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HISTORICAL NOTE

A review on rock paintings of India: Technique, pigment and conservation

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Abstract
Rock painting spans thousands of years of creative efforts and is as diverse as India's cultural practices, literature, and tradition. In India, there are over 1000 rock shelter sites with paintings. Amateurs discovered the majority of these sites. Archibald Carlleyle (1897), a British archaeologist, made the first systematic documentation in the mid-nineteenth century. Since the discovery in 1958 of a large collection of rock paintings found by Wakanakar at Bhimbetka in Madhya Pradesh, extensive research projects have been devised speculating on local and regional chronologies and styles. This paper provides a brief overview of Indian rock paintings, assisting readers in comprehending the history and distribution of rock paintings in different regions of India and its painting techniques and materials, pigments and binders, cause of deterioration, and management and conservation.

Keywords Rock · Painting · Pigment · Binders · Materials · Technique · Conservation

1 Introduction

The only direct, credible source of visual evidence to decipher the world of early man is rock art. Visual imagery is used to convey their perspectives on environmental and social realities. The oldest 'written' records of man are paintings and engravings made on the bare rock surface in naturally shaped caves and shelters by Stone Age man. These records, which are depicted in the universal language of drawing, show the inner world of prehistoric social groups, including their thoughts and beliefs, as well as provide details about their society, religion, ritual, technology and material culture, economy, contemporary fauna, and flora. Paintings (Fig. 1) and other artistic works are often the only evidence of the past life of some species of animals that have since become extinct in the absence of skeletal remains (Rai, 2013). The use of rock surfaces for paintings in various colours and styles over time attests to man's long existence in an area (Mathpal, 1978).

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In terms of style and theme, the selection of rock art available in India is extensive. Its sequence can be uncovered from the upper Paleolithic to the Historic era, and it contains a small glimpse of today's tribal cultures. The remnants of rock paintings have been discovered on the walls of rock shelters in India, including Madhya Pradesh, Uttar Pradesh, Bihar, Uttarakhand, Telangana, Andhra Pradesh, Kerala, and Karnataka (Khatri, 1964). The hill forested country of Bundelkhand and Baghelkhand, which is an extension of the Kaimur range south of the Ganga, is home to the majority of rock shelters in Northern India. 90% of rock shelters have been discovered in Central India, with the maximum concentrations in the Vindhyas, Satpura, and Kaimur Hills (Lal, 1976). Sandstones make up these hills, which weather easily to create rock shelters and caves. These are densely forested areas that were ecologically ideal for subsistence hunting and gathering. Several Central Indian paintings look like Neolithic paintings from Australia, Rhodesia, South Africa, and Eastern Spain. Hunting, fights, dance scenes, and various human and animal figures are depicted in the paintings (Khatri, 1964; Mathpal, 1978).

The majority of the rock shelters are near riverbanks, where food, water, and raw materials for lithic implement fabrication were readily available. They were often found on higher ground in rocky outcrops that offered a panoramic view of the countryside and provided forest and rock shelter dwellers with strategic hunting vantage

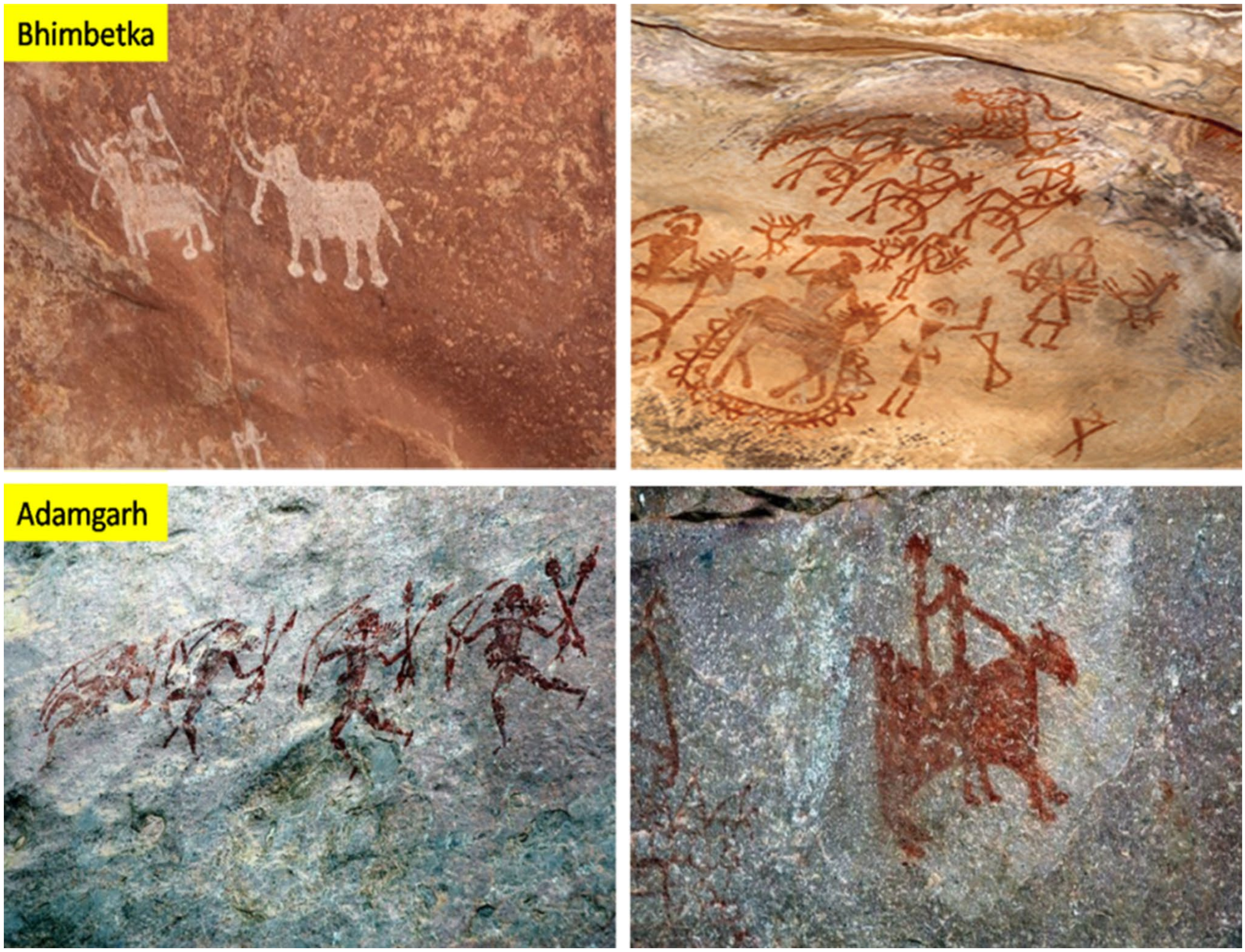

Fig. 1 The image shows the rock painting at Bhimbetka and Adamgarh, India.

points. The rock paintings of India's various regions form a rich artistic legacy. These paintings are found in areas of the Indian subcontinent where sandstones, quartzites, and granites are abundant. Rock paintings on limestone have not been discovered, nor have they been discovered on shales or slates. The paintings are mostly found in rock shelters, but they have also been discovered in rock caves and natural caverns. The people who painted the paintings, hunted, gathered food, and processed food in rock shelters as evidence of habitation has been discovered in the form of charcoal, ash, pottery, human skeletal remains, and microliths. The paintings are a visual manifestation of the primitive people's creative urges, and they depict various aspects of their way of life (Bednarik, 1993; Brown, 1960; Chakravarty & Bednarik, 1997; Ghosh, 1932; Sonawane, 2002; Wakankar, 1973).

Archibald Carlleyle, an English archaeologist discovered the first painting in India in 1867–1868 at Sohagighat near Mirzapur, Uttar Pradesh,which was twelve years before the recognition of Altamira in Spain. What's more important is that Carlleyle was convinced at the time that the paintings were produced by Stone Age people whose cultural and physical remains he had discovered on the shelter floors. He was most likely the first person in the world to understand the age of rock paintings. Many other workers have since then found paintings, carvings, and engravings in various parts of the world. Carlleyle, unfortunately, did not publish any of the important discoveries he made in this field between 1867 and 1868, or later. Carlleyle's experience died with him, as Cockburn correctly observed. Carlleyle had fortunately left some of his notes with a friend, Rev. Reginald Gatty, and these were later published by V. A. Smith. They are our only source of knowledge about his rock painting discovery (Brooks & Wakankar, 1976; Carlleyle, 1883, 1885; Malla, 1999; Mathpal, 1976; Waller, 2002).

Cockburn published the first scholarly paper on Indian rock paintings in 1883 (Cockburn, 1883). Cockburn published an account of his findings in 1899, in which he compared the drawings to those made in Australia, South Africa, North America, and South America (Cockburn, 1899). Bhimbetka (UNESCO World Heritage Site) was discovered in 1957 by Wakankar, an eminent archaeologist and *pitamaha* or father of Indian rock art. It is one of the most beautiful rock art sites on the planet. In India, this place has become synonymous with rock art. This finding changed the fortune of Madhya Pradesh's rock art (Dales, 1978). Pandey (1975, 1993), Tiwari (1975), Srivastava (2003), Varma (1984), Sundara (1984), Neumayer (1983, 1993), and Mathpal (1984, 1995) are among the contemporary Wakankar researchers who have made significant contributions to the creation of a potential relationship between the rock art and archaeological data to assess its antiquity in terms of historical importance. Later explorations of sites in Kharwai, Bhopal, Raisen, Chiklod, Narwar, Amargarh, Adamgarh, Kathodia, Nagori-Sanchi, Firangi, Bori, and other Central Indian regions resulted in the discovery of vivid paintings. A new group of painted caves has been discovered between Tamia and Pachmarhi, with striking similarities to those found in Madhya Pradesh's other rock caves (Khatri, 1964). Recently, a new large group of painted rock shelters have been discovered in the Gawilgarhrange in Betul District, Madhya Pradesh. It has enthused the researchers with rock art that has opened up a large number of paintings and petroglyphs (Randive et al., 2021). Another site, Daraki Chattan in Indergadh hills, Mandsaur has yielded, a fascinating over, 500 Palaeolithic cupules (Kumar et al., 2002).

Only after Fawcett's (Fawcett, 1892; Gordon, 1951) visit to Kupgallu in 1882 did the first rock engraving of south India come to light. Fawcett is most famous for discovering Edakal Cave (Gordon, 1951). Huburt Knox of the Bellary district of Karnataka had previously registered rock bruising. Allchin (1963), Sundara (1974), Paddayya (1968), and Chandramouli (1995) all informed more rock bruising in the region after that. Manoranjan Ghosh discovered a group of painted rock shelters in Adamgarh, near Hoshangabad, in 1921 (Ghosh, 1932). Gordon sought to resolve the chronological concerns of rock art in the 1930s by observing the superimposition of paintings, their style, and technical contents. He mainly worked on the Pachmarhi rock paintings, which are situated in the Mahadeo Hills of central India. Unfortunately, he could not envision a long period of autochthonous creation of Indian rock art in its natural habitat. Despite this, he was the first antiquarian to publish a book on the thematic elements portrayed in rock paintings (Gordon, 1958).

Generally speaking, this class of art can be divided in to two main types: pictographs and petroglyphs. The latter term refers images created by removing part of a rock surface by incising, picking, carving, and abrading. The former refers to images drawn or painted on a rock face. In many cases, the paintings of an earlier period are superimposed by subsequent paintings and as a result it is often quite difficult to identify the paintings of a particular phase.

A deep cupule and a meandering line on a boulder lying in Acheulian context came to light in the course of excavation in the rock shelter III F 23 of Bhimbedka also known as Auditorium Rock Shelter. The main areas of petroglyphs and main areas of rock paintings had been clearly identified in Kupgul (Bellary, Karnataka), Hiwale (Sindhudurg, Maharashtra), Barrsu (Ratnagiri, Maharashtra), Edakkal (Wayanad, Kerala), Kethaiyurumbu (Dindigul, Tamil Nadu) and Ladakh regions. Fig. 2 shows the Ladakhi rock art petroglyphs discovered in India.

2 Distribution of rock painting in India

Table 1 provides the distribution of rock painting sites in different states of India with their coordinates.

3 Painting techniques and materials used in rock arts

The number of rock art paintings is very high. The paintings are usually in the form of drawings, which are known as pictographs or petrographs. They're painted on the undersides of projecting or overhanging rocks, or on vertical or near-vertical rock faces. Drawings that were produced without the use of color are often preserved on rock surfaces including engravings, carvings, and brushings. Indian rock paintings were made using four different techniques. These are (1) Wet transparent color technique (watercolor painting), (2) Wet opaque color technique (oil or tempera color painting), (3) Crayon technique (dry color painting), and (4) Stencil

Fig. 2 Petroglyphs in Ladakhi art from Ladakh, India.

Table 1 Distribution of Rock Painting in India showing region, coordinate and name of site.

Region	Coordinate	Name of site
A. Ahiraura (Bahraich district)	[27.113287, 81.585498]	Likhunia
		Bhaldaria
		Lohari
		Kohbar
		Sugdaria
		Andar Sukhdar
		Tharpatra
		Vijayagarh
B. Bhainsur (Singrauli)	[25.344906, 83.399721]	MohranaPahar
		Bedia
		Lad Bedia
		Bega
		BaghaiKor
		Morchahawa
		Khari Patheri
		Munni Baba
		Lakhania
C. Rajpur (Barwani district)	[26.303408, 79.686691]	Panchamukhi
		Kandakota
		Chemanva
		Lekhania (Son)
D. Banda	[25.492249, 80.336151]	Banda
		Markadi
		Manzawan
		Serhat
		Malwa
		AmwaUldan
		Bargad
		Karpatia
		Chitrakaut
E. Panchmari (Narmadapuram district)	[22.4679, 78.4331]	JambuDwip
		NimbuBhoja
		Dorothy Deep
		Montiruzi
		Imly Kho
		Mahadeo
		Aprara Falls
		Bori
F. Sagar	[23.834030, 78.746567]	Bhopal
		Naryawala
		Abchad
G. Bhanpura-Chambal	[24.51117, 75.73689]	Aria-Antralia
		Chibarnala
		Sita Khardi
		KartiriaKund
		Indergadh
		Kanwala
		Modi
		Sujanpura
		Chaturbhuj-nala
H. Kota	[25.1800, 75.8300]	Darra Kota
I. Bhopal	[23.259933, 77.412613]	ManwaBhan
		Sivamandir
		Hospital Hill
		Shyamla
		Dharampuri
		Bhadbada
		Shahad Karad
J. Bhimbetka	[22.957390, 77.625275]	Seven areas
K. Raisen	[23.326809, 77.784920]	Kharvai
		Raisen (Hathi Tol)
		Ghatpala
		Sanchi
		Udayagiri
		Putlikarar
L. Hoshangabad	[22.744108, 77.736969]	Vanjari Mata
		Adamgarh
M. SeoniMalwa (30 miles southwest of Hoshangabad)	[22.451598, 77.469497]	Badhu Maj
		Bor Rani
N. Fatehpur-Sikri (20 miles west of Agra)	[27.095018, 77.668846]	Patsar
O. Gwalior- Shivpuri	[26.117309, 78.080251]	Gwalior
		Tikla
P. Narsinghgarh (60 Miles northwest of Bhopal)	[23.714859, 77.088103]	Narsinghgarh
		Kotra Bihar
Q. Raichur-Karnataka (Halfway between Hyderabad and Bangalore)	[16.200829, 77.362289]	Kuppagal
		Karikal
		Vitragalf
		Hebbal Buzurg
		Rupai Gundu
		Kuppagal
		Piklihal
		Maski
		Bellarayan-Gadda
		Benakal
		Kallur
		TogalGudda
R. Tekkalkota	[15.533333, 76.883333]	Tekkalkota
S. Kishkinta	[15.457498, 76.528591]	
T. Badami	[15.91495 75.67683]	Badami
		Sitalfadi
		Tatkoti

Table 1 (continued)

Region	Coordinate	Name of site
		Ramgudiwar
U. Kerala	[10.850516, 76.271080]	Edakal
V. Raigarh	[21.900000, 83.400002]	Singanpur
		KabraPahad

technique (spray color painting) (Mathpal, 1978; Wakankar, 1984).

In rock paintings, transparent and opaque color techniques are most ordinary than the stencil technique, which is traditionally used to make negative handprints. Colors are used heavily diluted in water in the transparent color technique. Except for the emerald green and white colors, all colors were added as transparent in previous phases. Dark crimson and dark red can also be used as non-transparent colors in historic paintings. The man painted on bare rock surfaces with basic earth colors when he lived in caves. The oldest known rock paintings date back over 30,000 years. In Europe, the opening caves are sometimes situated far away from the oldest known rock paintings. Rock paintings are created on bare rock surfaces all over the world without any ground planning, such as grinding, plastering, or smoothening. The artists opted for plain ceilings and walls in most cases. When surface irregularities were impossible to prevent, they were cleverly inserted into the composition to depict different parts of the body, such as bosses for shoulders and buttocks, stalagmitic columns for hips, and drip marks and holes for wounds (Coomaraswamy, 1934; Mathpal, 1977, 1978; Misra, 1965).The ancient artist, in fact often utilized the rock morphology to show the physical settings of the scenes they wanted to convey (Mondal & Chakraborty, n.d.).

3.1 Support and ground

The rock paintings are supported by sandstone or quartzite, with some paintings done on granite as the carrier. The brushwork was applied to a bare rock surface that was neither smooth nor perfectly even. However, there was no attempt to dress the rock, which was neither plastered nor painted before the art forms were portrayed. To put it another way, the pigments were applied directly to the rock surface (Kannan, 2003; Lal, 1976).

3.2 Painting brushes and tools

Early Sanskrit literature uses three terms to describe an artist's brush, *Kurchaka* (Hindi Kuchi), *Tulika* (or Lekhani), and *Vartika* (Hindi Vatti). The *Kurchaka* was probably a brush made of grass twigs and was derived from Kurch stiff grass. *Tulika* refers to a tul or cotton brush, while *Vartika* refers to a rolled and pointed piece of pressed cotton or other material. *Tulika* and *Vartika* are still used as brushes by folk artists in Indian villages. The mural painters of Ajanta, Bagh, and other rock-cut temples used fine and sharp-pointed brushes without a doubt. Artists in the Mughal and post-Mughal periods used brushes made of camel, squirrel, mongoose, and goat fur. The tool (mostly a hand-axe stone tool or a metallic tool to a lesser extent) was used to peck, bruise, batter, groove, or engrave the rock surface by using a hammer stone tool over it in the case of petroglyphs. The surface of the rock was never chiselled. Cupules were formed by pounding with a pointed stone tool, most likely a hand-axe. Since cupules are located on vertical surfaces of the rock canvas, the blows were delivered from above rather than below or sideways (Lal, 1976; Mathpal, 1978).

3.3 Pigments

The petrographs were paintedwith naturally occurring earth pigments such as red ochre, yellow ochre, and white clay. In other words, the earth colourswere used to paint the rock art, which was available as pigments in the vicinity of the rock shelters as residual products of the rocks (Mathpal, 1978; Rai, 2013). In a separate section, a detailed description of pigments was given.

3.4 Binding medium

It has long been thought that pigments contain some kind of sticky material. The pigments for painting on a smooth dry rock surface contain the sticky substance as a binding medium. The yolk of an egg and the juice of orchid bulbs are commonly used as fixatives by Australian aboriginal artists (Mountford, 1961). In the Ice Age art of Europe, fat (Breuil & Lantier, 1965), and blood and albumen (Breuil & Berger-Kirchner, 1961) are supposed to have been used as colour binders. According to Bandi (1961), albumen, diluted blood, vegetable juices, or melted honey were mixed in colour by Levantine artists. Goodwin (Bandi, 1961) speculates that the rock painters of South Africa may have used marrow, fat, or even hyrax-urine as a medium for their paints. Breuil and Lantier (1965) wrote "*The ochre was scraped or ground into powder, pounded with a pestle in cups, then transferred to saucers or hollow bones and mixed with fat or some other fixative, or as the case required, it could be applied by blowing either by mouth or through a tube*". It could also be applied with fingers (Ucko & Rosenfeld, 1967) or a fibrous brush, with the outline drawn with brushes made of animal hair (Burkitt, 1923). On the other hand, Berenguer (1973) dismisses the idea of using eggs and blood as a medium.

Eggs, he believes, is too mundane, and blood, too dramatic. Furthermore, the man did not need them, either as a mode of transportation or as colours, since blood, which is bright red when young, becomes a dull brown when dried. The man used natural earth pigments, hematite, manganese, animal marrow, and natural and burned charcoal as a vehicle.

According to Cockburn (1883), hematite as the red pigment was mixed with animal fat as a binder and applied using a fibrous brush, while a pointed stick was used for drawing the outlines. Percy Brown (Chakraverty, 2009) believed that "*pigment was probably applied using bamboo or reed brushes, the tool most likely used being a rigid blunt point, rather than a brush, and the treatment of some of the painted surfaces seems to show this*". Brooks and Wakankar (1976) said that the mineral powder was mixed with water, and applied using a brush which was probably made from a palmetto twig with one end pounded free of pulp to expose the fibres. After the pulp has been pounded off and the fibres have had a few minutes to dry, the result is a stiff brush that can hold a substantial load of pigment and draw good sharp lines.

To determine the type of the binding medium, Lal (1976) studied several pigment samples from painted rocks. Chemical analysis, microscopic examination, and spot checks for gum, glue, fat, and resin were all performed. These organic materials were not detected during the experiments. No organic matter was discovered in any of the pigments. This negative proof of the lack of a binding medium, on the other hand, proves nothing. The organic materials in question are not very long-lasting, and in exposed conditions, they are vulnerable to rapid decay and eventual destruction over centuries. Even if any organic material had been used as a medium for fixing the pigments to the rock surface, it could not have remained unaltered and un-decomposed but would have completely perished under the prevailing tropical and sub-tropical climatic conditions. The pigments would have been physically removed from large areas by exposure to the sun, rain, wind;c bacterial attack and chemical reaction in the presence of air and moisture would have destroyed the organic medium; and failure to detect and recognize the medium in the pigments does not rule out the possibility of its use. Whether a binding medium is also needed for painting on a rough rock surface is unrevealed, because there isn't any data on the topic. The pigments also permeated deep into the rock fabric in some instances, suggesting that they were used in a fine liquid form. Pulverization of lumps of naturally occurring pigments and levigation (grinding into a fine powder) of powder in water for preparation of a fine aqueous suspension would have been a laborious method for preparing the medium in a fine liquid form.

Experiments were thus carried out on selected samples of roughly dressed medium-grained sandstone blocks to see how well ochrous clays mixed with water alone, without the addition of an organic binding medium, fixed to the rock surface. The findings of these experiments have already been published, and they show that when aqueous suspensions of ochrous clays are applied to bare rock, they adhere so tenaciously to the surface that after a few years in the atmosphere, they become insoluble in water, and even gentle abrasion of the rock face fails to dislodge the pigments. The black pigment has been discovered to be the same. As a result, the pigments were likely incorporated in water without any binding medium and then applied to the bare rock to create the petrographs in most cases. The pigments have a fair amount of permeation into the rock's fabric, and the bond between the two is quite strong. Water was most likely the pigment medium because of the rock art's durability, and the slow action of water on the siliceous rock likely resulted in the formation of colloidal silica, which formed an imperceptible coating on the pigments, thus fixing them firmly to the rock surface and rendering them resistant to the solvent action of water (Ghosh, 1932; Kannan, 2003; Malla, 1999; Mathpal, 1978). However, evidence of the presence of a possible organic binder is reported in one of the extracted pigment samples of Bhimbedka (Ravindran et al., 2013).

Bandhodaka, and Ashtabandha are mentioned in ancient Indian literature (*Bṛhat saṁ hita, Viṣṇudharmottarapurāṇa, Śilparatna, and Mānasollāsa*) (Bhattacharyya, 1963). These were made of different kinds of decoctions of fruits and tree barks and were used for ground coating and binding the materials. The use of decoctions of *Bhūnimba*, *Tulsī*, *Kuśa*, *Maulsirī* seeds, and *Campā*, as well as *Sindūr* milk, according to *Citrasūtram*, a part of *Viṣṇudharmottarapurāṇa*, lends permanency to colours (Jha, 2020). *Vajralepa* was made by boiling a piece of fresh buffalo skin in water, as defined in *Abhilaṣitārthacintamaṇi* (Shama Sastri, 1926).

4 Pigments used in rock painting

The surface of the rock shelters was painted with various pigments. The rock shelters were painted with naturally occurring pigments such as red ochre, white clay, and yellow ochre. The following compounds (Table 2) have been detected in these pigments.

Minerals, such as ochers, or ferrous oxide clays, ranging from pure red to yellow, orange, and violet; and manganese oxide for black, were used by prehistoric rock painters. The caves themselves were always stocked with these pigments (Marshack, 1975).

Hematite as red was the most common colour. Hematite has been used in Africa (Leakey, 1958), Europe (Rolland, 1992), and India (Paddayya, 1978; Ravindran et al., 2013) since the Acheulian period. It was also used in Europe by the Mousterian man. Hematite was widely used in Europe during the Upper Paleolithic period, and it was transported by hundreds of pounds (Leroi-Gourhan, 1968). From the Mesolithic era onwards, hematite has been found in nearly every prehistoric site in India. As early as the 1960s, A. Carlleyle (Smith, 1999) collected red ochre from the floors of painted rock shelters in the Mirzapur area. G.R. Sharma (Misra, 1965) confirmed the use of hematite in Mesolithic burial rites from the same area. Soft hematite with smooth rubbed surfaces has been found at the Mesolithic site of Langhnaj in Gujarat (Sankalia 1974). 'Geru' (hematite colour) was reported by Misra (1972) from phase I of the Mesolithic site of Bagor in Rajasthan. In his excavation in the Chambal Valley, Wakankar (1975) discovered a heap of hematite items, a stone palette, and a painted stone. Other colours (manganese, yellow ochre, and green earth) were discovered during his excavation of shelter IIIA-23 at Bhimbetka.

It's impossible to say if the colours were made by simply rubbing the nodules with water on a stone or by mixing them with a fixative and putting them in containers. Nothing that can be called a colour pot or a palette has been discovered in excavations. Painters from all three periods likely used colour pots in some way. These could have been made of gourds, hollow bamboos, and leaf cups in the beginning, but later on, they may have taken the form of pottery vessels. Large-scale drawings in high-altitude locations, such as the silhouetted drawings of mythical boar in Bhimbetka shelter C-19, would have necessitated a large amount of prepared pigment. A receptacle would have been needed to store a large quantity of colour (Mathpal, 1978; Wakankar, 1975).

Only a few pigments in liquid form were used, including red, yellow, white, and black. There is no indication that these pigments were used in powder form. The use of dried pigments such as charcoal or ochrous clays in the form of crayons, sticks, or lumps has been ruled out in many rock paintings. Only natural earth pigments such as red and yellow ochres, as well as white clay, were used in these petrographs, aside from charcoal. The availability of earth colour as a residual result of rock weathering in the vicinity of rock shelters was the key reason for using it. Brown's theory, according to which the black pigment used in the Jogimara rock paintings was made by combining a ferrous salt (copperas) with an aqueous extract of myrobalans, is important in this regard (*Terminalia chebula*). Brown's view has not published any chemical research to back up this argument. While copperas produces a deep black pigment when combined with an aqueous extract of myrobalans, it does not last long and fades quickly, eventually disappearing due to aerial oxidation and decomposition of the organic colouring matter, iron tannate, which is responsible for its black colour. The petrographs' black pigment is fast and durable, and it has avoided weathering in places where it is not directly exposed to wind and rain. Where the surface has been weathered or eroded, however, the black pigment has vanished along with the other pigments, red yellow, and white. The primary colour is red, which is derived from red ochre and comes in several shades (Brown, 1960; Lal, 1976).

Pink, buff, brown, and chocolate were often used as mixed colours. The green colour is uncommon, and no blue colour has been observed as many petrographs' colours have faded. The palette cannot be recreated in its entirety. The use of the black manganiferous ore, pyrolusite, in the paintings investigated so far has been ruled out. Similarly, there has never been any evidence of lime or gypsum in the white pigment, which has always turned out to be white clay. In the rubble or floor deposits of the rock shelters, lumps of red ochre or hematite have been discovered. It's difficult to tell if the red pigment was obtained by calcining yellow ochre, but the presence of red ochre or hematite, as well as its readily available existence, contradicts the calcination theory. The pigments also permeated deep into the rock fabric in some instances, suggesting that they were used in a fine liquid form. There was no sign of permeation in other instances, and the pigments did not stick well to the rock surface.

The laborious method of pulverizing lumps of naturally occurring pigments and levigation of the powder in water for the preparation of a fine aqueous suspension must have been involved in the preparation of the pigments in a fine liquid form. It's also possible that the pigment lumps were rubbed with water on grinding stones, and the resulting aqueous paste was thinned with water before being used for painting. However, determining the exact mechanism is daunting and impossible in the absence of material proof. Grinding stones, mortars, and pestles have not been discovered in caverns or rock shelters, nor have pits and hollows with grinding marks been discovered in the rock floors (Bean, 1977; Johnson, 1959; Marshall, 2020; Moore, 2001; Plets et al., 2012; Rudner, 1973; Taylor et al., 1974).

5 Status of rock paintings

The rock paintings can be found in several states of preservation depending on their location. Because of the prolonged exposure to light, wind, and rain, many of these paintings have faded to some degree. The paintings are on a medium to coarse-grained ferruginous sandstone substrate. The rock surface has been heavily eroded. Over wide fields, it has spalled and flaked away. Many rock shelters have fallen as a result of extensive weathering to physical and chemical forces; others are located in difficult-to-reach locations. Weathering and substrate deterioration also caused major damage to the petrograph. The accumulation of clayey and siliceous material held in the water flowing over the rock surface has left extensive stains on the painted surface in several places. Patination of the rock surface has also been found at several locations. Long exposure to the elements can cause the painted surface to take on a weathered appearance. Pigment loss is not uncommon; some paintings have experienced severe degradation due to pigment layer impairment. Mildew and algae have overgrown many painted surfaces. Insect mud nests, cobwebs, and accretions of dust and grime have all contributed to the paintings' degradation. In certain instances, the paintings have been destroyed, and many others are undergoing active decay. The remaining fragments of these rock paintings require immediate conservation measures. The paintings' decay and disintegration can be traced, at least in part, to the unscrupulous actions of vandals who have defaced and destroyed these artistic works of great archaeological significance (Brown, 1960; Lal, 1976).

6 Causes of deterioration

The state of rock art reveals that the causes of degradation are numerous and diverse. As a result, these degradation causes must be addressed broadly in terms of the three key elements that make up paintings, namely the "carrier" (substrate), the pigments, and the binding media. Degradation of the substrate as a result of weathering, both physical and chemical, is one of the most common causes of deterioration. There are cracks in the rock surface, as well as cracking, flaking, and spalling. On painted walls, salt efflorescence has been discovered. Moss and lichen have colonized the painted surface where it is exposed to rain, percolation, and water seepage. The smoke and tar from fires lit within the painted caves and rock shelters have destroyed several paintings. On painted surfaces, mud nests and hives are sometimes seen. Significant damage has been caused by extremely hard encrustations and extensive flow marks caused by running water.

The majority of the above-mentioned causes of degradation can be attributed to an unfavourable climate. In most instances, where the paintings are placed in exposed conditions, environmental stresses such as insolate bright light, abrasion, and water erosion are inbuilt influences. The paintings are on a medium to coarse ferruginous sandstone substrate. The rock has been subjected to extensive physical and chemical weathering. As a result, the ferruginous cementing material that keeps the grains of silica together has broken down, allowing iron oxide to escape and settle on painted surfaces, resulting in a rough, deeply coloured encrustation in some cases. Evaporating water has carried colloidal ferric hydroxide to the surface of the rock, where it has precipitated. Silica was also released as colloidal silicic acid and accumulated on the painted surface as extremely rough, white patches. As a result, the rock surface has become softer and spongier, making it more susceptible to weathering. The rock has formed cracks and fissures as a result of diurnal and seasonal temperature fluctuations; both mineral disintegration and block disintegration are visible. Rainwater has seeped onto the painted surfaces, which are otherwise shielded from driving rain, due to the cracks in the overhanging rock. Moisture seepage has occasionally resulted in an accumulation of water-soluble salts on the painted surface. Because of repeated crystallization and solution under changing humidity conditions, the soluble salts have caused considerable physical harm. In terms of the third factor, the medium, it has already been identified that the pigments contain no binding medium. The pigments are being physically extracted by flowing water, which is causing the observed damage. These are the causes of the paintings' degradation. The condition of preservation of these works of art is far from satisfactory, and they are gradually deteriorating. Even though the paintings have been surveyed and scientifically analyzed in a few cases to reconstruct their technique and diagnose the causes of their degradation, little has been done to conserve them. Natural decay due to unfavourable environmental factors is a significant challenge that will ruin these paintings over time unless successful preservation methods are established and enforced (Bean, 1977; MacLeod, 2000; Marshall, 2020; Plets et al., 2012).

7 Conservation step

There should be a conservation step that describes how these rock paintings should be preserved and restored for future research and study. Many researchers worked hard to investigate and record these locations. They also made a significant contribution, and this should not be overlooked. Furthermore, there is a need for thorough, scientific documentation of this deteriorating art to produce a reliable record of their degree and state of preservation for reference and research by those scholars who find it difficult to analyze them firsthand due to the extreme remoteness of many rock shelters and the lack of easy access in most cases.

7.1 Documentation

Given the substantial financial outlay needed to take appropriate steps to remove environmental stresses that pose a serious threat to the paintings' protection, a comprehensive conservation program for these works of art might not be feasible in the immediate future. Due to the rapid decay of many paintings, delaying chemical conservation can result in large-scale disintegration and eventual destruction of many of them. In reality, nature and vandalism pose a significant threat to the survival of monochrome and polychrome rock paintings. As a result, there is an immediate need for meticulous documentation of these works of art to create a detailed and reliable record for future reference and research. The problem of recording rock drawings, pictographs, and petrographs easily and accurately has been attempted in the past with mixed results. With the increasing interest in rock-art documentation, appropriate recording techniques should have been established before natural or human agencies obliterate and destroy them. As a result, it's shocking that there's so little research on scientifically appropriate reporting approaches. Cross-cultural comparisons and contrasts of documented paintings cannot be accurate or precise in the absence of information about the techniques used in capturing rock paintings. A survey of the literature shows the alarming fact that, while many researchers have researched and interpreted recorded paintings, little is known about the technique used in reproduction. In reality, for rigorously controlled research, the vast majority of reproductions are practically useless, and in many cases, they do not indicate size or composition. In India, the majority of rock paintings have been replicated as eye-copy reproductions, with only the most basic types preserved, with no attempt at accurate and thorough documentation. In the literature, faithful copies based on tracings and rendered to scale are hard to come by; the facsimiles that have been published offer no indication of the original size. The methods used to prepare the reproductions have not been described in detail. Site surveys and thorough mapping should be undertaken first, as they will provide us with new information about the sites' condition and the sources of real and future threats. Conservation issues can, in reality, is sorted out by a group of experts from various fields. In certain cases, detailed documentation may be the only way to save imagery, especially if it deteriorates or if a site is endangered. Since the contents of rock paintings are so deep and enigmatic, they need meticulous analysis to obtain more reliable data. As a result, high-tech methods such as shooting, copying, colour mapping, close shotting, drawing, and so on should be used to record and computerize rock paintings (Malla, 1999). A detailed and painstaking study of Chaturbhuj Nala had been done by Giriraj Kumar and published more than a decade back (Kumar et al., 2002).

Today the documentation of rock art should meet multiple aims. Along with its main role as a research tool, rock art recordings are essential in monitoring the processes of degradation affecting rock art assemblages in the short, medium, and long term. The understanding of the physical processes that have created and continue to act upon rock art is fundamental to research and management. The portable x-ray fluorescence spectrometry and micro-computed tomography are being used to study the materiality of rock art and associated sites. These case studies illustrate the types of information that can be generated using non-invasive techniques and demonstrate their application in developing an understanding of paint composition, rock art panel taphonomy and the physical properties of pigments (ochre), mineral accretions and shelter substrates. The power of non-invasive material scientific techniques as tools in cultural heritage management can play in emergent community-driven research. The rock art cultural heritage sector is experiencing a digital revolution driven by the increasing availability of cutting-edge analytical and imaging techniques generating large multidimensional datasets.

Table 2 List of several pigments used in Rock Art of India.

S. No	Color	Pigment	Chemical formula
1	White	Kaoline	$Al_2[Si_2O_5][OH]_4$
2	Red Light red Intense red	Red ochre (Indian red) Cinnabar	Fe_2O_3 HgS
3	Orange	Red ochre + Kaoline	$Fe_2O_3 + Al_2[Si_2O_5][OH]_4$
4	Yellow	Yellow ochre	$Fe_2O_3.H_2O$
5	Black	Manganese oxide, hydroxide minerals plus or minus iron oxides	$MnO_2 + (OH) + FeO$
6	Green	Green earth	Celadonite: $(K[Mg,Fe^{2+}]Fe^{3+}[Si_4O_{10}][OH]_2)$ Glauconite: $([K,Na][Mg,Fe^{2+},Fe^{3+}][Fe^{3+},Al][Si,Al]_4O_{10}[OH]_2)$
		Emerald Green	$3Cu(AsO_2)_2.Cu(CH_3COO)_2$
7	Brown or Reddish-brown	Umber	$FeO + MnO_2$
8	Yellow–brown	Sienna	$FeO + MnO_2$

7.2 Protection

The Archaeological Survey of India has identified many rock paintings sites as "government-protected sites." It's possible that no unified planning can be done because these sites are protected in different ways and can't be joined and protected in a wide area. A fully protected area of the site should be situated to organize it properly. If at all possible, all large rock art sites should be fenced, as this will help keep animals away from the imagery in rock shelters, which can be damaged by rubbing against them or licking them with salts from the walls. However, inside a fenced area, it can cause additional issues. It can contribute to an accumulation of dense vegetation, which can be harmful to rock paintings. As a result, vegetation growth must be regulated and excessive fuel accumulation must be avoided within fenced areas. Tree felling must be prohibited in those protected areas where forests have become scarce in recent decades, exposing paintings once concealed in these woods to sunshine, wind, and rain, hastening the deterioration of rock paintings. Wherever forests are scarce, it should be attempted to preserve the natural landscape by planting trees. No factories should be allowed to build in or near protected areas; particularly those that emit harmful gases and wastewater, to minimize pollution and keep the environment clean (Malla, 1999).

7.3 Management

Rock art sites dating back to prehistoric times are abound in India. According to a rough estimate, these rock art sites, which number in the thousands, have been registered all over the country's rich cultural heritage. There are no two ways about it: these sites should be preserved for future generations because of their historic, artistic, educational, or scientific significance. Unfortunately, despite being one of the most valuable types of cultural property, they are likely one of our nation's most forgotten treasures. There are several explanations for this neglect, and it would be incorrect to attribute the current state of neglect and degradation to a single cause. However, it cannot be denied that human intervention (in the form of vandalism) or inaction as a result of improper or inadequate information about conservation and management methodologies has greatly contributed to their degradation in the majority of cases.

The management and conservation of rock art sites is a difficult job, and there is currently little expertise available in the region. The role of preserving rock art can be easily divided into two categories: management of rock art sites and rock art restoration. Conservation refers to the measures taken to slow the rate of degradation and conserve the current materials to prevent the deterioration of different components of art forms. This aspect of rock art conservation is a highly-skilled job that necessitates adequate skill on the part of the conservator to produce successful results, and it will be discussed in a separate communication. However, the management aspect is more important in the sense of rock art since it maximizes the proper use of the site and directly contributes to the conservation objective. The management of rock art sites, while appearing to be a simple activity, is a highly specialized job that requires knowledge of archaeology, anthropology, history, sociology, law, landscape, architecture, chemistry, and other fields. On the other hand, a rock art manager does not need to be knowledgeable in any of the disciplines mentioned above. He will complete the job by serving as a supervisor of various specialists working against a common objective (MacLeod, 2000).There have been some attempts in the past to formalize a management strategy by some scholars working in the field (Sundara et al., n.d.).However, a comprehensive strategy, which can tackle the need of different types of sites is a far cry now.

The prehistoric people produced the precious rock art for ceremonial and other purposes and these are undergoing rapid destruction caused by unaware society. The ecological disturbance and bio-deterioration are creating havoc in the preservation of rock art other damaging factors include birds dropping, fly masks, accumulation of dust and smoke, hydration, dehydration, oxidation of organic binding materials etc. Threat from human vandalism due to lake of knowledge and pressure from tourism are other important factors.

It is necessary to control unnecessary vegetation growth and burning of fuel within fenced rock art sites. The restoration of ecological environment wherever woods are rare and paintings are exposed to sunlight, wind, rain etc. should be undertaken. No factories discharging harmful gases and waste water should be allowed near rock art sites. The practice of applying chalks on petroglyphs must be discouraged. Insect mud nests and salt deposits should be removed from the rock art periodically. The water seepage through the rock must be arrested. Proper water drainage management system at rock art sites has to done. All the loose paintings should be glued with appropriate materials and edging undertaken. It is necessary to provide a general educational programme for local public and tourist to develop awareness and responsibility towards preservation of Rock art sites. This can be achieved by organizing seminars, lectures, video films, group discussion, distribution of leaflets etc. For interpreting imaginary paintings visitor centres may be made functional near rock art sites.

7.4 Conservation

Many rock paintings have suffered greatly as a result of extreme temperature and relative humidity fluctuations. The degradation of these cultural relics is, in reality, an inevitable consequence of an unfavourable climate. Tropical climate conditions with high relative humidity and high temperature and significant variations in these climatic parameters are unsuitable for the successful preservation and proper maintenance of these works of art. Since caves and rock shelters are exposed to sunlight, wind, and rain, the key issue that must be effectively addressed is how to change this condition to meet the preservation requirements. Because of the adverse environmental conditions of the rock shelters, the preservation of these paintings is fraught with difficulties. Insects thrive in stagnant humid air, which must be combated by destroying them and incorporating adequate ventilation to remove pockets of humid air inside the caves. The algal growth that has infected some paintings must be removed and eradicated to prevent it from happening again. Since high humidity promotes algal growth, the issue of managing and removing algae is one of management. Unless the rock shelters and caves are made water-tight by introducing successful structural conservation and repair measures, moisture seepage will continue, promoting algae development. Insolation and wind erosion are also issues of cave and shelter management, and measures must be taken to reduce the negative effects of insolation, break the wind velocity, and reduce the sand-blasting effect of dust-laden winds. Apart from the above conservation issues, chemical cleaning of the paintings is needed for the removal of extraneous accretions as well as the consolidation and fixation of pigments. The weathered and friable rock surface must also be carefully consolidated (Bean, 1977; Brown, 1960; Johnson, 1959; Lal, 1976; Marshall, 2020; Plets et al., 2012). The researchers on Indian rock art have assigned fading of pigments, exfoliation of rock art surface and encrustation as main factors responsible for the loss of earliest paintings. While the first two are irreversible process, the third gives some scope for intervention as shown by nature itself at Bhimbedka. Some of the earliest paintings covered by calcium encrustations have been found to be occasionally re-exposed. At Bhimbedka and adjoining areas like Lakhajoar, there are several instances of rain water flowing over the iron oxide pigment paintings forming a thin layer of lime over it and subsequently due to changes environmental conditions, dissolving the lime cover exposing the earlier paintings. The action of faunal excretion particularly of birds, the acidic solutions coming down from edges and other riches have caused a pathway of corrosion creeping down.

8 Conclusion

The review of this paper does not only deal with the distribution of rock painting in India but also enriches the understanding of the painting technique and materials. Red ochre as red and kaoline as the white colour were two pigments used in most of the rock shelters of India. The majority of Indian rock paintings are found in Central India, with many of them in Madhya Pradesh. Natural weathering is causing the painted rock surfaces to deteriorate, and strong winds, rain, and moisture seepage are destroying the pigments. Many sites have been vandalized, and some have disappeared as a result of development. Visitor management may reduce the risk of vandalism, prevent inadvertent harm to rock art, reduce the effect of visitors on the environment, and increase visitor awareness of rock imagery. To efficiently control the sites and combat vandalism, arrangements for site policing/monitoring or prohibition of visitation and the will of the relevant government authority to exercise its legal powers must be invoked. The analysis of processes of exchange between the rock and the external environment from geological, climatological, and hydrological perspectives is urgently needed to understand the current state of the painted wall and its future evolution. Pigment analysis is also useful in conservation studies to identify salt traces and other contaminants. The National Research Laboratory for Conservation of Cultural Property (NRLC), Indira Gandhi National Centre for the Arts (IGNCA), Archaeological Survey of India (ASI), and State Archaeological Departments can play an important role for taking extensive protective measures to save rock paintings. These divisions should be staffed with specialists who are knowledgeable in the field and given additional funding to achieve their objectives. Furthermore, several rock shelters have superimposed paintings, and many more have superimposed paintings adjacent to vacant and unpainted regions. Intensive superposition has been observed in some cases. Whether the practice of superposition was determined by a lack of room, or whether the rock shelter people purposefully superposed their petrographs over earlier drawings, are curious questions to which no answers seem to have been attempted. It is self-evident that a planned survey and accurate documentation of the rock paintings are needed. Due to the above considerations, extra caution must be exercised when creating accurate reproductions that include all specifics of shape, scale, composition, and colour. Environmental disruptions and bio-deterioration issues are wreaking havoc on the preservation of rock art. Scientific conservators tend to have an unmet need for microbial treatment to conserve this primitive art for posterity, with the aid of research laboratories. Various preservatives are now used in various parts of the world to prevent moisture and rainwater from damaging the rock paintings. Scientists seem to have a pressing need for microbial treatment to preserve this primitive art for posterity, and research laboratories seem to be willing to help. Various preservatives are currently used in various parts of the world to prevent moisture and rainwater from negatively impacting rock paintings.

Future Scope and Work: Developing 3D digitalization of rock paintings and implementing an advanced tool for providing all information regarding rock paintings and sites at a single click is needed. The dedicated authority should involve more and more scholars and researchers in the special project for preparing documentation, records, and data of unexplored sites through scientific study. It is important to provide a general education program, on a larger scale, for the public to raise public consciousness of the importance of cultural heritage protection, as has been suggested and practiced, though not quite enough, to the required extent. This target can be accomplished by conducting exhibits, seminars, webinars, with color slides, video films, and public group discussions. It would also necessitate the participation of rock art researchers on a personal level.

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