



Bijoliya Vindhyan Supergroup Sandstone Region of Rajasthan, India: Conservation of Geoheritage and Geotourism

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Abstract

The Bijoliya region of Bhilwara district, Rajasthan, is bestowed with good quality sandstone. The Menal-Bijoliya-Bhimlat terrane dominantly composed of Vindhyan Supergroup sandstone. This sandstone forms a plateau-like feature with two important waterfalls, namely Menal and Bhimlat. This terrane exhibits sandstone sedimentary features and mediaeval Menal, Kaner ki Putli, Bijoliya Shiva and Jain temple monuments. The large sized rock inscriptions of 1170 AD are marked on the Bijoliya sandstone. Due to high durability and resistant to weathering quality of the sandstone, these rock inscriptions are still intact. Several Prehistoric cave art, stone tools and rock shelters paintings are present in the Bijoliya region. These signify early human social development and life style. Bijoliya sandstone is an important Heritage Stone Resource, which was used for shelter and rock art by the prehistoric human dwellers, and later on during the ancient, mediaeval and present time. Mandakini Kund, Hazaresvara Mahadeva or Hazaralinga temple, Kaner ki Putli, Menal Shiva temple and other historic monuments were constructed from the Bijoliya sandstone. Archaeological Survey of India listed these monuments and declared protected. Presently, widespread mining and poor preservation of sites causing distortion of geoheritage from the region. These sites require attention of society and the government for conservation, and should be developed for geotourism.

Keywords Vindhyan Supergroup · Bijoliya sandstone · Bhimlat · Geoheritage · Geotourism

Introduction

The present study is focused to highlight geoheritage and geotourism potential of Menal-Bijoliya-Bhimlat area, which is part of Hadoti Plateau of Rajasthan state, further referred as the Bijoliya region. This is having a linear length of approximately 45 km. The highest point is approximately 520 m from MSL (mean sea level) and the lowest point is 360 m from MSL in the region. The area is covered with Proterozoic Vindhyan Super Group of rocks. The Bijoliya region is the second largest sandstone producing area in the state. The region mainly comprises sandstone and shale, which belongs to the Lower Bhandar Group (Bundi Hill Sandstone) of the Vindhyan Supergroup (Coulson 1927; Prasad 1984; Nagar et al. 2017). The Bijoliya is part of

Bhilwara district, and the Bhimlat (Bundi District) located in northeast of Bijoliya (Fig. 1). The Menal (Chittaurgarh Distt) is situated in the southon of Bijoliya (Fig. 1). The Great Boundary Fault (GBF) separates the Archaean rocks and Palaeoproterozoic supracrustals of the Hindoli Group from the lower and middle parts of the Vindhyan Supergroup of rocks (Fig. 1). The GBF is exposing in and around the Chittaurgarh-Bundi region.

The Bhandar Group sandstone of Vindhyan Supergroup is having best quality of stone because of their regular bedding, uniform grain size, split able nature and durability. The Sandstone is used for roofing, flooring, paving, paneling, beams, pillars, doors and window-sills, wall facings, fence-posts, milestone etc. It is also suitable for carving and making perforated windows and stone net locally known as jallis. The Bijoliya sandstone is red to yellow coloured with medium to fine grain size. For several centuries, this is mined for the fort, buildings, sculptors, artifacts and other purposes (Tarun 2012).

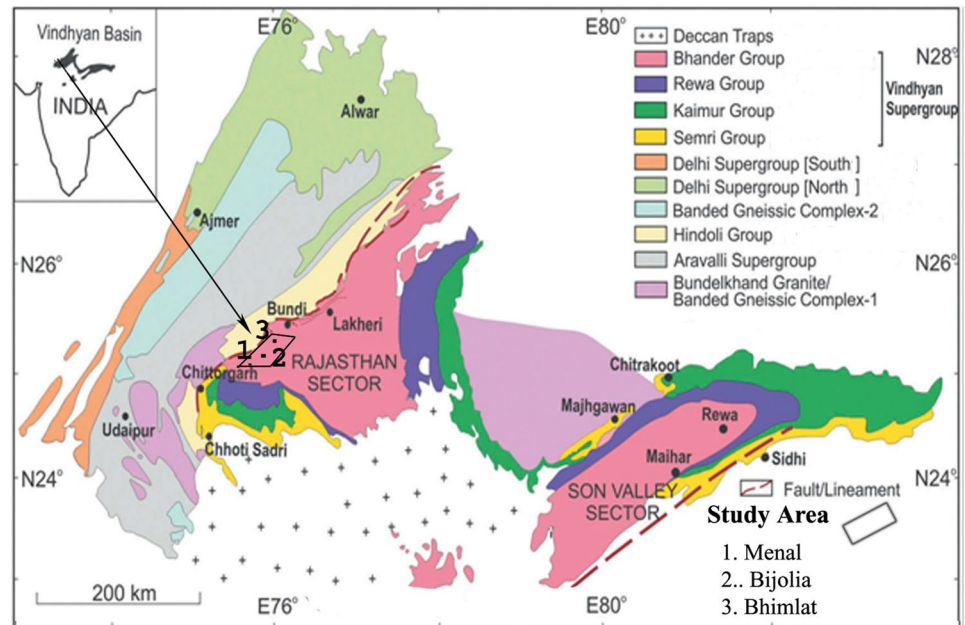
The Bijoliya was part of erstwhile Mewar Province prior to Independence. Geomorphologically, the region forms plateau and described as Uparmal (Todd 1832). Imperial

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Fig. 1 Geological map of west-central India showing the location of Vindhyan Supergroup (modified after Shukla et al. 2020)



Gazetteer of India (1908) mentioned three Shiva temples of tenth century, five Jain temples, two rock inscriptions and remnant of palace of twelfth century at Bijoliya. This region was prosperous from tenth to the twelfth century and marks construction of Bhumija-style temples dedicated to Shiva and Parshavanath.

The Archaeological Survey of India (ASI), Kumar (1981), Wakankar (1983), Kumar et al. (1992), Sharma (1998) and Saleem (2014) documented prehistoric rock shelters and paintings in the Hadoti region of Rajasthan. Rock paintings in natural caves, stone tools and rock shelters indicate Upper Palaeolithic and Mesolithic human settlement in the region (Saleem 2014). The Bijoliya region remained the cradle of human civilization from Palaeolithic-Mesolithic to Chalcolithic time. The sandstone terrane provided rock shelter, perennial water source and food for the prehistoric settlers in the region. There are two waterfalls in the region, one at Menal and another at Bhimlat. The Menali river forms a waterfall near the Menal temple complex; similarly, the Mangali river forms a waterfall at Bhimlat.

The word geoheritage is a descriptive term applied to sites or areas of geologic features with significant scientific, educational, cultural or aesthetic value. This word is also used for research, education and reference localities at the local to global level (Chauhan et al. 2021). Presently, there has been a considerable increase in awareness for preserving geoheritage sites through promotion of the geotourism (Mukherjee 2021). The Bijoliya region is an important destination exhibiting heritage Bijoliya sandstone resource depicting geological features. This sandstone was used for construction and making stone tools from prehistoric time to present day. The prehistoric paintings of Bijoliya region

help to understand early human, their lifestyle, food habits, activities and thought process. These are the greatest wealth, and the primitive humans have left behind.

The conservation of geoheritage, monuments and rock art will help the society to understand the earth science, history and human evolution. Rajasthan attracts a large number of national and international tourists every year. The development of these sites and awareness programme will benefit the society immensely. Geotourism promotes geological, environmental and cultural awareness, and economic development of the local community. The geoheritage of the Bijolia region requires conservation so that these may remain unaffected from further deterioration. There is need of infrastructural development, proper connectivity of Bijoliya and adjoining important sites for geotourism promotion.

Regional Geology

Oldham (1857) proposed the name “Vindhyan” for a thick sequence of unmetamorphosed sediments occurring in the Vindhya region of central India. Medlicott (1859), Mallet (1869), Oldham et al. (1901), Heron (1932, 1936), Coulson (1927) and Auden (1933) were pioneer workers, who mapped the entire Vindhyan region and presented stratigraphy. Mallet (1869) after a regional study of Vindhyan rocks in the north-western and central India introduced the term “Lower Vindhyan” for the “Semri Series” and grouped other three units Kaimur, Rewa and Bhandar as part of “Upper Vindhyan.” The Vindhyan rocks form a large arcuate belt roughly 104,000 km², situated along the northern-central part of the Indian Shield. These sediments are flat-lying with minor dip, except

some structural disturbance especially at the basin margins (Fig. 1). The Vindhyan sequence overlies structurally disturbed and metamorphosed basement rocks with a marked erosional unconformity. The Vindhyan Supergroup is having maximum thickness over 4200 m.

The Vindhyan Supergroup outcrops in the Rajasthan sector, the Bundelkhand sector and the Son Valley Sector (Venkatachala et al. 1996). The Vindhyan Basin is divided into two terranes—the Rajasthan terrane is the western part and the Uttar Pradesh-Madhya Pradesh-Bihar region in the eastern sector (Mitra 1996). The trondhjemitic gneisses of c. 2600–2500 Ma old Bundelkhand Igneous complex (Sarkar et al. 1995) act as a basement ridge between the Rajasthan and Son Valley terrane (Prasad and Rao 2006). The Great Boundary Fault (GBF) of the Rajasthan separates the Vindhyan Supergroup rocks from older Aravalli Supergroup and basement granitoids.

Mondal et al. (2002) stated that the Vindhyan Basin developed on the Aravalli craton, which stabilized by 2.5 Ga; Bose et al. (2001) expressed that the rifting caused a series of east to west trending faults in a dextral transtensional setting and this caused development of basin in the region. The lower Vindhyan units are unconformably overlies basement rock of the 1854 ± 7 Ma old Hindoli Group (Deb et al. 2001) and the 2492 ± 10 Ma old Bundelkhand granites (Mondal et al. 2002). Malone et al. (2008) and Turner et al. (2014) reported closure of the Vindhyan basin around 1.0 Ga on the basis of absence of younger than 1000 Ma old zircons in the Upper Vindhyan sediments.

The Sandstone deposits of the North-Eastern part of Rajasthan are confined to the Vindhyan Supergroup of rocks, and exposed over an area of about 34,000 km². The Vindhyan sediments in Rajasthan overlie the Bhilwara Supergroup metamorphites and the Berach Granite. These sediments exhibit an alternating sequence of sandstone, shale and limestone having a total thickness of about 3200 m. The Lower Vindhyan rocks are mainly calc-argillaceous while the Upper Vindhyan are dominantly arenaceous (Fig. 1).

The Vindhyan Sedimentation in Rajasthan took place in two different sub-basins, the Chittaurgarh-Jhalawar sub-basin in the southwest and the Sapotra-Karauli sub-basin in the northeast. The two sub-basins later covered by common layer of sediments. These sub-basins are separated by a median upland near Bundi (Prasad 1984). The Vindhyan basin was mapped by Heron (1932, 1936) in Karauli, Bijoliya and Chittaurgarh region of Rajasthan. Heron (1936) used the word Bijoliya platform for the upper Bhandar sandstone exposed in the study area.

Geology of the Study Area

Coulson (1927) mapped and established stratigraphic relationship of Vindhyan rocks of Bundi-Bijoliya area. Heron (1932, 1936) divided Bhandar Group of Karauli and Mewar

(Chittaurgarh, Bijoliya and Mandalgarh region) into four mutually conformable lithologic units, namely Ganurgarh shale, Bhandar limestone, Sirbu shale, Bhandar sandstone. Coulson (1927) worked out eight mutually conformable lithologic units of Bhandar Group in Bundi area, namely, “Ganurgarh shale, Lower Bhandar limestone, Samri shale, Lower Bhandar sandstone, Sirbu shale, Upper Bhandar sandstone, Upper Bhandar limestone, Upper Bhandar shale”. Heron (1936) identified fault in the region based on straightness of a scarp on Bijoliya platform. Coulson (1927) reported Lower Bhandar sandstone (792-m thick), Sirbu shale (152-m thick) and Upper Bhandar sandstone (24-m thick) in the Bijoliya-Bundi track.

The Bijoliya area comprises sandstone and shale belonging to the Lower Bhandar group (Bundi Hill Sandstone) of the Vindhyan Supergroup (Prasad 1984). There are three major sandstone horizons separated by two horizons of shale. The Bijoliya sandstone exhibits different types of bedding and laminations, ripple marks and cross-bedding (Fig. 2a, b). The Lower Sandstone horizon outcrops in the southern area have a thickness of approximately 20 m. This is pink, greyish and reddish brown in colour, showing fine- to medium-grained texture. The middle sandstone is approximately 35 m in thickness. This horizon is bedded and at places show joints. This is light green to brownish in colour and medium- to fine-grained in nature. The upper sandstone is generally white to light pink in colour, this is fine to medium-grained, and outcrops in the northern part of the area. The bedding plane in the region is almost horizontal; at some places, it shows a dip angle of 1 to 5°. The sedimentary structures are well preserved in the sandstones; besides this weathering and erosional features are developed in the sedimentary rocks (Nagar et al. 2017).

Nagar et al. (2019) described the sedimentological characteristics of the Bijoliya sandstone in detail. The sandstones are well sorted and consist of quartz up to 84 to 97%. The quartz is fine-grained and sub-angular to sub-round in shape. Under microscope, quartz grains show uniform extinction and fractures filled with opaque material. Feldspars are present in minor amounts. Nagar et al. (2019) described Bijoliya sandstones fall under the texturally “mature stage” category and are plotted in the field of Continental Block Province. The sedimentary Structures and petrological characteristics indicate shallow water littoral origin of these sandstones. The weathering and erosion of sandstone caused development of pedestal rocks, sandstone caves and rock shelters in the region. The erosional caused development of waterfalls at Bhimlat (Fig. 2d) and Menal respectively.

Archaeological Sites of Bijoliya Region

The Bijoliya, Menal and Bhimlat area is having magnificent ancient monuments. The Bijoliya region gained prominence as a sacred location for the Jain and Shiva.

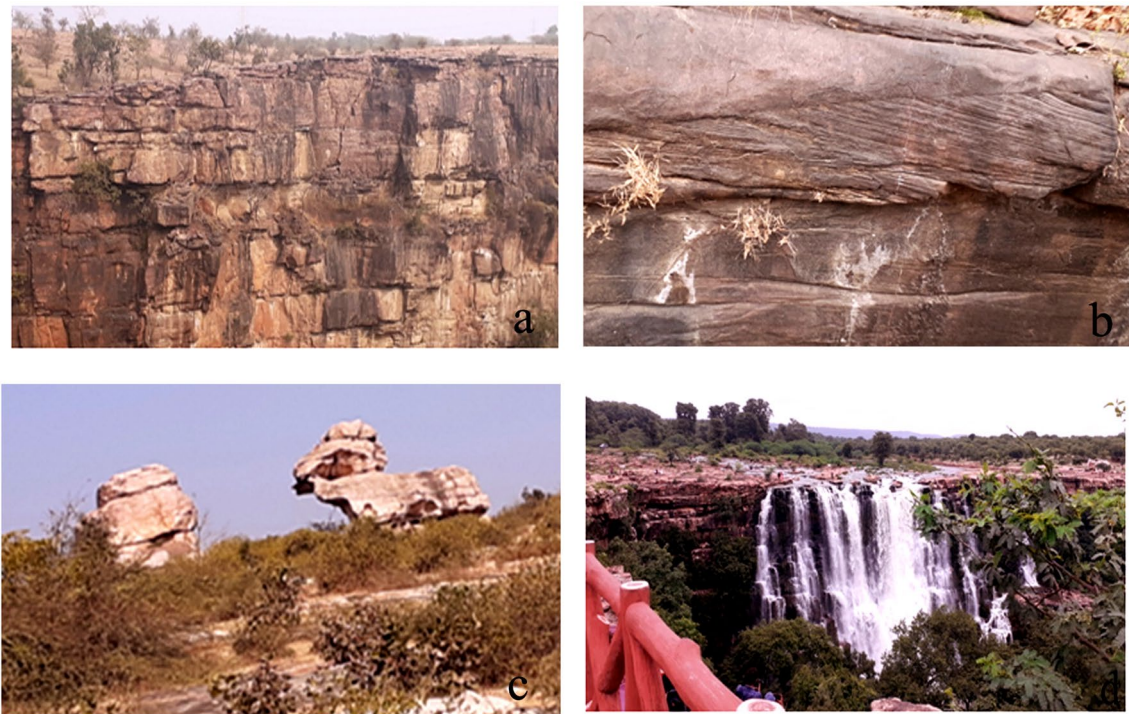


Fig. 2 Sedimentary and erosional structures of Bijoliya sandstone. **a** Horizontal bedded Bijoliya sandstone. **b** Cross-bedding structures in the Bijoliya sandstone. **c** Pedstal rock structure of Bijoliya. **d** Bhimlat waterfall

Archaeological Survey of India listed all these monuments and declared protected. The Bijoliya sandstone was used for sculpture, carving, pillars and construction of all these monuments. The high durability and resistant for weathering are significant properties of the Bijoliya sandstone. Due to this, even after thousand years after construction, these monuments are still preserved. The inscription made on this sandstone is almost intact and will remain for several hundred years.

Bijoliya

The Archaeological Survey of India (ASI) listed following protected monuments (Table 1) at Bijoliya (Fig. 3a, b, c and d). These monuments are made from Bijoliya sandstone.

Mandakini Kund and Temples

The Mahakala temple, Hazaralinga temple, Undesvara Mahadeva temple and a water tank named as Mandakini Kund form a temple complex at Bijoliya. Temples are of varying periods ranging between tenth to thirteenth centuries. The Mahakala temple is the oldest and conforming to the Gujarat style of architecture. It is a double-shrined temple consisting of two shrines, the main one facing east and the subsidiary one facing south, with a common *sabhamandapa*, a porch facing west and two small side chambers, one above the other (Fig. 3a, b and d).

The Hazaresvara Mahadeva or Hazaralinga temple is of a variant Bhumija style of architecture and consists of a shrine and a *mandapa*. This shrine contains high *linga*, covered with hundreds of small *lingas* and hence called Sahastralinga.

Table 1 Ancient monuments made from Bijolia sandstone

S. N	Locality	Location	Name of monument
1	Bijoliya	25.15674344 N 75.32820672 E	Mahakal, Mandakini Kund and two other temples
2	Bijoliya	25.15125285 N 75.33825092 E 75.33825.92	Rock Inscription near Parsvanath Temple
3	Bijoliya	25.15055361 N 75.33759043 E	Rock Inscription in the Parasvanath Temple compound



Fig. 3 Bijoliya region monuments (ASI-protected monuments). **a** Mandakini Kund and Shiva Temple. **b** The Undeshvar Temple. **c** Rock inscription marked on the Sandstone Near Parsavnath Jain Temple. **d** ASI Notification for the protected Bijoliya monuments

The Undesvara Mahadeva temple is of the typical Bhumija style with a stellate shrine and *sabhamandapa* approached from the east, with porches on the south and the north. The sanctum is situated about 2.4 m below the level of the *sabhamandapa* floor and water seeping from the Mandakini Kund keeps the *linga* immersed for most parts of the year.

These temples carved with detailed craftsmanship and a beautiful design. A closer look, however, reveals the intricacies on the walls of this shrine, which depicts figurines engaging in intimate acts, like Khajuraho in Madhya Pradesh and the Sun Temple in Konark.

Bijoliya Parshvanath Temple and Rock Inscriptions

The Teerthankar Parshvanath Jain temple is situated about 1.5 km to the southeast of Bijoliya and constructed at the time of the Chahamana king Someshvara in 1170 AD. Kielhorn (1906) and Todd (1832) reported two Sanskrit rock inscriptions from Bijoliya, both dated 1170 AD (Fig. 3c). One inscription provides the genealogy of the Chahamanas of Ajmer and the other is a Jain poem called *Uttama Sikhara Purana*. This latter inscription incised near the shrine door of the temple of Parshvanatha. This records the obeisance of Manoratha, son of

Mahidhara. The mythological treatise called the *Uttama Sikhara Purana* was composed and engraved on a large rock at the site. The Parshvanath temple is supposed to be the place of penance (Tapa Bhumi) of God Parsvanath, the place of provocation (Upsarg Bhumi) by Kamattha (Enemy of Parsvanath since previous lives) and the place of achieving Kevalagyan (omniscience).

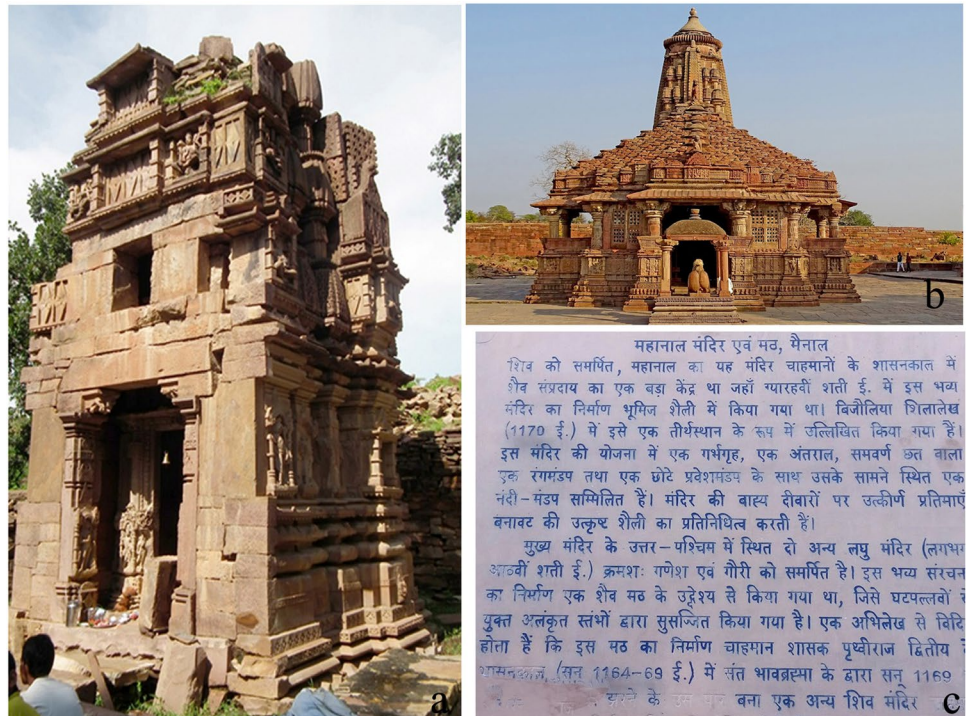
The Menal Region Monuments

Menal and Kaner ki Putli monuments are situated in southern part of the Bijolia region. These are ASI listed sites and constructed in the mediaeval time. These are made from Bijolia sandstone.

Kaner ki Putli

The Kaner ki Putli monument (25.11805067 N, 75.23581166 E) is situated in a valley formed by water erosion in the Bijoliya sandstone (Fig. 4a). The sanctum enshrines a Shiva Linga. Though relatively rare, Atiriktanga Bhairava or Tripada Bhairava sculptures are present at this site. This is unique at comparable to Modhera, Jarai Math at Barwa Sagar between Jhansi and Khajuraho, Kiradu to the north of Modhera, in Rajasthan (Mankdit 2009).

Fig. 4 Menal region monuments (ASI-protected monuments). **a** Kaner ki Putli Temple. **b** Mahanal Temple of Menal. **c** ASI Notification at Menal



The temple is of late eleventh century old. The Archaeological Survey of India listed this site and located near Khadipur or Khadipura village. The temple is situated at the bank of a small spring, in a grove of the flowering Kaner or oleander trees. It bears the charming name of Kaner ki Putli, “Oleander Flower Dolls”. The Tripada Bhairava is situated on the northern wall of temple.

Menal Temples

The Menal village (25.09304238 N, 75.17255612 E) is situated in the southern direction of Bijoliya. The name Menal is given after the Menali River, which feeds the waterfall near the temple complex. The eleventh century Mahanal Siva temple was a great centre of Shaivism under the rule of the Chahamanas. The temple built in the Bhumija style of architecture with a stellate pancharatha (Five Chariot) ground plan. This superstructure carrying strings of angasikharas (rising towers), which is characteristic of the Hindu temple architecture of North India. A separate Nandi-mandapa exists in front of temple. The sculptures are of a high order. The pillars and walls at the entrance of the temple have amazing erotic sculptures. Besides this, ruined Shiva shrines are situated to the northwest of the Bhumija temple. An inscription records that the *matha* was built by an ascetic Bhavabrahma in A.D. 1169 during the reign of the Chahamanas king Prithviraja II (Fig. 4b and c).

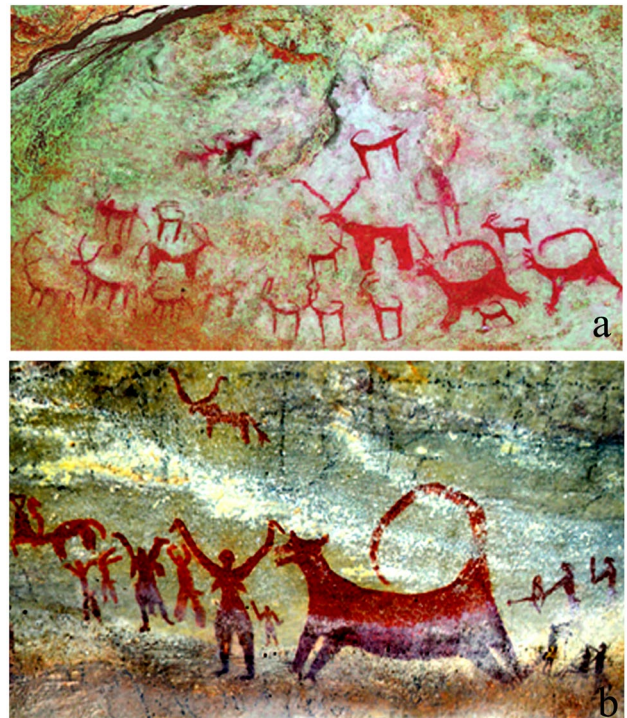


Fig. 5 Bhimlat prehistoric rock arts. **a** Mesolithic rock art depicting animals and humans at Bhimlat. **b** Mesolithic rock art depicting animal hunting and human Bhimlat

Prehistoric Cave Paintings and Rock Art Sites of Bijoliya Region

The Bijoliya sandstone terrane forms a plateau, on which weathering and erosion caused development of pedestal rocks, caves, waterfalls, rapids and stand-alone shelters. The Bijoliya sandstone is good aquifer and water seepage developed in vallies. The availability of water, greenery and wild life along with caves and shelters in the region made this place suitable for settling of human during prehistoric time. The Bijoliya sandstone plays an important role for sustaining early human life in the region. The gradual human evolution from Palaeolithic to Mesolithic and further is depicted in the form of cave paintings and rock art.

Cave paintings are drawings on cave walls or ceilings primarily of prehistoric origin. The rock art is prehistoric man-made markings on natural stone. The paintings and drawings are the oldest art forms used by human beings to express themselves with cave wall as the canvas.

The Bijoliya-Bhimlat region has treasures of rock shelters and rock paintings. Om Prakash Sharma ‘Kukki’, a freelance archaeologist and rock painting site discoverer of Bundi, identified more than 100 rock-painting sites in Kota, Bundi and Bijoliya region. A large number of researchers have explored and documented numerous rock art shelters and painting of the Bijoliya-Bundi-Kota region (Archaeological Survey of India; Sharma 1998; Wakankar 1983 and Saleem 2014).

Dubey-Pathak and Clottes (2016) identified and described nine rock paintings from the Bhimlat waterfall area (25.30280702 N, 75.41138269 E). The Rock paintings of Bhimlat are made from natural colour, organic medium, blood and other natural things (Fig. 5a, b). The rock paintings depict figures of ancient man, animals, hunting, weapons, dance, bird rider and other figures. During the late Mesolithic phase, the size of the bow was reduced, and it can be seen clearly in those depictions found at Bhimlat. The preservation of the art in the Bhimlat area is poor as the paintings are facing natural erosion and human interference.

Bijoliya Sandstone—A Heritage Stone Resource

The Bijolia sandstone outcrops over an area of 5000 km². It is one of the largest sandstone production centres of Rajasthan. Early human used this sandstone since Palaeolithic and Mesolithic time for shelter, making stone tools and monoliths. The presence of cave paintings, rock shelters and sand stone tools implies heritage stone resource designation for the Bijoliya sandstone. The Bijoliya sandstone was used as important building material for the construction of forts, palaces and several archaeologically significant monuments in the region during ancient and mediaeval history.

The Bijolia sandstone is an excellent building stone and can be chiseled and dressed to a smooth surface in various attractive shapes. It is especially useful for exterior cladding in seashore buildings due to its acid and thermal-resistant properties. The effect of saline winds is negligible on sandstone. The Bijoliya sandstone has regular bedding, uniform grain size and high durability; this makes it an important stone resource. This sandstone is mined in large quantity, and exported through Gujarat’s Kandla port, to the several countries. The Bijoliya sandstone is having high density and compressive strength, which makes it one of the significant stone resources used for the centuries to present day.

Chauhan (2010) lamented for environmental degradation and its impact on the geoheritage of the region. Urgent attention is required for a scientific and environment friendly mining operation in the region, to protect the national importance monuments and sites of the rock art and paintings. Summarising all, it is opined that the Bijoliya sandstone should be designated under the Global Heritage Stone Resource (GHSR) category (Cooper et al. 2013).

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Author Contribution Kamal Kant Sharma: conceptualization, field studies, manuscript writing, evaluation, supervision.

Lokesh Tripathi: field studies, initial draft writing, supervision, analysis, evaluation.

Declarations

Conflict of Interest The authors declare no competing interests.

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