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FRESCO PAINTING: THE DICHOTOMY OF RIGOROUS CRAFT AND ARTISTIC EXPRESSION*

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Abstract

In this paper, the term "fresco" is used to describe *buon fresco* technique: painting executed on fresh lime plaster while the plaster is still wet, so that the pigments, diluted in water only, are fixed by carbonation of the lime.

Fresco technique has been used in mural painting for millennia by diverse people and artistic traditions. It has left an enormous legacy due, in no small part, to its high degree of permanence. Although this legacy fuels passionate interest in historic frescoes and their conservation, the painting method itself—with its traditional craft origins—has fallen into obscurity.

This paper presents an overview of the fresco process and materials, which revolve around lime. To promote consideration of fresco as a contemporary medium, exact observations and comparisons of different lime products in a fresco application will be given, along with specific requirements for "good" fresco carbonation. Furthermore, a look at modern support panels will serve to extend the range of application beyond the traditional wall.

Keywords

buon fresco, *intonaco*, *arriccio*, lime putty, carbonation, pigments

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1 Introduction

1.1 Overview of the fresco process

1.1.1 The lime cycle

A fresco painter enters the lime cycle at a very opportune moment. Once the lime plaster has been laid on the wall and begins to dry, the window of opportunity opens. *Buon fresco* is unique. Other painting techniques use a modifying medium, such as oil or tempera, to bind the pigment and adhere it to the painting surface. By contrast, the fresco process uses carbonation of the lime itself, and so the wall plays the adhesive role. Each brushstroke of waterborne pigment *depends* on the transformation of calcium hydroxide into calcium carbonate to bind it to the surface. As the plaster dries, the pigment layer becomes fixed by the crystalline skin of calcium carbonate that forms on the surface of the lime system as it chemically reverts to stone, completing the cycle. In the process, the painting becomes an integral part of the plaster's setting history, achieving permanence via slender means.

1.1.2 Origins and development

During the Neolithic period, rock painting—which is executed directly on the rock—evolved into painting carried out on the plane of a wall that had been constructed and squared by man. For these earliest paintings, the wall's irregular surface was smoothed with a covering made from locally-available raw materials. The silt from the Nile, for example, consists of a mixture of sand, clay, lime, and gypsum. In Mesopotamia, the use of clay was traditional from the Neolithic period, and lime mortars appeared there much earlier. A lime kiln dating back at least to 2500 B.C. was discovered near Baghdad (Mora *et.al*.,1984, pp 72-74).

In this way, painting first became associated with architecture. In geographical regions with advanced lime technology, the prevalence of lime-based renders must have encouraged the development of fresco and lime painting in different forms without necessarily eliminating traditional tempera techniques, and even combining with them. In addition to straight lime/pigment interactions, what is now known of original methods indicates that many organic additives were used in mural painting during many time periods. Evidence indicates that the discovery and exploitation of the possibilities offered to painting by the process of lime carbonation must have taken place at the beginning of the second millennium B.C. in Mesopotamia and in Crete. Later, the technique was used by the Etruscans, reflecting its development in Archaic Greece in an analogous, but more refined, form (Mora *et al*., 1984, p 85, 88). Using different procedures and technical approaches, the Romans systematically perfected wall painting. Roman frescoes display the use of impastos, polished surface treatments, and modeled stucco relief.

Another important center of ancient wall painting is found in Mesoamerica, where the vast majority of pre-Hispanic murals were executed on lime-plastered walls. In certain regions, pre-Hispanic frescoes display a perfectly polished, flat and homogenous surface that was created using a technique in which the properties of clay are exploited to polish the plaster (Alvaraz 1999).

1.1.3 Structure and terminology

The lime rendering, or "ground", on which a fresco painting is executed is often composed of two layers, or when various strata are used to build up the surface, two types of layers. They are referenced by their Italian names *arriccio* and *intonaco*. The *arriccio* is the coarser, ground layer. It is applied to smooth the surface of the wall and also to hold moisture. It generally consists of lime and sand in a 1:3 ratio. The carefully smoothed *intonaco* is thinner and finer, generally not exceeding one eighth of an inch. This layer receives the painting. The *intonaco* generally consists of lime and sand (or marble dust) in a 1:2 or 1:1 ratio. It is applied in a piecemeal fashion over the *arriccio*.

The nature of the fresco ground is determined by its strata. The building up of various plaster layers, from lean and rough to fat and fine, produces what is referred to as a “deep” ground. In the case of a deep ground, the various strata may still be classified in terms of the two types of layers: course preparatory layers and finer finish coats. For example, the ground for Roman wall paintings often consisted of at least six layers: three layers of lime and sand (*arriccio*) and three layers of lime and marble powder (*intonaco*) (Mora *et al.,* 1984, p 16).

1.1.4 Traditional fresco technique

According to its etymology, the word fresco comes from the Italian for “fresh”. Thus, painting *affresco* refers to painting on a freshly laid *intonaco*: the final coat of wet lime plaster. The relative freshness of the *intonaco* is key, because the painter must keep pace with the drying rate of the lime. Therefore, the painting session that follows is limited—usually only six to eight hours in length, or the estimated time frame of the initial setting reaction. Because of the time constraint, only a portion of the work at hand is undertaken on each day. Therefore, only so much of the *intonaco* is laid by the plasterer. The size of the section corresponds to the amount of painting that the artist plans to finish in a day’s work, or *giornata*.

How is a fresco-mural created? A full-scale preliminary sketch, or *sinopia*, executed *in situ* directly on the *arriccio,* serves as a guide for the plastering and subsequent execution of the *intonaco*. Early in the day, the predetermined portion of the *intonaco* is laid on the wall and then carefully smoothed with a trowel. In order to maximize painting time, a *cartoon* or full-scale drawing is transferred onto the damp *intonaco* by “pouncing” pigment through pricked outlines in the drawing paper, or by tracing the outlines of the drawing with a pointed instrument, or by direct incision onto the fresh rendering. The fresco colors are prepared in advance. The pigments are ground with water to a creamy liquid consistency, and then intermixed in small containers to achieve various hues. Painting begins when the damp *intonaco* is firm enough to resist the pressure of a natural bristle brush. Using the transferred drawing as a guide, the painter uses a hatching technique to lay-in the under-painting, and gradually builds up the values. More saturated colors are superimposed over the under-painting using a variety of applications to create a range of transparencies and densities, and even a slight impasto. At the end of the day, the unpainted pieces of plaster are trimmed away and the edges of the completed *giornata* are carefully beveled off to allow the next day’s plaster to be joined-up to the current day’s work.

The ideal process is to complete each portion of the painting in one sitting, because any after-touching will lack the textural quality and permanence of the *buon fresco*. Due to the specific nature of fresh plaster, every brushstroke is committed and cannot be reworked. Therefore, major changes and reconsiderations can only be made by removal and re-plastering of the *intonaco*.

In the mid-sixteenth century, the Renaissance painter and architect Giorgio Vasari described the fresco process as follows:

> *Of all the methods that painters employ, panting on the wall is the most masterly and beautiful, because it consists in doing in a single day that which, in the other methods, may be retouched day after day, over the work already done...There is needed also a hand that is dexterous, resolute and rapid, but most of all a sound and perfect judgment; because while the wall is wet the colours show up in one fashion, and afterwards when dry they are no longer the same...It being supremely difficult to bring fresco work to perfection...Many of our artists excel*

in the other kinds of work, that is, in oil or in tempera, but in this do not succeed, fresco being truly the most manly, most certain, most resolute and durable of all the other methods, and as time goes on it continually acquires infinitely more beauty and harmony than do the others. (Vasari 1960)

1.2 Qualities and characteristics of the medium

1.2.1 The dichotomy of rigorous craft and artistic expression

A fundamental distinction between fresco and other painting techniques is founded in its traditional craft origins; the greatest artistic endeavor is soon lost if plaster and pigment are not applied according to rule. In addition, as one practitioner points out, "*The question of a suitable wall for the fresco-mural, or how to make any available area a permanent foundation for the plaster coats making up the fresco ground, has vexed the fresco painter from ancient times to our days.*" (Nordmark 1947) A further challenge is presented by the fresco pigments, the raw predecessors of modern calibrated paints, because each behaves differently depending on its mineralogy. Thus, each requires different handling and preparation. Also, as Vasari pointed out, the wet pigments change markedly upon drying, both in the short term and over a longer period. This is particularly challenging, because it means that a painter working on the wet *intonaco* does not see the exact tones of the colors until the plaster dries.

Yet, it is the time constraint—dictated by carbonation of the lime—that is the most obvious limitation of the medium. This limitation is fresco's most distinguishing characteristic, informing and shaping every part of the process. From a modern point of view, this is also its most incredible and inconvenient aspect. For the painter, it is indeed a race against time. The adhesive power of the rendering diminishes as it dries, and so the risk of the pigments not adhering increases proportionately as time passes. As we will see, the setting reaction of a fresco is a subtly unfolding process, and it is not necessarily evident to the painter when the lime has become too dry to continue. Hence, the process must be guided by strict adherence to the rules of craft.

Despite the challenges of the medium, fresco's enormous legacy proves that the process can, nonetheless, be mastered. In the West, fresco is synonymous with the Italian Renaissance, when a new freedom of artistic expression—the hallmark of the era—brought about a profound transformation of mural painting. One is most impressed by the skill and clear conception required of the traditional fresco workshop. They are proficient at enhancing the architecture in both public and private spheres. The great fresco cycles of the period create passageways into pictorial space, extending the architecture beyond the physical plane and serving to expand the consciousness of the viewer.

Through an understanding of the fresco process and an exploration of materials, the technical requirements of working in fresco will not be felt as hindrances to achievement of the artistic goal. Rather, this dichotomy between rigorous craft and artistic expression offers the artist a depth of process to explore a unique expressive potential and physicality in the fresco medium that speaks to the origins of painting itself.

1.2.2 Contemporary possibilities

The ultimate expression of the fresco medium has traditionally been the monumental, large-scale wall painting connected to and comprising the architecture, where fresco's inherent qualities are especially adapted. But fresco is not restricted to that context. A distinction can be made between fresco painting's historical application—mural painting within architecture—and the fresco medium itself. Accepting this distinction, we can consider fresco as a medium with a special character that may be explored and interpreted in the modern sense, like any other medium.

1.3 Goals and approaches of the paper

To promote a contemporary exploration of the subject, this paper provides a brief overview of the fresco process and materials. By including this information, it is the author's intent that technical problems and challenges will not discourage artisans from discovering new possibilities for this versatile medium.

Fresco begins with lime: Exact observations and comparisons of different lime products in a fresco application will be given, along with specific requirements for "good" fresco carbonation. Furthermore, an overview of materials and moveable panel construction for fresco supports will serve to extend the range of application beyond the traditional masonry wall.

2 Carbonation

2.1 Setting reaction of a fresco

When the *intonaco* begins to dry, the calcium hydroxide ($Ca(OH)_2$) solution in the rendering is drawn by evaporation of the water. It migrates towards the surface, passes through the paint layer, and coats the pigments. It comes into contact with and reacts with the carbon dioxide (CO_2) present in the air, forming calcium carbonate ($CaCO_3$):

$$Ca(OH)_2 + CO_2 = CaCO_3 + H_2O$$

During the course of this reaction with carbon dioxide, the supersaturated solution of calcium carbonate is precipitated in the form of minute elongated crystals that weave together. They form a sort of felted structure with the pigment particles, binding them as if they become an integral part of a slab of limestone (Mora *et al.,*1984, p 52). The water that remains on the surface evaporates, while some of the water in the rendering penetrates the wall or support, according to its degree of porosity. Carbonation takes place from the surface of the rendering inwards. After a certain time, a surface crust forms that slows down the reaction within (Mora *et al.,*1984).

Eighteenth century fresco practitioners, ignorant of the chemical process and without the benefit of scientific examination of paint in cross-sections, wrongly explained the setting of fresco paintings by imagining a penetration of the pigments *into* the plaster. But, in fact, the reverse occurs: the calcium hydroxide underneath migrates towards the surface, advancing through the paint layer coating and finally fixing the pigments in a superficial crystalline skin. Thus, the cross-section of a fresco under magnification normally presents as clear a division between the pigment layer and the rendering as is found in tempera paintings (Mora *et al*.,1984, p 12).

2.1.1 Historical interpretation

The misinterpretation of the carbonation process by eighteenth century scientists begs the question, how did the ancient fresco painter imagine or explain this reaction? The only surviving text on ancient architectural practices was written by the Roman architect Vitruvius, in the first century B.C. Vitruvius dedicated several chapters to the technique of Roman wall painting in Book VII of *De Architectura,* where he gives this explanation:

> *These colours, when carefully laid on stucco still wet, do not fade but are permanent. This is because the lime, having its moisture burned out in the kiln, becomes porous and loses its strength, and its dryness makes it take up anything that may come in contact with it. On mixing with the seeds or elements that come from other substances, it forms a solid mass with them and, no matter what the constituents parts may then be, it must, obviously, on becoming dry, possess the qualities which are peculiar to its own nature.* (Vitruvius 1960)

Here Vitruvius clearly states his understanding that the colors are fixed by the properties of the lime, and that the rendering must be wet in order for the colors to become permanent.

2.2 Good fresco carbonation

Fixation of the fresco pigments by carbonation is a sensitive process that is dependent on temperature, moisture, the thickness and pore structure of the fresco ground, pigment applications, and the lime itself. When lime plaster is allowed to dry too rapidly, the carbonation process is disturbed. In the case of fresco, the result is a stunted painting period and a surface that lacks cohesion. To produce a slow hardening of the fresco, the wall or substrate must be sufficiently wetted and able to retain moisture so that it does not draw excessive moisture away from the rendering. This will encourage formation of the skin of carbonized lime that is, in effect, the protective sealer of the colors. A deep fresco ground composed of stable plaster layers, progressing from lean and rough to fat and fine, will hold moisture for an extended period of time. This promotes slow hardening of the *intonaco*, and improves the permanence of the fresco painting.

According to the craft, the painting session is limited to between six and eight hours in length—the estimated time frame of the initial setting reaction. Painting done during the middle part of the session allows for the best carbonation with the pigments. During this time, the colors set with a rock-like cohesion. (This is the so-called “golden-hour” of the Italians.) Initially, the *intonaco* may be too wet and soft; pigments applied during this premature phase mix with the lime because the action of the brush displaces the plaster. As a result, the colors become clouded and dull. Pigments applied too late in the day, after the carbonate crust has already partially formed, do not become an integral part of the lime system. Thus, they adhere badly, remaining powdery, water-soluble, and nonresistant to abrasion.

2.2.1 The carbonate binder

On the surface of a fresco, the calcium carbonate binder is transparent and cannot be distinguished from the pigment colors. We may observe the formation of this crystalline binder on the surface of lime water (calcium hydroxide) exposed to air, where it rapidly appears as a semi-opaque crust. With continued exposure to carbon dioxide, larger and larger crystals will continue to form until the water has evaporated and only a white powdery crust of carbonate remains.

3 Fresco materials

3.1 Pigments

A pigment is a colored substance that is ground and mixed to a workable consistency for use with a binder for painting. Pigments are classified into various categories: mineral pigments, natural or artificial; organic pigments, natural and synthetic; and mixed pigments. The most important and stable fresco colors are mineral pigments. They are based on metal compounds and can contain iron oxide, manganese, cobalt, zinc, and other metals. An example of a natural mineral pigment is ochre, natural yellow earth consisting mainly of iron oxide. An example of an artificial mineral pigment is Egyptian blue, a copper silicate manufactured by boiling quartz with copper and calcium (Kremer, 2003). Historically, many of the earth colors were mined and collected from local deposits, but rarer pigments—like natural ultramarine made from lapis lazuli—were imported.

Dry pigments come in graded batches of different particle sizes. Natural earth pigments have a larger particle size (20-50 microns), compared to modern manufactured organic pigments (0.1-5 microns) (Kremer 2003, p 16). Although commercial fresco pigments are generally ground with a glass muller and distilled water before use, the goal of the process is not necessarily to reduce the particle size (although some reduction is inherent), but rather to evenly distribute and suspend the pigment particles in water to form a cohesive, creamy liquid consistency. Furthermore, grinding certain pigments alters them and enhances the color.

3.1.2 *Secco* painting

Fresco pigments must be "lime-proof" or resistant to the caustic alkalinity of lime. Historically, the blues and greens proved to be the most fugitive colors. For this reason, non-resistant pigments—copper colors like azurite and verdigris, and other incompatible pigments like vermillion (mercuric sulphide) and lead white - were "tempered" with an organic binding medium, such as egg, and applied "*a secco"* or on the dry rendering after the fresco had already set. Painting done *a secco* was less resistant to the ravages of time than painting done *affresco.* Nevertheless, it was often common practice to "touch up" the fresco afterward with tempera out of necessity to some degree, but also for artistic reasons. This practice is outlined by Cennini in his fifteenth century treatise, *Il Libro dell'Arte.* However, he also insists that "*to paint on the fresh, that is a fixed portion on each day, is the best and most permanent way of laying on the colour, and the pleasantest method of painting.*" (Cennini 1968) Vasari warns to, "*not retouch in the dry, because, besides being a very poor thing in itself, it renders the life of the pictures short*" (Vasari 1960).

3.2 Fillers

Filling materials function as the rigid skeletons for lime-based grounds. Various grades of different filling materials impart specific qualities to the plaster layers. Marble dust, for example, produces an exceptionally fine, white, smooth *intonaco*. Historically, the most common filling materials for fresco grounds were sand, crushed stone and marble, pozzolana, and crushed brick. Of these, sand is probably used most often in fresco preparations. Sand must be sifted and batch-graded for use in course and fine applications. Only siliceous sand from a quarry or riverbank is used and not sea sand. Only clean, dry sand that is free of contaminates, with good particle size distribution so that empty spaces left between the largest particles are filled by the smaller ones, should be used. This promotes minimum contraction on drying. The grains should not be rounded, but rather have rough surfaces so that they lock together under the trowel, increasing the friction between them and strengthening the plaster as it sets.

Depending on available resources, fresco painters may find it necessary to "build" their own sand by sifting together local and commercial varieties. The importance of the choice of filler, its preparation, and its thorough incorporation with the lime must be emphasized. This process determines the performance of the plaster and the specific surface quality of the *intonaco*.

4 Fresco lime

4.1 Traditional aged lime putty

Good workability is essential in fresco. The piecemeal plastering of the *intonaco* is a detailed and precise operation fit for a master plasterer. The properties of a good lime for fresco have been well established. Cennini wrote that the plaster intended for frescoes was made with lime which was, "*so well slaked that it has the appearance of an ointment*" (Meiss 1968, p 19) In Roman times, lime had to be aged for a minimum of three years. As lime putty ages, un-slaked particles of calcium oxide become hydrated and a finer crystalline structure forms, producing a more plastic and unctuous paste that readily mixes with filling materials.

After traditional slaking and aging, lime putty generally still contains bits of stone that will not break down over time. To further refine the texture, these particles are removed by wet sieving the putty through progressively finer screens. Well-aged putties produced in this manner have exceptionally fine textures and enhanced “off-the-trowel” properties that yield excellent working conditions for fresco painting.

4.2 High-calcium vs. dolomitic

A commonly-held belief is that only high-calcium lime that has benefited from aging can be used in fresco. Conventionally-slaked and aged high-calcium lime putty is most often associated with traditional quality. Therefore, aged high-calcium “pit lime” is marketed specifically for use in fresco painting and commands a very high market price. Its dense creamy quality off-the-trowel and its purity are why it is recommended.

The purity of lime depends on the type of sedimentary carbonaceous rock used to charge the kiln because rocks vary in their state of crystallization and in their impurities. Therefore, lime and lime putty contain variable amounts of calcium hydroxide and magnesium hydroxide, based on the composition of the limestone used to make them. The calcium hydroxide and magnesium contents determine how the lime is rated based on ASTM standards. High-calcium lime contains less than 5% magnesium. Dolomitic lime contains 35% to 46% magnesium.

The suitability of dolomitic lime (Ca(OH)2 Mg(OH)2) for use in fresco is often questioned because of the magnesium content. However, the initial setting reactions of high-calcium lime and dolomitic lime are identical. If we look at the materials used historically in fresco painting, we find that ancient builders employed local lime and aggregate to finish the architecture. Therefore, the geological formations of the surrounding region are reflected in the use of locally-available materials for the construction of wall paintings. In many regions where dolomites are the predominant carbonaceous rocks, mainly dolomitic lime was used for construction. One such area is Trier, Germany, where dolomitic lime was used ever since Roman times (Blauer-Bohm, Jagers 1997, p 224).

4.3 Hydrated lime

Advances in lime technology have made bagged hydrated lime, both Type S dolomitic and Type N (high calcium), widely available for a fraction of the cost of traditional aged lime putty. Hydrated lime is produced when quicklime (calcium oxide) is chemically combined with a precise amount of water. This slaking process takes place in a hydrator and the result is a dry, free flowing powder. Water is mixed with hydrated lime to make lime putty and to prevent the dry lime from carbonating in bagged storage. This “slurry” may be used immediately, or left to age for an indefinite period of time.

The texture of hydrated lime is refined in its dry state by using an air separation process to physically remove the heavier/larger particles. By another method, the hydrate is ground in a high-speed mill to reduce the particle size before it is mixed with water to form putty. Hydrated lime refined in this manner is used to make high quality commercial fresco lime with a smooth creamy texture and good workability that is comparable to traditionally-slaked lime putties

4.4 Lime comparisons and observations

To determine if the preference for traditionally-slaked, high-calcium, aged lime putty is based solely on workability and a perceived sense of tradition, or if there are other factors that influence the overall success and permanence of fresco work, an evaluation was made of several types of lime. The purpose of the evaluation was to determine whether a type of lime, or lime product, yields superior results in a fresco application. In the evaluation, tests were conducted in which an *intonaco* was prepared with four different limes, consisting of:

(1) Type S dolomitic hydrated lime (mixed straight from the bag)
(2) dolomitic aged lime putty—three years old (commercial fresco lime, from hydrate)
(3) freshly-slaked high-calcium lime putty—two months old (slaked by the author from high-calcium quicklime in wheelbarrow-sized batches)
(4) high-calcium aged lime putty—5 years old (commercial fresco lime, traditionally-slaked pit lime)

The test limes were mixed in a 1:1 ratio of lime and quartz sand, which produced a workable consistency across the board. The *intonaci* were laid on identical grounds and supports. Painting was carried out over an eight-hour period; the same pigment applications and brush techniques were systematically used for each *intonaco.* Only lime-compatible pigments were used. At the eight-hour mark, painting stopped and the frescoes were left to dry for seventy-two hours. After the drying period, each fresco was subjected to a "wipe test", in which the *intonaco* was wiped with a water-wet natural sponge, using multiple passes, in order to compare how the different limes carbonated with the pigments during the given test period. Non-adherence was characterized by powdery, friable, water-soluble colors. This was more typical of the pigments applied after the six-hour mark, or in the last two hours of the painting period. The results showed pigment losses occurring at varying degrees: (1) and (3) showed more pigment losses than (2) and (4).

This process was repeated multiple times. The tests confirmed that the commercial aged putties (2) and (4) showed the best carbonation with the pigments, and (3) showed the least, with (1) somewhere in-between. Because the rendering loses its adhesive power as it dries, the degree to which the colors are fixed is indicative of the lime's carbonation rate. The difference in the drying rate of the lime plasters became evident after the six-hour mark, when only the *intonaci* made from the aged putties remained "wet" enough to fix the pigments to varying degrees.

The variation in the carbonation rate of the test limes may be due to differences in the mass of lime solids per unit volume. More specifically, putty made from freshly-slaked quicklime contains a greater amount of water (70% water based upon mass) compared to hydrated lime (50%). However, as slaked lime ages, the mass of solids per unit volume increases and the crystal habit and size change. Therefore, a well-aged putty has a very large amount of lime per unit volume, compared to a young putty made from freshly-slaked quicklime. The amount of lime per unit volume has an effect on the carbonation rate (Hansen *et al*., 2004).

To summarize the test results: the *intonaci* prepared from the commercial aged lime putties, both the traditionally-slaked high-calcium (4) and the dolomitic type from hydrate (2), performed similarly in the tests. They showed better carbonation with the pigments during the eight-hour test periods and produced the frescoes with the most stable, brilliant colors after the drying period and wipe test. The *intonaco* prepared from type S dolomitic hydrated lime (1) fixed the pigments for a shorter period of time (about six hours) and showed more pigment loss after the wipe test. The *intonaco* made from freshly-slaked high-calcium lime putty (3) fixed the pigments to a lesser degree, and showed the most pigment loss after the wipe test.

Finally, the relatively short drying period of the test frescoes (seventy-two hours) before they were subjected to the wipe test does not take into account changes in fresco paintings that may occur due to long-term carbonation, e.g. a more cohesive surface, deepening of the colours, etc. These effects do seem to occur, based on the author's observation of changes in fresco paintings over a five-year period, and are a subject for further study.

In conclusion, artists have always selected their materials based on available technology, economy, performance, and convenience—and lime is no exception. Hydrated lime (Type S or Type N), which is inexpensive and widely available in the U.S., can be used for fresco work, especially in building *arriccio* ground layers. Based on the author's experience, it is perfectly legitimate to execute a fresco using hydrated lime mixed straight from the bag, and the author would not hesitate to recommend it as a viable means for getting started. However, for the *intonaco*, a seasoned fresco painter generally prefers the fat, creamy texture and enhanced "off-the-trowel" properties of a top-of-the-line aged putty. Benefits of the aged putty are two-fold: workability and, according to the tests, a slower carbonation rate that will promote good fixation of the pigments and accommodate an extended painting period. Whether this fresco lime is made by traditional slaking, or is produced from hydrate, becomes a matter of preference in which economy and available technology are significant factors. Ultimately, the specific nature of the wall or substrate has a definite impact on the carbonation rate of the lime and the overall success of the fresco. The benefits of a deep ground and sound craftsmanship are clear.

5 Moveable panels

5.1 Materials and constructions

In order to expand the current use of fresco painting, the medium must be explored in a variety of different contexts. Moveable panels offer artists a suitable surface on which to gain an understanding of the medium. The panel may serve as a small study surface for large-scale mural work, or it may be viewed as fresco painting's equivalent to the blank canvas. In this case, the finished fresco functions in a context analogous to an easel painting, as a framed object separate from the wall and removed from the architecture. Creating a stable support system for fresco painting is a special challenge. For this reason, an overview of materials and construction possibilities is given here.

5.1.1 Wooden frame and metal lath

A rigid fresco support is made by fastening metal lath to a sturdy wooden frame with a solid board backing. The frame is made deep enough to build up the ground layers. The plywood backing is waterproofed with tarpaper, and the first coat of render is applied to the metal lath using one part of portland cement. This type of rigid panel has certain disadvantages: it is heavy and cumbersome. But if the fresco will rarely be moved, it provides a sturdy support system.

5.1.2 Foam and "stucco"

A considerably lighter panel is modeled after modern stucco panels. A piece of polystyrene (EPS) is cut and coated with acrylic stucco base adhesive and plastic mesh to form a rigid lightweight panel. The fresco ground layers are then applied to this surface. Adhesion of the first coat of render is improved with PVA plaster bonder. This type of support has the advantage of being lightweight and there is an ease to the construction. However the edges are vulnerable, requiring a secondary frame and hanging device. Also, in the author's opinion, polystyrene is not an ideal material for fresco applications.

5.1.3 AAC

A new material for the fresco panel is AAC, autoclaved aerated concrete, which is a lime based technology. AAC offers the fresco painter a plaster-ready, porous and toothy surface, which is a huge advantage. It is relatively lightweight, and its pore structure allows it to retain water for an extended period of time, thereby producing a slow carbonation. Furthermore, AAC's "breathable" quality produces a good wicking action, similar in effect to working on a traditional masonry wall.

5.1.4 Tile, brick, and natural materials

Small frescoes can be executed on terracotta and stone tiles, unglazed bricks, and the unglazed side of ceramic tiles. Organic supports can be fashioned with traditional woven wattle, or reed panels and bamboo. Also, the eco-building supply industry offers some new environmentally-friendly substrate possibilities, e.g. strawboard, clayboard, etc.

5.1.5 *Strappo*

Strappo is a specialized conservator's technique used to detach a fresco from the original wall support in order to transfer it to a new "ideal" support. The restorer uses detachment only as a last resort due to the risk of irreversible alteration to the mural painting, and also because the "wholeness" of the architecture is compromised by its removal. The technique is mentioned here as a viable option for the transfer of new frescoes to moveable supports. In this case, the painter is able to execute a fresco on a permanent surface, such as a brick wall, and then detach the finished painting by *strappo,* which "strips" off the pigment layer, or *stacco*, and removes the *intonaco* with the pigment layer. The painting is then transferred by reverse onto a moveable panel.

6 Conclusions

Only through an understanding of the craft can we fully grasp fresco painting's enormous legacy. Moreover, we can credit the tenacious quality of calcium carbonate for passing on a diverse visual history of cultures and civilizations. While work in fresco is notoriously demanding, it is exactly because of the rigors of the craft that the fresco process remains so conceptually rich and compelling to a contemporary audience. Furthermore, with the availability of different lime products and a knowledge and understanding of the craft, fresco painting is not relegated to an obscure and unknowable tradition, but is alive with new possibilities.

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