

TECHNIQUE OF THE PAINTING PROCESS IN THE TEMPLE OF VIJAYALAYA CHOLISVARAM IN THE PUDUKKOTTAI STATE.¹

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Introduction.

WHILE experimental investigations have been carried out by Chaptal,² Davy,³ Berger,⁴ Raehlmann,⁵ Laurie,⁶ Noël Heaton⁷ and Eibner⁸ to reconstruct the methods of production of ancient mural paintings in the West, very little has been done in this direction for Indian paintings. With the exception of the paintings in the Brihadisvara temple at Tanjore,⁹ in the cave temple at Sittannavasal,¹⁰ and, to a limited extent, of Ajanta,¹¹ no other Indian painting has so far been investigated. Recently the author had an opportunity of studying the chemistry of the methods and materials used in the paintings* on the inner walls of the front hall of the ruined temple of Vijayalaya Cholisvaram, which is situated on a hillock in the village of Narttamalai (10° 31' N. and 78° 45' E.) in the Pudukkottai State in S. India. These paintings probably belong to the 14th-15th centuries A.D.†

Experimental Investigations.

In order to determine experimentally the painter's methods and materials, some fragments of painted stucco were collected from relatively unimportant places. They consisted of rough lime plaster, which had been

* There are figures of Bhairava, Nataraja and Sakti (?) on the northern wall of the front hall of the temple. On the southern wall, the paintings have almost disappeared leaving only three heads, and a hand with finger nails in white.

† Dr. C. Minakshi drew my attention to a stone inscription in the temple which speaks of the destruction of the temple by rains and its subsequent renovation (*vide* S. R. Balasubrahmanyam and K. Venkataranga Raju, "Narttamalai and its temples—The Vijayalaya Cholisvaram temple in Mela Malai," *Journal of Oriental Research, Madras*, 1934, 8, 208).

On palæographic evidence, this inscription belongs to the 12th century A.D. But there is no mention of the paintings in it, so that they should have been executed after the 12th century A.D. From a comparative study of the style of the paintings here with those of the Chola and the Nayak Paintings in the Brihadisvara temple at Tanjore (*vide* S. Paramasivan, "A Note on the dating of the frescoes in the Brihadisvara temple at Tanjore," *Journal of Oriental Research, Madras*, 1935, 9, 363), it seems probable that these paintings, or at least most of them, belong to the 14th-15th centuries A.D.

laid on the wall, with a smooth coat of lime-wash thereon to receive the paint. The thickness of the painted stucco varies from about 3 mm. to 4 mm. In some places, the minimum thickness is about 2·3 mm. and the maximum about 12·7 mm. depending upon the inequality of the surface on which it had been laid.

In the production of paintings, there are four principal factors to be considered: (1) the *carrier* which supports the *ground*, (2) the *ground* on which the paintings are executed, (3) the *pigments* used in elaborating the designs, and (4) the *binding medium* by which the pigments are attached to the *ground*. Of these four factors, the last one is specially important. It determines the technique employed in the painting process, that is, whether it is one of *fresco*, *tempera* or any other. It also exerts a certain influence on the optical effects of the pigments, and gives a certain indication of the technique of the painter's art.¹²

1. *The Carrier.*

The inner walls of the front hall of the temple act as the *carriers*. The inner and the outer walls of this hall are constructed of large blocks of horn-blende-gneiss, measuring roughly 2' 1" by 9", with hollow space between. The hollow space has been filled with concrete composed of mortar and small pieces of brick. The inner walls have rough surfaces, which act as "tooth" so that the rough plaster or the first application of rough plaster adheres firmly to them.¹³ In many places, the blocks of stone of which the walls are constructed have been displaced with the result that the *ground* and the paintings have fallen down.‡ The paintings are covered with white efflorescence caused by the presence of gypsum, sodium sulphate, magnesium sulphate, etc. These must be removed by washing with water before the paintings are made clear. The efflorescence can be traced to the *carrier*.§

‡ As a result of unequal expansion, the concrete mixture has displaced the blocks of stone of which the walls are constructed, thus disturbing the *ground* and weakening its hold on the wall. The damage which the *ground* and the paintings have suffered is not a little due to this.

§ While a hard, non-porous wall will eliminate all chance of salt efflorescence, the paintings here are not free from them. The reasons are not far to seek. While water on the surface of a fresco does no damage to it, a wet wall behind it ruins the paintings entirely. The moisture penetrates into the plaster ground and carries with it any salt that might be present in solution to the surface. There they crystallise forming white or coloured efflorescence upon the paintings. Moisture breeds moulds too, and is, on every account, disastrous to lime paintings on walls. The moisture should have crept from the ground between the inner and the outer walls and the concrete mixture, through the weak binding between the blocks of stone, carrying with it the salts in solution.

2. *The Ground.*

A series of experiments were conducted to study the nature of the *ground* that has been prepared to receive the paintings.

Nature of the Particles in the Plaster.—(i) The rough plaster was subjected to mechanical separation by carefully breaking it down under water and washing out the finer particles through a 70-mesh brass wire-cloth sieve and pestled with a rubber pestle until a clean residue was left on the sieve. The mesh retained particles whose diameters were greater than 0.2 mm. There was almost no particle of this size present in the plaster. The particles were next subjected to mechanical separation by the application of a principle enunciated in Stoke's Law, namely, that the limiting velocity of a particle falling in a fluid is proportional to the square of its diameter. The separation of the particles composing the stucco was effected by Robinson's method¹⁴ and thus particles whose diameters were greater than 0.02 mm., but less than 0.2 mm. were separated from still finer particles. The former consisting mostly of sand was present to the extent of 60%, while the remaining 40% consisted of fine sand, lime and a little of clay.

(ii) A small fragment of the rough plaster was treated with dilute hydrochloric acid. The lime dissolved in the acid, leaving the particles of sand unaffected. The latter were almost of uniform size to the naked eye. Under the microscope, they looked sharp and angular, ¶ without being rounded, and varied in size from 0.0014 mm. to 0.0042 mm. A few of them varied in size from 0.0070 mm. to 0.0643 mm.

Study of the Microsection.—With the help of a fine saw, the fragment of the painted plaster was cut across vertically through the different layers composing it. The freshly exposed edge was ground to a flat surface by rubbing it on a plate of ground glass. It was then carefully treated with dilute hydrochloric acid to remove the fine dust. Thus a section showing all the different layers of the painted stucco was prepared.

An examination under the microscope revealed two lines of cleavage at depths of 0.6 mm. and 1 mm. respectively below the top of the painted layer. They suggest two separate junctions due the presence of three distinct layers in the stucco. The first junction is between the layer of paint and the lime-wash, and the second, between the lime-wash and the rough plaster. Their respective thicknesses may be set down thus :

¶ These sharp and angular grains interlock with each other, hold more firmly and thus contribute better to the firmness of the plaster than would be the case with rounded grains which would slide on one another.

		mm.
Painted Stucco	..	3.3
Rough Plaster	..	2.3
Lime-wash	..	0.4
Paint Film	..	0.6

From the difficulty in effecting a separation between the rough plaster and the lime-wash, it is clear that the binding is very strong. Probably, the lime-wash was given while the rough plaster was still wet. The layer of paint can be easily separated from the lime-wash, and this shows that the binding here is not so strong as between the rough plaster and the lime-wash.

Analysis of the Plaster.—To determine how the rough plaster was prepared, its composition was ascertained. For this purpose, a few samples of stucco completely freed of the paint and the lime-wash was analysed. The results of analysis of representative specimens are as follows :

	Rough Plaster (per cent.)
Moisture	1.39
Carbon dioxide (CO ₂)	20.95
Loss on ignition (excluding moisture and carbon dioxide)	4.29
Silica (SiO ₂)	37.83
Iron and Alumina (Fe ₂ O ₃ and Al ₂ O ₃)	1.79
Lime (CaO)	31.73
Sulphuric anhydride (SO ₃)	0.03
Magnesia	0.66
Undetermined (Mostly alkalis)	1.33
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TOTAL ..	100.00
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Thus the ground is composed of lime plaster with lime and sand as the principal components. The causes leading to their consolidation are very well known.¹⁵

From the results of analysis, it is clear that—

(i) A pure rich lime was used having no hydraulic properties. The proportion of clay, as is evident from the amount of iron and alumina, is very small. If it were hydraulic, a much larger percentage of clay would have been present.

(ii) Gypsum in plaster prevents its setting and gives rise to efflorescence. Thus it is an element of weakness in the *ground* so that the quality of lime for painting is determined by its gypsum content. But the proportion of it is very low as shown by the amount of sulphuric anhydride.

(iii) Pure rich lime without the admixture of sand or other 'inert' material is not satisfactory for plaster. It becomes friable on carbonation and lacks setting power. The function of the inert material is to provide the necessary space for expansion between the particles of lime. The percentage of silica is too large to be taken merely as an impurity, but should have been purposely added as sand to serve as an inert material.

The preparation of the lime for the *ground* is too well known to be discussed here.¹⁶

Inert Materials in the Plaster.—The results of chemical analysis do not reveal the presence of any other inert material except sand. If the artist had added marble dust|| or powdered shell or limestone—the original material from which the caustic lime was prepared—as an inert material, the problem would be different. Since these substances have the same chemical composition and give the same chemical reactions, they could not have been identified in the course of chemical analysis, and the following further experiments were necessary to decide their presence:—

(i) A microscopic slide was prepared from a fragment of plaster from the painted stucco reduced to fine powder, and this was examined under the microscope. Similar parallel experiments were made with fragments of modern plaster (without marble dust) to which a known proportion of marble dust was added. While the former yielded uniformly fine particles without any recognisable crystalline forms, the latter showed crystalline particles characteristic of marble.

Under polarised light, the fragments of crystalline marble showed themselves bright on a dark ground. Under the same conditions, the fragments of plaster from the temple remained entirely dark, no crystals other than those of silica being revealed. The results were identical in all the specimens of plaster collected.

It may be argued that the marble dust, originally present, might have interacted with the lime in the plaster, and become converted into non-crystalline carbonate. This theory is untenable because Davy¹⁷ has identified marble dust in the ancient stuccoes in the ruins of the baths of Titus,

|| In Italy, the ancient practice was to add marble dust as an inert material to the lime in the preparation of plaster.

Livia, etc., which are more than 1,000 years old. While marble dust has not changed in the classical stuccoes, there is no reason why it should have changed in the plaster of Vijayalaya Cholisvaram temple, which date from much later times.

(ii) If limestone or shell had been used as an inert material, it would have been very difficult to powder it to such a degree of uniform fineness that fragments of it could not be isolated and recognised by microscopic examination. The following experiments were conducted in this connection:—

(a) The surface of the plaster was etched with dilute hydrochloric acid on a microscopic slide and the process of disintegration observed under the microscope. Even under careful observation, larger particles were not seen.

(b) Taking a small fragment of the plaster, the lime was completely dissolved in dilute hydrochloric acid and the insoluble residue was examined under the microscope. In all cases, the residue consisted of small fragments of silica with iron oxide as impurity, and the latter was always in anhydrous condition as red ferric oxide indicating that the lime containing them had been burnt. In the absence of any fragments of hydrated yellow oxide, it is clear that no unburnt shell or limestone had been used.

(c) A fragment of the plaster was carefully reduced to powder so as to separate the grains without breaking them up. A study of the density of the powdered plaster by means of a diffusion column¹⁸ showed that the specific gravity of all the carbonated lime particles was almost the same and that there were no particles which corresponded to the density of limestone (2.72) or of shell (2.55). It is thus shown that no unburnt shell or limestone had been used in the plaster as an inert material.

Technique of Laying the Ground.—The rough plaster suffers a loss of weight on ignition to the extent of 4.29%, which shows that some organic matter is present in it either as a binding medium or as an impurity. Thus the next problem is to determine whether the technique employed in laying the *ground* in one of fresco or tempera. The following experiment was conducted to settle this point:—

A fragment of the plaster was treated with dilute hydrochloric acid. It completely disintegrated under the action of the acid with evolution of carbon dioxide, and the solution gave tests for calcium, thus showing that the technique employed in laying the ground was one of fresco. Had it been tempera, the plaster would have remained as a flake without disintegrating under the action of the acid.

Method of Laying the Ground.—The experimental results indicate that the artists applied the first coat of rough plaster to a thickness of about

2.3 mm. In a few places the thickness varied up to 12.7 mm. according to the inequalities of the surface of the wall. The plaster then received the lime-wash\$ to a thickness of about 0.4 mm. From the strong binding between the rough plaster and the lime-wash it is evident that the latter was applied while the former was still wet.

3. The Pigments.

Six colours were recognisable in the fragments of painted stuccoes that were collected, namely, white, black, yellow, red, green and bluish green. Their identification was as follows :—

White.—This dissolved in dilute hydrochloric acid with evolution of carbon dioxide and the solution gave tests for calcium. The colour thus consists of calcium carbonate originally employed as the hydrate of lime.

Black.—It lost the colour on ignition with evolution of carbon dioxide and suffered loss in weight. It also left a colourless residue, which was soluble in water and acids. It did not give any tests for calcium phosphate, nor did it give an extract either with ether or carbon disulphide. All these experiments clearly showed that it was not bone-black or lamp-black, but only wood charcoal.

Yellow.—Its appearance under the microscope was very heterogeneous with particles of various colours and of different optical properties, yellow and brown predominating along side of colourless and light coloured particles.^{19a} On ignition, the yellow was converted into a pigment similar to Venetian red. This pigment was also characterised by the presence of iron, which was detected as Prussian blue after evaporating it several times with strong hydrochloric acid and testing with potassium ferrocyanide. These are characteristic of ochres.

Red.—Its appearance under the microscope differed little from that of the ochres generally. There was only one kind of coloured particles, and not, as in the case of yellow ochres, particles of various tints. There were also colourless particles, which were doubly refractive. These are all characteristic of red ochre,^{19b} the iron in which was detected as Prussian blue as in the case of yellow ochres.

Green.—Under the microscope, it gave the impression of a product with a heterogeneous composition resembling a mixture containing an

\$ The untreated surface of the wall is not ideal for painting. It cannot always be made perfectly smooth and even, and different parts of the grain take the paint differently and thereby produce different optical effects. Thus the lime-wash serves a double purpose; first, to even out the wall surfaces to which they are applied, and secondly to provide a uniform ground underneath the painting.

ochre with some blue pigment. Though the blue resembled cobalt blue, it gave negative tests for cobalt. Further, the blue was doubly refractive, which is not the case with cobalt blue. On igniting it several times with strong sulphuric acid, the iron in it, which is quite characteristic, was confirmed as Prussian blue.^{19c}

Further tests were applied to confirm the result. On adding dilute hydrochloric acid to the green on a microscopic slide, it did not dissolve. On allowing it to dry and adding a drop of dilute solution of sodium hydroxide, the colour was not affected. On warming it with a drop of concentrated hydrochloric acid, it was not affected or dissolved except that there was slight effervescence.^{20a} All these reactions are characteristic of terre verte.

Bluish Green.—Under the microscope, particles of blue and green were distinctly visible. The green gave tests similar to the ones indicated under terre verte. The blue particles were not birefringent. They were decolourised by dilute hydrochloric acid, but no green-to-brown residue was obtained with as copper compounds. The experiments showed that the blue particles consist of ultramarine.^{20b} The bluish green is thus a mixture of terre verte and ultramarine.

4. *The Binding Medium.*

As explained already, the binding medium determines the nature of the painting process, that is, whether it is one of fresco, tempera, oil or encaustic. In the case of tempera, the problem of identifying the binding medium is difficult and complex. Here the binding media are not well-defined substances, but are accidental mixtures such as nature furnishes in the form of gum, resin, linseed or poppy seed oil, albumin, etc. The problem of their identification is complicated by three facts, namely, (i) the amount necessary to fix a pigment to a surface is very small; (ii) even if the binding medium remains *in situ*, it changes its character in course of time through the chemical actions of moisture and atmospheric oxygen; (iii) since the chemist cannot be allowed to destroy large surfaces of paintings, he can get only small fragments of the painted layer from which to extract the binding medium. For these reasons, it becomes exceedingly difficult to decide definitely what they were originally composed of. While the identification of the particular organic medium is difficult, its presence or absence is not difficult to settle, even though small amounts of it are available.

The following experiments were carried out to determine the nature of the binding medium:—

(i) The paint layer was brushed over with a wet sponge and rubbed with the fingers. A small fragment of it was soaked in water and the water boiled for 15 minutes. In all these cases, there was no damage or injury to the painting. It was noted that the pigment had not penetrated into the plaster.

(ii) A fragment of the paint layer was treated with pure ether and other solvents like chloroform and carbon disulphide. With these solvents no vehicle was extracted.

(iii) A fragment of the paint film was treated with dilute hydrochloric acid. It did not disintegrate, but there was considerable effervescence with evolution of carbon dioxide, and the fragment remained as a flake. Had tempera process been employed, there would have been no effervescence and evolution of carbon dioxide, but the paint film would have remained as a flake.

These experiments showed that the medium employed was both tempera and lime, in fact, a combination of both. Further experiments were necessary to elucidate this point.

A portion of the paint film was carefully separated from the underlying lime-wash and analysed, the results of chemical analysis being as follows :—

	Red paint film (per cent.)
Moisture	1.71
Carbon dioxide	11.67
Loss on ignition (excluding moisture and carbon dioxide) ..	11.86
Silica (SiO ₂)	38.85
Alumina (Al ₂ O ₃)	0.73
Iron (Fe ₂ O ₃)	6.90
Lime (CaO)	25.09
Sulphuric anhydride (SO ₃)	0.27
Magnesia (MgO)	1.68
Undetermined (Mostly alkalis)	1.24

100.00

It is clear from the results of analysis that the percentage of iron is higher here than in the rough plaster. This is due to the fact that the fragment chosen for analysis was a red paint, for which red ochre had been used.

The interesting point to be considered is the loss of weight on ignition, to the extent of 11.86%, which is very much higher than with the rough plaster. This can be explained only on the assumption that an organic substance has been purposely or accidentally added as the binding medium to fix the pigments to the plaster. At the same time, the presence of lime in the results of analysis shows that it was purposely added to the pigment as a binding medium.

The following experiments were conducted to find out the nature of the organic medium :—

(i) A sample of the paint layer was subjected to Lessaigne's test for nitrogen, but it failed to give the Prussian blue colour, thereby showing the absence of nitrogenous substance in the binding medium.

(ii) The absence of nitrogenous substance in the binding medium is proved further by the absence of any stain characteristic of glue, albumin or casein with either acid green (dissolved in water to which a little hydrochloric acid had been added) or iodoeosin (dissolved as the ammonium salt).^{21a}

(iii) A drop of freshly prepared dilute solution of methyl violet placed on a fragment of the paint film for over 15 minutes, yielded violet colouration.^{21b} This indicated the presence of a drying oil. Under these conditions, neither resin nor glue nor any nitrogenous substance will be dyed by methyl violet. A freshly prepared dilute solution of methylene blue gave the same violet stain characteristic of drying oil.^{21c}

Thus the presence of an organic binding medium in the paint film is due to some drying oil. It is not quite clear whether the oil was added accidentally or purposely to the original material, thus imparting the additional characteristic of tempera technique to simple painting in lime medium.

In conclusion, the author desires to express his thanks to the Pudukkottai Darbar for providing him with all facilities to study the paintings *in situ* and to Sir Alexander Tottenham, C.I.E., Administrator of the Pudukkottai State, and to Dr. F. H. Gravely, Superintendent of the Government Museum, Madras, for their encouragement and kind interest in the work.

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