Replication of rock paintings at Chaturbhujnath Nala
on Bhanpura plateau in Chambal Valley, India - Part 3

Pigment selection and their processing for replication of rock painting compositions: A preliminary study

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Summary

Haematite and red ochre were the most popular pigments used in the rock art of Chaturbhujnath Nala (CBN). Most of the early rock paintings in this period have been executed in line drawings in dark red colour, sometimes, with dark brown tone. We did experiment to understand the selection of the pigments used and their processing to obtain colour from them by replication process. Our team collected iron oxide pigment nodules from the area near Chaturbhujnath temple in March 2019 and again in April 2021. We short listed ten pigments, and produced a colour scale based on the variety, intensity and visual appearance. We observed that darkness of the colour was directly proportionate to the hardness of the pigment nodule and it required physical work accordingly.

The scientific analysis of the pigments will be followed in the second phase of the project. However, the present experiment throws light on the abilities of the authors of rock art to find the source and collection of the desired pigment nodules, the processes of obtaining colour from them, and their choice of pigments to execute the desired rock art compositions. It indicates about the cognitive abilities of the authors of early rock paintings of CBN, and the socio-cultural aspects involved in it.

Keywords: Rock art replication, Pigments, Processes, Socio-cultural aspects, Chaturbhujnath Nala

Riassuno (Scelta dei pigmenti e loro lavorazione per la replica di composizioni di pitture rupestri: uno studio preliminare)

L'ematite e l'ocra rossa sono i pigmenti più usati nell'arte rupestre di Chaturbhujnath Nala (CBN). La maggior parte delle pitture rupestri più antiche sono state realizzate al tratto con colore rosso scuro oppure marrone. Per arrivare a replicare queste opere sono stati necessari molti esperimenti, per individuare i giusti pigmenti e le tecniche necessarie per ottenere il colore.

Il nostro team ha raccolto noduli di ossido di ferro dall'area vicino al tempio di Chaturbhujnath nel marzo 2019 e di nuovo nell'aprile 2021. Abbiamo selezionato dieci pigmenti e prodotto una scala di colori basata sulla varietà, l'intensità e l'aspetto visivo. Abbiamo osservato più il nodulo era duro, maggiore era l'intensità e la gradazione del colore e d conseguenza maggiore era lo sforzo fisico per ottenerlo.

Le analisi di laboratorio saranno eseguite nella seconda parte del progetto. Tuttavia, il presente esperimento mette in luce le capacità degli artisti preistorici di trovare i noduli e raccoglierli, la conoscenza dei processi per ottenere il colore, la padronanza della relazione fra la qualità della materia prima e il pigmento ottenibile da essa, la capacità progettuale per eseguire le composizioni di arte rupestre desiderate. Tutte queste osservazioni ci danno un quadro sulle capacità cognitive degli autori delle prime pitture rupestri del CBN e sugli aspetti socio-culturali coinvolti in esso.

Parole chiave: Riproduzione dell'arte rupestre, Pigmenti, Processi, Aspetti socio-culturali, Chaturbhujnath Nala

1. Introduction

Haematite and red ochre were the most popular pigments used in Chambal Valley, former especially in the Stone Age paintings (Mesolithic and Upper Palaeolithic). Haematite is basically an iron oxide ore with a molecular formula of Fe2O3. Its colour is red, reddish brown to brown, black to steel or silvery grey. This ore is much harder than pure iron but also very brittle. Ochre is a natural clay earth pigment which is a mixture of ferric oxide and varying amounts of clay and sand. It ranges in colour from yellow to deep orange or brown. Besides, black pigment obtained from Manganese minerals was used in bichrome paintings. White is also used in Gandhisagar, but rarely in Chaturbhujnath Nala.

The early rock art of Chaturbhujnath Nala belongs to Pre-cattle domestication Stone Age period I, Mesolithic. Most of the rock paintings in this period have been executed in line drawings in dark red colour, sometimes, with dark brown tone. While, most of the rock paintings of period 2, Cattle Domestication phase, have been done in different shades of ochre. We did experiment to understand the selection of the pigments used and their processing to obtain colour from them by replication process in April 2021. Our team collected iron oxide pigment nodules from the area near Chaturbhujnath temple in March 2019 and April 2021.

Study of the pigment used for the execution of the compositions, finding the similar pigments from the

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field, their processing and execution process form one of the major factors for understanding the cognitive, technological and cultural development of the authors of rock art in different periods. We tried to follow these aspects in our study and understanding of the nature and behaviour of the pigments.

2. Pigment analysis: literature review

The major experiments made on the analysis of rock paintings in the overseas countries have been discussed in the Part I of our replication project (Kumar *et al.* 2021, in the current volume). In Indian context Late S. Subbarao and S. S. Kamavisdar of the School of studies in Geology, Vikram University, Ujjain, on the request of V. S. Wakankar, analysed the pigment obtained from the excavations at Bhimbetka and Modi respectively (Subbarao 1980, Kamavisdar 1980). Subbarao found that Copper compounds were used to produce a bright shade of green. Black or deep purple was obtained from Manganese oxides. To provide colour in red, yellow or brown, haematite or other oxides of Iron were used. Kaoline and kankars were used to obtain white pigment. Kamavisdar on analysing the pigments from Modi excavations, observed that the solubility of the pigments only in inorganic acids, and the absence of any band in the Infrared spectrum in between the wave number (cm^{-1}) 2000 to 2300 and then up to 2900 indicate that Modi pigments are inorganic in nature. Again, he says that Modi pigment is a complex matter of haematite, Iron, Sulphur, Phosphorus and Silica along with Aluminium, Magnesium and Calcium in little amounts (Kumar 1983, pp. 330-331).

Tej Singh and Kamal K. Jain analysed the pigment samples from Mirzapur rock paintings, provided by Rakesh Tewari (Singh and Jain in Tewari 1990). They used Emission Spectrographic Analysis and X-Ray Differection Studies. They observed the presence of minerals gypsum (CaSO4.2H2O) and haematite (Fe2O3) in all the samples. However, gypsum was the main mineral in all the four samples analysed. The presence of haematite, the main constituent of Red Ochre, in samples 2-4, which are blackish red in colour, indicates that red ochre was used as pigment in these paintings.

Katta Ganeswar Rao and his team analysed the rock painting pigments from Telangana by using portable Raman Spectrometer (Rao *et al.* 2019, pp. 9-14). They analysed four samples from rock paintings without interfering with it. The most prominent bands in the Spectra recorded on the red particles of the pigment on the rock art sample 1, 2, 3 and 4 bands at 406, 602 cm^{-1} are present which are characteristic of haematite.

The above analytical studies of the rock painting pigments from India including Chambal Valley indicates that Indian rock paintings have been executed by using earthen mineral colours. No organic material or binder has been traced so far.

3. Geomorphology of Chaturbhujnath Nala region

Basaltic flows of amygdular and vesicular type poured out from fissures and spread around over the existing pre-Cretaceous surface about 65 million years ago (Singh 1971, pp. 567-573). The basalt rocks, commonly known as Deccan trap, are overlying the Sandstones and shales of Vindhyan super group, which are about 600 million years old. The latter form linear deposits in this region and have been metamorphosed to quartzite and slatestones.

The Deccan trap rock is usually a form of olive basalt or augite-andesite, rarely porphyritic, but often vesicular with amygdale of beautiful zeolites, calcites and agate which sometimes form the principal part of the rock. Nodules are very often coated with gluconite. Traps are easy prey to weathering and weather with spheroidal exfoliation giving rise to rounded boulders (Singh 1971, pp. 568-589).

4. Denuded laterite: the source of pigments

Bhanpura plateau is a part of the Malwa region in western India which witnessed the subareal decomposition of the basalt rocks into laterite due to hot and humid climate. The peculiar structure of laterite is the result of molecular segregation among its products (Singh 1971, pp. 567-573). In its typical form laterite has a vesicular or scoriaceous appearance, occasionally having a pisolitic structure and is often mottled through irregular distribution of the ferric hydrate. Most of the laterite of the region has been washed off already in the pre-Pleistocene Age and formed thin sheets on almost entire Bhanpura- Gandhisagar plateau. It has been a good source of iron-oxide pigments of different chemical compositions and different colour shades. These pigment nodules were used for creation of rock paintings in the region. We collected iron oxide mineral colour nodules from the area around Chaturbhujnath Nala, in March 2019 and selected 7 pieces from them on the basis of variation in hue (red ochre). We did experiments of the replication of selected Mesolithic compositions on the red sandstone slabs at Dayalbagh Agra.

5. Numbering of the pigment nodules and obtaining colour out of them

To experiment in the studio (in the month of April 2021), we used the iron oxide pigment nodules which were collected from near Chaturbhujnath temple in March, 2019 (the rock art site of the same name in Chambal Valley). They were numbered from 1-7. Pigment No. 1-6 were of different shades of red colour, while No. 7 is dark brown haematite nodule, with high density and hard to obtain colour from it. All the pigment nodules we have were numbered and put in plastic bags bearing the same number. We obtained colour from them by grinding them with water on a flat sandstone slab and replicated Mesolithic compositions on sandstone slabs at Agra in the first half of April 2021.

We also prepared small plastic containers to hold the colour of the same number of the nodule, to be used for making rock art composition on sandstone slab of the agriculture field of Dayalbagh near our home. While working in the field in the replication rockshelter, we tried to use bowls made of leaves of Banyan tree (*Fis-*

cus benghalensis) and Dhak tree (*Butea monosperma*).
We selected three pigment nodules of reducing size and of varying shades, photographed the nodules along with IFRAO colour scale, rubbed one by one on a piece of sandstone slab and made vertical line from so obtained colour each side by side on another sandstone slab. We also made lines below them by crayon colour of each of them by scratching the pigment dry on the surface of the slab. So obtained colour is of three different shades of red.
We also collected pigment nodules again from near the area of Chaturbhujnath temple, on 17 April 2021. We selected three out of them and numbered as pigment nodule No. 8-10. Pigment nodule No. 8 is rich red ochre colour, No. 9 is yellow ochre, while No. 10 is light yellow ochre colour. Pigment No. 8 was used many times because of its colour matched with many of the original rock art compositions and its chunk being big in size was easy to grasp for grinding (Fig. 1). Thus, we had a range of both red ochre and yellow ochre, and that of No. 7 is dark brown.

5.1 Roasting of pigments
Most of the Mesolithic paintings are in dark red colour. Hence, we did experiment with the three nodules (No.1, 2 and 3), in the hope of getting dark red colour from the nodules we were using. Kumar first brought out a small piece of them by breaking and kept it safe in a marked plastic bag for record and analysis by XRF and XRD. The large portion was roasted for 190 minutes (3:10 hrs from 2:50 pm to 6:00 pm) in a sand-bath on 11 April 2021 at home. For this purpose, Kumar used a heavy Kadhai (an Indian kitchen utensil) half full of Chambal sand and put the pigments inside it. Sand-bath was used for smooth heating and proper roasting of the pigment nodules.

5.2 Colour obtained from the roasted pigment nodules
After cooling the pigments whole night for about 14 hrs, Kumar first photographed the roasted pigment nodules along with IFRAO scale in the sand-bath inside the Kadhai. IFRAO scale was not used in the initial photographs before roasting. The colour of the sand changed from light to brown, but not that of the pigment nodules (Fig. 2).
Then, Kumar obtained colour from all of the three roasted pigments nodules by grinding them on the same sand stone slab used previous day, close to the corresponding line of each pigment. It was surprising that there was almost no difference visible by naked eyes in the shades of colour of each nodule before and after roasting (Fig. 3). Analytical study of them in future may throw proper light on this issue.

5 .3 Pigments are not water soluble
We put the pigment nodules in water for more than 24 hrs, but to our surprise we observed that they are not water soluble. They do not yield colour even after rubbing them by hand. It is like '*hinna*' leaves, the mignonette tree (*Lawsonia inermis*). The leaves do not yield colour unless they are well crushed and made a paste of them. It is used for body decoration and hair colouring in India.
The pigment nodules produce colour only on grinding with water. So obtained colour is a suspension in water. The colour quality depends on the fineness of the grains. If the pigment grains are coarse as in case of crushing the pigment and obtaining the grains to make colour, they would not mix with water and we cannot achieve colour consistency.
It means the damage or disfiguring of the colour of rock paintings at CBN site is due to weathering of the applied pigment layer, not because of the solution of the pigment colour.

5.4 Leaf-Bowl making to collect colours and water
To collect the processed colour and to store water for replicating the rock painting compositions we required containers. We collected the large leaves of 'Dhak' tree (*Butea monosperma*) and 'Banyan' tree (*Fiscus benghalensis*), used the thorns of Karonda (*Carissa carandas*) plants available around the site to make the leaf bowls. We have to make fresh bowls every day, as the leaf became dry and would start cracking by the end of the day. We also tried coconut shell to store ready pigment, but the colour was drying very fast in it (Fig.4).
In these leaf bowls, water used to evaporate from the colour within two hours, leaving powdery colour residue behind. Therefore, we tried to cape the bowls with a leaf cap but it did not work. Then we tried narrow-elongated leaf bowls. It was observed that narrow-elongated deep leaf-bowls worked better as compared to the shallow and wide ones (Fig. 5).
We tried re-mixing the dried powdery pigment with water, but it did not work. While painting it used to become difficult to manage two bowls, one with colour and second with water, in the afternoon as the wind used to get fast and the bowl having colour sometimes used to fly away with the wind. Usually, we could make one composition only from the colour obtained by grinding the pigment for two to three hours on a stone slab in the replication shelter.

5.5 Process of colour preparation
We also tried to use verity of pigments to understand, grinding properties, pigment texture, quality of its grains, hardness, ability to mix with water, visibility and exclusiveness. Pigment no. 2, 4,7,8,9 and 10 were used for replication of the compositions. We used pigment No. 8 for many compositions as it was rich red colour closest to most of the compositions and was easy to grind, and being a big chunk, was comfortable to hold for grinding. Out of the ten pigment nodules, a small nodule No. 7, a haematite piece, was very heavy and dark in colour. It was very hard to obtain colour from it by grinding on quartzite rock with water, two times more as compared to other pigments. However, it yielded dark brown colour, almost similar to the early rock paintings of Chaturbhujnath Nala.
While preparing the pigment one has to maintain the grinding rhythm, pressure and consistency of water, then only we will get the paste appropriate for executing rock art figures comfortably. If it is not of the right consistency, one can't fix it with ease. One must follow

the entire grinding process again to prepare the fresh pigment.

Two different consistencies would result in two different colour appearances after drying. It also affects how the brush will move, hence affecting the smoothness of the strokes and causing different types of blotting. Also, if there is too much water the brush doesn't hold colour and while touching on the rock surface the colour blots uncontrollably. On the contrary if the colour is too thick it dries very fast, within minutes in the open bowl, depending on the heat and humidity in the air. Secondly the brush holds too much pigment at the tip, resulting in having a colour blob at the starting point of the line. It also restricts the brush movement.

5.6 Colour binders

We collected the milk oozing from Banyan tree leaves in a plastic bowl having some water in it. Initially it was milky, but turned to greyish after sometime. We used it as colour binder. We observed that when it was mixed with mineral colour of iron oxide, it separated water from the pigment and the pigment became sticky, not suitable to draw lines or apply strokes (Fig. 6 and 7).

6. Observations

Pigment number 2,7,8,9 and 10 were prepared at the site. Except pigment 9 and 10, all other pigments are of different shades of red ochre colour. They are fine grained and can mix with water well. Whereas the pigments 9 and 10 are of yellow ochre colour, they are of comparatively not fine grained and get separated from the water in the form of mud in bottom of the bowl.

There is no conclusive information about the binder. It needs the chemical analysis of the pigment which will be done in the next phase.

Preparing the pigment for the paintings is a tedious task. Pigment is prepared by grinding the iron oxide pigment nodules by hand on a flat stone surface using water. Some of the pigments (comparatively soft ones) were easy to grind, whereas No. 7, haematite, needed more effort and time. Preparing the pigment for 2 - 3 figures of an average size of 15-20 cm, took minimum of two hours. While making the pigment, it is observed that it needed to be collected instantly because if it was left on the stone for even a minute then it got dried up and became a powder. However, it's not certain whether the dry powder mixed with water can be used as colour or not. It can be presumed that rock painting is a group/community activity. Because during this process we did need support from other team members and that support can be physical, emotional or social. It cannot be done by an individual.

We did experiment with the milky substance of banyan tree leaves using as a binder, mixed it with the pigment 8. Approximately 30-40 ml of colour mixed with one tea spoon of binder-water (50% banyan tree milk mixed with 50 % water). The behaviour and property of the pigment changed after adding binder to it. It became even more difficult to use the brush with it. The pigment became sticky, lumpy and started sticking at the bottom of the bowl separating from the water. After drying the colour on the surface, it became dusty and would fall just by touching. It appeared that binder was restricting the rock surface to hold the pigment. The brush was not able to hold right amount of colour consistently. Once the stroke dried it would reveal that some of the strokes did not have enough pigment, just water mark is left.

7. We are presenting our experience while working with different pigment colours and their temperament in Table 1.

Sr. No.	**Pigment No**	**Pigment Colour**	**Quantity**	**Grinding Time**	**Hardness a. Hard b. Harder c. Hardest**	**Working Place Agra Bada-Mahadev (BM)**	**Residual and Texture**
1	Pigment 1	Red Ochre	05 ml	90 min.	b. Harder	Agra	Residual was a paste of fine grainy texture.
2	Pigment 2	Red Ochre	05 ml	90 min.	b. Harder	Agra and Rep. Site-BM	Residual was a paste of fine grainy texture.
3	Pigment 3	Red Ochre	-	-	-	-	-

4	Pigment 4	Red Ochre	05 ml	90 min.	b. Harder	Agra and Rep. Site-BM	Residual was a paste of fine grainy texture.
5	Pigment 5	Red Ochre	-	-	-	-	-
6	Pigment 6	Red Ochre	-	-	-	-	-
7	Pigment 7	Dark Brown Ochre	03 ml	150 min.	c. Hardest	Agra and Rep. Site-BM	Very fine residuals with smooth paste. Comfortable to work with.
8	Pigment 8	Rich red Ochre	10 ml	120 min.	a. Hard	Agra and Rep. Site-BM	Residual was a paste of fine grainy texture.
9	Pigment 9	Yellow Ochre (shade)	05 ml	60 min.	a. Hard	Agra and Rep. Site-BM	Rough residuals with grainy texture. Coarse particles separated from water.
10	Pigment 10	Yellow Ochre (light)	05 ml	60 min.	a. Hard	Agra and Rep. Site-BM	Rough residuals with grainy texture. Coarse particles separated from water.

Table 1: Nature of pigments used for replication.

8. Comments

From the present phase of replication of CBN rock paintings, we located the source of pigments and understood their processing for obtaining colour out of them, the efforts and working hours it requires and their consistencies and nature. However, the chemical analysis of the pigments of the original rock paintings on the site will help in finding the proper pigments for replication and the binder if any was used. It will be done in the next phase of the project. However, it was a good learning experience.

Acknowledgement

Rock Art Society of India for supporting the rock art replication project.

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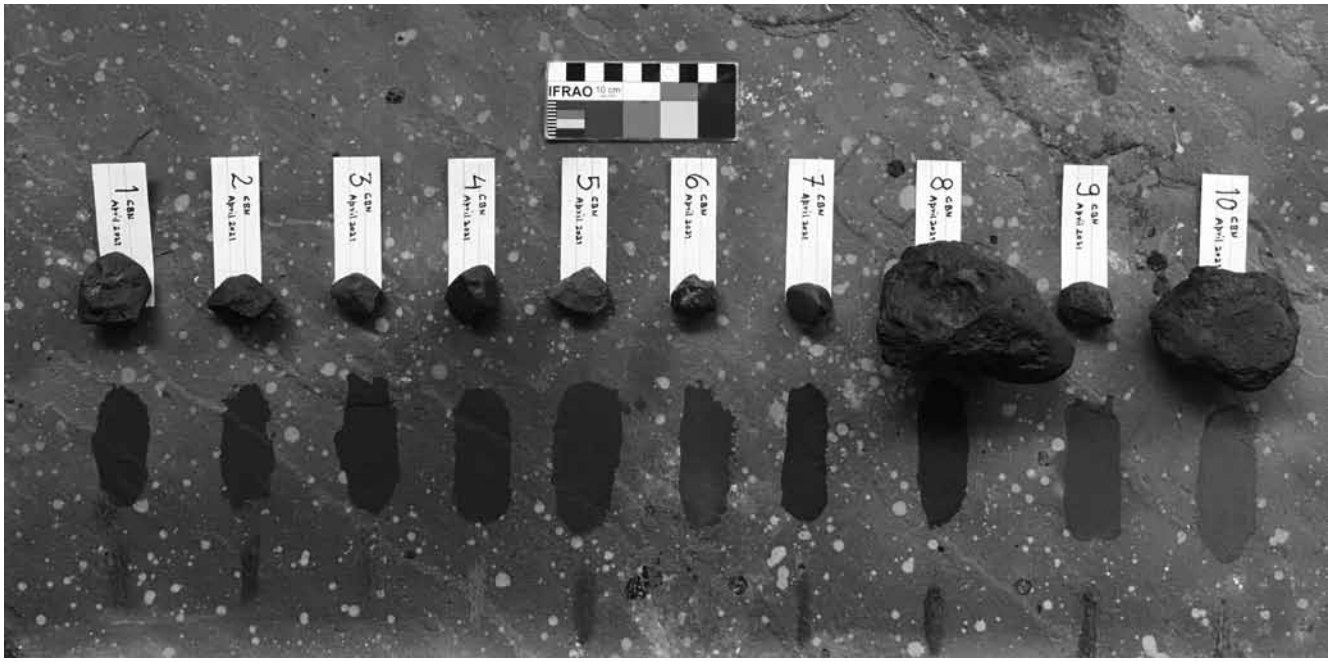

Fig. 1 - Hue scale of the pigment nodules No. 1-10, collected from in front of the Chaturbhujnath temple.

Fig. 2 - Roasting of three pigment nodules.

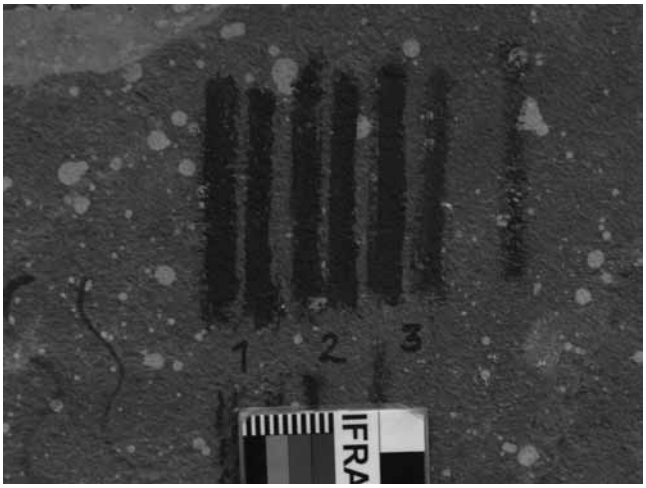

Fig. 3 - Three bands of colour in the pairs of two; left one is before roasting the pigment and right one after its roasting. The bands do not show any major difference in their colour shades.

Fig. 4 - Colour processing from the pigment nodules (pigment 4, upper one and pigment 7, lower one) by grinding on the quartzite flat surface and collecting it in banyan leaf-bowl at the replication site. Dhak leaf bowl, lying by its side, didn't work, because of cracks in it.

Fig. 5 - Colour processed from pigment 5 and collected in narrow leaf-bowl. The broad one in the upper side contains water used for grinding the pigment

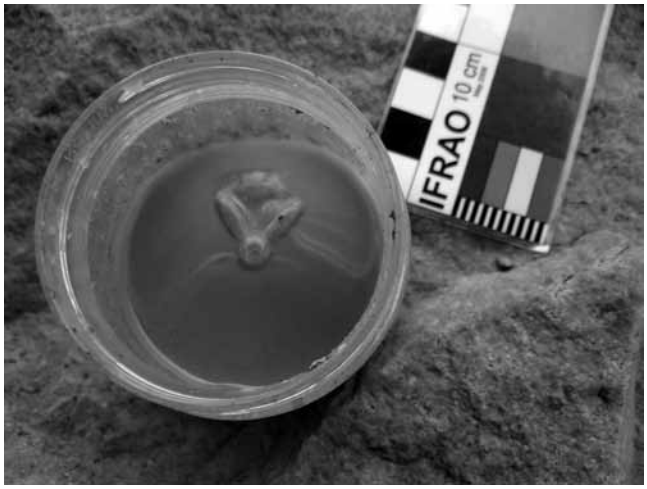

Fig. 6 - Colour obtained from pigment No. 8 and mixed with binder (Banyan tree leaves' milk).

Fig. 7 - Replication of dancing lady, Composition No. 2, with pigment No. 8 mixed with binder (Banyan tree leaves' milk).