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# Surface Properties of Frescoes on lime

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**Abstract**

*The fresco painting technique has been widely used throughout history in the occidental world, in particular in the Roman period, and is known to be the most durable form of mural painting. The traditional technique consists in applying water-dispersed pigments on a fresh lime plaster, which later hardens through carbonation reaction. The historical and practical aspects of the lime technique are well documented, but the fundamental mechanisms responsible for the properties of a fresco surface have rarely been investigated and are still poorly understood. Based on analyses of ancient frescoes and on laboratory reconstructions, this study brings new insights on the formation of a fresco surface.*

***Keywords: Fresco,Lime plaster, Surface***

## 1.Introduction

Fresco painting is aornate technique consisting in employing water-distributed mineral colorants on a wet sticking plaster - usually lime - that strengthens through carbonation. It is believed as the bestlasting but also the extremely difficult structure of mural portrait. This procedure has been generallyemployedduring the course ofrecord, from just about 2000 B.C. just before the present-day day[1]. For command, the works of Henri Marret or Marcel Magne[2, 3]present on their paintings the same general exterior aspect and the same durability as old-fashioned lime frescoes.

Many archaic and modern wells provide a comprehensive description of the lime method and its variants.[4]Various layers of lime plaster including mineral plasters (mainly sand and limestone) of diminishing granulometry are continuously applied on the side to be painted. The last coating, called *intonaco*, is a team of millimeters heavy. In the standardprocedure the colors, mainly of stone origin, are dissolved in pure mineral water and utilized on the fresh *intonaco* with a brush. In a few of the most familiar variants, the dyes are separated in a lime solution instead than in pure tap water.[5, 6]Dependent on the period, the crisp*intonaco* is every so often mechanically gleaming with a tool already or after the colour are applied. This is commonplace in instance in the Roman period.[5]Severalarchaic frescoes have been methodically studied mainly for maintenance and renovation purposes[7],however the structural mechanisms taking place on the fresco plane are not fully realised. Two question mark are of specific interest: first, how can the superficial properties of the painting (roughness, porosity and microstructure) be associated to the artist's practice and the materials used? Furthermore, what is the character of the connections between the colors and the plaster?

Verycreatorsdecide on the fact that the color or dye adhesion to the sticking plaster lies on technical and mechanical effects. It is nevertheless unclear how the colours end up confined inside the sticking plaster. For some poets and authors, the carbonation responsesandwiched between lime and carbon dioxide spreading into the plaster stimulates the growth of calcite minerals above the pigments layer[4, 8]. For others, the colors diffuse from the exterior into the plaster throughout the setting.[9, 10]Likewise, carbonation alone cannot clarify the practicability of the lime fresco system procedure since cement surfaces do not set all through carbonation but all through hydration.Centred on studies of ancient murals on limeon research laboratoryreenactments, this study creates new visions on the formation of a fresco surface from the accumulation of the *intonaco* to the accomplishment of the setting.

## II.2.0 Methods

### 2.1 The method of antique frescoes

The methods of various old-fashioned frescoes were examined and learned and the below are the different ancient methodologies frescoes on the lime.

(i) The lime based**Fourqueux fresco** (figure 1a), decoratedthroughMarret in 1922, and it comprises of a sequence of 14 existing solid or concrete boards representing the Stations of the Cross. It is located in the Fourqueux church, 20 km away from Paris. This fresco remained painted in Marret'sworkspace on a lime *intonaco* applied directly on the material solid panels.

(i) The lime based**Lero frescoes** (figure 1b) are the one which are millimetric pieces or fragments of Roman lime frescoes gather together in the ruins of the Lero acropolis sitting on the Ste Marguerite Island in the bay of Cannes (France). They go out back to the Istperiod or era or centuary A.D.

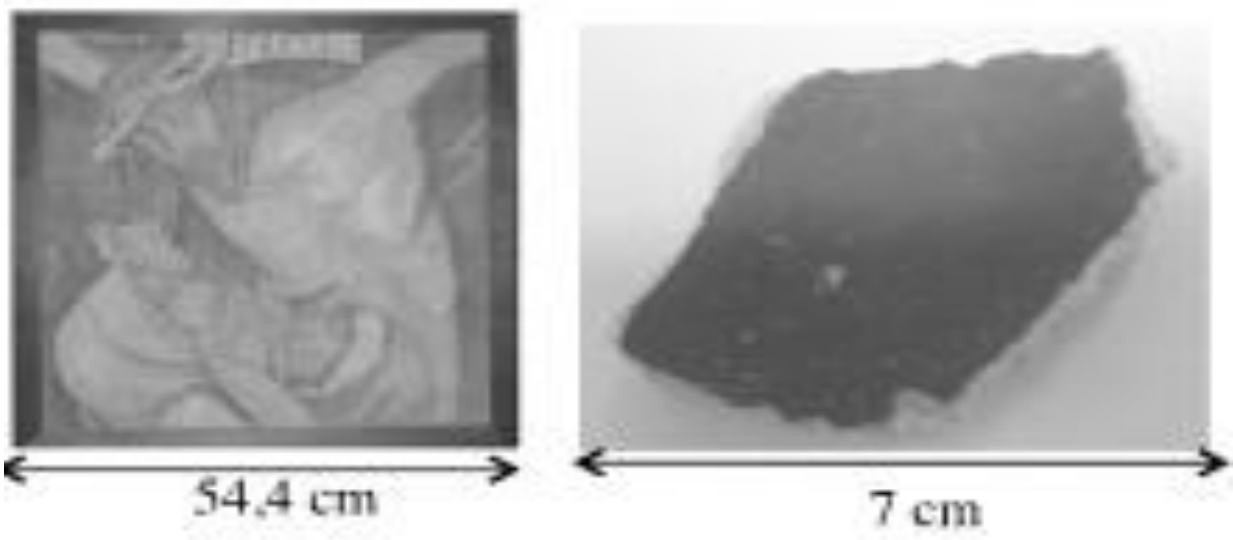


**Figure 1** The studied frescos: (i) One of the 14 panels of the Fourqueux fresco (ii) A Roman fresco fragment from the Lero acropolis.

### 2.2 The reconstructions of the frescoes

The Fresco restorationsremained and having beenimplemented and performed on 30x30 $cm^2$ mortar panels. The categories and sorts of *intonaco*wereexamined and checked:

- A lime plaster comprising of 2 volumes of sand, 2 volumes of Ca $(OH)_2$ and 1 volume of tap water. The intonaco was applied on the material panels with a made of wood spatula. The colour was a red-faced ochre containing hematite. It was scatteredand also sprinkled either in the natural and deep pure distilled water, or in limemineral water (1 mL of $Ca(OH)_2$ in 6 cL of water), or in a gypsum mixture (0,5 mL of plaster over of Paris in 6cL of water) and applied on the *intonaco* with a brush. The *intonaco* was but then either left unscathed or directly polished with a flexible spatula. The polishing comprised in several phases of mechanical crushing of the sticking plaster, with a total interval of around 20 moments.

## 3.0 Results

### 3.1 Characterization of ancient frescoes

The colors, which are created by grinding dry-face powderdyes or colors in the pure water, dry and setting with the plaster to turn into a permanent part of the wall up. Fresco painting is perfect for producing and creating paintings because it contributes itself to a massive style, is robust and tough, and has a flatexterior surface.

#### 3.1.1 General surface properties

The St Hippolyte fresco produces a very much extremely textured and toughfaçade surface, with many milli metrical fillers cropping out of the exterior and traces of the spatula employed to apply the plaster. The Fourqueuxlard painting is in typicalsofter and easier than the St Hippolyte fresco, simultaneously al together with a lowest intensity and mass of fillers at the surface and maybe a shallow flattening of the plaster in a littlespace. The Lero frescoes show a heavy and dark and shiny aspect, standard of the Roman practice. Regarding thecomposition of the*intonaco*, the solid plaster over of St Hippolyte presents all the characteristics of a Portland solid plaster with ashes and quartz glass as fillers blended with and also combined with coal as contaminations.

#### 3.1.2 Surface microstructure

OM and SEM observations of elegant and refined sections from the Classical and ancient frescoes display that there is no clear frontier and boarder line between the pictorial coating and the lime plaster (figure 2). The pigments are dispersed in the bulk of the plaster, from the top surface to a depth of about 120 micrometers. The microstructure of the first tens of micrometers of the surface of the plaster differs from the microstructure of the bulk, with a higher density and less fillers (figure 3a). Observed from the superficial or the surface, it consists of extremely smooth areas overlapping a more porous and harsh structure (figure 3b). This microstructure looks and seems like to indicate that the artist honed and gleaming the fresh plaster.[5]

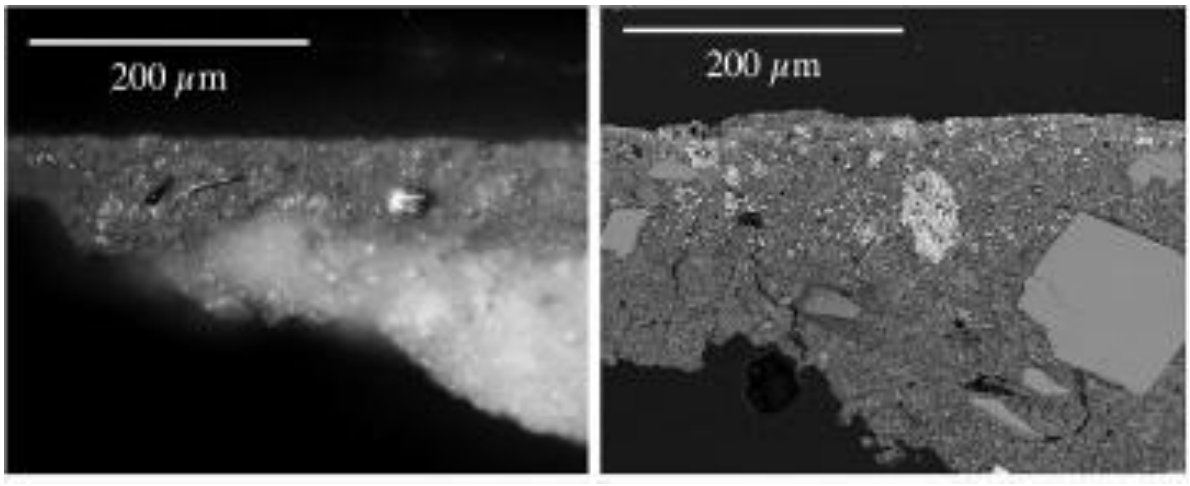


**Figure 2** OM (left) and SEM (right) observation of a polished section from the Lero frescoes.

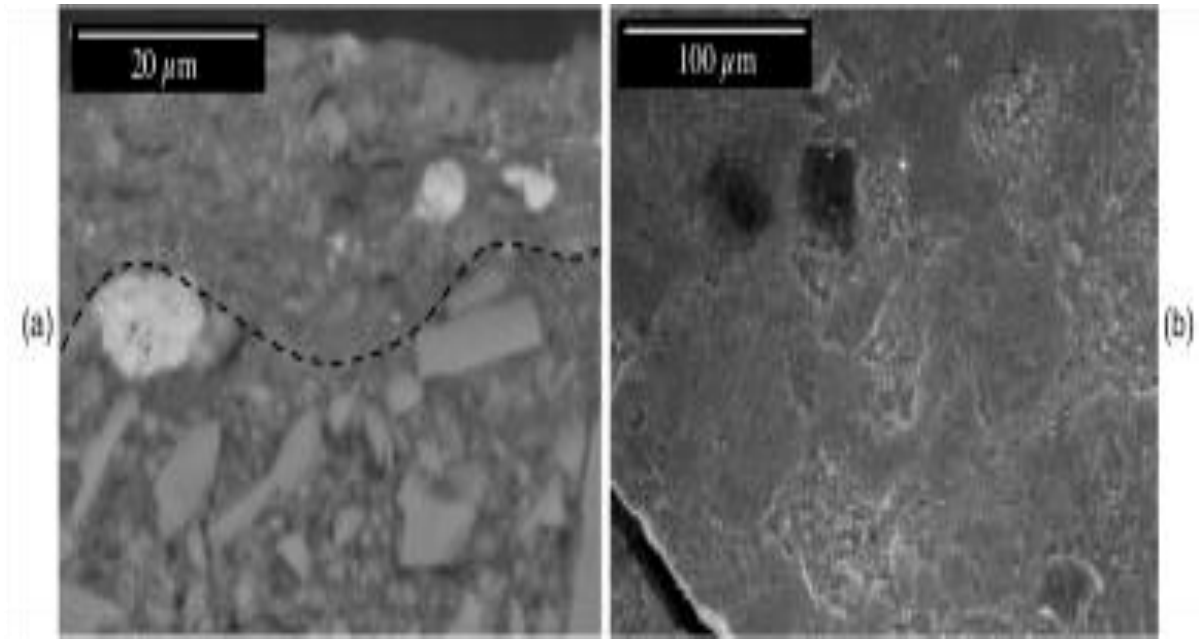


**Figure 3** SEM observation of Lero samples. (a) polished section. (b) surface.

### 3.2. The reconstruction of traditional technique

The renovated and reconstructed frescoes have beenmanufacturedby the following the customarypractice (i.e. lime *intonaco*, colorants and dyes dispersed in pure marine and no mechanical action on the *intonaco* other than the applying step), and they show the same microstructure and narrow and superficialhouses as the Fourqueux fresco.Several and anonly several and certain of the polished sections of these frescoes show the presence of quartz grains in the pictorial layer by proving that the pigments invaded and the *intonaco* and not vice versa. The hypothesis of the calcite growing above the dyes and colorants is thus invalidated and nullified.

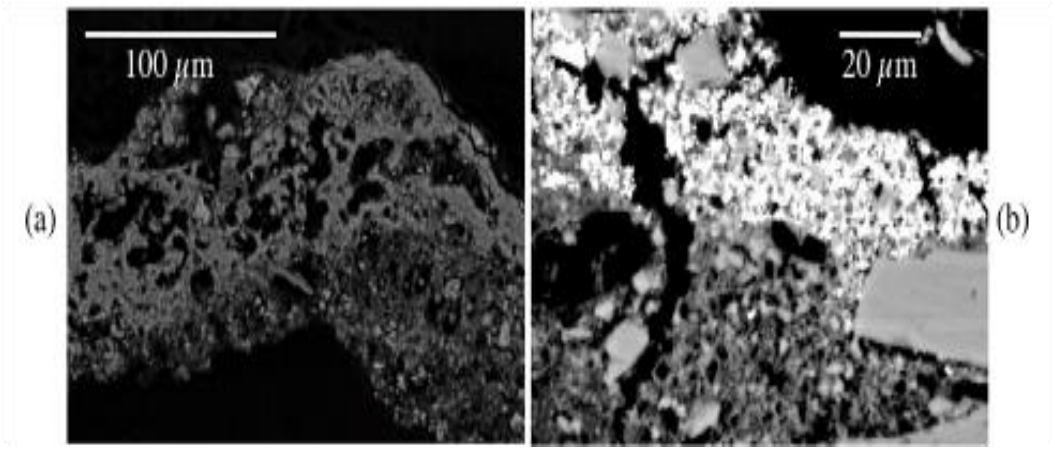


**Figure 4** Comparison of a polished section from the Fourqueux fresco (a) and a polished section from the reconstitution (b).

## 4.0 Discussion

Centered and based on the various and different results, it is feasible to elaborate variousscenario of the fresco exterior formation dependent on the procedure used by the painter.

### 4.1 The traditional technique on lime

The traditional technique on lime, with pure water as a binder for the pigments and no mechanical flattening, can be described as follows:

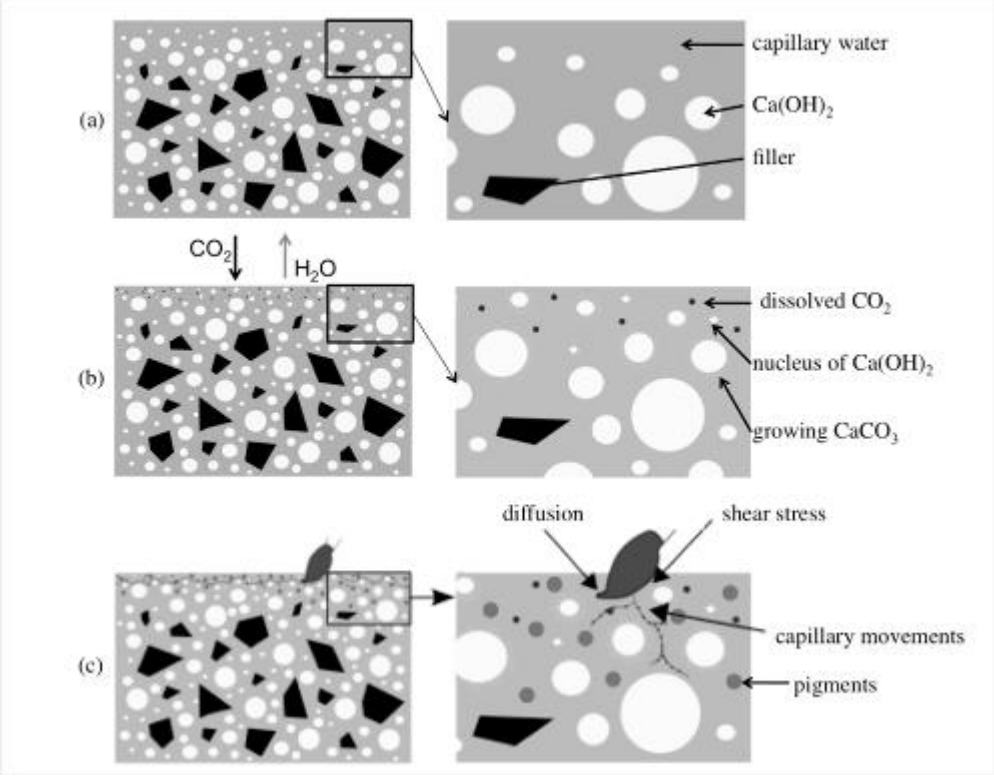


**Figure 5**Schematic representations of: (a) step 1 (b) step 2 (c) step 3.

Step 1 (figure 5a): The *intonaco* is applied on the surface. The fillers and the $Ca(OH)_2$ particles are dispersed in the plaster, with a grain size decreasing with the distance from the surface. An ionic water film floats at the top surface.

Step 2 (figure 5b): The plaster starts hardening through two simultaneous mechanisms.[11, 12] First, the atmospheric carbon dioxide begins dissolving into the capillary water of the *intonaco*, which induces a carbonation reaction with $Ca(OH)_2$. At the same time, the capillary water evaporates, inducing the nucleation of new $Ca(OH)_2$ particles.

Step 3 (figure 5c): When the plaster is hard enough, but still in the setting process, the artist applies the pigments with a brush. As they are dispersed in water, the pigments immediately diffuse from the brush into the water film at the surface, and are also mechanically separated from the brush by the shear rate on the plaster $Ca(OH)_2$ and $CaCO_3$ particles. The pressure of the brush on the surface induces capillary movements inside the plaster, which allows the pigments to penetrate deeper in the capillary network.

Step 4: The drying and the carbonation of the plaster keep happening simultaneously. At some point, the first tens of micrometers of the *intonaco* have entirely turned into calcium carbonate and the pigments are durably trapped inside the crystalline network.

### 5.0 Conclusion

The exceptional and excellent durability of a fresco painting is due to a mechanical encapsulation of the pigments inside the porosity of the *intonaco*.This work constitutes a first attempt at understanding the fundamental mechanisms of the fresco painting technique. It opens several research possibilities, such as a detailed study of the setting mechanisms of the *intonaco* or of the crystallographic consequences of polishing.

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