Conservation and Restoration Research on 2nd BCE Murals of Ajanta

M.Singh[1*] and B.R.Arbad[2]*

Abstract

This paper outlines new approach for the removal of varnish coatings from the surface of wall paintings. Covered under very thick layers of different kinds of varnishes applied in the past for copying, the few sq.mt. 2nd BCE painted plaster still surviving in cave no 9 and 10, Ajanta pose most difficult task of cleaning the historic surfaces. The paintings diagnosed to be executed on a very thin lime plaster ground with inorganic colors by portable XRF; the FTIR spectra of the pigments and lime ground denote that varnishes have seeped through due to its repeated application in the past. The usual organic solvents mixture technique being used as well as the micro-emulsion technique applied for cleaning proved non-effective in the treatment of that part of the paintings covered with thick bats excreta. Microclimatic condition and state of conservation of painted plasters are also discussed.

Introduction:

One of the biggest challenges in the cleaning of the painting is the removal of substances from the surface of the painting having chemical composition quite different to the original material[1]. In the past many different kinds of varnishes such as shellac, copal, mastic, polyvinyl acetate etc. have been widely used as consolidant or protective coating for the conservation of wall paintings. At Ajanta, many of these varnishes found to be applied repeatedly in cave no 9 and 10 (2nd BCE) for the purpose of copying the paintings in 19th century by various artists ever since its discovery in the year 1819.

The Japanese copyist of 1916 Mr. Kampo Arai wrote about the condition of paintings during copying, "When British conducted their reproduction activity, they covered entire wall surface with varnish which made the surface greasy and rather unpleasant appearance and changed colour of the paintings from the original". Finally, the Italian conservators of Ajanta paintings applied shellac varnish as preservative on painted surface without removing the earlier varnish coats in the year 1920. Moreover, looking towards the history of scientific cleaning of the painted surface in India, it is observed that acrylic polymers are still being used as consolidant and protective coating. It is also observed that in certain instances following removal of acrylic polymers from the painted surface, the same materials was subsequently applied as protective coat to the painting[2].

The most serious problems associated with all these materials are related to change in their physico-chemical property due to their natural aging[3]. Thermal and photo-chemical reaction of these materials alter the colour and physical appearance of the surface, causing mechanical stress to the paint layers that lead to formation of cracks, ridges, gaps, lacuna etc on the painted surface[4]. They also result in the alteration of physico-chemical property at the interface between the work of art and its environment. One of the main

[1] Archaeological Survey of India, Science Branch, Western Zone, Aurangabad-431004
[2] Department of Chemistry, Dr.Babasaheb Ambedkar Marathwada University, Aurangabad-431004)
*For correspondence (e-mail:abr_chem@yahoo.co.in or m_singh_asi@yahoo.com)

consequences of polymeric degradation of these materials is the drastic loss of their solubility[3] which makes their removal much more difficult by using conventional mixed solvent system for cleaning the painted surface presently being applied at Ajanta. It is also noticed that reversibility of previous coating with polymer is reduced with time.

Since the conservation of historic surface can often cause chromatic alteration, it is essential to minimize this impact through the development of new conservation methods and materials or improvement of those already in use. Hence, one of the biggest challenges the conservators face is the removal of substance that have a different chemical composition from the original materials. The complete removal of these materials is often a delicate problem due to heterogeneous and porous nature of the support. The use of organic solvent mixture on porous surface for cleaning can also result in the partial redistribution of the unwanted substances through the porous ground. The frequent appearance of chalkiness on the cleaned surface of cave no. 17 murals at Ajanta is attributed to this factor[5]. However, controlled cleaning with the minimum use of same solvent mixtures have not produced any chalkiness over a period of 15 years during the cleaning work of many square meters of painted surface in various cave at Ajanta[6]. A solution to this problem can also be found by using micro-emulsion in which the dispersed solvent phase is specifically tailored to solublize the substance that are to be removed[7]. The micro-emulsion is stabilized by the surfactants which have polar and non-polar group. With this the environmental impact of previous treatment technique is drastically reduced in closed cave interiors[8]. The re-distribution of the solublized material into the porous ground is avoided since the solublization takes place within the core of the micro droplets. This system is also stable throughout the wide range of environmental operating conditions.

Both these techniques were successfully employed in the cleaning of few sq. meters of painted surface in cave no 10 left wall by the side of stupa at Ajanta. However, the techniques could not produce any result during the cleaning operation of some other painted plaster within the same panel which were found badly infested with bats excreta and totally dried out. These papers outlines the techniques employed and stress the need for finding newer methodology for cleaning painted surface having thick bat excreta that has seeped through the porous surface into the interior of the painted plaster. Large parts of bats droppings have also made the upper part of the painted plaster illegible.

General condition of the cave 10, Ajanta

One of the major reasons for damage to the paintings at Ajanta is the roosting of bats in the corner and dark part of the cave interiors ever since these caves were abandoned in 6th A.D by Buddhist monks. During this period the façade have fallen, the pillar, support and walls in the many caves also fell and in some caves the rain water which is supposed to flow into the ravine of Waghura River has entered inside the cave. Photograph (1A) shows the condition of the cave no 10 in 19th century when muddy water flowed inside the cave causing damage to the structure and paintings up to 4-5 feet from the floor level of the cave. In the long run this has also caused crumbling and falling of pillars, wooden rafters etc. into the cave interior. Major structural conservation measures were taken in the form of removing the filth from the cave interior and making new support pillars as per requirements, photo (1B).

Photo 1A- Showing Cave no 10 in 19th Century.
Photo 1B- Showing Cave no 10 at Present.

As the cave no 10 has the largest opening at Ajanta, wire mesh in wooden frame were fitted so as not to allow any bats/birds to enter inside the cave. A few square meters of painting belonging to 2nd BCE that survived on both side walls of cave no 10, were also damaged by visitors graffiti. To save the paintings from graffiti, it was caged under glass on both the side wall. However, 3-4 sq.mt. 2nd BCE painting surviving on the left side wall by the side of the stupa above 8 feet from the floor of the cave were left as such without any cover. As the painting work were executed by the side of the stupa behind the pillars, the place is always dark compared to front portion and on this part of the paintings much bat excreta are noticed. Atmospheric condition of the cave has dried the excreta into a compact mass within the painted surface. Figure- 2 shows the plan of the cave no. 10 Ajanta with area marked where conservation treatment was carried out.

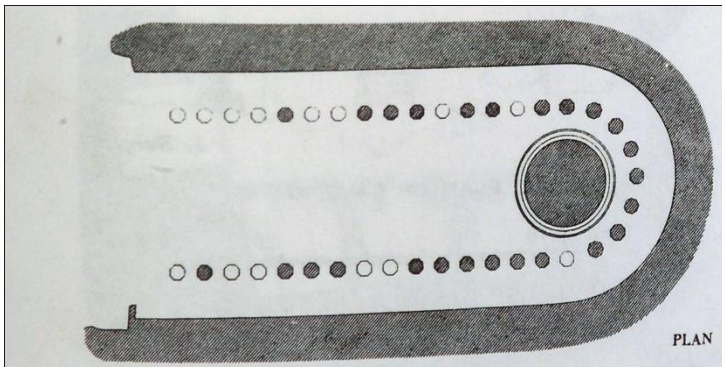

Figure- 2 showing ground plan of cave no 10, Ajanta

Outlines of the painted surface

As this part of the paintings were repeatedly applied with varnish coating for copying under the light of oil lamp in 19th century, the whole painted figure were totally covered under varnish layers accompanied with dirt, dust, smoke etc. Large expanses of bats dropping have made the painted surface further illegible by naked eye. Before undertaking any cleaning operation, it is essential to have at least a primary knowledge about the design and shape of the painted figures for ease in treatment. The panel painting was observed under an adjustable illuminated magnifier. The paintings were observed by this process though the thick layer of varnishes. Figure-3 shows the original condition of painted plaster and outlines drawn after examining the painted surface through thick varnish layer under magnifying lenses. As from the outside no figures are visible to naked eye due to thick varnish coats, the outlines helped the conservators in planning the conservation operation.

Figure-3 showing the original painted plaster and its outlines.

IR image of the painted surface

The painted surface was also observed under infra red light to visualize the painted surface and its condition. Figure-4 shows the view of the painting under IR light source. The outlines of the figures are very clearly visible under the IR light which is very thin and sharp, an essential characteristic of 2nd BCE painting. The missing part of the painting can now be easily seen. The bat excreta and soluble salts accretions over the painted surface is clearly visible. This has clearly given primary information about the painted figures, varnish layers and accretions present on the historic surfaces.

Figure-4 showing painting under IR light source

XRF Analysis:-

Pigment analysis using portable energy dispersive X-ray fluorescence (ED-XRF) was carried out in this cave along with Italian conservation team[9]. The technique identifies the elements present and not the compounds that make up the materials under study. This limitation cannot be considered a handicap as it is possible to establish the pigments from the presence of particular elements, associated with the colour analysed.

As already reported[10] the most ancient 2nd BCE paintings of cave no. 10 is executed on lime plaster ground on a basaltic rock support which has been chiseled into a smooth surface. As compared to other 2nd BCE painting existing in cave 10, the pigment and plaster layer thickness of the panel painting under question is very thin. The approximate thickness of various layer are: - Lime plasters layer ~0.5 mm

Pigment Layer <0.5 mm

Varnish layer (uneven) ~0.5 to 1 mm

The lime plaster was found applied in one layer, the outer surface of which was smoothened to receive the colors. As obtaining sample of sufficient size is a major problem in this case, it was proposed to apply non-destructive technique to get information about the composition of support and pigments applied in this cave painting. Portable XRF was used for this purpose and the data obtained is shown in table-1 for lime, mud &pigment layers of cave 10, Ajanta.

Table-1 Showing data for lime, mud &pigment layers, cave no 10, Ajanta.

Sr.no.	Colour	Description	ca	Fe	As	pb	Sr.
1	Brown-red	figure	115	101	900	-	18
2	Yellow	figure	136	96	99	-	-
3	White	figure	70	850	-	18	88
4	White	lime plaster	51	30			
5	Grey	mud plaster in Arch (Thin layer)	41	173			
6	Grey	mud plaster in Arch (Thick layer)	33	113			

The data indicates that pigments used in 2nd BCE paintings are inorganic in nature mostly yellow ochre or orpiment for yellow, red-ochre or realgar for red and lime for white. The 2nd BCE paintings on both the side walls have been executed on a thin lime plaster ground whereas the paintings in the arch of the same cave have been executed on grey colour mud plaster containing ferruginous earth and pertains to the period of 3-4th A.D since it is of different artistic significance than the 2nd BCE paintings. It was also observed that stone surface in the arch is very rough so as to receive and hold the mud plaster layer. In contrast the side walls of the cave have been smoothened as the lime plaster can easily hold to such surface.

FTIR images of pigments and plaster:-

Few grains of pigment and lime plaster support from the panel were observed under FTIR spectroscopy. Figure-5 shows the FTIR image of lime support. The main functional group observed are FTIR cm^{-1} 3404 (phenolic OH), 1620(NH), 1392(NO2) (C-N of amine), 781 (phenyl). From the above it is clear that the sample contains various groups like phenol, amine, nitro & alkenes which are the major component of copal, mastic or shellac

varnishes. From this, it can be claimed that during the process of copying the paintings in 19th century the varnishes have seeped into the lime layer since as per record the paintings were never been cleaned so for.

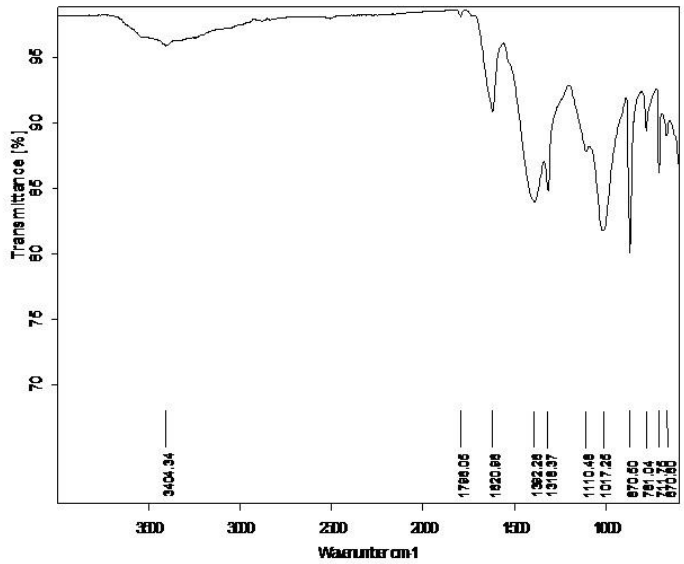

Figure-5 showing FTIR image of lime support Cave no 10

FTIR image of pigment grain is shown in figure 6. The main functional group identified through FTIR spectra are 3043(phenolic OH), 1619(NH), 1390(NO2), 1112 (C-N of amine), 779 (phenyl).From this, it is clear that the sample contains various groups like phenol, amine, nitro &alkenes which are the major component of copal, mastic or shellac varnishes. As the pigment layer is the outer layer of the painting, the intensity of the groups in the spectra of pigment is more as compared to the intensity to the lime spectra. From the above studies it can be claimed that varnishes have seeped through the painted layer into lime support.

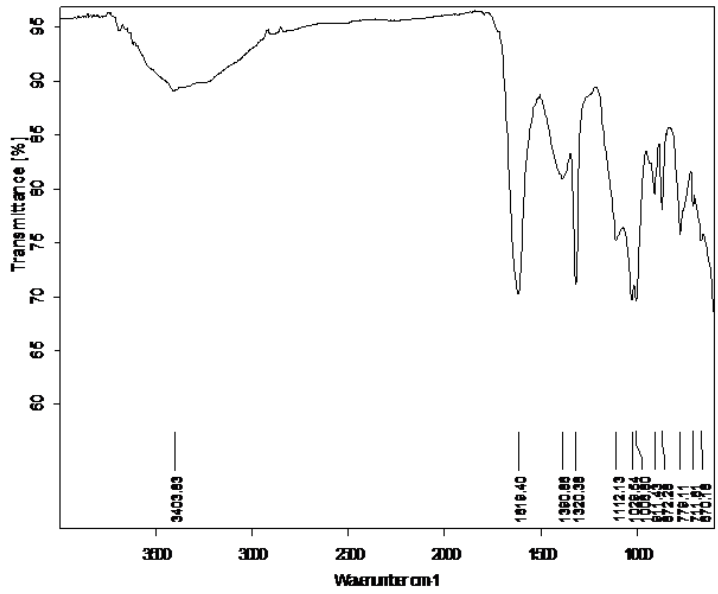

Figure- 6 Showing FTIR image of pigment grain Cave no 10.

Microclimatic condition of the cave:-

Cave no. 10 has one of the widest open door arches at Ajanta which is about 75 feet in height and 40 feet in width. The door arch is fitted with iron mesh in wooden frame, the upper part of which is closed with tinted glass leaving about 10 feet height from the floor all along the width for air circulation through iron mesh. This has inhibited entering of birds and insects into the cave interior. The basaltic rock on the outside of cave no 10 get heated up considerably in sunny days and heat radiation enters the cave with wind through the opening of wire mesh

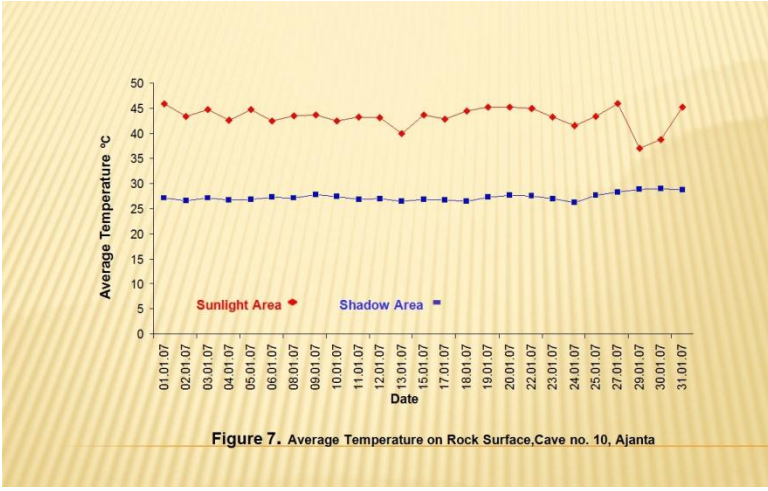

Figure 7. Average Temperature on Rock Surface,Cave no. 10, Ajanta

Figure-7 shows the surface temperature of basalt rock both in the sun lighted area and shadow area. As cave no 10 does not have any porch to stabilize temperature /humidity as in cave no 1, 2,11,16,17 etc. at Ajanta, there is a direct bearing of these parameters inside the cave[11]. The comparison of data recorded using the data logger and spot measurement for measuring temperature and humidity in the case of cave no 17 was found highly satisfactory and confirms the suitability of both the methods of measurement. Spot measurement of temperature and humidity both inside (near the center of the cave) and outside shadow area of cave no. 10 Ajanta was carried out from 10.02.2007 to 31.10.2007. Figure 8 and 9 show data for temperature and humidity both inside and outside cave 10 Ajanta.

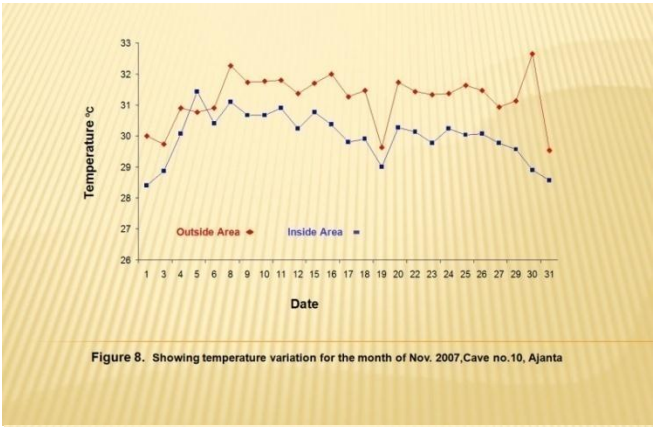

Figure 8. Showing temperature variation for the month of Nov. 2007,Cave no.10, Ajanta

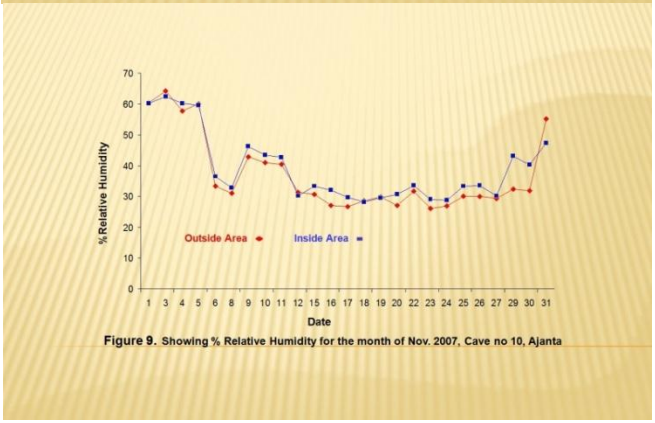

Figure 9. Showing % Relative Humidity for the month of Nov. 2007, Cave no 10, Ajanta

From the graph it is observed that the temperature inside the cave is approximately in consonance with the temperature in shadow area outside the cave as difference noticed is about 1 to 1.5°C. From the hygrometric graph, it is also observed that inner part of the cave is just 2 to 3% more humid than to the one under shadow area outside the cave. This is only due to reason of wide opening of this cave through which air circulation is possible thus the atmospheric condition of cave no 10 is quite in contrast to other caves at Ajanta. It is also observed that drop in humidity inside the cave are closely related to the humidity outside due to proper circulation of air and absence of any porch. In order to better assess possible spatial gradients linked to the shape of the cave and the distribution of visitors, grid survey was carried out. The result has, however marked homogeneity in the temperature and humidity values. The maximum variation in temperature and humidity is noticed near the entrance door. The maximum spatial thermal gradient is around 0.5°C and hygrometric variation of 1% noticed inside the cave. The temperature is always above 25°C and this confirms low probability of condensation on the painted surface and moisture content level on the painted wall.

Methodology for conservation

The panel painting was brushed very softly for the removal of adhering dust, dirt, etc. from the surface followed by general cleaning with ethyl alcohol with the help of cotton swab. Many gaps, lacuna, cracks etc. noticed on the painted surface were fixed by slowly injecting lime plus casein mixture and pressing the surface with rubber roller. The painted surface was left as such for about 2 months for proper consolidation of loose and defective parts.

For scientific cleaning of the paintings two different technique were applied. In the first technique, the mixture of organic solvents, two component system as described elsewhere[10] was used to clean the surface with the help of cotton buds. In this process, it was ensured that the minimum quantity of cleaning solvent mixture was used for removing accerationary deposits of varnishes, dust, dirt, smoke etc. without giving any chance for the chemical mixture to seep into the ground of painting. The process is very delicate and exclusively depends on the dexterity and precision of the conservators. As the pigment layer in this panel is too thin, during cleaning operation it was not possible to reach up to the pigment surface with human eye due to great fear of losing any grain of pigment during the process of chemical treatment. Hence, the cleaning operation was carried out for superficial removal of 75-80% of varnish layer leaving 20-25% margin for cleaning by other sophisticated technique in future. The main purpose of the treatment was to reduce the thickness of varnish layer to render

the underlying surface to breath. Highest dexterity and precision was taken during the operation and figure-10 shows the before/after conservation work of the painting executed through this technique.

Figure-10 showing before/after conservation photographs Cave no 10, Ajanta.

As the solvent mixtures applied in the above technique are slightly harmful for conservators, it was proposed to replace it with micro-emulsion technique. For this 1.0 gm of citric acid was dissolved in100 ml of deionized water. This solution is added into 1.5 gm of carbopole (polyarcylic acid) with constant stirring followed by addition of 5.0ml of triethanolamine drop wise with stirring. This will form a gel namely solvent-gel chelante. For cleaning the painted surface following solutions were also prepared.

A. Petroleum spirit- 15ml B. Acetone- 1ml C. Dimethyl sulphoxide- 25ml Dimethyl sulphoxide-5ml Ethyl alcohol- 4 ml. Ethyl acetate- 50ml

Isobutyl ketone- 25ml

D. Dimethyl sulphoxide- 1 part E. Dimethyl sulphoxide 60 ml (pH adjusted to about 8.5 using ammonia)

Ethyl acetate- 1part Isobutyl ketone 40 ml

On the specific area, the Japanese tissue paper is stick with the appropriate concerned solution. The solvent gel chelante and concerned solution mixed properly is applied on Japanese tissue paper with fine brushes very gently. The solution is spread equally on the tissue paper and kept for 5, 10, 15 & 20 minutes as per thickness of the varnish layers. After this the tissue paper was removed and the surface cleaned slowly with concerned solution with vey soft brush with great precision and dexterity. Again precaution was taken not to reach up to the pigment layer and 15-20% of varnishes were left as such due to fear of losing any grain of pigment layer. Figure -11 shows the painting cleaned by this technique in this panel. All the chemicals used in the cleaning are the AR grade chemicals as supplied by the firm.

Figure-11 showing before/after conservation Photographs Cave no 10, Ajanta.

As we moved little inner in the same panel, it was noticed that the painted surface has suffered due to hard and dried bats excreta. Attempt to clean the surface with both the above technique proved futile. As many part of the painting in the inner area and corner are infested with bats excreta in Ajanta cave, there is need for proper research to find exact methodology for cleaning such historic surfaces**.**

Acknowledgement

We thank The Director General and the Director science, Archaeological Survey of India for help and support extended for this work**.** The help extended by Shri. R.S.Trambake, Project Modeller, Shri. A.S.Patil, Asst.Archl.chemist, and Shri. N.E.Mahajan, Photographer Ajanta is gratefully acknowledged.

References:

1. Tintori L, Studies for the preservation of the frescoes by Giatto in the Scrovegni chapel at padua,

the state of conservation of the frescoes and the principal technical conservation problems, studies in Conservation, No. 8,1963, pp.37-41.

2. Hari C.V,Materials for Conservation: organic consolidants, Adhesives and Coatings, Ist edn.,Architectural press(Butterworth-Heinemann),oxford,1987.
3. Feller R.L., 'Influence of wavelength',in Accelerated Aging-Photochemical & Thermal Aspects, ed.R.L.Feller,The Getty Conservation Institute, Los Angelos, 1994,pp.63-90.
4. Morimotto K. and Suzuki S.,Ultraviolet Irradiation of Poly (alkyl acrelates) and Poly (alkyl methacrylates),Journal of Applied Polymer Science 16,1972,pp.2947-2961.
5. Mathur M.S, Conservation of Cultural Property in India, Proceeding of 3rd National Seminar, 1968, pp. 10-14.
6. Singh M. and Trambke R.S.,The Hinyayana Paintings of Ajanta and their Conservation, Festschriff for Dieter Schlingloff on the occasion of his Eightieth Birthday, Vol II,2010, pp. 939-946.
7. Ferroni E, Gabrielli G. and Caminati G. Removal of hydrophobic imprurities from pictorial surface by means of heterogeneeens system, Science and Technology for Cultural Heritage,4(2),1995,pp. 67-74.
8. Rance. D.G, and Frieberg S., Miscellar solutions versus micro emulsion, Journal of Colloid and Interface Science, 60,1977,pp.207-209.
9. Artioli. D.,Capanna F., Giovagnoli A., Ioele M., Marcone A., Mariottini M. and Singh M., Mural paintings of Ajanta caves, part II: Non-Destructive Investigation and Microanalysis on Execution Technique and state of Conservation,9th International seminar on NDT of Art, 2008, Jerusaleme, Israel.
10. Singh M., Trambake R.S., and Gupta D.A, Chemical Conservation of Hinyana Paintings 2nd BCE, Cave no.10,Ajanta, Art, Myths and Visual Culture of South Asia,Warsaw Indological studies, 4,2011,pp.251-259.
11. Singh M., Microclimatic Condition in Relation to Conservation of Cave no 2 Murals of Ajanta, Current Science, Vol.101, No.1,2011, pp. 89-94.