

# **Geoheritage in Rajasthan: A strategy towards Sustainable Practices**

## **Abstract**

Geoheritage refers to geological features that have significant scientific, cultural, aesthetic, or educational value. Rajasthan, with its vast desert landscapes, ancient rock formations, and rich fossil records, is a treasure trove of geoheritage sites. These sites not only provide insight into the Earth's geological past, but also offer significant educational, recreational and economic benefits. The Geological Survey of India has identified and protected numerous sites of geological significance, fostering both conservation and geo-tourism. This paper explores the potential of geoheritage conservation in Rajasthan as a tool for promoting sustainable development. It discusses the challenges and opportunities associated with the development and management of these sites. It examines key geoheritage sites, the threats they face, and strategies to integrate their preservation with eco-tourism, education, and community participation.

**Keywords:** Geodiversity, geoheritage, national geological monuments, geotourism in Rajasthan.

## **Introduction**

Geological diversity refers to the natural portion of the planet that is not alive both at the surface and in the planet's interior. By geodiversity, we mean the earth's minerals, rocks, fossils, soils, sediments, landforms, topography and hydrological features such as rivers and lakes (Hjort et al., 2012). The term 'geodiversity' also spans the processes that create and modify these features (Ren et al., 2021). At a time when humanity faces the greatest challenge of modern age – human-induced climate change – geodiversity helps us to understand past changes to the climate. This knowledge will be vital to predict future changes in the climate and help us adapt more effectively (Brazier et al., 2012). Geodiversity is present in every aspect of our daily lives, in the objects and services we use v. Geodiversity is the foundation of all biodiversity. It creates the conditions in which life can develop and thrive, and underpins all the environments and ecosystems in on earth. As such, conserving geodiversity is an essential condition to protect biodiversity (UNESCO, Gray, 2004).

No other body in the Solar System has the geodiversity of the Earth and it is suggested that the major factors explaining this are:

- Plate tectonics - absent on all other planets, with the possible exception of periods of plate growth on Mars;
- Climatic differentiation through space and time with related diversity of physical processes, sediments and landforms;
- Evolution and extinction - creating the diversity of the fossil record.

'Geoheritage' are those parts of the 'Identified Geodiversity' of the Earth that are deemed to be worthy of conservation because of their scientific, educational, cultural, aesthetic or touristic value. importance/value. 'Geodiversity' is a value-neutral term describing the variety of abiotic phenomena on Earth, the abiotic equivalent of biodiversity. 'Geoheritage', on the other hand, is a value-laden term used to identify those specific elements of geodiversity that are selected for geo-conservation (Brilha, 2018a). Mining, tourism, climate change and

urbanisation are just some of the potential hazards faced by geoheritage (Alahuhta et al., 2022).

A UNESCO Global Geopark uses its geological heritage, in connection with all other aspects of the area's natural and cultural heritage, to enhance awareness and understanding of key issues facing society, such as using our earth's resources sustainably, mitigating the effects of climate change and reducing natural hazard-related risks (Crisp et al., 2023). UNESCO Global Geoparks (UGGp) are single, unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education and sustainable development. Their bottom-up approach of combining conservation with sustainable development while involving local communities is becoming increasingly popular. At present, there are 213 UNESCO Global Geoparks in 48 countries. Little help is required from the local communities to maintain these sites through a bottom-up approach. but India still hasn't managed to get any of its sites on the list(UNESCO).

### **Geotourism**

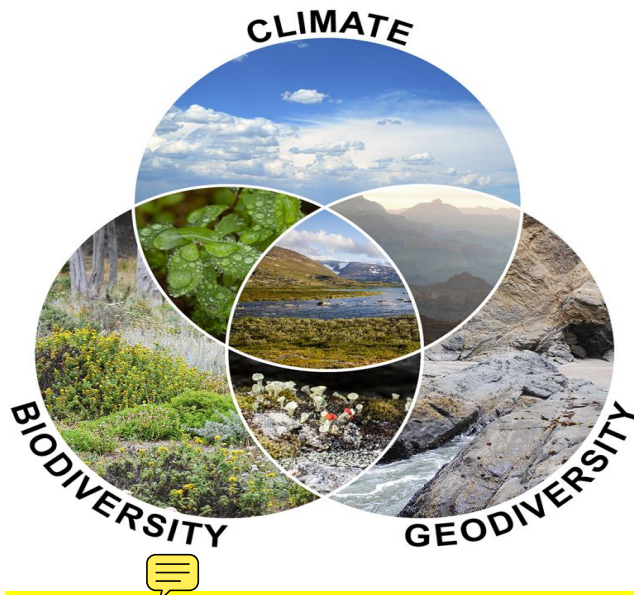
Geotourism is defined as tourism that sustain or enhances the distinctive geographical character of a place – its environment, heritage, aesthetics, culture and well-being of its residents.

### **Geotourisms...**

- *Environmentally responsible* - committed to conserving resources and maintaining biodiversity.
- *Culturally responsible* - committed to respecting local sensibilities and building on local heritage.
- *Synergistic* - bringing together all elements of geographical character to create a travel experience that is richer than the sum of its parts and appealing to visitors with diverse interests.

### **Why are geodiversity and biodiversity related?**

Geodiversity is the abbreviation for 'geological diversity' and refers to the non-living portion of the planet, while the term biodiversity describes the living portion. Soil, for instance, is part of the Earth's geodiversity but the micro-organisms that live in it are part of the planet's biodiversity. Although geodiversity is not alive, it is key to sustaining life on Earth; there would be no biodiversity without geodiversity. In general, when the abiotic setting changes, changes in species or communities follow (Gray 2013).



**Fig 1:** Geodiversity, biodiversity and climate are intimately interlinked

## Objectives

In this research paper I have attempted to demonstrate:

1. The differences and relationship between geodiversity, biodiversity, geoheritage, geoparks and geotourism.
2. The Study of The National Geological Monuments (NGMs) of Rajasthan, their SWOT analysis, Challenges and conservation strategies.

## Geoheritage sights (NGMs) of Rajasthan

Geological Survey of India has declared many rare geo-sites in India as National Geological Monuments (NGMs) to protect and preserve the country's geological heritage which display significant geological features and processes for enhancement of geotourism. These sites serve as important resources and attract geotourists around the world for:

### *Educational value*

NGMs serve as natural laboratories for students and re-searchers in geology. They provide opportunities to under-stand geological processes, rock formations and fossil records in their natural settings.

### *Conservation and heritage*

Designating sites as geological monuments helps in the preservation of unique geological features and promotes awareness about the importance of geological heritage.

### *Economic and recreational benefits*

Geotourism has the potential to boost local economies by attracting tourists, generating employment and promoting local crafts and products.

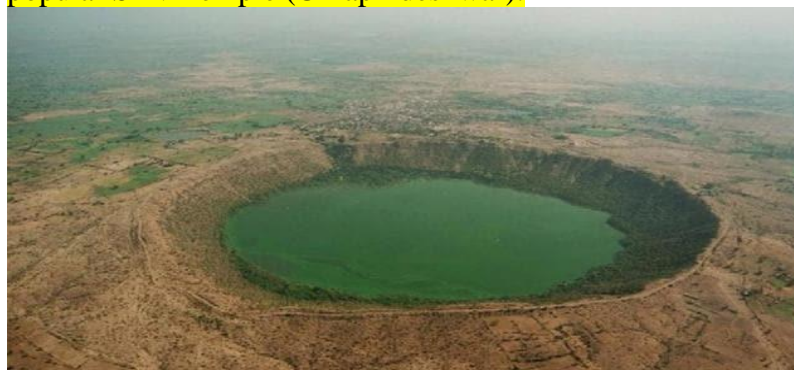
### *Collaborative efforts*

Collaborations between Government agencies, academic institutions and local communities can enhance the conservation and promotion of geological sites.

In Rajasthan, twelve geosites are National Geological Monuments (NGMs) declared by GSI. These are:

### 1. Ramgarh Meteorite Impact Crater, Baran District, Rajasthan

The Ramgarh Meteorite Impact Crater (MIC) displays a circular bowl-like geomorphologic depression of about 4 km diameter that is surrounded by a chain of hills conspicuously rising above nearly plain area of Vindhyan sedimentary rocks (240 m MSL). The central area of the crater has a small "Central Uplift Mound", considered a "Natural Shivling" hence a few Shiv Temples were built near it in the tenth century CE. Including the popular Shiv Temple (Ulkapindeshwar).



Picture 1 : The Ramgarh Crater in Rajasthan's Baran district

### 2. Akal Wood Fossil Park, Jaisalmer District, Rajasthan

An NGM marked amidst the desert city of Jaisalmer that is surrounded by the Thar desert from various sides. Akal wood fossil park is spread across a total area of 21 hectares and gets its name from its location that is in the Akal village situated 18 km from Jaisalmer. The terrain around the village is rocky and barren. This fossil park has the potential to be turned into a geological park as well. It boasts the fossils and footprints of pterosaurs near the Thaiyat area. The park consists of fossils of wood from the Jurassic period. Majorly found species are of petrophyllum, ptylophyllum, equisetitis, dicotyledonous wood and also gastropod shells (Ranawat *et al.*, 2016). This site has a great potential to be transformed into a Geopark. 180 million years old fossils of animals and plants are preserved at Wood Fossil Park at Akal, situated 17 km away from Jaisalmer city. The Jaisalmer Basin formed part of the southern shelf of the Neotethys during the Jurassic. The area is well known for its rich geodiversity, both in terms of landscapes and outcrops of rock types and the variety of fossils that these rocks have preserved. Lithostratigraphy of the mapped formations, namely the Lathis, Baisakhi and Bhadasar formations, is well established, and displays an array of Jurassic siliciclastic, mixed carbonate-siliciclastic, and carbonate rocks that range in age from Early Jurassic to Tithonian. The desert landscape include a variety of stable and active dune fields including parabolic, linear transverse and barchans of different size and generations, desiccated rocky plains and pebble-boulder spreads as deflation lag deposits and salt lakes. Here the fragile dryland ecosystem supports unique and varied wildlife. The vegetation is sparse, and patches of *sewan* grass and *aak* shrubs (*Calotropis*) can be seen in abundance. Desert National Park harbours a wide array of flora and fauna species and naturally supports the symbolic and protected Rajasthan State bird: Godawan – the Great Indian Bustard; animal: Camel; tree: *Khejri* and flower: *Rohida*. The Chinkara or Indian Gazelle (*Gazella gazelle bennetti*) is a common antelope of this region.



Picture 2 : Wood Fossils at Akal park

### 3. Welded Tuff, Jodhpur District, Rajasthan

Another NGM in the Jodhpur district of Rajasthan, the welded tuffs are a product of emanations that spurted millions of years ago from the volcanic vents and then were carried down by air till they finally settled down. Welded tuff is a pyroclastic rock, (volcanic materials) that was sufficiently hot at the time of eruption to weld together. During welding, the glass shards and pumice fragments stick together, deform and compact. When this air cooled down it gave rise to terraces and columnar structures. These structures are composed of glass, quartz and also feldspar. The malani rhyolites essentially comprise of welded tuff, pyroclastic rocks and various coloured rhyolites such as green, grey, pink, maroon, brown and purple. The terraces and the columnar structures are hexagonal to rectangular in shape and stretch to nearly 30 meters in dimensions.



Picture 3 : Welded Tuff

### 4. Zawar Mines, Udaipur District, Rajasthan

Zawar in Rajasthan is the world's oldest mining and metallurgy site, dated to have existed around 750 BCE, marking ancient India's acumen in the sector. Zinc and lead mined from the Aravalli rocks, extracted through a unique distillation process was shipped to Europe to bolster brass instrumentation for the industrial revolution. The American Society of Metals (ASM International) recognized Zawar as an "International Historic Landmark" in 1988 "At this site are preserved the zinc retort distillation furnaces and remnants of related operation. A geo-



archaeological site of this importance thus mandates a holistic conservation. Zinc is a metal that can be difficult to extract from the core, the process being known as ‘Smelting.’



Picture 4 : A wall made of used clay retorts, Zawar Mines

#### 5. **Stromatolite Park, Bhojunda, Chittorgarh District, Rajasthan**

Bhojunda stromatolite park is an exposure inside the Bhagwanpura Limestone of the Lower Vindhyan range. They are formed by blue-green algae which forms a mat by attracting and bonding carbonate particles through their filaments into stratiform, columnar and nodular structures in carbonate rocks. Stromatolites are an indication of the earliest form of life on earth and is formed by a combination of life activity, sediment trapping and binding activity of algae and bacteria. They generally form in shallow water. The location of the Bhojunda village lies 7KM south-west from Chittorgarh, which hosts one of the best exposures of the stromatolites (*Ranawat et al., 2016*).

#### 6. **Stromatolite Park, Jhamarkotra, Udaipur District, Rajasthan**

It is the largest and richest deposit of phosphorite associated with stromatolite. It is another site preserving pieces of evidence of early life on the earth. The stromatolites occur over a strike length of 15 km in rock phosphate within the Precambrian Aravalli Supergroup of rocks. The rock phosphate occurs in dolomitic limestone associated with stromatolites appearing in grey to bluish-grey color shades and invariable forms and shapes. The presence of unique algal stromatolite fossils in the Proterozoic Aravalli dolomitic limestone 1800 Ma at Stromatolite Park. Jhamarkotra attracted the attention of geologists all around the world. This NGM is present in the Udaipur district of Rajasthan and is nearly 25 km away from the city of Udaipur (*Ranawat et al., 2016*).

#### 7. **Barr Conglomerate, Pali District, Rajasthan**

Another geologist friendly spot in the Pali district, this conglomerate is composed of quartzite and rare granite pebbles, which then seem to be combined in some form of grained pelitic matrix. This structure rests conformably on Barr vicinity. A conglomerate is particularly of interest to geologists as it helps subdividing geologic history on the basis of various sedimentary breaks. The weathering process of millions of years have stretched the pebbles in this place by 20 to 30 times of their original dimensions (*Ranawat et al., 2016*).

#### 8. **Sendra Granite, Pali District, Rajasthan**

Nature is the best sculptor and this NGM is a representative of that fact. The Sendra granites of the Pali district in Rajasthan were formed nearly 900 million years ago and is a set of plutonic igneous rocks. They also intrude in the Delhi supergroup of meta sedimentary rocks (Ranawat *et al.*, 2016). Over millions of years the natural phenomenon of weathering and erosion have constantly acted on the granite and this has created marvellous structures in the place. Granite batholith (900 million years old), undergone years of sculpting by wind and water action to form beautiful structures.

### **9. Gossan, Rajpura- Dariba, Rajsamand District, Rajasthan**

A spectacular in-situ zone of gossan is found in the form of a ridge cap between Dariba and Rajpura villages of the Udaipur district. It is a unique world-class gossan formation that acts as the principal guide and indicator of the base metal mineralization of Zn-Pb-Cu-Ag deposits in this area. The gossan here is intensely oxidized, weathered, decomposed rock consisting of erosion-resistant iron oxides and quartz, giving it a reddish-brown, orange or yellow color. The mineralization is confined to graphitic mica-schist, dolomitic marble, and cherts of the Pre-Aravali group. Rajpura-Dariba is a typical area for the study of oxidized ores and is declared as a geological monument by the Geological Survey of India in collaboration with Hindustan Zinc Limited.



Picture 5 : Gossan, Rajpura- Dariba

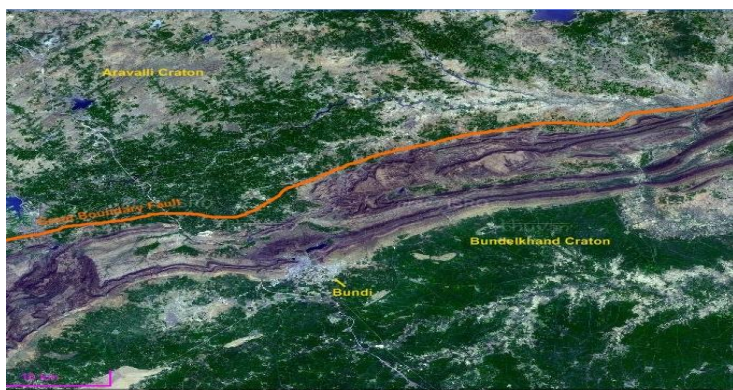
### **10. Nepheline Syenite, Kishangarh, Ajmer District, Rajasthan**

An interesting suite of alkaline rocks with nepheline syenite as the most dominant component occurs in the area around Kishangarh, northeast of Ajmer. The syenite body extends for about 25 km long and 1–5 km wide. The syenite body consists of feldspar minerals and variable amounts of mafic minerals. Nepheline syenite here is an intrusive igneous pluton emplaced along with the core of an antiform of metamorphites in the Aravalli craton which has been dated 1590 million years to 1910 million years old. Nepheline syenite at Kishangarh showing the gneissose appearance, form one major body and nine smaller bodies to the north and NE of Kishangarh. They are emplaced conformably within Precambrian schists, gneisses, and quartzites of the Aravalli system. This holocrystalline plutonic igneous rock consists largely of nepheline and alkali feldspar.

### **11. Great Boundary Fault at Satur, Bundi District, Rajasthan**

The great boundary fault is a major tectonic lineament in the south-eastern Rajasthan along the Bundi-Sawai madhopur hills. It separates Aravalli and Vindhyan. It is extended over Chittorgarh in the south, Bundi and Sawai Madhopur (Machilpur) in the north, and has a strike length of about 400 km. The Great boundary fault zone contains different types of fault

rocks, ductile shear zones, and multiple sets of fractures and faults. Great Boundary Fault at Satur, Bundi district in Rajasthan represents a zone of disruption constituted by a number of parallel and oblique faults resulting in a step-like feature. Deformed limestone at the site is worth viewing. Geologically the area consists of diverse rock types belonging to the oldest Archean metamorphites of the Bhilwara Supergroup and the Upper Proterozoic sedimentaries of the Vindhyan Supergroup. NE-SW part of the district is exposed by the rock types belonging to Bhilwara Supergroup and in the remaining part rock types of the Vindhyan Supergroup exist.



Picture 6 :Great Boundary Fault at Satur, Bundi District

## 12. Jodhpur Group, Malani Igneous Suite Contact, Jodhpur, Rajasthan

The Jodhpur group of Malani rocks is a geological feature that represents the last phase in the Precambrian age in the Indian subcontinent. This group of rocks lies at the bottom of the famous Mehrangarh Fort in the heart of Jodhpur city and forms a vivid picturesque. Rajasthan was formerly divided into two regions namely Mewar and Marwar. Malani was the name of a district in the former state of marwar. This was one such place in the region of Marwar where volcanic rocks were found and hence the name Malani bed rocks. The name had undergone several changes over the years: Malani Beds (1877), Malani Volcano Series (1902), Malani System (1933), The Malani Granite and Volcanic Suite (1968) and finally it came to be known as Malani Igneous Suite.

Besides above, there are many other potential geoheritage sites also which hold promise for being future National Geological Monuments (NGMs) in Rajasthan.

## SWOT Analysis

The following are the findings of the SWOT analysis (Strengths, Weakness, Opportunities and Threats):

### Strengths:

- These location has a great biodiversity.
- It is a nature-based geotourism attraction.
- This location boasts a wide range of breathtaking scenery.

### Weakness:



- The natural and geographical beauty is being ruined by encroachments and illegal constructions.
- The roads, transport, and conveyance facilities are not conducive to tourism.
- Large amounts of noise and plastic waste are caused by a variety of religious programs.
- Lack of Awareness: Geoheritage is often overlooked in mainstream heritage conservation policies.

### **Opportunities:**

- Developing a vision for the benefit of all residents and stakeholders is a possibility.
- Possibilities for employment, socioeconomic growth, and travelling.
- Develop and improve geotourism education initiatives.

### **Threats:**

- Unregulated development and mining activities have caused irreversible damage to many geological features.
- The resources are under pressure due to the increase in tourism activity.
- Vehicle trafficking is not environmentally beneficial.
- The natural and geographical beauty is being ruined by the unplanned and uncontrolled growth of geotourism.
- Infrastructure associated with tourism is not being built in a way that respects the environment.

### **Conclusion**

Rajasthan has extraordinary geoheritage, whereas the Aravali ranges and the Thar Desert are iconic landscape features, there is countless other fascinating and exquisite landforms and landscapes that have immense cultural, socio-economic and scientific value. All the geomorphosites or geoheritage sites are important not only from the standpoint of public interest and economic benefits, but also from the viewpoint of geo-science studies. Geoheritage conservation in Rajasthan is more than an environmental imperative—it is a pathway to sustainable development. By recognizing the value of its unique geological features, the state can promote eco-tourism, education, and community empowerment. NGMs and geotourism sites of Rajasthan offer a unique blend of natural beauty, scientific value and cultural heritage. Preserving these sites is essential for future generations to understand and appreciate the Earth's geological history. By addressing the challenges and leveraging opportunities, Rajasthan can enhance its geotourism potential and contribute to sustainable tourism development. Collaborative efforts, innovative approaches and community involvement are key to ensuring the successful conservation and promotion of these invaluable natural assets.

### **Recommendations For Preservation of These Geoheritage Sites**

1. Illegal activities such as mining in these sites should be prohibited. A lot of places in our country have lost their mineral wealth to miners and mining activities. Thus stringent rules need to be laid down and adhered to so that these sites can be preserved.
2. Proper fencing should be done around the area to protect geological monuments.

3. Water bodies around geological sites often are subjected to sewage, garbage and industrial waste dumping. This needs to be resolved and checked to better maintain these sites.
4. Incorporating geoheritage into school and university curricula can raise awareness and interest in Earth sciences. Field visits, workshops, and citizen science projects can foster a connection between youth and their natural environment.
5. NGMs with an immediate need or ability to be converted into a Geopark should be identified and such projects should be launched by the Government at the earliest. This will also help display these sites on an international radar with the help of UNESCO's initiatives.
6. There is an urgent need for a national and state-level geoheritage policy. Rajasthan can pioneer this effort by mapping its geoheritage sites and integrating them into regional planning and conservation laws.
7. Installation of proper signage boards along with cleaning activities for these sites should happen periodically, at the same time the area that leads up to these sites should also be maintained, and cleared of any blockages.
8. A lot of these sites get affected by expansion of roads, construction of homes, or expansion of the railways network. Again, these sites should be subjected to 'Buffer Zones' and not treated as any other patch of land.
9. Proper fencing and demarcation of these sites should be done by the Government with the help of Geological Survey of India (GSI).
10. Engaging local communities in the management and promotion of geoheritage sites ensures economic benefits while fostering a sense of stewardship. Training locals as guides and facilitators can create employment opportunities and reduce outmigration.

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