# THE WALL PAINTINGS IN THE BAGH CAVES—AN INVESTIGATION INTO THEIR METHODS

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Received August, 1, 1939

## *I. Introduction*

The Bagh caves (22° 22′ N. & 74° 48′ E.) contain some of the finest examples of Indian wall paintings. Mutilated and faded as these paintings are, they still constitute a priceless treasure comparable to those at Ajanta. They have attracted considerable attention.[1]

The caves, which are nine in number, are situated on the southern slopes of the Vindhya hills in the Amjhera District of the Gwalior State. They are 70 miles from Mhow, the nearest Railway station, on the Rajputana-Malwa section of the B. B. & C. I. Railway. The cliff side on which the caves are excavated rises to a height of about 150 feet above the Bagh river and is remarkable as being only the outcrop of sandstone in an otherwise basaltic region. These sandstone caves are surmounted by a deep band of claystone.

The interior of these caves was at one time fully decorated with paintings. But the caves have crumbled due to the excessive weight of the superimposed band of claystone. Moisture percolating through it has also contributed to their destruction. Thus, with the crumbling of the caves many of the paintings have disappeared except a few in caves III and IV.[2]

The paintings probably date from the early seventh century A.D., being contemporaneous with the paintings in caves XVI and XVII at Ajanta.[3]

The paintings of Bagh and Ajanta form a distinct class by themselves, and belong to the golden age of Indian classical art, which inspired more than half the art of Asia.* They will bear comparison with the best that Europe could produce down to the time of Michael Angelo.[4]

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* "As far as their artistry is concerned, there is little to choose between the pictures of Bagh and Ajanta. Both exhibit the same broad handling of their subjects, the same poetry of motion, the same wonderful diversity in the poses of their figures, the same feeling for colour and the same strong yet subtle line-work. In both, decorative beauty

## *II. Experimental Investigations*

In reconstructing the technique of the painting process adopted by the ancient classical artists at Bagh, one has to consider the four principal factors[5] that go to make up the paintings. They will be considered here in order. Samples of three kinds of *painted stuccoes* that were available were collected from damaged portions of the paintings in cave IV at Bagh, and experiments conducted with them. Two of them had *rough plaster* of deep red and light red ferruginous earth, while the third had *rough plaster* of lime. Over them was a layer of *fine plaster* of some white material, the latter supporting the painted layer.

### (1) *The Carrier.*

The walls of the cave temples, and probably also its ceilings, serve as the mechnical supports for the paintings, and function as the *carriers*. They are of sandstone. The surface of the *carrier* has been specially left rough so that the *rough plaster* might hold well.[6] The sandstone caves were unable to support the excessive weight of the superimposed band of claystone. Consequently, the walls and ceilings, which are otherwise fairly firm and compact, have crumbled and fallen to pieces, thus destroying the paintings. Moisture has been percolating into the cave from the top, and it has softened and damaged the earth plaster and the paintings attached to them. In several samples, the paintings are covered with white efflorescence caused by the presence of gypsum, sodium sulphate, magnesium sulphate, etc. The efflorescence can be traced to salts carried over by the percolating water from outside and deposited over the surface of the paintings, and not to the presence of salts in the plaster (*vide* results of analysis below).

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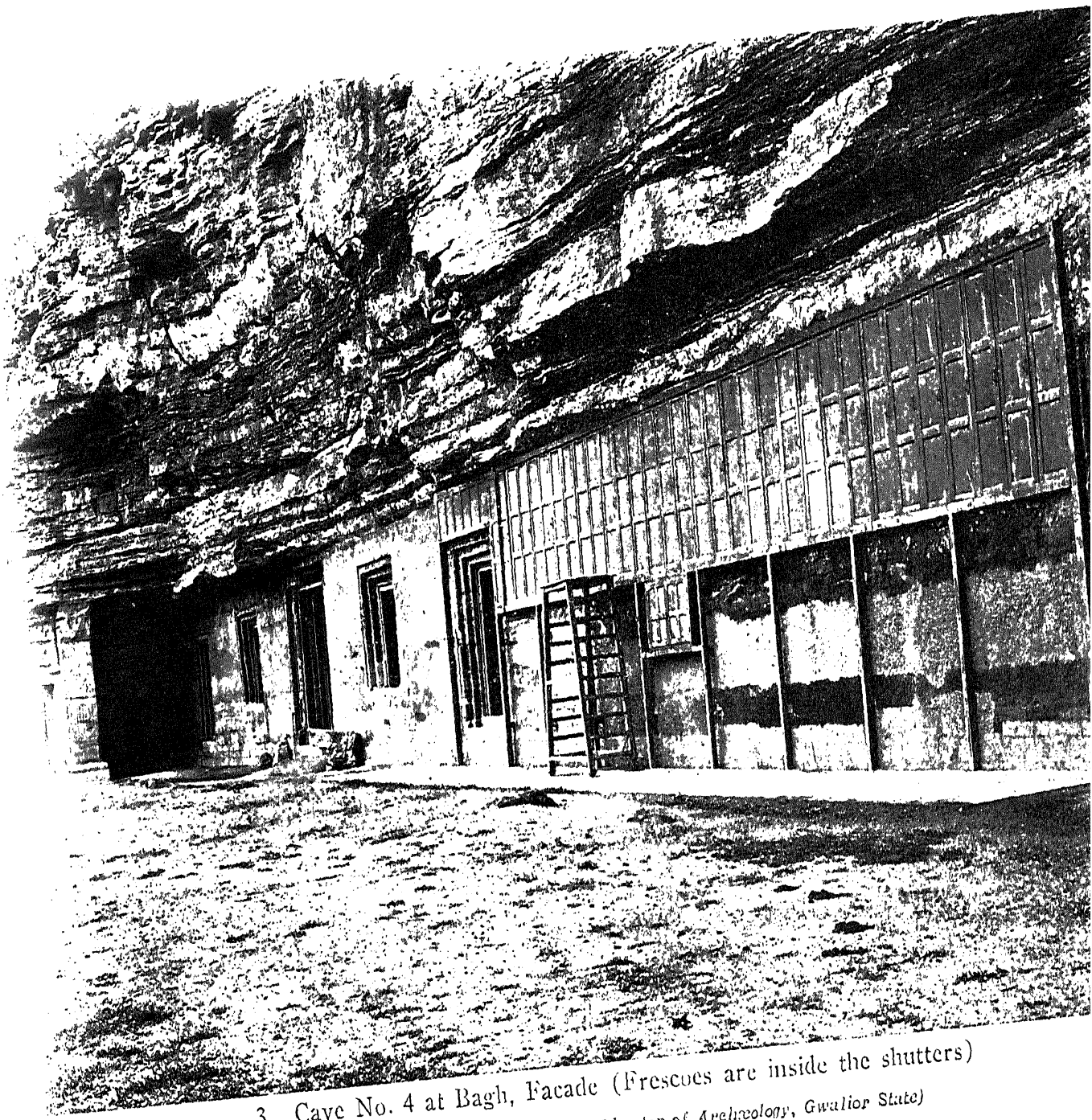
is the key-note to which all else is attuned, and both are as free from realism as they are from stereotyped convention. The artists, to be sure, have portrayed their subjects direct from life—of that there can be no doubt, but however fresh and vital their portrayal may be, it never misses that quality of abstraction which is indispensable to mural decoration, as it is, indeed, to all truly great painting. True, there is nothing left at Bagh to equal some of the surprisingly majestic figures, such as the famous Bodhisattva, at Ajanta, but in one respect at any rate the paintings of Bagh have an advantage over those of Ajanta. For whereas at Ajanta most of the paintings appear to have been done piecemeal—at Bagh they give the impression of having been conceived and executed at one and the same time, or at any rate in conformity with a single well-thought out scheme....To be adequately appreciated they (the paintings) must be seen to their full scale and in the architectural setting for which they were designed."—SIR JOHN MARSHALL.

*Vide* Sir John Marshall & others, *The Bagh Caves* (London: India Society), 1927, pp. 17–18.



3. Cave No. 4 at Bagh, Facade (Frescoes are inside the shutters)

*(With the kind permission of the Director of Archæology, Gwalior State)*

(2) *The Ground.*

The following experiments were conducted to study the nature of the *ground* which had been prepared by the Bagh artists to lay the coloured designs on.

*Study of the microsection.*—Microsections of the *painted stuccoes* containing all the different layers were prepared.[7] Since the earth *stuccoes* were very soft, considerable care was bestowed in preparing them. Particles of dust adhering to the prepared surface were removed very carefully with a soft brush. An examination of the surface under the travelling microscope revealed three lines of cleavage† or junctions in the case of the earth *stuccoes* and two in the case of the lime *stucco* thus showing the presence of four and three distinct layers respectively in them. They consisted of the top layer of paint with a layer of some white material serving as *fine plaster* just underneath, with two layers of *rough plaster* in the case of the earth *stuccoes* and one layer in the case of lime stucco. The thicknesses of the different layers were as follows :

| | Earth Stuccoes | | Lime Stucco |
|---|---|---|---|
| | Deep red | Light red | |
| | mm. | mm. | mm. |
| Painted Stucco .. | 8–20·2 | 8·1–20·2 | 3·8–6·9 |
| Rough Plaster— | | | |
| First layer .. | 6·8–19·9 | 6·9–19·0 | 3·4–6·5 |
| Second layer .. | 1·0 | 1·0 | |
| Fine Plaster .. | 0·1 | 0·1 | 0·2 |
| Paint Film .. | 0·1 | 0·1 | 0·2 |
| Average thickness of of the painted stucco | 17·2 | 17·2 | 4·9 |

† On account of the softness of the *earth stucco* it was difficult to separate the different layers along the junctions. In the case of the *lime stucco*, such separation could be effected with greater ease.

The earth *stuccoes* are very much thicker than the lime ones. The paint film in the *lime stuccoes* is twice as thick as that on the earth *stuccoes*. In other words, the paint film on the *lime stucco* shows a certain lack of delicacy in the artists' handling of the brush. It is, therefore, probable that the *lime stucco* does not belong to the palmy days of Bagh, or that the paintings on the earth and lime stuccoes were done by different groups of artists.

*Size of the Particles in the Plaster.*—The rough plaster was carefully separated from the layer of *fine plaster* and the layer of paint film and gently crushed between fingers so as to avoid breaking the larger particles into smaller ones. The particles composing it were mechanically separated and graded according to size by Robinson's method.[8] The proportion and sizes of the particles were as follows :—

| | < 200 $\mu$ (Per cent.) | 200 $\mu$–700 $\mu$ (Per cent.) | >700 $\mu$ (Per cent.) |
|---|---|---|---|
| Earth Plaster : Bright red .. | 17 | 50 | 33 |
| Light Red .. | 20 | 40 | 40 |
| Lime Plaster .. | 60 | 40 | nil |

In the case of the earth plaster, particles smaller than 200 $\mu$ are mostly composed of laterite, silica and clay, while the larger particles are mostly of sand and laterite. In the case of the lime plaster, particles smaller than 200 $\mu$ are composed of lime, clay and sand, while the larger particles are mostly composed of sand.

The sand grains and particles of laterite are larger in size in the *rough plaster* than in the *fine plaster*, the latter containing minute particles whose diameters vary from 14 $\mu$ to 28 $\mu$. The use of coarse sand grains for the underlayers and finer ones for the top is recommended by artists in the West.[9]

*Analysis of the Plaster.*—In order to determine the method originally employed by the Bagh artists for preparing the *rough plaster*, its chemical composition was ascertained, the results of analyses of representative specimens being as follows :—

| | Earth Plaster | | Lime |
|---|---|---|---|
| | Deep Red (Per cent.) | Light Red (Per cent.) | Plaster (Per cent.) |
| Moisture .. .. .. | 0·27 | 0·42 | 0·91 |
| Carbon dioxide, $CO_2$ .. .. | 1·25 | 0·65 | 12·68 |
| Combined Water and Organic Matter .. .. .. | 0·55 | 1·03 | 9·34 |
| Silica, $SiO_2$ .. .. .. | 87·22 | 87·10 | 51·18 |
| Iron, $Fe_2O_3$ .. .. .. | 6·12 | 3·11 | 2·23* |
| Alumina, $Al_2O_3$ .. .. | 0·44 | 5·29 | |
| Phosphoric Acid, $P_2O_5$ .. | 0·12 | 0·10 | |
| Titanic Acid, $TiO_2$ .. .. | 0·09 | 0·07 | |
| Lime, CaO .. .. .. | 2·11 | 0·75 | 22·41 |
| Magnesia, MgO .. .. | 0·56 | 0·44 | .. |
| Manganese, MnO .. .. | 0·75 | 0·39 | .. |
| Sulphuric Anhydride, $SO_3$ .. | .. | .. | 0·04 |
| Alkalies .. .. .. | 0·44 | 0·62 | 1·21 |
| Nitrogen .. .. .. | 0·13 | 0·09 | .. |
| TOTAL .. | 100·05 | 100·06 | 100·00 |

* Only iron and alumina predominate, phosphoric acid and titanic acid occurring in negligible quantities.

Some of the scrapings of the *fine plaster* were completely freed from the paint film and the rough plaster. On treating them with dilute hydrochloric acid, they dissolved with effervescence and evolution of carbon dioxide with the separation of fine particles of silica. The acid solution gave reactions for calcium and for a sulphate, the latter occurring only in relatively small proportions. Thus the *fine plaster* was a mixture of lime and calcium sulphate which had been applied to the surface of the *rough plaster* to serve

as *fine plaster*.[10*] In the lime stucco, the *fine plaster* was composed of lime alone without any trace of calcium sulphate. Since it was impossible to get samples of the *fine plaster*, unaccompanied by *rough plaster*, the proportion of lime and calcium sulphate was not determined.

Thus the *ground* was prepared out of naturally occurring ferruginous earth or of artificially prepared lime plaster. The principal components of the earth plasters are silica, iron, alumina and lime. In the case of the lime plaster, the principal components are lime and silica.

The proportions of silica in the earth plasters are almost identical, while their colour seems to have been influenced by the proportion of iron. The proportion of lime present in the earth plasters is too low to have been purposely added to the original material. Hence it should have been present in the original materials as an impurity. The earth plasters are fairly firm and strong.† It will be shown below that the *rough plasters* do not contain any organic binding medium. Hence the consolidation of the earth plaster may be attributed to the plasticity of clay[11] present in it, and this is evident from the proportion of iron and alumina. In the case of the lime plaster, lime and sand contribute to the firmness and strength of the plaster.[12] The plasters have also been reinforced and bound with vegetable fibres,[13] the lime plaster containing considerable quantities of them.

The percentage of alkalies and sulphuric anhydride in the earth plasters is low. In other words, presence of soluble salts and of gypsum which gives rise to efflorescence on the surface of the paintings can be ignored. The other impurities in the earth plasters are not of much significance in reconstructing the technique of the painting process or in affecting the permanence of the paintings.

From the small proportion of iron and alumina in the lime plaster, it is clear that the percentage of clay in it is very low. Thus a pure rich lime having no hydraulic properties has been used. From the low percentage of sulphuric anhydride, one can ignore the presence of gypsum, which

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* *Fine plaster* of gypsum has been used in the wall paintings of Bamiyan in Afghanistan and Kizil in Chinese Turkestan, which had cultural contact with India.

† In *The Bagh Caves* (London: India Society), 1927, pp. 16–17, Sir John Russel remarks that, "the rinzaffo is less tenacious than at Ajanta—a fact that has contributed in no small measure to the deterioration of the paintings." This is to be attributed to the larger proportion of clay in the Ajanta plaster than in the Bagh ones. Further, the Ajanta plaster has a larger proportion of vegetable fibres in it than the Bagh plaster has. This has also contributed to the better consolidation of the Ajanta plaster.

Bagh, fresco-painting. A part of an elephant procession

prevents the setting of mortar and causes efflorescence to appear on the surface of the paintings. The small proportion of impurities such as alkalies and other soluble salts, the firm adherence of the plaster and the absence of slaking on the *ground* indicate that special attention should have been paid to the preparation of lime.[14]

*Inert Materials in the Plaster.*—Since the consolidation of the earth plasters is due to the plasticity of clay present in it, silica, iron, manganese and lime (present as the carbonate) are the inert materials. Silica alone occurs to the extent of 87%. In the case of lime plaster, the results of chemical analyses show that sand alone is the inert material, for a pure rich lime without the admixture of an inert material would not have yielded a satisfactory plaster.[15] But further experiments[16] conducted show that marble dust (which was invariably used with the Italian frescoes and which give the same chemical reactions as carbonated lime) is not present in the plaster. But the plaster contained particles with density 2·72[16]. The silica present in the plaster was associated with hydrated yellow oxide and anhydrous red oxide of iron, thereby showing that unburnt limestone has been added to the lime for preparing the plaster or that partially burnt limestone has been used for the purpose.[16] The sand grains serving as the inert materials looked sharp and angular and have contributed to the firmness and strength of the plaster.[17]

*Technique of laying the ground.*—The percentages of combined water and organic matter in the two earth plasters and in the lime plaster are 0·55, 1·03 and 9·34 respectively. That this is not due to the presence of any organic binding medium like drying oil, glue, albumin or casein is proved by the absence of any stain[18] when the plaster is acted upon by methylene blue, methyl violet, acid green or iodoeosin. Thus the organic matter present in the plaster must be the vegetable fibres and some organic impurities. In the case of the *rough plaster* of lime, a sample of it softened considerably under the action of water. On treating it with dilute hydrochloric acid, it disintegrated with evolution of carbon dioxide and separation of silica, the acid solution giving tests only for calcium. Thus the lime plaster has been composed of a mixture of burnt and unburnt limestone or of limestone partially burnt, and hence lacking in consolidation. The approximate probable composition of the limestone used for the preparation of the plaster seems to be as follows :—

| | (Per cent.) |
|---|---|
| Calcium carbonate, $CaCO_3$ .. | 44·17 |
| Silica, $SiO_2$ .. .. .. | 53·30 |
| Iron and Alumina, $Fe_2O_3 + Al_3O_2$ | 2·45 |
| Calcium sulphate, $CaSO_4$ .. | 0·08 |
| TOTAL .. | 100·00 |

The *fine plaster* did not soften when acted upon by water. Otherwise its behaviour towards staining agents and dilute hydrochloric acid was exactly similar to that of the *rough plaster* of lime. Thus lime has brought about the consolidation of the *fine plaster*.

*Method of laying the ground.*—From experimental results it is clear that the artists applied the first coat of earth plaster or of lime plaster containing vegetable fibres. The former received a second coat of rough plaster of earth to a thickness of 1 mm. The total thickness of the *rough plaster* varied from about 7·8 mm. to 20 mm. and from 3·4 mm. to 6·5 mm. respectively depending upon the inequalities of the surface of the *carrier*. While the ferruginous earth was naturally occurring, the lime plaster had been prepared either by mixing burnt and unburnt limestone or by partially burning the limestone, and preparing the plaster out of it. The *rough plaster* has been given a coat of *fine plaster* containing a mixture of lime and calcium sulphate in the case of the earth plaster and of lime alone in the case of lime plaster and the surface smoothened.

(3) *The Pigments.*

The following pigments were identified[19] in the paintings at Bagh :—

Yellow ochre.
Red ochre.
Terre verte.
Lapis lazuli.
Carbon.
Lime.

Over the lime plaster, the pigments that were identified were the yellow and red ochres, carbon and lime. Thus the colour scale is very limited. Evidently only those colours which were easily available locally were employed.

(4) *The Binding Medium.*

The paint film is fairly adhering to the plaster. It easily disintegrates when soaked in cold and boiling water and no gum could be extracted with

water from it. No vehicle or organic binding medium could be extracted from the paint film with ether, carbon disulphide and chloroform used separately and successively. There was no stain on the paint film when it was acted upon by methylene blue and methyl violet, but acid green stained the paint film thereby showing the presence of glue as a binding medium.[18] When a small particle of the paint film was covered with a drop of water, a glue ring with characteristic glue crackle formed on evaporation of the water.[20] Thus a *tempera* technique had been employed in the execution of the paintings. With a few samples of the earth stucco, no stain was developed on the paint film either with acid green or iodoeosin. On treatment with dilute hydrochloric acid, such paint films disintegrated with evolution of carbon dioxide, the acid solution giving tests for calcium. This reaction was characteristic of the paint film on all the samples of lime plaster collected. But the pigments had not interfused or spread beneath the plaster *ground*, and hence the technique is one of *lime medium*.[21] This is to be expected for the layer of lime on the earth plaster is too very thin for the *ground* to remain wet for sufficient time for *true fresco* process to be adopted. In the case of the lime stucco, the *rough plaster* has not well consolidated on account of the poor quality of the lime which is mostly unburnt while, for the *true fresco* process, well burnt and well slaked lime is used.[22] The *fine plaster* on the *rough plaster* is too thin to retain any moisture for any considerable time for the paintings to be done in the *true fresco* style.

Black wets poorly and a little gum or glue must be added to it before grinding.[23] A sample of the black paint gives the usual stain for glue with acid green.[18]

Since the paintings have been done either in *tempera* or in *lime medium*, it is very difficult to say the extent of the *ground* that was covered in the course of a single day from a detailed examination of the joinings of day-to-day's work.[24] Joints in the plaster are more easily visible in *true fresco* than in *lime medium*. Further colours employed for the background makes it difficult to detect any joint.

In conclusion, the author wishes to express his thanks to Mr. M. B. Garde, Director of Archæology of the Gwalior State, who took the trouble to collect the samples of *painted stuccoes* on which investigation were carried out, and for his generous help, to Mr. J. F. Blakiston, formerly Director-General of Archæology in India and to Rao Bahadur K. N. Dikshit, Director-General of Archæology in India, for their great interest in the subject.

## REFERENCES


1. *Transactions of the Literary Society of Bombay*, **2**, 206–14.
2. *Journal of the Bombay Branch of the Royal Asiatic Society*, **4**, 543–573.
   *Indian Antiquary*, **39**, 225.

Sir John Marshall and others — *The Bagh Caves in the Gwalior State* (London : India Society), 1927.

Burgess, J. .. — *Notes on Bauddha Rock Temples of Ajanta, their Paintings and Sculptures and on the Paintings of the Bagh Caves* (Bombay Government Central Press), 1879, 94–95.

Benjamin Rowland and others — *The Wall Paintings of India, Central Asia and Ceylon* (Boston : Merrymount Press), 1938, pp. 79–81.

———— .. — *Loc. cit.*, pp. 79–81.

3. Sir John Marshall and others — *Loc. cit.*, p. 22.
4. ———— .. — *Loc. cit.*, p. 5.
5. Daniel V. Thompson .. — *The Materials of Medieval Painting* (New Haven : Yale University Press), 1936, pp. 43–47.
6. ———— .. — *Loc. cit.*, p. 39.
7. S. Paramasivan .. — " Technique of the Painting Process in the Temple of Vijayalaya Cholisvaram in the Pudukkottai State," *Proc. Ind. Acad. Sci.*, 1938, **7**, 284.
8. Norman G. Comber .. — *An Introduction to the Scientific Study of the Soil* (London : Arnold), 1927, 48–49.

G. W. Robinson .. — *Soils : Their Origin, Constitution and Classification* (London : Murby), 1932, 12–13.

9. A. P. Laurie .. — *The Painter's Methods and Materials* (London : Seeley & Co.), 1926, 197.
10. Rutherford, J. Gettens .. — " The Materials in the Wall Paintings of Bamiyan, " *Technical Studies*, 1938, **6**, 186.

———— .. — " The Materials in the Wall Paintings from Kizil in Chinese Turkestan, " *Technical Studies*, 1938, **6**, 283.

11. Searle .. — *The Chemistry and Physics of Clays and other Ceramic Materials* (London : Ernest Benn), 1924, 262–63.
12. J. W. Mellor .. — *A Comprehensive Treatise on Inorganic and Theoretical Chemistry* (London : Longmans, Green & Co., 1923, **3**, 677.
13. .. — *Encyclopædia Britannica*, 14th Edition, **18**, 39–40.
14. Max Doerner .. — *The Materials of the Artist and their use in Painting*, translated (New York : Harcourt, Brace & Co.), 1934, 269.

15. S. Paramasivan .. *Loc. cit.*, p. 286.

16. *a* ———— .. *Loc. cit.*, p. 286-87.

16. *b* ———— .. *Loc. cit.*, *p.* 287.

16. *c* ———— .. *Loc. cit.*, p. 287.

17. ———— .. *Loc. cit.*, 284.

18. William Ostwald .. "Iconoscopic Studies (Microscopic Identification of Homogeneous Binding Mediums)," translated, *Technical Studies*, 1935–36, 4, 138–42.

19. Martin de Wild .. *The Scientific Examination of Pictures* (London: G. Bell & Sons, Ltd.), 1929.

Rutherford J. Gettens and G. L. Stout "The Stage Microscope in the Routine Examination of Paintings," *Technical Studies*, 1935-36, 4, 224–28.

20. ———— .. "The Materials in the Wall Paintings of Bamiyan, Afghanistan," *Technical Studies*, 1938, p. 190.

21. Mary Hamilton Swindler *Ancient Painting* (New Haven: Yale University Press), 1929, p. 418.

22. A. P. Laurie .. *Greek and Roman Painting* (Cambridge: University Press), p. 83.

23. S. Paramasivan .. "The Mural Paintings in the Brihadisvara Temple at Tanjore—An Investigation into the Method," *Technical Studies*, 1936–37, 5, p. 283.