PRESERVATION OF SALT-AFFECTED MURAL PAINTINGS FROM ANCIENT SHRINES IN CENTRAL ASIA

BY

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THE decay of exhibits charged with soluble salts is a well-known phenomenon in museums, but it is sometimes extremely difficult to devise a remedy to counteract this evil. An acute problem of this kind has been offered by the mural paintings which are on exhibition in the Central Asian Antiquities Museum at New Delhi.

These paintings were discovered by Sir Aural Stein in ancient Buddhist shrines in the ruins of Central Asia, in the course of his expeditions extending over the periods 1906-08, and 1913-16. The paintings have been executed on mud plaster which is finished with a fine and smooth layer (*intonaco*) of the same material and a thin wash of burnt gypsum, made into cream with water, has been applied over this surface in order to form the painting ground. The colours employed are gypsum, red and yellow ochres, lamp black, malachite, terre verte and *lapis lazuli,* which were evidently mixed with a suitable medium (glue or gum), and applied with brushes on this ground which might have been still moist, or dried off completely.

In the process of mounting, as carried out in this museum, the slabs bearing the paintings were placed face down on a glass plate and the superfluous mud backing was carefully scraped off until the plaster was left only ⅛″ to ¼″ thick, *i.e.*, barely sufficient to hold the surface intact. Now the slabs were strengthened by the application of a thin layer of plaster of Paris cream on the backside. Several continuous slabs were then brought together in proper order to form a panel of convenient size, and an aluminium angle frame of suitable size, with expanded aluminium netting stretched across it, was placed over these slabs in the correct position. Sufficient plaster of Paris cream was then poured all over the slabs to cover the meshes until the whole assemblage was embedded in a uniform layer of the plaster. When the plaster had set hard the whole was lifted up from the glass plate as one unit. The section of such a unit is shewn in Fig. 1. For exhibition, these aluminium

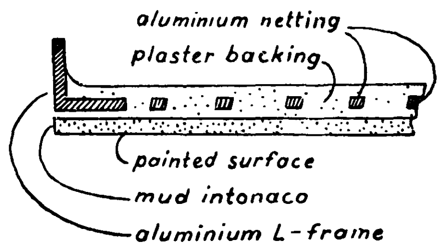

FIG. 1

frames were arranged in proper order and hung against the walls of the museum, by means of adjustable hooks resting on fixed iron chanelling; so that an empty space, about 2″ wide, was left between the wall and the panels. The paintings have been finally encased in wooden almirahs with glazed doors in front. After the lapse of several years signs of decay developed on some of these paintings, which began to spread and affect several more in a short time. The decayed plaster was examined and found heavily charged with sodium chloride and sodium sulphate. There is no doubt that the salts were present in the original plaster, since the ruined sites (whence these paintings were recovered) are situated in very saline areas. The decay of the surface was caused by a continuous cycle of solution and crystallization of the salts, which is set up by variation in atmospheric humidity. In the wet season, when the humidity remains excessive over long periods, the salts remain in solution and do not get a chance to crystallize. However in the dry weather the humidity of air remains low during the day; but it may rise up to the saturation point at night with the fall of temperature. Therefore the cycle is repeated with great frequency and rapid decay occurs. This explains the marked intensity of decay due to injurious salts, in the cold season.

The atmospheric conditions prevailing in the museum galleries, also cause the salts to move out and concentrate gradually on the painted surface, which is consequently subjected to severe deterioration. In the rainy season, the exposed walls as well as the floors of the museum absorb appreciable amounts of water which is given off to the air slowly for a long time afterwards. Therefore, the 2″ airspace (which exists between the walls and the picture panels), must have remained saturated with moisture for sometime after the rains when the humidity of atmosphere in the gallery had fallen low. In other words, necessary conditions for the establishment of a humidity gradient across the picture panels must have prevailed in certain parts of the year, which would force the salts in the panels to move out and concentrate on the painted surface.

Before going further it seems desirable to explain the principle underlying the movement of salts in porous bodies under the influence of a humidity gradient. It is well known that if one side (A) of a porous partition is exposed to higher atmospheric humidity than the other (B), then movement of water vapour takes place through the partition from surface A to surface B. Suppose the porous partition be impregnated with soluble salts and the Relative Humidity on the surface A is sufficient to cause the salts to deliquesce while that (Relative Humidity) on B is low enough to cause their efflorescence, then the salts will go into solution at the surface A, spread through the material by capillary action, and crystallize out gradually at the surface B. This process will go on as long as the humidity gradient is maintained. In other words the salts also will move from A to B and concentrate at this surface.

The material of the *intonaco* (*i.e.*, mud) and tempera style of the paintings preclude the application of wet paper pulp or soaking in water, which constitute the common methods for the elimination of soluble salts from more rigid materials, such as terracotta, stone, etc. Coating with cellulose acetate and vinyl acetate solutions were tried but failed to arrest the process of decay, due to the fact that the thin films are not impervious to moisture. After much experimentation it was decided to break the concentration of the salts on the soft painted surface and to induce them to concentrate on the surface of the plaster backing instead by the reversal of the humidity gradient. In actual practice, the treatment of these salt-affected panels has been carried out in a specially designed apparatus, named 'Humidity Chamber', which is illustrated in Figs. 2 and 3. This device consists of a

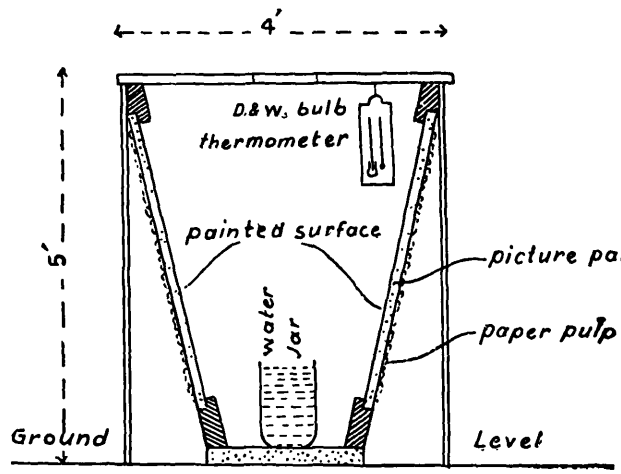

FIG. 2

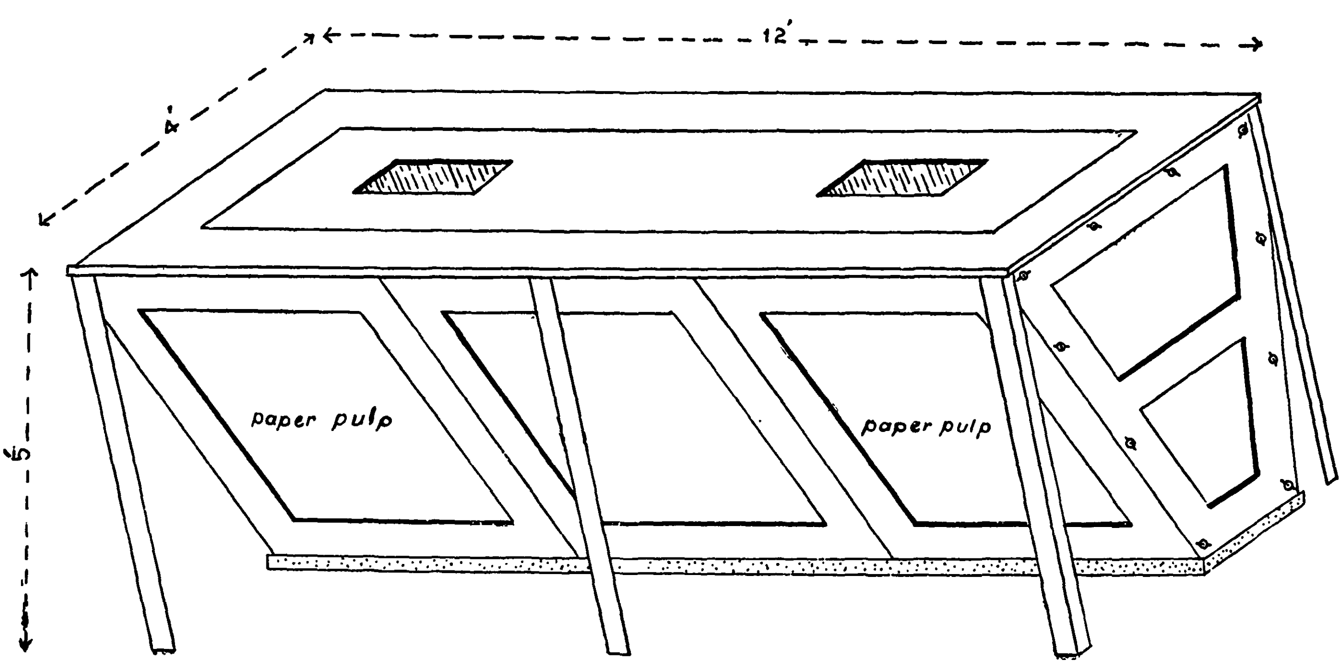

FIG. 3

skeletal frame of L-iron, having a trapezoidal section, which is supported on six iron uprights fixed in the ground. The top is covered by a wooden lid provided with two glazed windows, which is fixed down by means of fly-bolts and nuts. The flanks of the chamber are also provided with wooden frames, which can be partitioned off into two or more rectangular sections for the insertion of wooden adapters of suitable sizes. A number of frames bearing the paintings are secured to the sides of the chamber, with their painted surface inside, by screwing down wooden batons over them while the joints are rendered tight by means of felt packing. The front and back ends of the chamber are provided with glazed doors which can also be closed tightly by means of fly-bolts and nuts. A number of glass jars containing water are kept inside the chamber to humidify the air. Dry- and wet-bulb thermometers are suspended inside and outside, to indicate the relative humidities respectively. The slanting position of the panels helps to retain any fragments that may have loosened in the process of decay. The Relative Humidity inside is kept above 85 per cent.

After a week or so, paper-pulp of the consistency of porridge is applied to the outer (plaster) surface of the panels until a uniform layer ½″ thick has been laid all over it. The pulp generally adheres well but if the surface of the plaster is smooth it will tend to fall off. Therefore it will be necessary to keep the pulp in position by propping it at several points with the aid of flexible sticks, or, the whole surface may have to be pressed down by means of galvanized wire-netting of wide mesh fixed tightly over a wooden frame. Sometimes mildew develops in the pulp which will affect the paintings also. In order to counteract this danger it is desirable to sterilize the chamber by heating a quantity (½–1 oz.) of thymol inside, at intervals. Coating with thymol solution in alcohol was not found to be effective. However, the most effective remedy consists in the addition of a little carbolic acid to the paper-pulp mix-up.

The Humidity Chamber having been properly closed, the layer of the pulp is allowed to dry off, which takes a week or more, when it is removed carefully with the aid of a knife's point. Six-inch square specimen of the dried pulp is cut up, soaked in distilled water and its salt contents are estimated in a colorimeter. The applications of paper-pulp are repeated until mere traces of the salts can be detected. The panels are now removed from the chamber and the painted surface is impregnated with 5% vinyl acetate solution in toluene, until it has been strengthened sufficiently. Finally, the surface is pressed down gently with hot iron. A few typical examples of the analytical results are given below:—

Grams of sodium chloride found in one square foot area of the dried paper-pulp, in successive applications

Specimen	Paper-pulp applications							Remarks
	1	2	3	4	5	6	7	
(a) Panel Gha ..	10·0	2·4	1·0	0·43	0·72	0·38	tr.	Highest concentration found
(b) Panel M.C. 06 ..	2·2	0·7	0·13	tr.				
(c) Panel M.C. 111, 01 ..	1·1	0·67	0·4	0·043				
(d) Panel Kao 11·03 ..	?	?	0·25	0·40	0·64	0·30	tr.	
(e) Panel Bez XIII *(a)*	0·69	0·24	0·32	0·11				
(f) Do. *(b)*	0·80	0·14	0·13	0·10				

Finally it may be mentioned that this process works very slowly and takes several weeks to bring down the concentration of salts to a small fraction.

ALGAL INVESTIGATIONS IN THE BOMBAY PRESIDENCY

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THE history of the beginning of scientific exploration and recording of the plants in the Bombay Presidency commences with the arrival of the Portuguese at Bassein in the Island of Salsette about 1838 A.D. In those early days the object of botanical researches was to collect plants for the economic uses. A physician, named Garcia d'Orta has recorded some well-known medicinal and economic plants of this region. The man who materially laid the foundation of Systematic Botany of the Bombay Presidency was John Graham, a Deputy Postmaster-General. He published a "Catalogue of Plants Growing in Bombay and its Vicinity" in 1839. Thereafter, during the last hundred years the flowering plants have been investigated by several successive workers. But the lower plants and specially the algæ practically remained unnoticed for a long time. The systematic study of the Cryptogams is in fact comparatively a later step in the field of botanical research. The second half of the last century was the period of serious algological studies. The fields of the pioneer workers on Indian algæ were mostly outside this province.

The oldest record of algal collection from the Bombay Presidency is that of *Nitella acuminata* Br. and *Nitella dispersa* Br. made by Stokes in 1847. A paper on some Volvocales from Bombay was published by Carter in 1859.[1] During the last quarter of the century several attempts appear to have been made to study the marine algæ of the Presidency. Vice-Admiral Pullen had collected seaweeds from the coast of Karachi but J. A. Murray (1881–83) has left a more lasting mark of his own collection by recording some marine plants in his book on the plants of Sind. It is interesting to read a note in the *Journal of the Bombay Natural History Society,* 1887 which says: "Mr. Murray, late Curator of the Kurrachee Museum, exhibited a collection of Marine Algæ consisting of 212 species from the Coast of Sind, and described the same." The same Journal records that Mr. Kirtikar read a paper on Marine Algæ collected by Hon. Justice Birdwood on the Ratnagiri Coast. Kirtikar was a medical man and he has published a brief paper[2] wherein he describes a new species, *Conferva thermalis Birdwoodii* from the hot springs of Vajarabai in Thana District. He has noted three more species, *viz., Ulothrix radicans* Cooke; *Nostoc* sp.; and *Chætomorpha implexa.* It is needless to point out that this information is of only historical importance and would hardly stand the test of science.

In the beginning of the present century (1902–03) an account of some Myxophyceæ collected by Hansgirg in India was published.[3] Hansgirg's collection included about twenty-five species belonging to seventeen genera of the blue-green algæ from the vicinities of Bombay and Poona, majority of which was considered to be new to science. In 1909, Hate published a note on two species of Charophytes, *viz., C. verticulata* and *C. flacida* Br. from the Bombay Island. In 1924 Groves[4] published an important paper on the Charophytes of India wherein he recorded seven species from the Presidency collected by six different people at various times. Two years later, very brief references about the collections of algæ made by Hate (V.N.) and Dixit (D.L.) appeared in the abstracts of papers read at a meeting of the Indian Science Congress. In the same year, Carter published a paper on the Freshwater Algæ from India in which she mentioned two green algæ, *viz., Rhizoclonium hieroglyphicum* Kutz. and *Pithophora radians* W. & G. S. West from Bombay. Thus, upto the close of the first quarter of the present century our knowledge of algæ of this region was next to nil.

In 1927–28 the University of Bombay invited Dr. F. Boergesen of Copenhagen to investigate the marine vegetation of the Presidency. Dr. Boergesen with the help of some teachers and students of the University made large collections of marine algæ from Bombay and Dwaraka. This was indeed the most important landmark in the history of algology in the Presidency. During the last decade or so Boergesen has published a series of papers on his Indian collections.[5,6] Boergesen found a very impressive algal vegetation at Dwaraka and in