seek more complex technical solutions than
those previously used for the examples we have al-
ready taken into consideration. Although various
cases might be cited, we prefer referring here to
only a few works, chosen among those built fol-
lowing similar general principles: the Crucifix
by Cimabue from Santa Croce and the one by Giotto
for Santa Maria Novella. We will also analyze the
differences between these Crosses and the ones by
Giotto made for Ognissanti in Florence, and for
the Tempio Malatestiano in Rimini.

2.13 The painted Crucifix by Cimabue from the
Museum of Santa Croce

As is well known, Cimabue’s Crucifix suffered
severe damage from the flood that submerged
Florence on the 4th of November, 1966. The tech-
nical description that follows traces the panel’s
original construction, with the exclusion of any
modifications carried out during its restoration
after the flood disaster. This painting’s wood sup-
port embodies the excellent criteria adopted for
choosing and preparing the materials, as well as
their truly fine workmanship, which includes the
techniques of assembly and the ingenious solu-
tions devised to eliminate any contact between
the nails and the preparatory layers. The support

is composed of thirteen poplar wood boards, all
properly selected for their straight grain, almost
homogeneous consistency, and the scarce pres-
ence of knots or other defects. The load-bearing
unit in this case is a single plank of noticeable size,
cut from almost the entire diameter of the tree
trunk; a secondary piece has been joined to each
side of it to give form to the body board containing
the Christ figure, while other pieces of wood have
been similarly joined to create the spaces needed
for the inscription plaque and the footboard. The
arms are painted on another single board, with
two rectangular pieces of wood added to each end
to form the panels for the mourners. The halo has
also been fashioned of poplar wood, in the form
of a half-circle similar in shape to a segment of
an orange; its straight bottom edge has been in-
serted into the main body panel almost one cen-
timeter deep, and fits so perfectly that not even
the slightest interruption appears at the junction
with the flat surface. The thickness of the support
is well proportioned, and is adequate for receiving
the biscuits to place within, and for maintaining a
certain degree of stability in the presence of vary-
ing climatic conditions. As has been previously
mentioned, the boards are of excellent choice and
perfectly worked: after eliminating all sapwood,
they were assembled after having perfectly ad-
justed the edges for joining and carved housings
for the biscuits into their thickness; they were
then mounted with their “inner” faces turned in
the direction of the preparatory layers. A cross-
lap joint unites the body of the cross to the arms,
fixed by means of glue and nails. It has not been
ascertained with certainty whether the adhesive
is “cheese” (casein) glue, or perhaps animal glue,
or more specifically, carpenter’s glue.61 The frame-
work on the rear has been made of elm wood,
and is composed of two main vertical beams
and two horizontal bars; these are connected by
12 crossbars, distributed in pairs of two each for
the inscription and the mourners’ terminals and
for the footboard, and another two for the wider
part of the body and the arms. The battens have
been simply designed, and are linear and square
in shape with slightly beveled outer edges, suit-
able for the functions to which they were destined
on behalf of the construction: support, connec-
tion, and control of warp due to RH variations.

The fastening of the crossbar system to the sup-
port relied on nails as usual, inserted into the
battens themselves, with other nails fixed in the
spaces left between the intersections between the


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crossbars and the vertical elements to guarantee further anchorage. The nails have been clinched back into the wood, their tips hammered below its surface and then covered with plugs made of the same type of wood as the panel to eliminate any possible contact between the iron of the nails and the preparatory materials (Fig. 21). This mechanism underlines still more the care taken in the support’s construction: special attention has been paid to preventing damage to the painting, either deriving from the wood itself or from the other materials in such a complex artifact. Even the frame was designed to fulfill both an aesthetic and mechanical role, as was the presence of cloth beneath the ground, in this case made of a relatively fine textile with a very closely woven weft.

2.14 The painted Crucifix by Giotto from Santa Maria Novella

The Crucifix by Giotto from the Basilica of Santa Maria Novella (Fig. 22) represents one of the highest expressions ever achieved by panel painting, not only for the fundamental role this work has in the history of art, but also for the exceptionally fine quality of its craftsmanship and the technical criteria for its creation (Fig. 23). The investigation preliminary to restoration has offered us an extremely important research opportunity, and has provided invaluable information on the subject of wood support construction. As already specified, the entire cross measures 530 cm in height and 400 cm maximum width at the extremities of the arms, while the thickness of the wood is 5 centimeters. The support is made of very carefully selected poplar wood; the main body piece is composed of two radial boards, cut in half from two totally diametrical planks sawn from different trees, and assembled in a vertical position after eliminating the pith. Two separate boards have been joined on each side of the main panel to create the space needed for the Christ figure, and a similar operation has provided the panels for the inscription plaque and the footboard. Two radial planks have also been used for the horizontal arm board, and another two smaller portions of wood have been added to its upper and lower edges at the extremities to complete the rectangles for the mourners. The trapezoid forming the base consists of two pieces of wood joined horizontally. All of the boards have been planed down at the edges to eliminate the sapwood, and are positioned with the more suitable inner face towards the preparatory layers; the edges of the boards have been perfectly paired for joining, and the dowel housings accurately carved out. Two types of investigation were able to be done given the perfectly geometrical distribution of the dowels inside the wood: one to examine the dimensional changes which had taken place within the support immediately after its making, and in any case before it was painted; the second referring to the procedure followed to assemble the boards on which the body of Christ was to be painted (Fig. 24). The six dowels present in the join between the two central vertical boards in the area corresponding to the Christ figure may be considered uniformly distributed if one also counts the area where the arms join the main body. Equal care has been taken to place the six dowels in the central join uniting the two horizontal arm piece boards. Another two pins are present in the joins uniting the boards of each additional piece, that is, the inscription plaque, the terminals with the Mourners, and the footboard. The lateral apron boards and the main structure, instead, have only one dowel apiece, furthermore placed quite far down along the connection considering the panel’s full height. Reflecting on this matter, we deduced that rather than being an anomaly, this was the result of having glued the aprons to the body boards in a moment subsequent to the same step taken for other parts. This is understandable if we imagine that the woodworker waited to add the apron boards in order to facilitate the more demanding joining operation of cross-lapping the two main sections (body and arm panels). In fact, this was the sequence actually followed: the main parts were joined first, and only after were the sidepieces connected to the main panel and to the under edge of the arm piece (Fig. 25).
The various boards were glued together using lime-casein glue, after which the two horizontal and vertical elements of the support were united in a cross-lap joint; this was obtained carving out the necessary area on the rear of the vertical boards and on the front of the horizontal arm piece. A similar device was used to connect the lateral apron boards to the arm piece above: six centimeters of the uppermost portion of each sidepiece was united with the lower part of the arm board. To do this, the uppermost outer edge of each apron board was shaped in a “dovetail” form in order to improve the hold between the parts, which have also been glued together and secured with nails.
The making of the frame reflects typical thirteenth- and fourteenth-century canons: a part was first fastened to the front of the wood support, and a second part was then attached to its side edges, thus also completing the molding. The presence of the frame along the front perimeter and the side edges of the support has contributed noticeably to helping the wood resist warp, especially in the form of cupping, while the closure of the exposed edges of the wooden cross has acted as protection against risks deriving from variations of relative humidity in the environment.

The primary function of gluing cloth to the support during the phase of preparing for painting was to buffer the movements of the wood, in order to prevent transmitting them to the ground layers, but also to avoid having the juncture between frame and flats show up on the painted surface. Great care was taken in this case when applying the cloth in order to obtain an excellent surface to receive the ground layers, while maintaining the carved molding motif intact. For this reason, the area of the support corresponding to the frame has been covered with a fine, tightly woven cloth that is able to adapt better to the shaped frame; while a heavier cloth has been used continuously to span the width of the body panel, placing various pieces lengthwise to cover the entire surface. A layer of minium and glue was used to coat the rear of the panel and protect it from wood-boring insect attack. Since it may be affirmed that this type of panel painting was meant to be seen both front and back, the design would certainly take into account the appearance of the rear surface and the crossbar system. Beyond the structural connective function of the nails, the color of the metal used for them, the shape of their broad faceted heads, and their uniform distribution throughout the crossbar system also played a decorative role. The color of the minium pigment which covers the rear of the support completed the pleasing visual effect. The use of a grid-shaped crossbar system for this type of structure not only helped to maintain control over the tendency of the boards to warp, but also played an important role in distributing the weight of the panel among the various points of connection. In fact, the rings for hanging the work were inserted to a certain degree into the support itself, but rely for the most part on the crossbars for anchorage.
2.15. Further examples

The research undertaken during the course of restoration of the Giotto Crucifix from Santa Maria Novella was extended to studying other panel paintings attributed to the same workshop: the Crucifix for the Malatesta Temple in Rimini, the one for the Church of Ognissanti in Florence, and the Cross in the Scrovegni Chapel in Padua. The main difference we may immediately discern about the construction of these works regards neither the technical features nor the materials used, since equal criteria have been followed and in part using the same types of wood. Rather what emerges is a different sensitivity in their overall creation. This is comprehensible considering the different workshops and locations even if the artist were the same, while it may also be imagined that a church as important as Santa Maria Novella may have offered the privilege of contacts with an especially qualified workshop, and perhaps also the development of an awareness of the requisites involved in placing the cross in a position which would permit it to be viewed all around. The wood of the Rimini and Ognissanti crosses is thicker than that of Santa Maria Novella, while their battens are made of fir tree wood and are fashioned less carefully. Analysis of the Padua Crucifix has revealed a substantial difference that goes beyond just the smaller dimensions (223 x 124 cm): it is painted on both sides, which is obviously the reason for the lack of crossbars on the rear. However, the quality of the wood structure and the careful application of the fundamental rules for positioning the boards and for guiding the methods of construction have made this otherwise difficult situation less problematic. The condition of the area corresponding to the cross-lap which joins the body and arm sections confirms that the union has succeeded in keeping the two parts solidly united, as well as having at least partially contributed to controlling the wood’s behavior and to supporting the horizontal part. The structure has therefore stood up quite well to the effects of time, despite the absence of crossbars. Two strips of wood placed along the slanting outer edges of the base have contributed to strengthening it. Unfortunately, the need to use the “outer” face of the boards for the rear of the Paduan cross has resulted in detachments and color losses in the paint layers.

We may conclude from the analysis of the painted crosses examined up to this point, that the earliest examples (ranging from crucifixes such as the one from Rosano dating from the twelfth century, to that in the Pinacoteca of San Gimignano by Coppo di Marcovaldo, the one in the Uffizi known as no. 432, and lastly the Cimabue Cross from San Domenico in Arezzo) all connect the horizontal and vertical sections by means of a cross-lap join which places the arm piece in front of the body panel. Instead, in the case of Cimabue, his somewhat later Crucifix now in the Museum of Santa Croce in Florence, damaged by the flood of 1966, the vertical panel with the body of the Christ figure is placed in front of the horizontal arm panel. Giotto also employed the same method for his Santa Maria Novella Crucifix, as described above, as well as for those in the Church of Ognissanti and in Rimini; and we may say that this technique of construction will be used practically constantly, with few rare exceptions, by all the painters to follow. One of the few exceptions is the San Cresci Crucifix, painted after Giotto’s panel for Santa Maria Novella by Lippo di Benivieni; this example in fact deviates from the above-mentioned general rule, while furthermore both the support and the crossbars are of fir tree wood, although the other technical details of assembly are the usual ones.

The choice between following one or the other set of criteria may have been motivated by reasons regarding construction or questions of taste. The artists were certainly aware of the possible emergence of cracks along the joints on the painted surface, caused by the cross-grain placement of the fibers of the vertical and horizontal parts. The choice was therefore to decide between horizontal interruptions appearing across the entire body of the figure, or two smaller vertical ones more or less corresponding to the position of the shoulders. The choice of one or the other option may have been motivated by structural features, instead, such as the fact that the joints appearing on the surface could be directly connected to the use of grid-type crossbar systems. Attempts to compensate the noticeable structural weakness induced by the presence of the cross-lap joint both in the support and batten system, may be noted in the Giotto Santa Maria Novella Crucifix and in those subsequent to it. A solution was sought through the continuity of the long vertical battens, so that in general the weight of the union between the two parts—the support panel and the reinforcement grid—would be concentrated on these two longer elements, thus contributing to gaining a satisfactory degree of stability and resistance to flexing. We may easily understand that the desire to construct the work in a solid
way would be reflected in every single aspect, including the choice of wood for the crossbars that also had to conform to certain rules, in the sense that it was imperative to use wood strong enough to overcome the weakness of the joints.

Our ideas on how battens were prepared for nailing have been confirmed by direct observation of the paintings; it was in fact unthinkable that similarly fashioned nails could be forced to penetrate through as thick and hard a material as the wood used for the crossbars without producing cracks, especially when hammered in. In fact, we have observed the presence of various holes in the wood of Giotto’s Santa Maria Novella Crucifix prepared to receive nails and then never used, since their position would have made them emerge from the support in the part left uncovered by the frame. Thus only a few centimeters would have made much more work necessary to clinch the nails back into the wood and isolate them from the paint layers.70

2.16. Twelfth- and thirteenth-century altarpieces

The Madonna and Child Enthroned from the Church of Santa Maria Maggiore in Florence is a suitable example of panel painting construction during the last quarter of the twelfth century. This work, attributed to an anonymous artist belonging to the Byzantine school of painting, was made around 1180, and is still in an excellent state of preservation (Fig. 27). Its examination has revealed the extremely refined technique and quality of the painting. The support’s features are as follows: the dimensions are 250 cm in height by 123 cm wide; three butt-joined planks of chestnut wood have been put together, each 4 cm thick; the boards have been cut through the diameter of the trunk, with three biscuits71 per joint inserted mid-way into their thickness. Two robust crossbars of fir tree wood have been nailed on the rear to the upper and lower margins (Fig. 28). The frame is composed of two portions: one on the front that encloses the painted surface, and whose upper part furnishes the seat for the halo on which the head of the Madonna has been modeled out of gesso; another part attached to the outer edge of the panel, united to the front piece to complete the frame shape. This brief description already demonstrates the fact that the structure is as efficient as it is simple, a perfect union among the various parts with the crossbar system and the frame surrounding the support, so that the functions assumed by each component are at the same time specific and general. The same criteria for frame construction have been followed on all of the works dating from this period (as for the crucifixes). The frame, in this case in particular, plays an especially important aesthetic role, since it is decorated with eight full-length figures of saints painted on the longer vertical parts, and other half figures of saints on the shorter sections above and below. The parts covering the outer edges of the support not only finish the frame shape, but also reinforce the structure by contributing to warp resistance, and also protect the heads of the boards from RH exchange with the surrounding environment. The rear has been finished with a coat of gesso grosso and glue, which completes the protection and balances the forces influencing the two sides of the panel. The so-called Madonna del Popolo from the Florentine Church of Santa Maria del Carmine painted between 1270 and 1280, attributed to Coppo di Marcovaldo or to the Sant’Agata Master, (Fig. 29) was made according to similar principles. The support made of poplar wood is 262 cm high, 124 cm wide, and 4 cm thick; it is composed of three diametrically cut, excellently chosen boards, butt-joined edge to edge, with eight dowels inserted internally in the joints, distributed uniformly along their length72 (Fig. 30). The structural reinforcement and control of warp relies on four battens fixed to the support by means of two nails per board, inserted from the rear a few centimeters from the edges in pre-bored holes and clinched back into the wood on the front. Two battens placed diagonally to form an X complete the crosspiece system. The original frame (removed in the eighteenth century, when the shape of the upper part of the painting was also modified by transforming it from pointed to round-arched) was composed of two parts, one mounted on the front and another around the outer edges, in the same way as the work described formerly; a second horizontal frame element divided the rectangular area of the Madonna on the front from the gable above containing the half-figure of God the Father. The rear has been coated with gesso grosso and glue, similarly to the Crucifix painted by Maestro Guglielmo and the Madonna from Santa Maria Maggiore. As we will see, although poplar wood would be preferred from this point on for larger panels, the criteria for selecting the type of wood, the methods of board and frame assembly, and the type of protection to apply to the rear
remained basically constant. The striving for a greater degree of control over the board structure resulted in devising a reinforcement system which also entailed placing battens around the perimeter of the support. An example of this type of construction is Duccio’s Maestà panel now in the Uffizi Gallery (Fig. 31). “The great panel of poplar wood (450 x 293 cm) has been made according to the practice of the period, in a fixed structure fastened together with iron nails. Only the five vertical planks which form the flat surface were obviously also glued together, while the reinforcement grid on the rear and the large molded frame have never been glued, but were instead only fixed by nailing (Fig. 32). The reasons for this technical choice are evident: the semi-rigid nailing method was rightly preferred over the total and potentially dangerous blockage procured by gluing, due to the great stress that such a structure could provoke, especially in the areas where grid and frame meet.”

A similar situation is found on Giotto’s Ognissanti Madonna (Fig. 33): “...observing the structure of this great altarpiece, it is impossible not to be impressed by how absolutely similar it is to that of the other great wood construction, the Maestà by Duccio; both demonstrate identical functional principles of semi-rigidity which relies solely on
the hold produced by nailing” (Fig. 34). As the restorer has informed us and as is supported by our own observation of these works, we have seen that the supports were made of excellently chosen wood; before being united, the flat surfaces of the boards were carefully prepared, destined their “inner” faces for the preparatory and painting side. Joining was accomplished by gluing together the edges of the planks, with the aid of biscuits inserted internally to keep them level until adhesion was complete, and to increase the resulting joints’ solidity. Nails were inserted from the rear and the tips bent back and clinched into the wood on the front of the panel. Cloth glued to the front of the support extended over the frame elements. The frame of Duccio’s panel, given its large dimensions, was composed of two elements, one fixed to the front with points of glue and nails inserted from the rear of the support, while another covers the outer edges of the panel to complete the frame shape, as well as to contain the grid fastened to the rear. The early fourteenth-century panel by the Città di Castello Master in that city also has a cusped poplar wood support, composed of five sufficiently straight-grained boards arranged vertically. The structural reinforcement fixed to the rear of the support, one of whose purposes was to keep warp under control, is composed of four crossbars also of poplar wood, placed one at the lower edge and one at the base of the cusp, with another two in between. The batten grid is fixed to the support by means of nails similar to those described above, passed from the rear to the front and
failure of the fibers with this sort of insert may be observed either on the rear of the panels or on the front underneath the preparatory and paint layers. Dovetail cleats may be found on paintings dating from the fourteenth century, or even later although on a relatively limited number of panels.

The description of the constructions up to this point largely corresponds, as already mentioned, to the majority of the works painted on wood during this period, although several exceptions deviating from these rules should also be taken into consideration. Panels painted on both sides are a special typology that obviously could not rely on traditional crossbar systems for warp control. An important example of this type of object is the Maestà painted by Duccio for the Duomo of Siena between 1308 and 1311. As reported in the Bollettino of the Istituto Centrale del Restauro: “the original support of the Maestà was formed of a main board, to the rear of which a thinner board was glued and nailed. The main panel, or front side, was the support for painting the actual Maestà; instead the thinner panel, or rear, contained twenty-six scenes with Stories of the Passion of Christ. The front is composed of eleven poplar wood boards clinched into the wood on that side. This frame structure also consists of two elements, one placed around the perimeter on the front and the other around the outer edges, thus granting major stability and protection against climatic factors while also completing the frame shape. Furthermore, this panel reveals nine elements commonly called “dovetail cleats,” inserted in an irregular way into the joints on the face destined to be prepared for painting. These hardwood elements have been inserted cross grain to the fibers of the support, into which they are inserted to a depth of 1.5 cm. Their irregular distribution and the type of function such elements were expected to fulfill, makes it likely that problems had arisen immediately after the initial gluing of the boards, therefore making it necessary to resort to a further expedient to assure hold. As we will see in the chapter in which decay factors are treated, this technical detail has produced many cases of irreversible effects on the painted surface, although damage of this type is negligible in this case thanks to the use of cloth beneath the preparatory layers. The practice of reinforcing specific areas of the joins, or that of repairing the
about 7 centimeters thick, joined with rare perfection. The boards, whose grain runs vertically, were glued together edge to edge with lime-casein glue, united by means of oak dowels sharpened to a point at the tips. The rear portion is composed of horizontal planks about one centimeter thick, their fibers therefore running opposite to those of the front boards. This description also supplies some information about the nails used: “the heads of the nails that held the rear part to the front panel were covered with bees’ wax, to avoid their rusting upon coming directly into contact with the gesso…, while on both outer faces of the support a layer of glue was applied, then gesso grosso and glue; a cloth was then glued down, which in turn was covered with various coats of gesso sottile and glue.”

The work currently measures 370 x 450 cm; we know that it is made of poplar wood, and that the front portion was composed of eleven boards about 7 centimeters thick, glued together with casein. Dowels were inserted into the edges of the joined boards for a depth of about eight centimeters per side; joining was generally performed quite perfectly. This unusual technique of construction was certainly adopted in order to meet the special demands of its exhibition site; in fact, the need to paint both sides forced the woodworkers to change the type of support and its control system, which habitually employed the usual nailed-down horizontal crossbars. On the Maestà, the double board structure took on this function: after their separate assembly the two parts were fastened together with their fibers running cross-grain, using glue and nails. This method of assembly together with the use of glue has undoubtedly been the cause of the pronounced fissuring on the rear of the panel with the Passion scenes. It is difficult to say whether the painter and woodworker had actually evaluated all of the problems that could derive from this sort of technique of construction; the characteristics of the cracks in the panels certainly seem to suggest that the work was already suffering stress and fissuring even before its removal from the high altar of the cathedral. Besides Duccio’s great panel, other works have been made to be painted on both sides: Taddeo di Bartolo’s panel of 1403 for the Church of San Francesco al Prato in Perugia; and another large polyptych by Sassetta for the...
Ciro Castelli, Techniques of construction of wooden supports for painting

The polyptych

A subsequent and very special sort of altarpiece is represented by the polyptych, which appeared from the start of the fourteenth century. These are composite works, some of whose components were autonomous although each would be connected to the rest (from the Greek polypytikhos “having many folds).”

The development of the varied and complex construction of supports for the triptych or polyptych began with Giotto, Duccio, Simone Martini and other Tuscan painters, becoming fully established by the continued production of this type of artifact during the entire thirteenth and fourteenth centuries. With the rise of the International Gothic style, the works increased constantly in size, and the images were often placed on various levels, separated by spiral columns and pilasters. The various support construction typologies may be divided as follows:

- Structures formed of individual, continuous panels, with space provided for both the main and upper registers of painting. The arches were shaped in either straight or curvilinear forms, and were placed over further pieces of wood to make them protrude from the main plane.

- Structures in which the upper painted register was on separate single panels added to the support above the main level. Lorenzo Monaco’s panel now in the Galleria dell’Accademia in Florence (1410), of 277 x 259 cm, is an example of the first type of polyptych described above. The Madonna and Child occupy the central part, and four saints are represented laterally. This method of construction is typical of Tuscan woodworking techniques, combining three panel structures held together by two crosspieces; each separate part is composed of two vertically positioned popular wood planks, butt-joined at the edges. The three panels form the rectangular area for the paintings present on the main level, and have been shaped for the upper level, reducing the width where the Virgin, God the Father, and the Annunciating Angel were to be painted.

- A third type of construction is identifiable in a support formed of a single board structure with arches. The panels of the upper painted register rest on the arches, connected by strips of wood. Lorenzo Monaco’s Coronation of the Virgin in the Uffizi is an example of this. The architectural design elements, which punctuate the painted surfaces, assume a conspicuous upward thrust inspired by this period’s great cathedrals.

Variations with double predellas were also made, in which the predella was either conceived as a separate entity or was attached firmly to the main panel before laying down the ground layers. The rectangular predella had the dimensions of the entire width of the object including the side pilasters, and was designed to serve as a pedestal for the whole painting including the crossbars and frames, and also formed a step on the front. Some other panels show side pilasters that do not rest on the predella but rather continue down to the ground.

The predella in the form of a protruding base was formed of a board on the front, one for the base and another for the top, together with a panel on each side and others placed internally. The front board was usually prepared together with the rest of the painting, although cloth was
sometimes not present. The painted scenes on the front of the predella were often the same size as the corresponding painted areas on the main panel above. The bottom and top boards were attached to the front board’s long edges, while the side sections were added from the rear, all connected by means of glue and nails. The finishing of the predella foresaw attaching frame moldings on the front to separate the scenes, although these were sometimes omitted when the same effect was obtained by painting. The bases for pilasters or spiral columns were placed at the separations between the painted scenes. A shaped frame molding on the upper and lower edges of the predella concluded the entire assembly.

Certain rare examples exist in which the polyptych does not rest on the predella, with the main panel passing behind it to stand directly on the altar table; in this case the panel was not painted in the area covered by the predella. The triptych by Matteo di Giovanni in the Museo Civico in Sansepolcro is of this sort.

Besides Tuscany, Venice was another important area where this typology developed, through the work of Paolo and Lorenzo Veneziano who were producing similar objects. The polyptychs of these artists differed from those created in Florence and Siena in their architectural design and carving. The shapes, finish, and depth of carving of the pilasters and aedicules of the Venetian polyptychs were usually very elaborate, much more so than the architectural ornaments on the Tuscan panels. The latter were usually fastened to the main support before applying the preparatory layers, and the frame moldings that completed the ensemble were rather simple. Another feature of Tuscan woodworking was to reserve carving mainly for pinnacles and for decorating the edges of the gables with leaf motifs. The craftsmen of the Venetian school also continued to develop this type of object during the centuries to follow, with further variations in comparison to the works made in Tuscany in the way supports and frames were made, for example inserting the painted panels in very elaborate frame structures. Thanks to the cultural and commercial influence of Venice, this type of artifact spread across the cities of northern Italy, in the Po River plain, and in the main cities inwards from the Adriatic coast. Similarly, the influence of Florence and Siena predominated in central Italy where many examples of their production were exported.

In central Italy, and in particular in Tuscany, the basic support of flat boards constitutes the load-bearing structure of the polyptych: not only is it the carrier for the preparatory layers, it is also the seat of all the architectural elements and decorations. Any one of three fundamental typologies of polyptychs may be identified observing these works. The first includes multi-paneled works composed of a number of board structures closely united by means of dowels inserted into the support boards without gluing, and by crossbars on the rear. On the front, the support is unified by the predella placed as a pedestal along the bottom edge, the pilasters attached to the front, and the architectural frame elements—the latter often fastened with calcium caseinate glue and nails (Figs. 35, 36). The *Badia Polyptych* by Giotto (Uffizi) is one of the earliest and most important
examples of this type of polyptych restored in our Laboratory; more recently other works of this type have also been treated, such as the polyptych attributed to Segna di Bonaventura or Francesco di Segna from the Museum of Montalcino, and Lorenzo Monaco’s Coronation of the Virgin now in the Uffizi, and his Annunciation in the Church of Santa Trinita in Florence. This typology also includes works whose design allowed for the separation of the various pieces, by means of opening tongue and groove connections in the battens in correspondence to the joints between the single panels. This type of batten construction also permitted the disconnection and remounting of the previously assembled panels by means of wooden pins passing through the battens to block the joints. The Giotto polyptych from the Baroncelli Chapel and the one by Giovanni da Milano in the Museo Civico in Prato are examples of works supplied with this structural feature. The panels, each of which could be composed of one or more boards, were normally made of poplar wood. It was particularly important in the case of very large paintings to be able to separate the pieces, since this made it easier to move it from the woodworker’s shop to that of the painter for the various phases of execution, then finally place it in its final site in the church. This type of construction required formulating an overall plan that allowed for dismantling the main and upper tiers, together with the crowning pieces and all the rest: the step-shaped predella beneath, the side pilasters, the pinnacles, the spiral columns and the small pilasters dividing the main painted scenes.\textsuperscript{78}

Another type of polyptych or triptych structure involved constructing a single panel, though this could be quite large. Obviously no changes were necessary in the choice of the wood nor in the woodworking techniques, neither were the criteria for board assembly different. Very rigid crossbars were applied, however, according to the same rules as those described for the other types of polyptych. Woodworking in the Florentine area usually entailed placing one crosspiece along the lower edge of the panel and another at the base of the arches. If the painting was particularly large, a third batten could be added in the middle between the other two. The crossbars were nailed from the front of the wood support and their tips clinched back into the battens on the rear; the nail heads on the front surface were covered by the predella and the arches mounted in front of them. The construction of the polyptych or triptych in the Siena area had two crossbars, one upper and one lower one, positioned about ten centimeters inward from the margins of the support. A predella in the form of a “step” served as a pedestal and completed the general architectural composition. Its rectangular shape was the result of combining a front panel, on which the figurative parts would be painted, with two side panels (not always painted), several internal support elements, and an upper cornice and lower surbase.

Several examples reveal structural details that differ from these general and more frequently encountered characteristics (Fig. 37), of which the Santa Maria della Tromba tabernacle by Jacopo del Casentino is an excellent example. The structure of this work testifies to the technical richness...
has been repainted in the sixteenth century with a Madonna and Child over an earlier Martyrdom of St. Sebastian, has a predella attached to the main panel, together with a slim frame bearing the dedicatory inscription, rather than being a free-standing structure as was customary.

Lastly, the panels of another type of polypych typical of northern Italy were inserted into a structurally supporting framework, a method of construction that totally inverted the principal system used in Tuscany. Since the support itself was no longer the primary structural component, it tended to be thinner than in the other types, while crossbars were not always present since their function was partially assumed by the framework’s perimeter. The architectural and other decorative elements were arranged on the front face of the framework. Neither the mode of assembling the boards nor the nailing of the ornamental parts were different. The predella was no longer constructed autonomously but was rather inserted into the load-bearing structure, which was composed of a support system in the form of a framework into which the single scenes were arranged and the ornamental parts attached. This main structure served as the base for attaching the other components such as pilasters and the predella. While this type of construction found its greatest diffusion in northern Italy, it has also been identified in the region of the Marche and in central-southern Italy. An example is the Valle Romita Polyptych by Gentile da Fabriano, which our Institute studied while investigating the possible attribution to the same artist of a Crucifixion present on the antique market. The Olera Polyptych by Cima da Conegliano, the San Giacomo di Peghera Polyptych by Palma il Vecchio, and the Polyptych by Lorenzo Lotto from the church of Ponteranica in Bergamo are representative examples of this type of construction.

2.18. Polyptychs with panels held together by crosspieces

The type of polypych constructed of separate panels may be exemplified by at least three works by Giotto: the Badia Polyptych, another in the Pinacoteca of Bologna, and the one in the Baroncelli Chapel in Santa Croce; also by Taddeo Gaddi’s paintings in the Galleria dell’Accademia and in the Church of Santa Felicita in Florence. This chapter will discuss only the Badia Polyptych, while the others will be described in the one to follow. The study of this painting proved very interesting.
revealing a series of important technical features: the support has been tooled carving the arch frames from the wood itself; it has been confirmed that the nails were inserted through previously drilled holes; dowels were inserted in the joins to connect the panels, differently from what is ordinarily found on paintings coming from the Florentine area. Painted around the beginning of the fourteenth century, the Badia Polyptych is composed of five panels, each made of one large board; strips of wood have been added to the sides of the panels to increase their width, glued and fixed with four nails each. The join of the strip on the right side, seen from the rear, has been reinforced inserting ‘U’ shaped clamps. These portions of wood have been carved on the front to form a column with a capital and base, and have holes drilled through them to pass the nails to fix them to the main panel. The upper part of each panel is in the form of a cusp. The boards, made of very carefully selected poplar wood, are sub-radial cuts, and placed with their fibers running vertically. Each panel is 91 cm in height, while the width of the entire polyptych is 340 cm; the central panel with the Madonna and Child is slightly wider than the others. The panels show evident signs on the rear left when smoothing the wood with a slightly curved-blade adze. The front of the support has been accurately smoothed, using a small plane working horizontally to increase the porosity of the wood, in order to achieve better grip for the ground and paint layers. The assembly of the panels united them in a simple way, with a dowel inserted in their upper part, while it has not been possible to determine whether dowels were inserted in the lower portion to keep all of the panels level. Crossbars supplied connection, as was usual in these cases: one positioned at the bottom edge of the main support and a second at the base of the arches. The chromatic differences visible on the wood on the rear of the panels inform us about the type of original crossbar system: the battens were about 8 cm wide and 10–11 cm thick, and were fastened with nails inserted from the front of the support (therefore with their heads covered by the predella and arches), clinched back into the surface of the crossbars on the rear. Strips of wood attached to the outer edges of the cusps were used to form the frame moldings on the front to finish the architectural structure, and protect the exposed head-ends of the wood. Their function is therefore similar to the frames applied to the other types of panels and crosses already described, added to protect the extremely sensitive head-ends of the boards from RH exchanges. The architectural elements attached to the front also contributed to connecting the panels: the small predella fixed to the support at the bottom acting as a base for the frame molding and also to enclose the figurative representation; the cusps above and the pilasters filling the spaces between the panels. All of these components were glued to the support point-by-point and nailed. As was customary for panel painting in this period, cloth glued to the support played a strategic role in rendering the surface uniform for preparation, and absorbing the movements of the wood, as well as uniting all of the parts attached to the construction. The polyptych was also certainly intended to have lateral pilasters and pinnacles to crown the small pilasters dividing the scenes. Numerous examples exist of the fourteenth-century polyptych with panels situated one next to the other and united by the crossbars and architectural elements. A further example of this typology of construction is a triptych from the Church of Morgiano (municipality of Bagno a Ripoli) whose wood structure is still intact, painted by an unknown Florentine artist in the early fifteenth century (Fig. 38). Differently from the Badia Polyptych, this work is composed of three panels and side pilasters united to the rest by battens. This triptych was constructed with the poplar wood support composed of boards placed vertically, two crosspieces placed at the bottom and at the base of the arches, and a flat frame structure containing a simply shaped molding around the perimeter that encloses the figures. The final frame structure covers the connections between the panels and includes the small pilasters that separate the scenes together with the arches, and on the bottom a small predella with an inscription, enriched by moldings which outline the symmetry of the three panels and the bases of the pilasters. Every part is made of poplar wood.

Another example is the polypych by the Master of the Fabriano Altar from the Church of San Donnino in Certaldo. This work has been made in a quite essential form, composed of five panels each of which is a single vertical plank, united by a crosspiece at the base and another below the cusps. The painted images on the front are divided by small pilasters which originally concluded in pinnacles. Another polypych of the same type is that by Francesco di Segna now in the Museo Civico e Diocesano in Montalcino, composed of
2.19. The polyptych with separable panels

Numerous panels were constructed so that the various panels could be taken apart and then reassembled, mounting crosspieces divided in sections with inserts that enabled them to be separated. The parts of the frame placed over the areas where the panels were joined were usually mounted afterwards on a separate structure, again for the purpose of facilitating their removal. The crossbars were fitted with a joining mechanism inserted in them in correspondence to the edges of the panels, sometimes a tongue and groove or a cross-lap joint, or simply with the end portions of the sections slanted to fit together. The joins were held together by two pins passing through the crossbars, or else were nailed. The pilasters or small spiral columns were usually fastened only to one side of the join, or were added only after the final placement on the altar.

The *Coronation of the Virgin* by Giotto from the Baroncelli Chapel in the Church of Santa Croce in Florence,\(^{86}\) represents one of the earliest examples of wood constructions whose side panels could be separated from the central one (Fig. 39). The original shape of this work was in the form of a five-paneled cusped-arch polyptych, made of poplar wood with fir tree crossbars. Although the arches were modified in the fifteenth century together with all the other architectural elements, the painting still conserves important features that reflect the original criteria used to construct it. The two crossbars, placed at the lower edge of the panel and at the base of the arches, are sectioned in proximity to the margins of the central panel, united by tongue and groove joins.

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39. Giotto, *Baroncelli Chapel Polyptych, Coronation of the Virgin*, original crossbeam system with the tongue and groove joins in the battens that permit separating the central panel of the polyptych from the others.
fixed with passing pins; this device consented the
detachment of the four lateral panels from the
central one. Another polyptych by Giotto now
in the Pinacoteca in Bologna also had crossbars
which could be taken apart, which unfortunately
are now lacking after the intervention done in the
1950s. This painting is composed of five poplar
wood panels with full-length figures, the Mad-
donna and Child enthroned in the central panel
and the Saints Peter and Paul and the Archangels
Gabriel and Michael in the other four. As may be
seen in the X-radiograph and from the manner
in which the battens were nailed, as well as in a
photograph that still shows the presence of the
lower crossbar, the five parts were held together
by battens divided in sections at the margins of
each panel, united in a tongue and groove joint,
and fixed with a pin passing through the depth of
the bars themselves. As on the Badia Polyptych,
the sloping side edges of the arches were finished
with frame pieces carved in flame-like motifs,
characterized by their very refined workmanship,
and which served to protect the exposed wood
and to create a decorative closure on the points
of the arches. Another important example of this
typology is the polyptych by Taddeo Gaddi in
Santa Felicita in Florence, which still retains the
original batten bars and on which it is possible
to observe the system for separating the saints in
pairs from the central panel.

This batten system is also found on other works
dating from the second half of the fourteenth
century, as we will see, for example on the two
polyptychs by Giovanni del Biondo from the church
of Santa Croce in Florence. The one in the Rinuccini
Chapel has been structured to receive the figurative
representation on two levels; it is composed of a
poplar wood support, with well-chosen, sub-radial
boards cut centrally from the tree trunk; the wood
flats are sufficiently straight-grained, and have their
“inner” faces turned towards the preparatory layers.
The boards have been assembled with a butt-join,
glued together at the edges as previously described.
The nails to fix the three batten bars to the support
were inserted differently: the upper and lowermost
crossbars nailed from the front with the tips
clinched back on the rear into the wood; the middle
one nailed instead from the rear to the front of the
support. The joining mechanism in the battens
that enabled the panels and the side pilasters to be
separated is quite a “reduced” version in this case:
the crossbar sections extend beyond the edges of
the panels only about one centimeter, and their
slightly slanted ends overlap only about one and
a half centimeters. The nails holding the sections
together have been inserted crosswise. The
support rests on a predella, which however has been
altered in the past, and is flanked by two pilasters
made of a single rectangular piece of poplar wood
whose outer corner is turned towards the viewer.
The outer edges of the side pilasters have spiral
columns carved on the lower portion and pilasters
on the upper part, and their summit is tapered to
form a truncated pyramid from which three carved,
gilded pinnacles rise at the corners and a fourth one
from the center. The side pilasters are nailed to the
crossbars which extend beyond the sides of the
support. Another painting by Giovanni del Biondo
is a pentiptych in the last chapel to the right in the
transept formed of a single register, whose materials
and technical features are similar to the previous
one, aside from the method of connecting the
crossbar sections by means of a tongue and groove
join. The same crossbar system has also been used
for the polyptych with a Madonna and Child and Saints
by Giovanni da Milano, in the Museo Civico
in Prato (Figs. 40, 41). This work consists of three
panel structures: the main central panel, flanked
by two side panels each with a pair of saints, all
connected by two battens with tongue and groove
joints held by pins. Another characteristic feature
of this painting is the double predella in the form of
a stepped pedestal, constructed independently
from the rest of the support. Another polyptych by
Giovanni da Milano, now dismembered and whose
panels have been reduced in size, also originally had
such a separable crossbar system. Seven paintings
have been identified as belonging to the original
work, realized between 1365 and 1369: three from
the upper order, two panels from the predella, and
two paintings from the main order. The latter are a
Christ in judgment now in the Pinacoteca di Brera
measuring 152 x 69 cm, and a panel with eleven
saints in the Galleria Sabauda in Turin, 159 x 71 cm.

Several of these structural features are also
present in the polyptych with an Annunciation
by Bartolo di Fredi, conserved in the Museum of
Montalcino. The painted compartments are also
distributed on two levels, it has dividable cross-
bars with tongue and groove joins, and pilasters
positioned so that their corner edges face the ob-
server. As usual, the pilasters rest on the predella
which thus automatically serves as their base.

Among the panel paintings treated in our
Laboratory, we may cite several examples of
large-size polyptychs with detachable parts: the
the edges of the support, connected by means of the ends fashioned obliquely in the vertical sense. The final unification was obtained by inserting nails crosswise into the crossbar sections at the point of their juncture. The panels themselves were kept level also by means of dowels inserted into the thickness of the wood. The higher part is carved in the shape of a trapezoid, with a base on top of it to hold the upper level paintings. The construction of the entire support has been so carefully and precisely executed that it almost gives the idea that certain parts might not be original, given the excellent state of conservation of the wood itself and of the finishing pieces both of the main panels and those on the upper level.

In Umbria, the Polyptych of Donna Brigida in San Niccolò in Foligna by Niccolò Liberatore called l’Alunno is a creation whose original woodwork is still intact including the dividable crossbars with half-lap joins. Ten paintings compose this large polyptych, plus the scenes in the predella and the side pilasters. The main register may be separated in its five parts thanks to the crossbar system, while the five on the upper level may be removed from those below because of a “bayonet” mechanism in the form of a strip of wood in the upper panels, which fits into a small cleat fastened to the panel beneath.88

Annunciation by Giovanni del Biondo and the Coronation of the Virgin by Rossello di Jacopo Franchi, both from the Galleria dell’Accademia in Florence. These works demonstrate the use of the same type of materials and methods as those for the other triptychs and polyptychs examined. The rear of the three panels composing the Rossello di Jacopo Franchi has been treated with a very refined finish of gesso grosso and glue, decorated with nine tempera painted faux-marble partitions. Other important polyptychs made with separable side pilasters, main and upper painted panels, and pinnacles are found among those by masters from Siena. Among these we may mention the Polyptych of the Gesuati, also known as that of the Beato Colombini, created by Sano di Pietro in 1444, in the Pinacoteca in Siena. This tempera painting on poplar wood measures 335.5 cm in height and 291 cm in width overall. The lateral panels are formed of a single board, while the central one is a single, wide board with a smaller board added on the right. The vertically placed boards are generally well chosen, despite the presence of knots in several areas and some deviations of the fibers. The inner face of the boards has been used for the front side, and the rear has been roughly smoothed with an adze. Three chestnut wood crossbars unite the panels, and as usual in the area of Siena, are placed at a certain distance from the bottom and from beneath the arches. They have been inserted from front to rear where they are clinched back into the crossbars, with three nails for the central panel and two for the lateral parts. The system united the laterals stably two by two, while the central panel is by itself, and has been joined to the side units by the sectioned crossbars overlapping at

40. Giovanni da Milano, Madonna with Child and Saints, Prato, Museo Civico. Detail of the crossbar system for connecting the various panels forming the polyptych.

41. Giovanni da Milano, Madonna with Child and Saints, Prato, Museo Civico. A separated section of the altarpiece.

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2.20. The multiple panel polyptych mounted in a framework

Another type of polyptych is composed of separate scenes painted on single panels, inserted into a structurally supporting framework. As already mentioned, this type of panel painting is typical of northern Italy, the Venetian area, and the regions facing the Adriatic. It has a structural support framework which houses the single scenes, and also serves as the surface for attaching the ornamentation and other parts, such as pilasters, the crowning pieces, and the predella.

As already mentioned at the start of our discussion on polyptychs, many works were constructed this way, especially those by Venetian artists who continued to use this format even after adoption of the new language of the Renaissance. The large Sacred Conversation altarpiece made by Andrea Mantegna for the Church of San Zeno in Verona and the Olera Polyptych by Cima da Conegliano with its precious original frame; the Poghera Polyptych by Palma il Vecchio, and the Polyptych by Lorenzo Lotto in the church of Ponteranica in Bergamo (which no longer retain their original frames): all are important examples of this type of construction.

The Valle Romita Polyptych, painted by Gentile da Fabriano around 1400 for the church of the convent of the Minori Osservanti in Val di Sasso near Fabriano, is an example of this type of construction from the region of the Marche. Although we see it today in a modified form, this painting may still be considered a useful example of this structural type, and as representative of the relationships existing between the painter and the woodworkers. Study of the polyptych has shown that it was constructed on two levels: the main part composed of five panels, with five more panels placed on a secondary level above. These panels were all contained in a framework from the time of its making, with frames, carvings, and pilasters covering the frontal face and columns closing the sides. The particularly careful study of this polyptych also permitted us to compare it with other works by Gentile. This work, in fact, had a typical framework functioning as the structural support, into which the single painted panels were inserted to form the whole, together with the architectural elements attached to the front. Unfortunately, many components have suffered heavy interference in the nineteenth century when the work was dismembered. When the polyptych was recomposed in the Pinacoteca di Brera at the beginning of the twentieth century, the central upper panel was already missing. Gentile da Fabriano, like many other artists, produced paintings whose structural features differed according to the geographical area in which the artist was momentarily working. When Gentile was engaged in making the Adoration of the Magi altarpiece in Florence, while the work was indeed in the International Gothic style, the support was typical of Tuscan woodworking practices in the early decades of the fifteenth century. Our study has made it possible to discern the traces of the collaboration between the painter and the woodworkers, carvers, and gilders, valid both for devising the plan for building the painting support and for its actual execution. Although the criteria adopted for the framework system appear clearly distinct from those applied to works which rely on the support itself for structural strength (the former allowing for painting to be done completely separate from the framing, both in the physical and temporal sense), it is equally true that the making of altarpieces during the Gothic period also included the collaboration of various workshops and professional figures working separately.

Numerous examples of this sort of polyptych also exist in Tuscany at a much later date: the Trinity Triptych made by Domenico Beccafumi in Siena in 1504, whose exquisite frame includes the predella and the carvings. The broad trabeation rich in grotesque motifs and decorated with shaped, carved and gilded frame moldings, makes room for three finely executed panels whose rear is finished with gesso grosso.

2.21. The single panel polyptych

There are numerous examples of the polyptych constructed in the form of a single panel, without any great distinction between period or artist. A continuous support characterizes such triptychs as the Annunciation painted by Simone Martini in 1333, now in the Uffizi Gallery, the Annunciation by Lorenzo Monaco from the Church of Santa Trinita in Florence, and the same painter’s Coronation of the Virgin conserved in the Uffizi, signed and dated 1414 (Fig. 42). Lorenzo Monaco’s Coronation may be taken as an example of this type of construction to illustrate its structural features. This work was heavily restored in 1867, at which time the three crossbars originally nailed to the panel were removed and substituted with new ones, inserted into a dovetail-shaped track carved out of the wood across the rear. All of the architectural components originally glued and...
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Nailed to the panel were detached in the same moment, and remounted less securely; lastly, the original connections of the predella to the rest were altered. The historical and conservation reasons behind this episode of intervention are illustrated in the chapter on reasons for decay (Fig. 43). The study of this work, carried out during its restoration and presented in 1998, is the basis for whatever observations may be advanced regarding the original battens and certain parts of the architectural structure. The painted surface is distributed on two registers: the main structure where painting extends over the entire support whose upper part is shaped to form three trapezoidal arches; the level above consisting of three panels, again arched, fixed to those beneath. The main support measures 373 cm in width and 293 in height; its 3.7 cm thick boards are twelve in number, generally well selected with an intermediate sub-radial cut. The “inner” faces of the boards have been used for the preparatory layers, and each has been perfectly finished along the edges before gluing them together with calcium caseinate to form a very large single panel. After having accurately trued the support face destined to be painted, work continued on the rear to prepare it to receive the crossbars. Parallel pairs of red lines were accurately drawn on the rear of the support, which have remained visible, to indicate exactly where to position the crossbars. The areas thus marked were then carefully smoothed and the crossbars positioned and fixed, as was usual by means of glue and nails. The nails were inserted through the support front to back, thus coming out of the rear through the battens where they were clinched back into the wood; the heads of the crosspiece nails were covered by placing the predella with the inscription on top of those used for the lower batten, and the cusps over the nails of the upper bar.

Complex architectural elements attached to the front of the panel surround the painted surface. Each of the three cusps forming the upper portion of the main support is crowned with a jutting aedicule, itself trapezoidal in shape, decorated with gilded vegetable motifs carved from strips of wood glued to the front face, then also glued and nailed. The tops of these protruding architectural elements provided the space for placing the upper level painted panels, resting them on an intermediate pedestal designed to further elevate their height. These jutting cusps are united, and their outermost edges are attached to the lateral pilasters which terminate the polyptych on each side. The supports of the upper order of paintings, which measure 125 cm high by 57 cm wide and 3.5 cm thick, are composed of two boards each; these panels rise from the frontmost part of the thickness of the wood of the main panel’s cusps, and are themselves crowned with smaller triangular-shaped cusps. The upper level panels are made of poplar wood, the boards are sub-radial cut and...
style and composition, which in a brief length of time were destined to undergo great structural and formal changes. Although it is certainly true that the single panel polyptych does already exist during the first half of the fourteenth century, we may consider Lorenzo Monaco’s Coronation to be a high point of Gothic polyptych construction, and at the same time an anticipation of models for composition which began to demand a unified pictorial field to contain the figurative representation.

2.22. Small altarpiece for private devotion (altarolo)

This type of artwork is characterized by a wood support which generally includes a main arched panel, and two flanking shutters hinged to close like a door over the central image. The shutters were connected to the frame attached to the outer edges of the main panel. The main pictorial representations were on the central arched panel and on the inner sides of the shutters. The outer faces of the shutters and the rear of the main panel were prepared with a gesso ground similar to that of the painted front sides, and were decorated with faux motifs. The construction is simple: these little altarpieces were made of white poplar wood, and almost always consisted of a single vertical plank. Good quality wood was usually employed, and the placement of the boards very attentively carried out according to the thirteenth and fourteenth-century precepts as already described. The Florentine practice also included laying down cloth on the support for the purpose of absorbing eventual movements of the wood. The frame surrounding the painted surface was not an added element as it usually was on the formerly described panels, but was rather carved out of the inner face of the wood itself. The shutters, shaped with a triangular upper section, were designed to cover the main panel completely when closed, and were connected to its outer edges by means of two “hinge-hooks” which permitted their rotation until complete closure over the central surface was achieved. An example of a work constructed this way is the Madonna Enthroned with Child, Angels and Saints painted by Jacopo Landi called Jacopo del Casentino around 1340, now in the Gallerie degli Uffizi.

Comparing the examination of these technical details with those emerging from former studies of the construction of panel paintings, it is apparent that the work in question does actually represent the culmination of a phase. This regarded both sufficiently uniform in consistency, and are glued together edge to edge with calcium caseinate. The entire polyptych rests on a large predella, designed to also include the side pilasters thus completing the architectural structure. As previously mentioned, the study of this polyptych has furnished important information about the original structural design; in fact, besides the lines drawn on the rear to delineate the areas intended for the battens, further traces on the front have been observed, which mark the spaces on the support destined to receive the actual painting, the arches, and the predella with its moldings and inscription. Careful examination of the wood structure and the preparatory layers has further revealed the presence of a rectangular opening in the lower central area of the main support; although this aperture has been filled in at a certain point, it was possible to determine its original closure with a door (Fig. 44). The X-radiograph confirmed this by revealing the presence of notched strips of wood fastened to each side of the reconstructed area, a detail compatible with a door frame. Further confirmation is offered by the traces of two hinges visible in one of the strips, originally placed for opening a door inwards, in the direction of the rear of the support. Furthermore, the original preparatory cloth laid down on the support also covers the joints of the vertical notched strips, thus constituting additional confirmation of the original presence of a movable part inserted into the structure.

44. Lorenzo Monaco, Coronation of the Virgin, Gallerie degli Uffizi, Florence. Detail of the reconstruction of the original door.
of a single arched board, 3 cm thick, while the outer frame ornament, the cusped arch, and the columns together with their bases and capitals, are all carved directly out of the front of the wood support.

2.23. Birth tray (desco da parto)

The structure of this particular type of panel painting is basically quite simple, combining a board panel with frames on both sides around the support’s perimeter. Since the special function of these works usually required painting them front and back, no crossbar system was applied to keep the warp of the wood under control. The lack of this structural element was compensated by the circular or polygonal shape, however, as well as by the object’s relatively limited overall dimensions, and the applied frames also contributed to sustaining the support. The basic structure was normally composed of two or three boards, glued together with a butt join at the edges; the panels examined were of poplar wood boards, with their internal faces used for the principle painted surface, with no ultimate connecting elements inserted internally. Rather small carved or round-edged frames were added to finish the support around the edges, so that the entire thickness of the support’s outer edge formed the external part of the frame, and was therefore often shaped to complete the frame molding together with the decorative parts placed on the front and back. Some of these works have also been prepared using cloth. A few examples of this type of construction are the birth tray with a Nativity by Masaccio (Berlin, Gemäldegalerie), another that represents the so-called Gioco del civettino with Two nude children struggling and two coats-of-arms on the rear, painted by the artist known as Scheggia (Palazzo Davanzati in Florence), and the decagonal birth tray with a Last Judgment painted on the front (Horne Museum). The wood structure of the latter is formed of three poplar wood boards, butt-joined and sealed with casein glue. The outer edges are shaped into an “owl-beak” motif, while a wooden frame carved with plant motifs delimits the front edge, and a pastiglia molding encloses the painted surface on the rear.

2.24. Circular panel paintings

The construction of this type of circular painted panel differs in several ways from the others, especially regarding the crossbars, and to a lesser extent also the arrangement of the boards. Crossbars are not always present, with the frame itself sometimes assuming part of their control function. Even when a crossbar system has been found, however, it has not been possible to determine whether the criteria followed for its placement is actually similar to those observed on squared supports. Identical size round paintings may in fact be furnished with either one or more battens to control the panel, or none at all.

On the other hand, the selection of the wood and its transformation into the final object certainly followed the same fundamental criteria as those for the paintings described previously. Sandro Botticelli’s Madonna with a Pomegranate (Gallerie degli Uffizi) is an example of such a tondo, with a poplar wood support 143 cm in diameter, and butt-joined boards 3.5 cm thick. While the panel has never had crossbars, the solidity of the original frame, still in place today, has contributed to control of wood warp and afforded protection to the edges of the support. Another work belonging to this type is the Adoration of the Magi by Domenico del Ghirlandaio (Gallerie degli Uffizi), whose support is 172 cm in diameter. This panel has been made according to the canons regulating good quality construction practiced towards the end of the fifteenth century; it has vertically placed boards, and is backed with one sliding dovetail crossbar set into a track shaped accordingly. Filippino Lippi’s Madonna and Child with Angels (Florence, Cassa di Risparmio), dated 1487, is another contemporaneous painting. Its poplar wood support with a diameter of 173 cm is formed of boards joined only by gluing together their edges. Another very important work of this type is Michelangelo’s Doni Tondo, with the Holy Family and the young St. John, whose panel is made of three main poplar wood boards to which another two smaller pieces have been added to each side to complete the round form The painting is 120 cm in diameter and is sustained on the rear by two dovetail-shaped battens in their correspondingly shaped tracks. The generally well selected boards are arranged vertically and butt-joined at the edges; the central one is wider than the other three, with the one on the left showing slightly curved grain near the edge. Several very porous growth rings may also be noted. Dovetail inserts reinforce the main joins, two above and two below. The slightly tapered batten bars are fitted into parallel tracks whose sides have been slanted to receive them, and which are situated at the same distance from the top and bottom margins of the round panel. The side used to receive the ground layers was very carefully smoothed, working horizontally.
but leaving almost no traces of the operation. The magnificent carved and gilded frame with decorative motifs and sculpted heads is a separate wooden entity placed on it to complete the work. Raphael’s Madonna della Seggiola also has a poplar wood support and two battens fitted in dovetail-shaped tracks.

The Bartolini Tondo painted by Filippo Lippi (c. 1465–70) conserved in the Galleria Palatina in Florence is another example of a round tempera panel on wood, 135 cm in diameter. The rear of this work is coated with gesso, smoothed and painted with a coat of arms covering almost the entire surface, which might be related to a member of the Martelli family. Although larger than the Doni Tondo, this work had no crosspieces on the rear, and the painting on the front is not aligned with the axis of the boards.

### 2.25. Fifteenth-century Renaissance panel paintings

If we think of the end of the fourteenth and the beginning of the fifteenth century as moments of revolutionary cultural innovations, capable of producing a profound effect on artistic activity in general, we may be certain that wood construction for panel painting was not exempt from such changes. The recourse to models derived from classical antiquity must not be thought of only as a search for sources of inspiration to imitate, but also as a contribution to forming an actual historical awareness of past cultures. The search for innovative forms and new canons for painting lead to original ways to express spatial dimensions, which would eventually develop into the squared panel. These concepts conditioned the fabrication of wood objects, resulting in an amplification of the board composition, and imposing significant structural modifications in response to the new requisites.

The format for the renewed Renaissance altarpiece was essentially rectangular in shape,inserted in an architectural structure which reflected the revival of classical orders. As already for the polyptych, this confirmed the very close relationship between the art of painting and architecture, both in the format of the artwork and its correlation to actual buildings. The two typologies treated here were in fact destined to stand on simple altar tables as self-supporting objects, and thus also served as their own architectural framework. Only with the introduction of the great altars built of stone or from the walls of the churches resulting from the renovations imposed by the Counter-Reformation, will paintings themselves no longer play this important role. The need to refer to a variety of models therefore prompted development of adequate technical solutions able to respond to the new structural requirements. This implied a critical revision of past construction methods, and posed practical questions about the behavior of these objects and the recognition of the related problems. Woodworkers and painters of the period were certainly aware of the limits intrinsic in the thirteenth- and fourteenth-century wooden structures, especially when the board structure reached particularly large dimensions, whether in the form of an arched panel or single panel polyptych. By the beginning of the fifteenth century, these works had undoubtedly shown problems of conservation caused by the strong bonds created by nailing the board structure and the crossbars together. Beyond certain limits, this rather rigid system was destined to condition the movements of the wood and cause stress, provoking warp and cracking of the support boards. Very large panel paintings were particularly exposed to these risks, since they were unable to maintain enough elasticity among the various parts (support-battens), sufficient to withstand the dimensional variations of the wood caused by RH fluctuations and by the natural aging and modification of the material over the centuries.

As already mentioned, certain innovations in panel painting format had already been hinted at in Lorenzo Monaco’s Coronation of the Virgin polyptych, which although it maintained the basic shape of an arched triptych, provided an ample, open, and unified pictorial space in the main part. The Gentile da Fabriano Adoration of the Magi from the Uffizi Gallery also has an ample pictorial space together with the Gothic forms of the pointed arches and the architectural structure, although in this case the whole still remains within the canons of fifteenth-century perspective. Conceptually, neither the Coronation of the Virgin nor the Adoration of the Magi were affected by the changes in construction then in course, still being anchored to the guidelines for the fourteenth-century polyptych. Two quite similar paintings instead evidence very important changes in format: the Coronation of the Virgin attributed to Bicci di Lorenzo from the Church of Santa Trinita in Florence, dated 1431, and the Madonna and Child Enthroned with Saints by Giovanni del Ponte from another Florentine church, San Salvatore al Monte, dated 1434. These altarpieces are arched in shape, almost as if to evoke a fourteenth-century panel painting and its old-fashioned type of wood
construction: crossbars and wood moldings, superimposed frames and predella base are all nailed to the support. The changes in construction are evident instead in the type of workmanship used for the lateral pilasters, whose form is different and which are enriched on the front and sides by the presence of a carved groove motif, with rabbits and relief parts alternating on the upper and lower portions. These pilasters take on the function of frame moldings surmounting the edges of the painting, and themselves sustain a series of frame elements along the upper edge whose shape is almost that of a tympanum.

In any case it will be at the end of the third decade of the century that a decided change in panel painting format and size takes place, arising from the affirmation of a new Renaissance vision which will produce substantial technical mutations, as compared to the canons for construction typical of the preceding centuries. It will be the works of artists such as Fra Angelico, Filippo Lippi, Neri di Bicci, Domenico di Michelino and others, that will demonstrate conspicuous technical changes in wood construction. The diffusion of the new Renaissance taste among patrons and the adhesion of the artists to the new cultural climate determined a progressive affirmation of the new typologies.

Fra Angelico is certainly the painter who best represents these changes, reflected in the course of his activity: many are the works of his youth constructed according to fourteenth-century technical canons: for example, the triptych with the Madonna and Child and Trinity (Florence, Galleria dell’Accademia) which may be dated between 1420–1425; the triptych with Madonna and Child with Saints of 1428–30 (transformed in 1510 by Lorenzo di Credi); the Cortona Triptych; and the Deposition from Santa Trinita dated 1437–40, although in this work the figures are contained within a single continuous pictorial space. The Linaioi Tabernacle undoubtedly adopts fourteenth-century techniques, with the central Madonna and saints panel solidly supported by a rigid structure fastened to the rear. The three horizontal and four vertical parts that compose this structure are partially glued and nailed to the panel. A large splayed frame surrounds the painted area, including the round-arched upper part. The support on the rear has been nailed to the panel from the front, beneath the cloth under the ground, and the tips clinched back into the wood of the reinforcement. The heads of the nails have been beaten into the wood under the level of the surface and covered with plugs to avoid them coming into contact with the preparatory materials. We may recall that this is the same process used on the Cimabue Crucifix in the Museum of Santa Croce in Florence.

The turning point in Angelico’s works towards the new structural concepts may be distinguished in the altarpieces now in the museum of San Marco: in the Annalena, Bosco ai Frati, and Montecarlo panels, dated between 1437 and 1440, in which we may perceive the great changes both in the format and in the application of the technique of support construction. These important mutations will be found subsequently in the works of such artists as Filippo Lippi, Domenico di Michelino, Neri di Bicci, Giovanni di Ser Giovanni called lo Scheggia, and later with Botticelli, Filippino Lippi and Zanobi Strozzi.

In Siena, the Madonna della Neve painted by Sassetta around 1430 exemplifies the developments taking place in forms and construction devices. This painter’s acquaintance with Florentine art, coupled with his personal sensitivity to the cultural changes in progress, prompted him to design a formally complex work within an enormous pictorial space, taking advantage of “a method systematically adopted in Siena, using quite intrepid diagonals to suggest the spatial environment rather than measuring it out, evidencing this schematic representation through a profusion of matter.” In order to achieve the architectural design, the upper part of the panel is devised in the form of a triptych, characterized by the presence of cusps and arches and with carved and gilded frames enclosing the figures, thus still echoing the Gothic altarpiece. The wood construction is instead influenced by something else: the format is almost square and the system of structural reinforcement has been modified. The usual battens have been replaced in fact by a panel placed with the fibers running in the opposite direction, which covers the entire rear of the painting to which it is fastened with glue and nails clinched back into the support on the front, underneath the preparatory layers. The type of support construction found on the Madonna della Neve panel may well have been influenced, at least in part, by the nearby Maestà by Duccio, in fact both show the same criteria of structural reinforcement.

In the Siena area, Pienza is the place where such changes towards the concepts typical of the Renaissance may be noted, represented by the five “all’antica” panels painted by Matteo di Giovanni, Giovanni di Paolo, Sano di Pietro, and Lorenzo di
Pietro called Vecchietta. These works utilize two different experimental systems of wood warp control.

Among the artists in Urbino, Piero dell Francesca and Giusto of Gand were the protagonists of this evolution in construction techniques.

The innovations in the entire method of construction were radical: the format became rectangular, framed in an architectural setting deriving from the classical models then being revived. While the structural components remained basically the same—support, crossbars, frame—what changed was the way in which the parts were connected. The support with its board assemblage was reinforced and its movements regulated by the application of crossbars; however, rather than being nailed down, they were mounted using metal elements which permitted the wooden parts to maintain a minimum degree of expansion and contraction. The frame became an independent, load-bearing element (the frame on Piero della Francesca’s painting remains of the nailed-down type) into which the painting was fitted. At the same time, cloth began to be no longer used in the preparatory layers as an instrument to absorb the movements of the wood. The decades from 1440 to 1470–80 were rich in technical innovations, experienced by many painters and woodworkers as a fervid search for technological solutions, which could on the one hand live up to the new requirements, while simultaneously maintaining the functional qualities that a wood object must necessarily have.

### 2.26. Fifteenth-century altarpiece construction

The meaningful elements typical of fifteenth-century constructions reflect a continuous search for new solutions to the problem of anchoring the crossbars to the wood panel, so that control of warp could be maintained while allowing a degree of independent movement of the wood in the form of expansion and contraction. The new situation resulting from this also led to constructing autonomous frames which did not have to be tightly fastened to the support.

Lesser care began to be taken in choosing the wood to make the panels, together with a change in the preparatory layers with the gradual discarding of the cloth applied until then to buffer the movements of the wood. Protection of the rear of the support, previously done with layers of gesso grosso, or with minium or other materials, also practically disappeared.

While the panels dating from the preceding period follow the concept of a generally unified construction, with battens and frames intimately connected to the support, during the fifteenth century the various elements underwent a progressive separation. The criteria used for attaching the crossbar system were also revised, giving rise to solutions better able to respond to the requirements of the support.

As previously mentioned, works by Fra Angelico (Fig. 45) such as the San Marco Altarpiece, or the Annalena and Bosco ai Frati panels, or again the Montecarlo Annunciation, give us an idea of the technical evolution taking place at this time in the ways to attach crossbars. Similar methods were adopted by Filippo Lippi for his Madonna and Child Enthroned in the Uffizi; and in the Santa Maria Nuova Altarpiece with the Madonna and Child with Saints (127 x 108 cm) painted by Zanobi Strozzi probably in 1439, now in the Museum of San Marco in Florence. Another example is the panel by Domenico di Michelino for the Madonna and Child Enthroned with Saints Anthony Abbot, John the Baptist, Roch, Peter Martyr, Margaret, and Mary Magdalene, in the Museum of the Cathedral of San Giovanni Valdarno, which may be dated 1446–50. These paintings were constructed with boards made of well-chosen poplar wood, arranged according to the usual dictates prescribing use of the inner face for preparation; their edges have been accurately trimmed and leveled before gluing (Fig. 46). Neither biscuit nor dowel inserts were placed inside the joints, since metal pins for mounting the battens substituted such elements. A precise plan for assembly existed from the start, of course, demonstrated by the presence of marks traced on the wood to assure that the pins would be lined up exactly, and to indicate where to open the housings on the rear of the support designed to become the points of anchorage. It must be emphasized that warp control was still exerted point by point and on the sides of the panels, although the method of mounting the crossbar system was based on inserting a cylindrical metal rod at the moment of assembly, into the thickness of the two boards in correspondence to their join (Figs. 47, 48). A flat piece of metal, hooked to this rod through an opening created on the rear of the support, was then passed through a rectangular-shaped opening in the batten during mounting; lastly, the entire assembly was blocked by wedging another iron element into a hole made expressly for this purpose in the end of the bar protruding from the batten (Fig. 49). A similar device has been found
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secured by wedging an iron piece into the space remaining in the opening next to the bar.

A gold-ground painting dating from the same period, the *Madonna and Child with Saints* painted by Neri di Bicci for the Church of Santa Felicita, has a similar system of fastening the battens and support together. The mechanism relies on a T-shaped element, composed of a flat
In comparison to the nailed-down system, this seems to constitute a noticeable progress, having overcome the older method’s limitation of not permitting any operations to be carried out on the areas between the panel and the battens without first removing the crossbars definitively.

Research into the fifteenth-century techniques of construction has also helped to formulate an idea of the types of collaboration existing among various artists of the period. For example, similarities have been noted in the way Angelico, Filippo Lippi, Zanobi Strozzi and Domenico di Michelino have handled their wood structures: use of the same type of wood not only for the support, but also for the crossbars, together with similar methods for their fastening. On the other hand, other painters of this period adopted different systems although in order to achieve the same functions. It will be interesting to investigate whether the search for such mechanisms was actually performed by the wood craftsmen themselves in their workshops, or whether the influence of the painter was what determined the methods to use for panel construction. The evolution of these innovations lead gradually to substituting the mechanisms described above with another system, which employed metal cleats that formed “bridges” to hold the crossbars. The cleat consisted of a flat iron strip bent in such a way as to contain a square or rectangular crossbar; the battens were no longer positioned on the upper and lower edges of the panel, but displaced more towards the middle, slipped into the cleats which instead were nailed down to the support (Fig. 51).
climatic variations. This new system of securing the battens to the support also determined changes in the criteria for positioning the points of anchorage, which no longer needed to be placed near the outer edges of the boards since the cleats were more or less uniformly distributed across the panel. The wood structures used by lo Scheggia for the panel with a Madonnina and Child in Glory with the Saints Lazarus, Martha, the Magdalene, and Sebastian from the Museo Civico in Fucecchio, and the triptych panel by Domenico di Michelino with the Saints Nicholas and Justus (Prato, church of San Giusto in Piazzanese), are further examples of these construction methods. During the second half of the century, Botticelli applied this technique to the Primavera panel, as did Filippino Lippi on the Coronation of the Virgin, and at least, in part, Leonardo da Vinci for the Adoration of the Magi in the Gallerie degli Uffizi.

2.27. Several examples of panels made in the area of Siena

The most important moment of innovation in panel painting in the area around Siena took place in the early 1470s, precisely during the decoration of the Pienza Cathedral. As already mentioned, four important painters from Siena were commissioned to furnish the altars of the Duomo with five altarpieces. The Renaissance format of each of these panel paintings makes the idea plausible that they were all part of a single project designed by the Cathedral architect himself, Rossellino (Fig. 52). This may be deduced from the technical characteristics behind the “tabernacle” frames, and from the repetition of the architectural style in both the structures themselves and their carved ornamentation. The elements which make up the complete frame structures are: the predella in the form of a pedestal, the fluted pilasters, the architrave on which the tympanum rests connected to the pilasters.

Certainly more than one workshop was engaged in panel making, taking into account the structural differences evident among the various pieces. While the carved motifs and the moldings of the architecture containing the painted works may be similar, the systems used to control the board structures differ even quite radically.

The poplar wood panels have been made according to all the previously described construction rules: choice of material, board finishing to eliminate any remnant sapwood, adjustment of the edges of the boards before their uniting, their correct orientation in relation to the ground, inclusion of cloth to absorb the wood’s movements. The planks have been glued together with a butt-join using calcium caseinate. An X-radiograph has revealed the presence of dowels in the joins inside the wood of the panel by Matteo di Giovanni; it may be supposed, although it has not been possible to prove this, that dowels are also present in the joins of other works. The crossbars of all of these panels are made of chestnut wood, while the greatest difference among the various works dating from this period is in the type of crossbar system (Fig. 53). We may begin our analysis of these objects with the panel by Sano di Pietro representing the Madonna and Child with Saints, Pienza, Duomo. The complete work of art including the original frame in the form of a tabernacle.
bars complete the crossbeams, with each section fixed to the support by two nails placed in proximity to the margins of the relative boards. What intention the woodworker really had is not entirely clear, since on the one hand he conceived a sliding batten, and on the other created a fixed bond system by nailing down the two horizontal bars to contain it. The woodworker must have realized that something was changing in the way support and control of the panel structure could be achieved, but his knowledge was still too limited to permit him to fully understand the concepts behind the new mechanisms. The work by Vecchietta with the Assumption of the Virgin and the Saints Agatha, Pius I, Callixtus, and Catherine of Siena, also displays a similar system: the trapezoidal shaped batten crosses the entire width of the panel including the lateral pilasters, while the wooden rails forming the track are divided into three sections corresponding to the painted front of each panel, thus making it possible to divide the work into its different parts by removing the crossbar (Fig. 54). Instead, the two paintings with the Madonna and Child with Saints by Giovanni di Paolo and Matteo di Giovanni show a very modern system, practically the most advanced from various points of view among the works examined dating from this period, indicating what the future technical choices would be: the crossbeams are slipped through a series of wooden cleats, three for each batten, fixed to the support with cheese glue and nails. Without going into excessive detail in evaluating this particular technique, especially regarding the number of connecting elements used, it may be affirmed that this type of board control constitutes an important technical innovation, despite the fact that it is still a point by point method. In fact, its simple yet efficient functioning lets the wood move, thus avoiding the introduction of dangerous stress factors. The criteria behind this method of applying crossbars will be followed on most of the panel paintings made in the Siena area from the second half of the fifteenth through the first half of the sixteenth century.
Ciro Castelli, Techniques of construction of wooden supports for painting

placed at the panel’s outer margins. Analysis of these rings and their arrangement lead us to hypothesize that their only function must have been that of being part of the mechanism created by the woodworkers to achieve an elastic check of warp, in other words the rings were meant to provide anchorage for the battens. Similar criteria for fastening the crossbeams to the support were also at least partially realized on the constructions described in the former chapters, on the panels by Angelico, Filippo Lippi, and the other painters cited above.

Continuing our research into the constructions of painting supports, we have found confirmation of our hypothesis in the Giusto of Gand panels in the National Gallery in London: although their crosspieces no longer exist, several rings are still present with metal pins attached to them. The length and the presence of a slot in these pins must have been connected to the function of holding crossbars to the support, blocked by means of a wedge inserted into the opening in the metal piece. The panels representing Famous Men (Paris, Louvre), originally part of the Studiolo of Federico di Montefeltro at Urbino, are made with a wood strip inserted into the joints between the boards, and a method of connecting the battens similar

2.28. The San Bernardino of Siena Altarpiece by Piero della Francesca

The San Bernardino of Siena Altarpiece by Piero della Francesca (Milan, Pinacoteca di Brera) is without doubt one of the most representative works of art produced by Renaissance culture in Italy (Fig. 55). Beyond the refined painting technique that characterizes this work, the painting made in the city of Urbino between 1472 and 1474 also constitutes an important example of this environment’s woodworking techniques and the critical approach to the application of the crossbar system. The structure has been recently the subject of particularly in-depth study, especially regarding the support construction.

Our examination of the artwork has revealed that the support is composed of nine poplar wood planks, free of any significant defects such as knots or other anomalies; of generally homogeneous consistency, they have been placed horizontally as usual for this geographical area. The turning of the “inner” faces of the boards towards the preparatory layers follows the usual rules governing panel painting. The boards are medium size in width, with the exception of the two somewhat wider lower ones, and are 3 cm thick. The anatomical cut is generally sub-tangential. It has been hypothesized that the frame of this painting was originally nailed to the front of the support.

The procedure used to assemble the support included as usual the perfect rectification of the edges of the boards to join. To reinforce the joints, a channel was carved into the edges of the support boards, wide a third of their thickness and about 2 centimeters deep, into which strips of wood were placed, and in which three slots were bored on each side of the join. Into these, cylindrical iron rods in the shape of a capital letter Omega “Ώ” were inserted; these elements were designed and dimensioned so that the part forming the ring emerged from the wood along the line of the horizontal joins (Figs. 56, 57). The Omega-shaped iron pieces were distributed in three perfectly aligned rows: one at the center of the panel and the other two 13 cm from its outer edges. Presently, support and warp control are afforded by two fir wood crossbars slipped into a track with a dovetail section carved out of the wood of the carrier. Our observation of the painting has revealed that the perimeter where the frame was attached has been partly reduced and therefore lost; while this operation did not interfere with the painted surface, it has resulted in the loss of the small rings placed at the panel’s outer margins.
to the one described above. The technique of reinforcing the joints by inserting a strip of wood into the boards from their edges was certainly an efficient way to increase the solidity of the assembly, however not to the point of guaranteeing sufficient general strength of such large paintings especially when composed of horizontally placed boards. The type of bond created between support and crossbar by means of rings and pins is certainly quite functional and also provides structural reinforcement, besides allowing sufficient movement of the panel in relation to the crossbars, thus improving the work’s general stability.

The analysis carried out on the structures of this period permits us to conclude that the criteria adopted to achieve control of the board assembly foresaw exerting it near the joined edges, without involving the central areas of the boards. Giusto of Gand’s painting depicting Rhetoric is an exception to this, since its anchorage points have been inserted into an opening carved in the front face before laying down the preparatory and paint layers, without taking into account the divisions of the boards forming the panel but rather distributing them uniformly over the entire space.

2.29. Sixteenth-century panel paintings

The main technical features of sixteenth-century altarpiece construction may be outlined, although somewhat generically, as follows: thinner board structures in proportion to the dimensions of the panels; less attention to the choice of the wood; and adoption of a new system of structural reinforcement. There was an increased tendency to construct structurally independent frames, made to enclose the painting both on the front and sides; over time, however, frames gradually lost their structural functions due to the advent of new forms of monumental altars.

The techniques of support construction, and the types of wood, and the criteria for selecting it continued to follow those of the preceding century, together with the methods for assembling the boards using their inner face as the side to prepare for painting. Biscuits prevailed over dowels inside the joints; they were made of hard wood and were not glued in, penetrating into the board edges about 4–5 cm and fixed with one or two passing pins. The glue employed was generally calcium caseinate, which permitted a longer working time than carpenter’s glue.

The preparatory layers were simplified, eliminating the layer of cloth, although in the case of
particular carefully made works dating from the early years of the century, it is still possible to find strips of cloth over the joints or covering eventual defects in the wood. Rather than following the precepts described by Cennino Cennini, preparation of the panel was frequently influenced by the personality of the single artist. Only one or two very thin layers of gypsum and glue ground were often applied, and depending on the specific case, also a glue primer over the ground to make it less absorbent, and over this a colored background which could vary in the different areas. On many panels, even very large ones, hemp fibers (tow) were applied in place of cloth in strips over the board joints, incorporating the material into the ground mixture with the plant fibers arranged opposite to the grain of the wood, in order to reduce the repercussion of the joints on the painted surface. Especially for this period’s very large structures, episodes of boards being added to increase the height of the panel were frequent, as was repair of knots or other defects through application of plugs and fillers.

As already mentioned, the adoption of a crossbeam system which foresaw inserting dovetail-shaped battens into housings on the support, may be considered the single most characteristic technical aspect of the period. The constant striving for the correct structural functioning of the crossbar system continued for centuries, trying to achieve ever better control of wood warp, as we have already seen. The new method was the acme and conclusion of this search for the most advanced functioning. The earliest evidence of the use of this new technique may be identified around the last two decades of the preceding century.

The criteria previously adopted for applying the crossbars to the panel, which entailed point-by-point anchorage placed near the edges of the single boards, changed radically with this new system. In the new method, a continuous track opened across the entire width of the support surface made it possible to obtain uninterrupted connection of the batten to the support. The new concept differed from the earlier systems, in that the central portion of the single boards was no longer left partially free from direct attachment, and therefore subject to the forces of stress eventually present as a consequence of RH fluctuations, but rather systematic control of the entire support surface was assured.

This crossbeam system is commonly referred to as sliding, although the term is improper since it is the wood support boards rather than the battens which are actually allowed to move. The procedure for mounting the crossbars entailed the carving of a track with a trapezoidal section (commonly called a “dovetail” mortise) in the wood of the support, to a depth of about a third of its thickness; the sloped inner edges of this seat converge upwards towards the surface, while the width of the track tapers from one end to the other. Once the track was ready, the crossbar was fashioned to exactly replicate the shape of the seat and thus occlude it completely. The battens were fitted into the wood track, about 10–20 cm from each side of the support. Furthermore, in order to increase the strength of the oblique mortise walls and prevent them from breaking under the pressure exerted by the bar, the battens were devised with the part inserted into the housing in the form of a double dovetail tenon, thus making them able to achieve firm anchorage in the seat, while also protecting and strengthening the upper edges of the mortise opening. This crossbar system, thanks to the type of joint together with the tapering width of the batten from one extremity to the other, permitted the crossbar to be pushed in until good adhesion of its entire extension was achieved; this system also allowed successive adjustments to be made.

Analyzing the criteria behind this type of batten system, factors such as the friction created between the parts composing the crossbeam-support union, and the forceful method of insertion make it evident that the intention was to obtain maximum restraint over the movements of the wood. Placing the crossbars tapering in opposite directions also contributed to achieving this goal, by acting as an element designed to contrast warp across the entire width of the panel, while leaving a certain margin for the support to move in the case of tensions arising in the material, superior to the force exerted by the crossbars. All of these details present in the sixteenth-century methods strive in a new way, through a method which has done away with fixed bonds between the support and its crossbars, not only to achieve control of warp, but also to regulate the movement of the wood itself. Comparing the systems practiced during this period and the fourteenth century, we may see that in reality both methods aimed at reducing movement and warp of the boards to a minimum, although the means for achieving this were totally different. Several practical and technical considerations may be advanced about this type of batten system: a certain difficulty in making the
ly resorted to the other technique characterized by battens held by cleats. The three panels constituting Domenico Beccafumi’s *Trinity Triptych* of 1513 were constructed with rare perfection in the choice of wood and finding the correct proportions between size of the painting and board thickness, thus obtaining optimum planarity and stability for the wooden object and its paint layers. The three poplar wood panels were supported on the rear by two chestnut wood battens, perfectly introduced in trapezoidal mortise tracks about a third of the support in depth. The rear of the three panels was trued, and a slightly lowered portion along the perimeter was prepared to receive the bolts for fixing the structure to the framework. Lastly, an abundant coat of gesso grosso and glue was laid down on the rear. The three parts were mounted within a structurally supporting architectural composition. The use of the triptych format for sixteenth-century forms and style recalls one of the criteria of construction of the polypych in the late-fourteenth century. Beccafumi will later alternate this construction technique, based on inserted dovetail crossbars, with the other mechanism using cleats. Other painters from Siena constructed their panels according to similar criteria, alternating the methods adopted, up till the middle of the sixteenth century.

One anomalous construction for a painting by Domenico Beccafumi was the *Coronation of the Virgin* from the church of Santo Spirito in Siena, painted in 1540 for the Camaldolese Monastery outside Porta Romana. The original poplar wood structure made with battens passing...
through cleats was constructed in two different moments: the upper portion was made first, and for unknown reasons another part was later added to the lower part. This becomes evident from the way in which the two parts of the support were connected: in fact, there is a continuous half-lap joint uniting them along the entire length of the boards. If the increase in height had been foreseen from the beginning, it would have been more reasonable to lengthen each board singly, thus obtaining greater stability by avoiding that the entire length of the joint was all along the same line. This idea is confirmed by the fact that on the upper part of the support, the wood and method of assembly reflect the criteria typical for this type of construction, while on the lower part they seem more haphazardly applied. The preparatory layers also appear thicker in the X-radiograph of the lower part, which indicates that this phase of work had already been completed on the upper part at the moment of the panel’s increase in size. The observations based on the study carried out on various works by Francesco di Giorgio Martini, Domenico Beccafumi, Girolamo del Pacchia, and Bernardino Fungai generally concur in finding a quite good choice of wood (with the exception of the previously described painting), and noticeable structural solidity, thanks to the ample thickness of the boards and their good workmanship.

Two panels, made in Florence around the middle of the sixteenth century and both now under restoration in our Laboratory, demonstrate particularly interesting structural features: these are the Descent of Christ into Limbo by Bronzino and the Deposition from the Cross by Salvati, both from the Museum of Santa Croce in Florence (Fig. 59). The first, by Bronzino, is round-arched in shape and measures 439.5 cm in height and 292 cm in width. The panel is composed of seven median sub-radial cut boards of poplar wood. The special feature of this support lies in the fact that each single board has been obtained by uniting two separate planks head to head with a half-lap joint to form the entire length (Fig. 60). This was definitely the result of the difficulty of finding sufficiently long boards of good quality, centrally cut and free of defects, uni-
A special type of sixteenth century construction

A special sort of wood structure known as the cataletto, used in the sixteenth century by the Misericordia Companies as a funeral bier, had two head boards often elaborately decorated with molded frames and gilded carvings. A panel prepared with gypsum and glue and painted on both sides was often inserted into the U-shaped opening framed by the architectural elements. Examples of similar works, still intact, may be found in the Confraternita della Misericordia in Siena, and in the Church of the Collegiata at Casole d’Elsa. Four little panels by Beccafumi, representing the Madonna and Child, St. Anthony Abbot, a Deposed Christ with two Angels, and another St. Anthony Abbot, now in the Misericordia of Siena, were originally made for the Cataletto della Compagnia di Sant’Antonio. Research carried out in the early 1990s has shown that these panels formed the two head boards of a cataletto, each one a single poplar wood board painted on both sides, inserted into a channel in the inner edge of the framework.

Flemish panel paintings

In northern Europe, the choice of wood and the techniques of panel construction of Flemish painters were certainly conditioned by the woodworking traditions, and by the regulations put forth by
the guilds. Certain species of wood were deemed lacking in consistency and longevity, and were therefore banned from use in these areas. Various factors favored the spread of oak tree wood, instead, for use as a building material and for making artworks: the territorial availability of this species, either indigenous or imported; the recognized qualities and durability of this material, known for its resistance to certain adverse climate conditions and to wood-boring insect attacks, and the ease with which it can be worked. Observation of the objects reveals basically uniform criteria adopted for their construction over the centuries, thought to be the consequence of the perseverance of certain traditional techniques and materials imposed by the single guilds.  

Although our experience in this sector is based on a limited number of cases that we have had the opportunity to study, either during restoration or because they are present in the Florentine Galleries or in other museums, several observations may be advanced at least regarding the criteria which guided the construction of the works.

Their typical structural characteristics may be summed up as follows: a careful choice of the type and quality of the wood; usually a reduced board thickness in comparison to that of paintings made of other woody species; a system of control which functioned relying on the frame rather than on crossbars attached to the support. The painting panels were made of oak wood boards, usually cut radially and from which the sapwood part had been carefully eliminated. Radial boards were generally found on the paintings examined, and were often not very wide; this led us to conclude that the tree trunk must have been quarter sawn to obtain this type of longitudinal cut.

The best face of the boards was the side used for the ground and paint, and when the board was not perfectly radial, this meant using the “inner” face in relation to the center of the tree trunk. Supports formed of more than one plank were usually butt-joined, and despite their quite reduced thickness, this was accompanied by placing dowels or biscuits within them. The biscuits were inserted into their seats as usual without gluing, fixing them near the margins with pins passing completely through the support wood. After having glued the support together (with carpenter’s glue), the side meant to receive the ground was accurately planed, while on the rear, visible traces of the saw used for cutting, or tool marks from working with a curved or straight-edged adze often remained. As already mentioned, these supports did not receive crossbars for support purposes and control of wood warp, since the frame carried out such functions. A channel opened in the edges of the frame or a rebate around its edges were specifically designed to receive part of the panel’s perimeter, however leaving a certain margin for the wood to move. If the frame were of the channel type, the support would have to be inserted into the frame at the moment of its mounting, while frames with a rebate also permitted uniting the two components at different moments. Larger paintings would have frames made of two pieces: one designed to be the panel’s support structure with its main side facing forward, and with an area notched into the surface on the rear to receive the other frame piece, designed instead to enclose the work and complete the construction and shape of the frame itself. Exceptions to this were several very large paintings with battens inserted into dovetail tracks.

Although the supports of Flemish paintings were already quite thin in proportion to the dimensions of the panels, it was still necessary to reduce the thickness of the edges of the board supports around their margins as much as possible to receive the frame pieces. For this purpose, the support was thinned down around the rear perimeter beveling the edges outwards. Panels painted on both sides represented an exception to this. The evaluation of the aesthetic qualities of this sort of system and its efficiency in controlling warp cannot be anything but positive; the panel is held flat without having to use either nails or other constricting components for construction. This structural concept was originally applied to panel paintings both small and large in size, whether composed of a single panel or in the form of a triptych.

Regarding the special design and function of the chamfered edge on the rear of Flemish panels, various hypotheses besides the one provided here have been formulated: we believe that our explanation may be the correct one, since it appears coherent with the type of object. Furthermore, such a technique is a common part of the procedures used in carpentry and marquetry for mounting panels inside various structures, including antique furniture. An example of this type of construction may be observed on the Portinari Triptych in the Gallerie degli Uffizi, painted by Hugo van der Goes in Bruges in 1470, and brought to Florence in 1483. The work is composed of three separate
panels, the main painted part and two closeable doors; its overall measurements are 586 cm in length and 253 in height. The main panel comprises 10 boards, while the lateral panels are each formed of 5 boards, all vertically placed and made of excellently selected oak wood. The cuts of the wood are mainly central, while the joints have four biscuits each, fixed with pairs of pins. The support has not been covered with cloth. Given the breadth of the main panel (340 cm wide), a batten was inserted into a dovetail track in the center of its rear. Both the main and lateral panels are painted on both sides, and are inserted into a channel in the frame structure. The frame is composed of two elements: one for the front of the panel, with the channel to hold it carved into the inner edges; the other which closes the construction on the rear to hold the painting in place. Although the frame now on the work is not the original one (the triptych was dismantled in 1567), it repeats the original structural features. Another example of such rigorous construction is a work by Antonio Noro, Portrait of a Woman Painter from the Galleria Palatina (Inv. 1890 n. 1841). Its oak wood support measures 88 x 64 and is 1 cm thick, and is composed of three vertically placed, perfectly radial-cut boards. Despite the very limited thickness, dowels are present inside the joints. The rear shows tool marks from using a straight-edged adze, while the edges have been thinned down to further reduce the thickness of the margins of the support boards.

Other examples of Flemish paintings recently treated at the Opificio are those formed of a single board, showing the typical thinning down of the perimeter on the rear: the small panel paintings belonging to the series of the Seven Wonders of the World by Bernard van Rantwyck (Florence, storage deposits) dating from the 17th century, and three small panels by Met de Bles, Christ and St. Peter Walking on the Water, The Good Samaritan, and The Levite and the Priest on the Voyage to Jericho (Naples, Galleria di Capodimonte). Another interesting example is the panel representing a Deposition of Christ, a subject frequently encountered in the Low Countries. This work by a sixteenth century Flemish artist shows the Christ figure in the center with the Virgin, St. John and Nicodemus, and demonstrates all of the features typical of this school of painting. It measures 92 x 66.5 cm with the frame, the support is 7–11 mm thick with the chamfered edges reduced to 6–4 mm. The support is made of oak wood, with three straight-grained, radial-cut boards arranged.
vertically and butt-joined. The frame is original, although it has been the object of past restoration with application of new gesso and repainting with light-colored tempera which covers the original painted surface. The frame still retains the original structural features, that is the joins, moldings, and border designed to receive the panel.

One of the main characteristics of Flemish structures is the absence of crossbars, whose function is assumed by the frame, in two ways, aesthetic and supporting (Figs. 62, 63). This type of solution is not limited to Flemish paintings, however, and may be found on various Italian panels of the period between the fifteenth and sixteenth centuries. The Trivulzio Portrait and other works by Antonello da Messina undoubtedly foresaw the containment of the small, thin poplar wood support in a structure around the perimeter that enclosed both sides to protect it from eventual warp. We do not know today exactly how such an “original” frame might have been made; however the traces on the unpainted edges of the panel and the different chromatic appearance about 1.2 cm wide on the rear perimeter may derive from insertion into a frame, wooden paneling, or other sort of domestic furnishing.

Raphael also painted numerous portraits using this technique: the Maddalena and Agnolo Doni portraits in the Florentine Galleria Palatina, 65 x 45.8 cm, are prepared on the rear with gesso and decorated with a monochrome design; also the work known as the Gravida, 66.8 x 52.7 x 1.2 cm thick, from the same museum, whose rear is only covered with gesso; and the Portrait of a Young Lady (La Muta), 65 x 48 x 1.3 cm, from the Galeria Nazionale delle Marche, whose rear has been covered with a thick layer of wax, probably in the nineteenth century.
Research was also done during treatment on single works, for example on Lorenzo Monaco’s *Coronation of the Virgin* altarpiece from the Gallerie degli Uffizi; besides new documents dated 1867, a further piece of evidence was found hidden under a batten during work on the support, a paper signed by Tenagli, who identifies himself as a carpenter.

Seasoning is fundamental to prepare wood for transformation into an object; basically it consists in exposing the wood to atmospheric conditions over various seasonal cycles, for the purpose of making the wood achieve a balance with the environmental RH, which also contributes to increasing the material’s stability.

The pith of the tree trunk has poor consistency and is subject to rapid deterioration.

G. Giordano, *Tecnologia del legno*, Turin 1981. The basic anatomical sections are: the transversal section perpendicular to the tree stem axis, which in a standing tree is horizontal; the radial section, outward along a radius from the pith axis of the trunk; the tangential section, which passes through a secant of the transversal section parallel to the axis. L. Uzielli’s further clarifies these characteristics in his contribution in *Dipinti su tavola*.


Biscuit and dowel inserts are very seldom found together in the same object.

While it was usual to block the biscuits placed internally by passing pins through them front to back, the same was not done for dowels put in the joins because of their shape and size. However, Vasari’s *Last Supper* from the Museum of Santa Croce, in restoration at the Opificio, is an exception to this, in fact pins have been inserted through the wood to block the dowels that join the five panels.


Other examples of crucifixes made of chestnut wood are the *Cross no. 434* in the Museum of Villa Guinigi and another in the Church of San Michele, both in Lucca.

Some examples of paintings on lime wood are: *Adam and Eve* by Lukas Cranach, Gallerie degli Uffizi, and the *Portrait of Agnolo and Maddalena Doni* by Raphael in the Galleria Palatina in Palazzo Pitti.

Roberto Buda, who restored these wood panels in the 1990s, reported the information on the technique of construction in an oral communication.


Master Guglielmo’s Cross has two layers of cloth glued to the wood to isolate its irregular surface from the ground layers.


See Barili’s choir panel of 1490 in the Duomo of Siena. Another interesting example of visual information is found on the *Rotonda Triptych*, reassembled in the sixteenth century in a new frame which includes a predella and lateral pilasters, on which woodworking tools together with several musical instruments have been carved on the front and sides.

Paris, École des Beaux Arts.


By “inner” side of each sawn board we mean the side of the plank facing inwards towards the central pith when cut from tree trunk; this will produce a greater surface extension during the phase of adjustment and eventual warp of the wood. Woodworkers were certainly aware of such behavior over the centuries, allowing them to take advantage of it according to the type of object to make.

Placing the wider boards centrally reduced the marking of the joins on the painted surface. Naturally the best results were obtained choosing radial cuts.

Dowels (cavicchi) were spindle-shaped elements, inserted for joining purposes into specifically prepared seats opened from the edges in the boards’ thickness. Their function was to keep the boards level during gluing and to reinforce the joins. Dowels were made of hard wood and were not glued in, with their fibers running cross-grain to those of the support. They were shorter in length than their housings, so that in the case of shrinkage of the boards over time they would not exert pressure on the joins forcing them open. The biscuits (ranghette) had the same function, the only difference being the rectangular shape.

Mentions of this type of glue exist since ancient times. The monk Theophilus describes how to glue the boards together for panel paintings using casein and lime in the chapter “De tabulis altarium et ostiorium et de glutine casei,” in the text known as the *Diversarum artium schedula*, one of the most complete medieval compilations of scientific secrets and technical norms for the figurative arts.

As we will see, the support of Piero della Francesca’s *Sacred Conversation*, also known as the Brera Alterpiece, is made this way; other smaller panels of this type are those by Bernardino Campi in the Church of the Incoronata in Lodi.

Clamps were iron devices in the form of a rectangular bar whose section varied depending on the length, with a fixed flat piece and another one adjustable by means of a large cylindrical screw. Clamping with wooden strips functioned according to the same principles as the iron devices, and were composed of one or two elements: a fixed piece and an adjustable one, with the final degree of compression obtained by inserting wedges.

Ugo Procacci attributed these panels to Jacopo del Casentino. Luciano Berti proposed a highly convincing reconstruction of the polyptych (1952), identifying the central portion in the *Madonna and Child* in the Vatican Museums, and the last panel to the left in a *Brigittine Saint* now in the National Gallery in Washington.

The painting attributed to Duccio is the central portion of a much larger panel, and shows the *Madonna delle Grazie* on the front and episodes of the Passion of Christ on the rear.

Some of the information on the “forged iron” nail comes from the Encyclopaedia Italiana Treccani.

Only two nails placed close to the edges of the board was usually preferred, to avoid the central part which was the part most subject to warp and therefore cause of stress and possible cracking.


Triptych, Rossello di Jacopo Franchi, 1420, Galleria dell’Accademia, Florence.

Once seasoned, wood demonstrates excellent mechanical strength and stability in
the longitudinal direction; it behaves differ-
ently instead in the opposite direction, where
there is much less mechanical strength and
warp is influenced by the composition of the
anatomical rings. Consequently, support sys-
tems had to be applied to the wood construc-
tion to achieve the required structural solidity
and to limit board deformation.

35 I have recently had the opportunity to ob-
serve a mid-fifteenth century Flemish paint-
ing, an altare di Pisa. La pittura pisana del Duecento da Gi-
unta a Giotto, exhibition catalog ed. by M.

36 Referring to Giotto, Vasari says: “…in
poco tempo, aiutato dalla natura ed ammaes-
trato da Cimabue, non solo pareggiò il fanci-
ullo la maniera del maestro suo, ma divenne
così buono imitatore della natura, che sbandi
affatto quella goffa maniera greca, e risuscitò
la moderna e buona parte della pittura, intro-
ducendo il ritrarre bene di naturale le persone
vive.” See G. Vasari, Le Vie de più eccellenti
pittori, scultori et architetti nelle redazioni
del 1550 e 1568, R. Bettarini, commented

37 M. Bacci, “Pisa e l’Icona”, in Cimabue a
Pisa. La pittura pisana del Duecento da Gi-
unta a Giotto, exhibition catalog ed. by M.

38 E. Sendler, L’Icona, Immagine del invisi-
bile, Elementi di Teologia, estetica e tecnica,
Rome 1996. This text is on the history of icons
in the religious context of Byzantium until its
decline; the techniques and materials used are
also described.

39 Ibidem.

40 For this see the Bigallo Master dossal
whose frame includes a separate part en-
closing the outer edge; the gables of Giotto’s
polyptychs also have applied, shaped mold-
ings. E. Bartolozzi, A. Santacesaria, “Il
supporto “scavato” del Dossale di San Zanobi:
punto di confronto per l’identificazione di una
tipologia costruttiva dei dipinti su tavola,”
OPD Restauro, 17, Florence (2005), pp. 273–
284.

41 Also see the large group of Byzantine
paintings in the volume H.C. Evans, Byzan-
tium, Faith and Power (1261–1557), The Met-
ropolitan Museum of Art, New York, 2004,
p. 167–373.

42 Comparison of Giotto’s crosses from
Santa Maria Novella, Rimini, Padua and
Ognissanti has brought us to conclude that
the Crucifix of Santa Maria Novella shows
the maximum technical level, choice of
materials, and harmony of form, dimensions,
and finish. As formerly mentioned, Cimabue,
who preceded Giotto chronologically, was
also very important as an innovator of panel
construction methods. Observation of the
large Ognissanti Madonna in the Gallerie degli
Uffizi, and comparison with the San Giorgio
alla Costa Altarpiece presently deposited at
the Curia and the Stigmata of San Francesco in
the Louvre, shows that the first has a perfectly
functioning, harmonically proportioned and
finished support system, complete with nails;
the others are efficient and well-functioning
constructions based on the consistency of the
support and the reinforcement afforded by
the battens on the rear, while we may consider
the technical and material choices customary
together with the proportions and the finish.

43 This table was prepared by Elena Bar-
tolozzi for her thesis entitled “Tecniche del
supporto ligneo nella pittura Medievale,” Uni-
versità della Tuscia 2010. Irene Samassa car-
rried out further research for her specialization
del Bigallo: Tipologia, funzione, restauri,”
Università degli Studi di Firenze, Scuola di
Specializzazione in Beni Storico-Artistici,

44 The panel of the Master of Greve from
the villa of Casale is made from two vertical,
butt-joined planks. The picture plane is re-
cessed with a 10 cm frame that slopes down
on the inner perimeter. Crossbars at the top
and bottom complete the support.

45 The dossal with St. Francis and Six Mir-
acles by Giunta Pisano from the Church of
San Francesco in Pisa has a pointed arch, and
measures 132 x 155 cm and is 3.5 cm thick.
The structure is composed of six poplar wood
boards placed horizontally. The panel origi-
nally had a vertical batten in the center, while
the battens now existing—two on the upper
portion and one on bottom—are not original.
The rear of the panel was coated with minim.
The presence of cloth has been verified only
along the joints, along which several dove-tail
elements were originally inserted.

46 This panel from the Oratorio del Castel-
lare at Vicopisano is made of chestnut.

47 The Depositon panel by Enrico di Tedic
from the Church of San Bernardo in Pisa is
composed of a single poplar wood board cut
radially, measuring 57x35 cm. The painted
plane has been carved to form the frames
from the thickness of the wood. The perim-
eter frame is simply carved, flat on the front
and about 5 mm wide, and the edge also about
5 mm wide sloping inwards at a 45° angle.

48 The dossal panel with Stories of Saint
Catherine from the Church of San Silvestro
in Pisa has a pointed upper arch, and mea-
sures 118 x 112 cm by 3.5 cm thick. The board
structure is composed of four poplar wood
planks mounted vertically, butt-joined with
dowels inserted; two poplar wood battens are
present on the rear, each fixed with seven nails
placed centrally on the boards. The nail heads
visible on the rear are rather large, while the
points have been clinched back into the wood
beneath the ground. The presence of cloth has
been noted only along the joints.

49 The Madonna and Child attributed to
the school of Barnardo Daddi (now in the
Museum of Santa Croce in Florence) has a
pointed arch; its characteristics are those of
the central portion of a triptych or of a dis-
membered dossal. Three poplar wood boards
of sub- tangential cut are arranged horizon-
tally and butt-joined. Three nails aligned
vertically are the only remains of the original
crosspiece system. Aside from the horizontal
arrangement of the boards, the construction
of this piece is similar to that of Giotto’s Ba-
dia Polyptych: the inner flat plane has been
carved down 8 mm, forming a molded frame
around partially flat and in part shaped, which
forms a pointed arch in which God the Father
has been painted. The slanted parts of the arch
were finished with actual frame pieces nailed
to the support to enclose the outer edges. The
perfect execution of the hollowed-out portion
as well as of the shaped parts testifies to the
presence of a precise project together with
great woodworking skill in realizing it. As far
as the state of conservation is concerned, this
has been noticeably complicated by the dam-
age inflicted by the flood of 1966; in fact, at
the present, the boards forming the support are
heavily warped.

50 The small portable altar with wings (al-
tarolo) by Jacopo dal Casentino, the Ma-
donna with Child, Saints and Angels from
the Uffizi Gallery, is small in size, and conse-
quently a single, arched board has been used
for the main part. The two wings are also
single boards, and are attached to the central
panel with iron hinges (their slang term be-
ing “gangherelle”), forming doors that may be
closed perfectly over the main Madonna and
Child panel. The upper portion is covered with
the jutting part of the oblique frames on the
arches.

51 The Pietà panel attributed to Vitale da
Bologna was probably one half of a diptych
unknown to us today. The carving of the hol-
lowed-out support is so refined that we may
define it as sculptural. The support is a single
board structure formed of one vertical, sub-
tangential poplar wood plank; it is 60.5 x 38.2
x 2.3 cm in size and is without battens. The flat
plane for painting has been hollowed-down
7–8 mm; the architectural structure which
surrounds the image left on a higher plane has
a pointed arch forming a shaped, Gothic-style
frame, which rests laterally on the capitals of
half-columns each terminating in a shaped
base below. Another molded frame flanks the
outer portion of this construction around the support. The X-ray of this panel shows that the gesso has been laid down uniformly over both the flat painted plane and all of the parts in relief. As to the conditions of the work, the most noticeable element is the marked warp of the panel, resulting from the tangential cut of the wood and lack of a support system on the rear. While the eventual presence of applied rather than carved out frames would have perhaps in some way reduced such deformation, it would have certainly induced dangerous stress and could have resulted in detachment of the paint layers in the areas between the frame and the flats.

52 The support of this cross is formed of ten wood elements including the halo piece, one of them very large.

53 Bone glue (cola forte), commonly called carpenters’ glue, is derived from boiling parts of large animals including bones, nerves, cartilage, and other proteinaceous tissue.

54 A previous restoration of this painting by Giannino Marchig in 1947, included removal of the original batten and insertion of four large “dovetail” elements with the intention of reinforcing the body and arm board joints. This instead greatly affected the structure, not only compromising the stability of the arms by weakening the joints, but also provoking continuous stress since inserted cross-grain to the main panel, thus much worsening the general condition of the object. This is a typical example of intervention done without any true study of the work or its original construction technique.


56 Museo Civico e Diocesano d’Arte Sacra di Montalcino, A. Bagnoli (ed.), Siena 1997, pp. 120–121. These two works demonstrate quite special construction features: the cross-lap joint between the body and arm boards has been realized from the rear; the tablet is a separate piece made of a single board and is inserted into the top of the vertical part with its fibers cross-grain.


58 The Uffizi Cross no. 432, for example, is made of re-used wood.


60 For example, Cimabue’s crucifix in Santa Croce in Florence—which is 433 cm in height and 390 cm horizontally, with the parts united in a cross-lap joint having the arm board inserted from the rear—has a batten system consisting of two long vertical bars placed at the edges of the body board, excluding the side tablets, connect-ed to a series of crosspieces united among themselves in cross-lap joints. The batten system is arranged over the entire rear of the wood cross, including the upper tablet and the parts with the mourners. The mechanical strength of the cross has been achieved through the combination of its own joining methods with those of the bat-ten system; the battens are solidly nailed to the support.

61 In this case no scientific proof of the use of calcium caseinate or animal glue has been obtained.

62 This part is subject to rapid deterioration.

63 An exception to this are the two thin strips of wood placed along the outer edges of the body boards.

64 In this case, given the perfectly radial cut of almost all of the support boards, it is practi-cally indifferent whether or not the face nearer to the center of the tree trunk has been used; in such cases, in fact, the choice of which side of the board to use will depend of which presents the least amount of defects.

65 Technical observations revealed an increase in the length of the crucifix of about twenty centimeters, deriving from the addition of two pieces of wood to the bottom edges of each apron flanking the main body. The modi-fication also affected the placement of the bat-ten on the foot piece, again indicating that the variation took place when the crossbar was already attached to the support. In any case, all the hypotheses regarding these modifications are further developed in the catalogue of the work published after restoration.

66 This special placement of the dowels indicates a project formulated prior to work.

67 Analysis has identified the glue as calcium caseinate.

68 The type of joint denominated “dovetail” has been used in woodworking since the time of the ancient Egyptian civilizations.

69 Several crossbars between the long horizontal and vertical beams of the Ognissanti Cross are of chestnut wood.

70 The restoration report fully explains all the details of the structural modifications made during the work’s making.

71 See note 24 for the technical terminology and function of the “biscuit.”

72 See note 24.

73 A. del Serra, Gli Uffizi. La Maestà di Duccio Restaurata, Il Restauro, Studi e Ricercbe 6, Florence 1990, pp. 57–63.


75 Mora, Il restauro della Maestà… cit. p. 17.

76 From the Di Giacomo Devoto and Gian Carlo Oli Italian language dictionary.

77 Examples of polyptychs whose pilasters reach the ground are: two altarpieces by Giovanni del Biondo in the Church of Santa Croce, Florence, one in the Rinuccini chapel and the other in the second chapel starting from the Sacristy. Another is Orcagna’s polyptych in Santa Maria Novella.

78 Two polyptychs by Taddeo di Bartolo were built and then transported, one to the Duomo in Montepulciano, and the other, painted on both sides, made for the Church of San Francesco al Prato in Perugia, testifying to this method of construction which allowed the work to be taken apart.


80 It is true, however, that there is a work by Domenico Beccafumi, The Trinity Triptych in the Pinacoteca of Siena, of 1513, whose three panels are inserted into a framework whose front is completed with strips of wood, capitals and frame moldings.

81 Unfortunately the only surviving original frame is the one on the Olera polyptych.

82 The information about the nail holes has been supplied by the X-radiograph done at the Opificio delle Pietre Dure by Ottavio Ciappi.

83 Dowels to connect the panels are usually not present on Florentine polyptychs, while this technical feature is quite common on those from the territory around Siena.

84 The presence of pinnacles was revealed by traces visible on the upper parts of the frames that divide the painted panels.

85 The reconstructed part has been made using old wood and mounted so that it does not interfere with the original components and remains easily removable.

86 The transformation of the polyptych in an altarpiece will be treated in the part dedicated to problems of decay.

87 The crossbars in 13th and 14th century structures were always placed at the head ends of the boards; in the case of a triptych or polyptych, they would be positioned one along the bottom edge and another at the base of the arches; if their number was more than two, the median bars would be placed at uniform intervals between the other two.

88 R. Saccuman, Le Grandi ‘Macchine’ di Niccolò Liberatore: il caso del politico di Donna Brigida in San Niccolò in Foligno e il


91 The support of Botticelli’s Primavera is made of poplar wood with fir wood battens, almost square in shape and with the outer edges of their ends sloped.

92 Traces of horizontal tool marks would be possible to observe in an X-radiograph.

93 The boards were selected for the greatest uniformity of consistency, straightness of grain, and lack of defects. Their sides were finished to eliminate all traces of sapwood, they were used preparing the inner face, after being aligned perfectly one to another and glued together with calcium caseinate.

94 Criteria for arranging the boards is practically the same as on Italian works.