

Evaluating the potential and risk factor of salt deterioration in wall mural paintings at Ramalinga Vilasam, (Protected Monument), Ramanathapuram, Tamil Nadu, India

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Abstract - The conservator needs to have a thorough understanding of the painting technique including the nature of the pigments and media used. He/she should also comprehend how exactly the paintings have undergone deterioration and how to counteract the deterioration process and bring back the paintings to their original condition as much as possible. Lastly measures have to be taken for preventing future deterioration. It will thus be seen that this is a highly technical work requiring scientific knowledge, artistic ability, a high degree of manual skill and lots of patience.

According to archaeological conservation principles, it is not permitted to re-create any lost area of painting. Any gap, that may be present, is only to be toned down so as not be conspicuous.

Keywords: Salt weathering; Risk assessment; Environmental monitoring; Wall mural paintings; Monument; Heritage; Structure; Conservation; Restoration; Maintenance.

I. INTRODUCTION

Risk assessment is a valuable tool for cultural asset conservation since it determines the hazards that artworks face and calculates their extent, allowing for the development of effective mitigation solutions. To ensure the survival of the collections, this satisfies the principles of preventive conservation, which aim to determine the factors causing cultural heritage to deteriorate, comprehend the phenomena from which they originate, and control them by acting on the environment or building rather than the objects directly [1].

The study examines various approaches for evaluating the danger of mechanical damage to porous material more especially, wall paintings caused by salt crystallization [2-5].

One of the most prevalent and dangerous factors for built heritage to deteriorate is soluble salts. They could come from a variety of sources, including groundwater, marine aerosols, or construction materials. Deterioration phenomena can occur when salts dissolve and move through porous materials before crystallising in specific environmental circumstances [6-7].

The damage can be either mechanical, if the crystals form beneath the surface (subflorescence), creating pressure within the material's structure and, after repeated cycles of dissolution-recrystallization or hydration, causing the weakening, detachment, and loss of the surface layers, or aesthetic, when salt crystallisation occurs on the materials' surface (efflorescences), disrupting the artwork's appearance [8].

Wall paintings are especially susceptible to soluble salt damage because of their layered structure and the fact that the painted surface is the primary location for water evaporation, salt buildup, and ambient moisture absorption. The murals' veils or salt crusts, in addition to the previously noted aesthetic disruption, keep moist microenvironments in contact with the picture layer, raising the possibility of biological colonisation and colour change [9].

The primary changes associated with subflorescence include bulges, cavities, flaking, peeling, scaling, and powdering [10]. Since salt extraction can cause more damage to the already compromised material or set off other deterioration mechanisms linked to water consumption, climate control is frequently the only practical way to prevent or lessen damage caused by salts in murals. Thus, it is crucial to keep an eye on environmental factors and evaluate how changes in them can affect the salts found in the paintings.

The present investigation showed that the approaches examined are practical, affordable, and straightforward to use for determining the likelihood of salt deterioration in wall paintings. Since some of the salts that the model predicts will crystallise under the monitored environmental conditions were actually found in the efflorescence samples from the murals, the results obtained are in good agreement with observations made in situ. Additionally, murals for which ECOS identifies a higher risk of crystallisation already exhibit signs of salt weathering [11].

II. BRIEF HISTORY AND DESCRIPTION

In 1605 the Nayaka ruler of Madurai appointed a Chieftain of the Marava country (present Ramanathapuram region) as the local ruler and entrusted him with the responsibility of protecting the famous temple of Rameshwaram and safeguarding the pilgrims to this holy place. By virtue of this, these rulers assumed the title Sethupathi.

The ruler from 1674 - 1710, called Shri Raghunatha Sethupathi alias Kilavan Sethupathi was a powerful king. It was he who built the palace and the surrounding fortifications.

The next ruler, known as Vijaya Raghunatha Sethupathi (1711 – 1725) was a great patron and lover of the arts and it was during his time that the palace walls were decorated with mural paintings. The paintings are thus a little less than three hundred years old.

III. MURAL PAINTINGS

The entire wall surface as well as the ceiling areas of the Ramalingavilasam palace are covered with beautiful mural paintings.

In the front hall are painted historical events relating to the Sethupathis including the battle with king Sarabhoji of Thanjavur. The visit of English merchants to the court seeking permission for trade, Christian missionaries calling on the ruler and an earlier celebrated incident of the Nayaka king doing Rathnaabhisheka (showering of precious stones) to Raghunatha Sethupathi, etc. There is also an impressive portrait of Kilavan Sethupathi.

In the antechamber of the inner hall, which is at a slightly elevated level as well as within the inner hall itself, the paintings depict scenes from Ramayana and Bhagavatha as well as other mythological themes. There is a very interesting series of paintings on Krishna Leela.

The pilasters on the walls, the numerous arches in each aisle (their lateral as well as curved surfaces) and ceiling areas are decorated with floral and geometric designs. Only in a few cases are there figures on the curved surfaces of the arches.

There are also a few highly carved stucco figures of gods and goddesses at the upper level of the walls, which are painted.

On the first floor of the inner hall, the walls are painted with scenes of the Sethupathi enjoying music and dance and other worldly pleasures.

Any visitor to the palace gets an impression of witnessing a rich outpouring of art and is overwhelmed no less with the quality of the paintings than their profusion.

It need hardly be stressed that these paintings, not merely because of their historical importance but equally because of their great artistic merit must be preserved properly.

IV. TECHNIQUE OF THE PAINTINGS

The paintings have been executed on lime plaster in the tempera technique i.e., an organic binding medium like gum or flue has been mixed with the pigments for painting on dry lime plaster. When such a technique has been used, the paint layer has a distinct body of its own and though bound firmly to the lime ground, can still be distinguished as a separate entity when viewed in cross section. In some damaged portions of the paintings, it has been possible to observe the paint layer clearly as a distinct layer superimposed on the lime ground.

The colour scheme is rich and consists of reds, yellows, brown, light and dark green, black and white. The use of blue is limited.

V. MEASUREMENTS OF THE PAINTED AREA

1. Front Hall

(i)	Length of East Wall	:-	16 feet
(ii)	Length of South Wall	:-	80 feet
(iii)	Length of West Wall	:-	34 feet
(iv)	Length of North Wall	:-	80 feet
	Total Length	:-	210 feet
	Height of the wall	:-	22 feet

Total wall surface of paintings in front hall	:-	$210 \times 22 = 4,620$ Sq.feet
(v) Area of lateral surface of each arch	:-	$(8 \times 6 - \frac{1}{2} \times \frac{22}{7} \times 4 \times 4) \times 2$
	:-	$(48 - 25.12) \times 2$
	:-	45.76 Sq.feet
Area of the curved surface of each arch (width 2')	:-	$\frac{22}{7} \times 4 \times 2 = 25.12$ Sq.feet
Total area of each arch	:-	$45.76 + 25.12 = 70.88$ Sq.feet Say 70 Sq.feet
There are 64 arches in the front hall		
Total area of all the arches	:-	$70 \times 64 = 4,480$ Sq.feet
(vi) Each ceiling portion	:-	$8' \times 8' = 64$ Sq.feet
There are 54 ceilings portions		
Total area of ceilings portions	:-	$64 \times 54 = 3,456$ Sq.feet
Out of this, deduct 50% for paint loss	:-	$3,456 \times 50\% = 1,728$ Sq.feet
Hence, painted ceiling area present		
Total painted area in the front hall	:-	$4,620 + 4,480 + 1,728$ = 10,828 Sq.feet

2. Antechamber of Inner Hall

(i) Total length of all the walls	:-	147 feet
Height	:-	16 feet
Total wall surface	:-	$147 \times 16 = 2,352$ Sq.feet
(ii) Total area of the arches	:-	$70 \times 18 = 1,260$ Sq.feet
(iii) Total ceiling area	:-	$64 \times 18 = 1,152$ Sq.feet

Total painted area in the Antechamber :- 4,764 Sq.feet

3. Inner Hall

(i) Total length of all the walls	:-	166 feet
Height	:-	14 feet
Total wall surface	:-	$166 \times 14 = 2,324$ Sq.feet
(ii) Total area of the arches	:-	$70 \times 40 = 2,800$ Sq.feet
(iii) Total ceiling area	:-	$64 \times 20 = 1,280$ Sq.feet

Total painted area in the Inner Hall :- 6,404 Sq.feet

4. First Floor

(i) Total length of all the walls	:-	132 feet
Height	:-	15 feet
Total wall surface	:-	$132 \times 15 = 1,980$ Sq.feet
(ii) Total area of the arches	:-	$70 \times 40 = 2,800$ Sq.feet
(iii) Total ceiling area	:-	$64 \times 25 = 1,600$ Sq.feet

Total painted area in the First Floor :- 6,380 Sq.feet

Total painted area in the Ramalingavilasam palace :- 10,828 + 4,764 + 6,404 + 6,380 = 28,376 Sq.feet

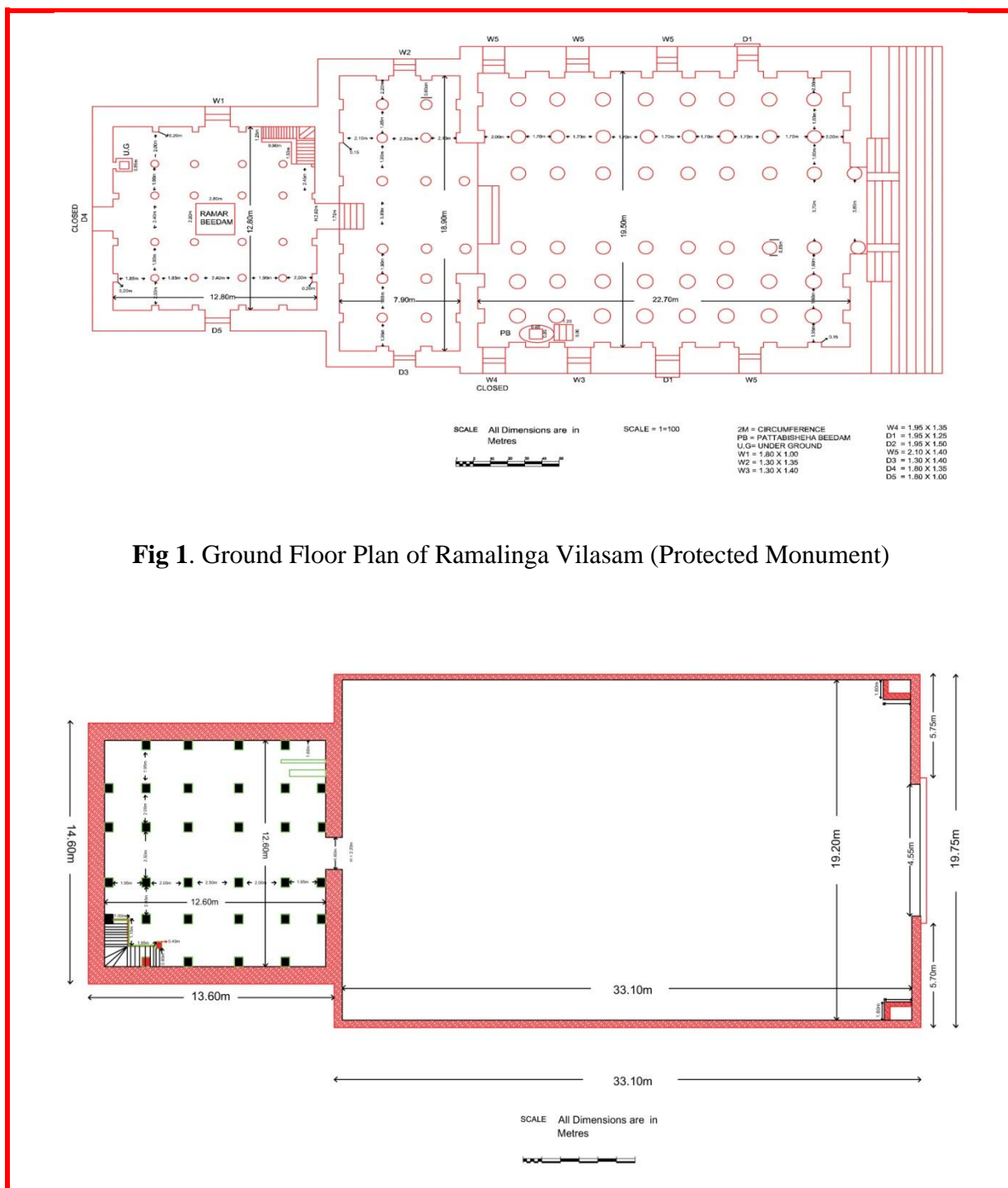
VI. STATE OF PRESERVATION OF THE PAINTINGS

In the front hall colours have been washed out over considerable areas at the upper portion of the wall, due to seepage of rain water from the roof. Due to the same reason, bulges are observed in the painted plaster in a number of places. In some places, actual loss of the painted plaster has occurred. In a few places, damages have occurred in the lower portions of the paintings also, probably due to rise of ground moisture, along with soluble salts, through the porous foundation and walls.

Damages also seem to have occurred due to sheer acts of vandalism, particularly the eyes of the figures have been singled out for attack. On the first floor, one is sad to see names (of visitors) scratched on the surface of very important paintings.

The paintings are over all covered with a thick coating of dust and dirt. Insect nests are noticed in a few places.

Another serious problem is the presence of bats in the darker recesses, particularly on the upper parts of the walls. The bat droppings form whitish deposits on the paintings, which are very difficult to remove with solvents. [Figure 1, 2, & 3].



Ground Floor Plan

Fig 2. First Floor Plan of Ramalinga Vilasam (Protected Monument)

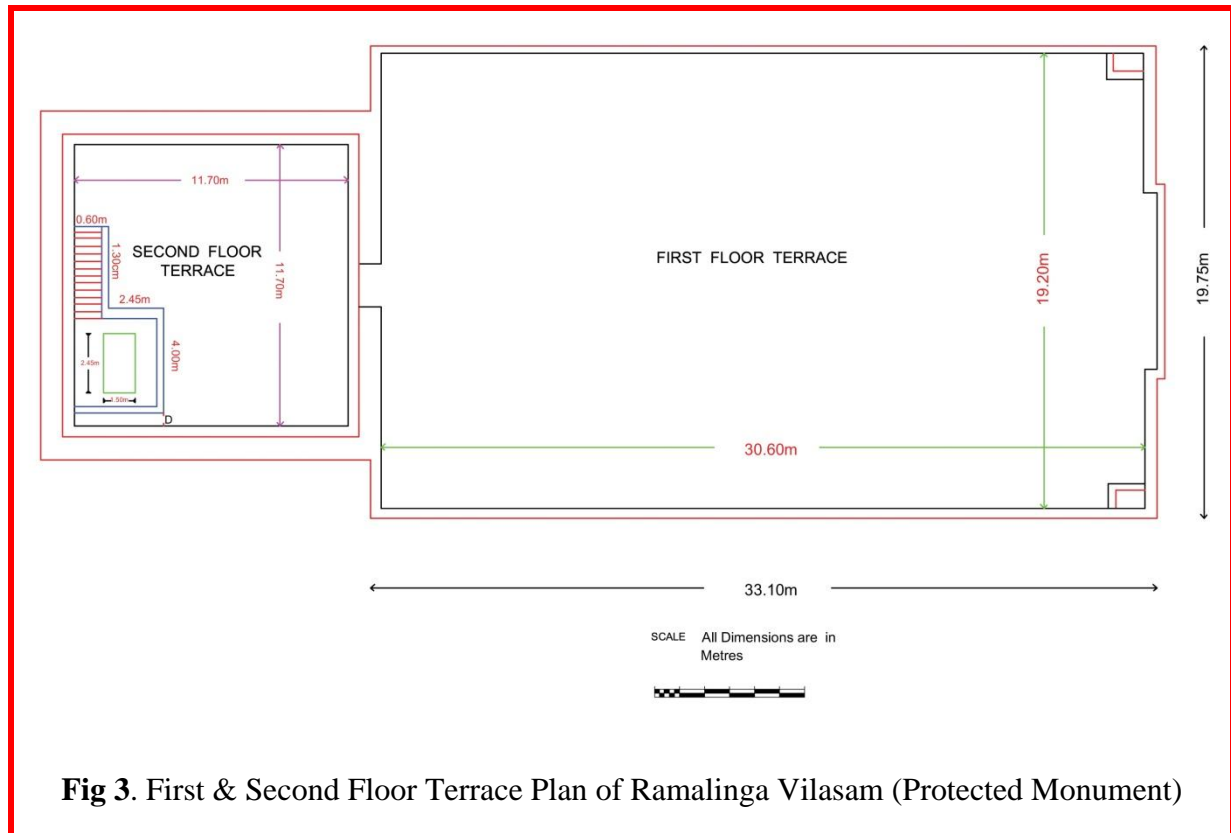


Fig 3. First & Second Floor Terrace Plan of Ramalinga Vilasam (Protected Monument)

VII. CONSERVATION AND RESTORATION WORK TO BE CARRIED OUT

Before commencement of work on the paintings, it is absolutely essential to stop the seepage of water from the roof completely by carrying out necessary repairs. It is learnt that the priority may be given to the repair of the roof.

The first step in the conservation treatment to the paintings is the consolidation and strengthening of the lime ground as well as the paint layer. All loose edges are filleted and fixed with lime plaster so as to prevent further loss. The filleted edges are suitably coloured so that they mingle with the adjacent areas and do not stand out obtrusively. All loose and hanging portions as well as bulges in the painted plaster will be fixed back to the wall by introducing adhesives behind the plaster and keeping it firmly fixed to the wall till the adhesive sets. Loose edges of the paint layer are fixed with the help of polyvinyl acetate solution.

The next step is the cleaning of the paint surface with the help of organic solvents. There is a wide range of these solvents and they will be selected as per requirement depending on the nature of the surface deposits and accretions to be removed. The aim of the cleaning is to remove the accretions completely and restore the paint surface to its original brightness as much as possible.

The third step is filling up of all the lacunae within the paint layer and touching up with suitable colours for integrating these areas with the rest of the painting.

This does not amount to repainting or adding something new to the old but only aims at restoring the unity of the colour scheme.

The last step is the application of Polyvinyl Acetate solution as a preservative coating. [Figure 4, & 5].

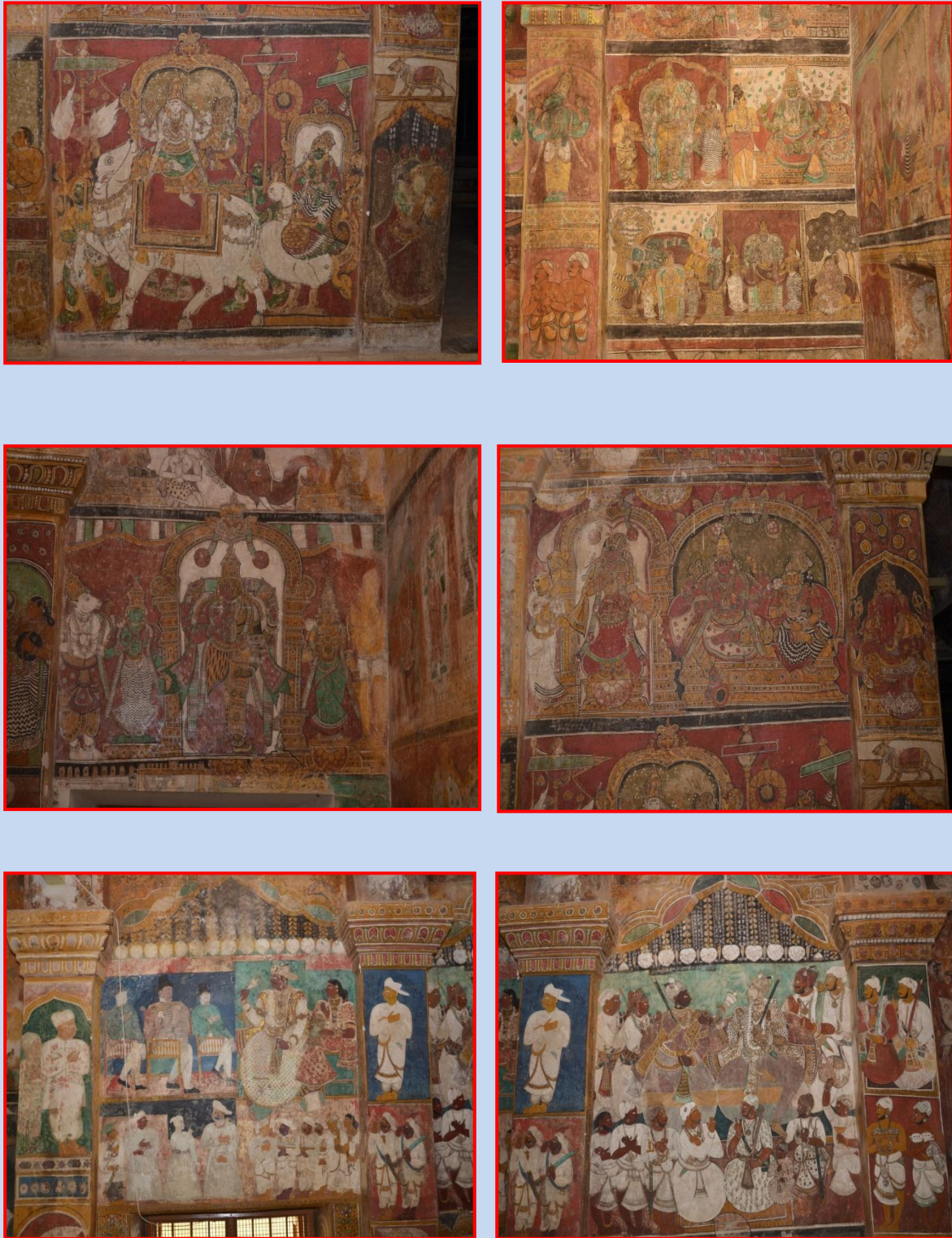


Fig 4. Paintings of Ramalinga Vilasam (Protected Monument)

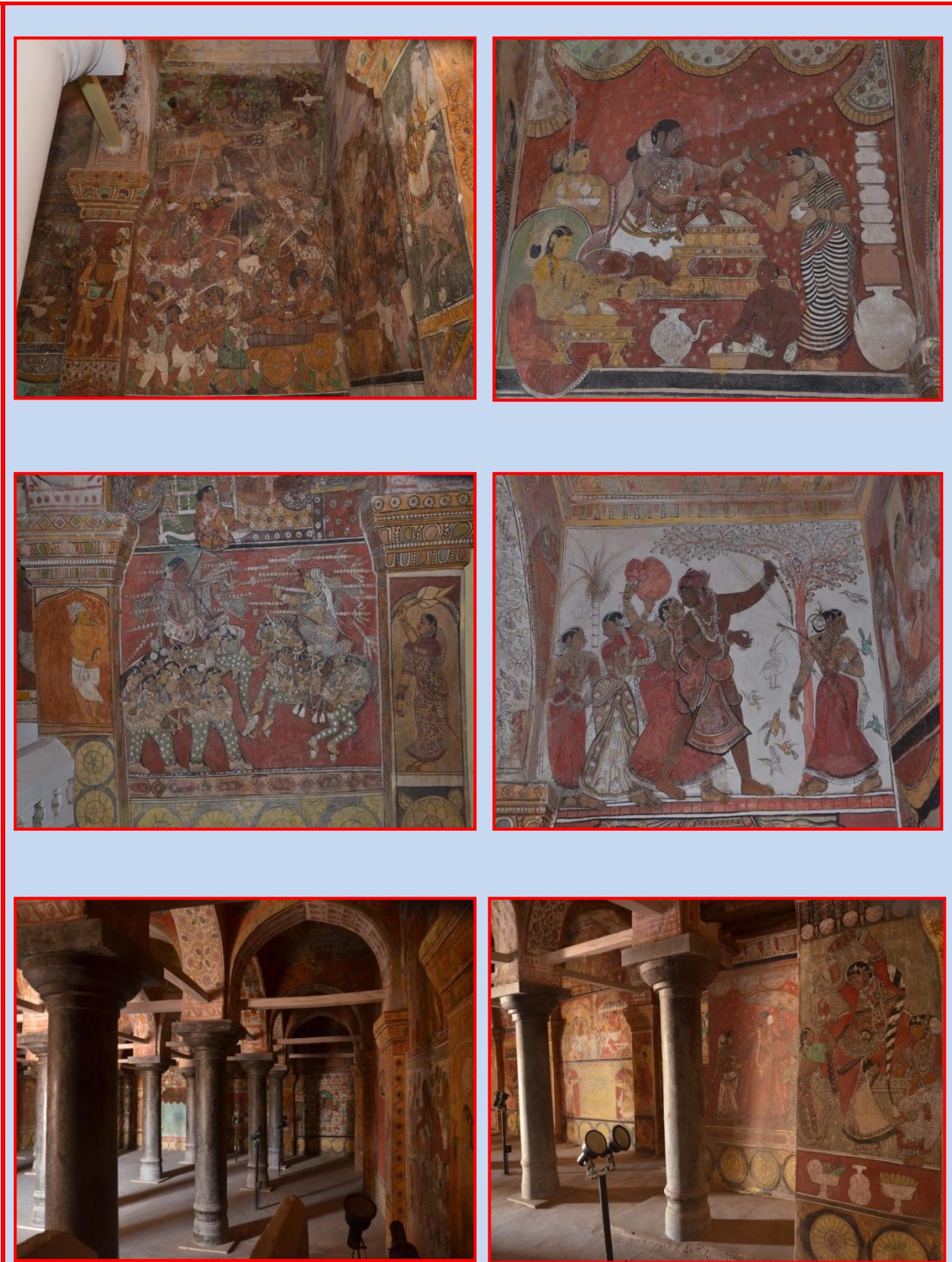


Fig 5. Paintings of Ramalinga Vilasam (Protected Monument)

VIII. SALT ANALYSIS : IONS AND CONCENTRATION

The results of the salt analysis of 12 samples of Plaster (P), Limewash (L) and Paint Layer (PA) from 12 different location (Ground Floor & First Floor) at Ramalinga Vilasam (Protected Monument) are shown in Table 1.

Table 1. Concentration of ions in the samples from murals of the Ramalinga Vilasam

Location	Sample	Moles ion/g Sample							
		Cl ⁻	NO ₃ ⁻	SO ₄ ²⁻	Na ⁺	K ⁺	Mg ²⁺	Ca ²⁺	Total ion content
Ground Floor Wall	1P	5.20	3.79	0.00	1.65	0.93	0.54	6.65	18.76
	1L	10.04	2.15	0.00	8.52	4.19	0.26	0.34	25.50
	1PA	0.94	0.82	2.50	0.93	0.24	0.19	3.64	9.26
Ground Floor Arch & Ceiling	1P	4.45	5.52	0.00	2.60	0.60	0.82	5.15	19.14
	1L	9.58	2.55	0.00	7.84	4.06	0.15	0.63	24.81
	1PA	0.96	0.80	2.48	0.85	0.26	0.18	3.66	9.19
First Floor Wall	1P	5.19	3.72	0.00	1.60	0.90	0.51	6.54	18.46
	1L	9.98	2.09	0.00	8.48	4.16	0.22	0.29	25.22
	1PA	0.92	0.81	2.52	0.91	0.22	0.18	3.52	9.08
First Floor Arch & Ceiling	1P	5.18	3.65	0.00	1.58	0.90	0.54	6.64	18.49
	1L	8.99	2.16	0.00	8.50	4.17	0.24	0.32	24.38
	1PA	0.90	0.80	2.48	0.91	0.22	0.19	3.62	9.12

IX. DISCUSSION

Since it just needs the equilibrium RH equations for each salt system and the monitored environmental conditions, the count of phase transitions for various salt systems proven to be a straightforward way to approximate the risk of harm from salt crystallisation. Given that 19 dissolution-crystallization cycles were recorded throughout the study year, the number of phase changes calculated for the various salts under the monitored environmental circumstances could represent a moderate risk to the wall murals of the Ribeira Sacra. In the case of the transition from thenardite to mirabilite, this would be particularly concerning because the associated rise in crystal volume suggests a pressure more than 10 MPa, which is high enough to damage porous construction materials [2].

However the method's accuracy is constrained by a number of factors: 1) While monuments are impacted by complicated salt mixes where the many ions would affect each other's solubility, it evaluates each salt separately [12-13]. 2) Although it can affect the patterns and pressure of salt crystallisation within porous materials, the approach does not take the transitions' kinetics into account [3]. 3) The RH might differ significantly between the surroundings and the interior of the porous material since the internal structure of the material and the fluid transfer qualities are also disregarded, making it impossible to pinpoint the precise location of phase transitions within the pores [3]. 4) More research is required because it is unclear how many annual shifts could begin to be regarded as a concern for the materials [14].

X. CONCLUSION

This paper effectively conveys that the methods examined are inexpensive, simple to use, and effective for determining the likelihood of salt deterioration in wall paintings. Since some of the salts that the model predicts will crystallise under the monitored environmental conditions were actually found in the efflorescence samples from the murals, the results obtained are in good agreement with observations made in situ. Additionally, murals for which identifies a higher risk of crystallisation already exhibit signs of salt weathering.

The most effective way to get around each method's drawbacks was to use both approaches to evaluate salt crystallisation: Phase transitions at the monitored environmental conditions are counted to determine the frequency and seasonality of the transitions and to estimate the risk of salt weathering. The deliquescence point for the salt mixture predicted by taking into account the ion concentration in the samples is then calculated. The calculations for the individual salts and the results

produced when taking into account a complex mixture of ions don't always agree, and occasionally the equilibrium relative humidity is significantly reduced.

The plan for painting conservation and environmental control are part of a preventive conservation strategy because they allow for the assessment of the paintings' risk of physical damage from salt crystallization based on environmental conditions and the establishment of safe conservation ranges where salt transitions would be minimized.

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