A MONOGRAPH ON
NATIONAL
GEOHERITAGE
MONUMENTS OF INDIA

March 2016

INTACH
Indian National Trust for Art and Cultural Heritage
Natural Heritage Division
71, Lodhi Estate, New Delhi-110003
Email id:intachnhd@gmail.com
Website: www.intach.org
Phone: 011-24641304, 24692774
Fax: 91-11-24611290
Acknowledgments

The need to initiate action on geo-heritage conservation was mooted by Ms. Rani Sarma, INTACH Convenor, Vishakapatnam. This was as a follow up to the ‘National Workshop on GEOHERITAGE’, jointly organized by Andhra University and INTACH in May, 2013, at Vishakhapatnam and sponsored by Ministry of Earth Sciences [GoI], Geological Survey of India, Vishakhapatnam Urban Development Authority and Greater Visakha Municipal Corporation. Maj. General [Retd] L.K Gupta, Chairman, INTACH, enlarged the initiative to cover the National Geo-Monuments in order to give a fillip to this neglected aspect of our heritage.

We would like to express our sincere gratitude to Dr. D. Rajasekhar Reddy, Advisor, Geoheritage Cell, INTACH for his vital contribution to this monograph. He has surveyed many extant sites and also drawn up the format [Annexure I] for listing fresh geoheritage sites. Dr. Pushpendra Singh Ranawat (INTACH Udaipur Chapter) has ably authored all sections pertaining to sites in Rajasthan. We are thankful to Mr. L.N. Aggarwal (Convenor, INTACH Kangra Chapter) for the section on Himachal Pradesh, and to Dr. Digvijay Parmar and Mr. Sukhanandi Pratik Jawaharbhai for covering the sites in Gujarat, Maharashtra and Chhattisgarh.

We also appreciate the efforts of Ms. Ritu Narwaria of Natural Heritage Division, who compiled and organized this report meticulously.
Foreword

Every country has various unique geological and geomorphologic features which constitute its geoheritage. Over time, the development process obliterates many of these features and this loss necessitates the preservation of representative and/or spectacular features which explain the geological process over geological time or otherwise attract interest due to their magnificent visual characteristics.

Geoheritage has been a neglected feature in the conservation landscape of India. Geological Survey of India [GSI] identified 26 geological sites over the years as National Geological Monuments. Most of these are located in geologically rich states such as Rajasthan, Odisha, Karnataka, Andhra/Telangana, Tamil Nadu.

In advanced countries the concept of geoheritage and geoparks has found much traction with sites being properly protected as part of larger bio-diverse landscapes and form part of tourism circuits.

Unfortunately, beyond declaration as geological monuments little else has been done to protect these marvels of the nature. The survey carried out for this report shows that most of the sites are lying forlorn and desolate and may well be lost to the country during the course of ‘development’.

In India, there is little realization of the significance of our geological heritage outside academia and the GSI. There is a need to develop and conserve these geological identities recognizing and understanding the scientific value of the features and landforms. The tourism departments and tourism industry would also need to be made a major stakeholder to establish a fresh revenue stream, generate additional livelihood opportunities as well as create the rationale to preserve more of our landscapes and associated biodiversity. The more spectacular the site the greater the tourism potential.

This monograph presents the results of a survey of the geo-monument sites, outlining threats and recommendations for their conservation. The endeavour is to influence the policy makers to adopt the draft legislation for protection of geo-heritage sites and encourage tourism departments to popularize these sites in tourism circuits. Thus, a major archaeological site such as Hampi is equally a rich geo-heritage site, an aspect which has been completely overlooked.
Similarly, rock art sites in Telangana such as Pandavulagutta [Warangal district] have been overlooked as spectacular geological formations. In Rajasthan, the ancient mining and smelting site (>2000 year old) at Zawar has been recognized by the British Museum London (1983) and American Society of Metals (ASM International, 1988) as a site of international significance.

There is a crying need to identify stakeholders who will actively protect these sites, sensitize local administrations, tourism departments, and the public at large about this neglected heritage. Simple measures of protection, raising visibility and awareness, can make a significant difference. There is a long road ahead.

Subsequently, it is anticipated that many more geoheritage sites will be identified and notified, thus affording these sites the necessary protection during the course of development. With serious effort some of these sites can make it to the UNESCO list of Geoparks. It is hoped that this monograph will help to trigger work in that direction.

Manu Bhatnagar
Principal Director
Natural Heritage Division
INTACH
### CONTENTS

SOME POTENTIAL GEO-SITES AND GEOPARKS IN INDIA ........................................ 6

Introduction ............................................................................................................. 16

ANDHRA PRADESH ............................................................................................. 22

1. Natural Arch, Tirumala Hills ............................................................................ 22
2. Eparchean Unconformity, Tirumala Hills, Chittoor District ............................... 25
3. Bedded Barites, Mangampeta, YSR District ...................................................... 29

CHATTISGARH ...................................................................................................... 32

4. Marine Gondwana Fossil Park, Manendragarh, Sarguja District ...................... 32

GUJARAT ................................................................................................................. 36

5. Eddy Current Markings, Kadana Village, Panchmahal District ......................... 36

HIMACHAL PRADESH ......................................................................................... 39

6. Siwalik Fossil Park, Saketi ................................................................................ 39

KARNATAKA .......................................................................................................... 45

7. Peninsular Gneiss, Lalbagh Botanical Garden, Bengaluru ................................. 45
8. Columnar Basalt, Coconut Island (St. Mary’s Island), Udupi District ................. 50
9. Pillow Lava, Maradihalli, Chitradurga District ................................................... 55
10. Pyroclastic Rocks, Peddapalli, Kolar District .................................................... 58

KERALA .................................................................................................................. 63

11. Laterite Deposits, Angadipuram, Mallapuram District ........................................ 63

MAHARASHTRA .................................................................................................. 66

12. Lonar Lake, Buldhana District ........................................................................ 66

ODISHA ................................................................................................................ 70

13. Pillow Lava, Iron Ore Belt, Nomira, Keonjhar District ....................................... 70

RAJASTHAN ......................................................................................................... 74

14. Nepheline Syenite, Kishangarh, Ajmer District ............................................... 74
15. Sendra Granite, Pali District ............................................................................. 77
16. Barr Conglomerate, Pali District ..................................................................... 80
17. Jodhpur Group–Malani Igneous Suite Contact, Jodhpur District ................... 84
18. Welded Tuff, Jodhpur District ........................................................................ 87
19. Akal Fossil Wood Park, Jaisalmer District ...................................................... 90
20. Great Boundary Fault at Satur, Bundi District ................................................... 94
21. Stromatolite Park, Bhojunda, Chittaurgarh District ................................................................. 98
22. Gossan, Rajpura-Dariba, Rajsamand District ........................................................................ 102
23. Stromatolite Park, Jhamarkotra, Udaipur District ................................................................. 106

TAMIL NADU .................................................................................................................................. 110
24. Charonockite, St. Thomas Mount, Chennai .............................................................................. 110
25. National Fossil Woodpark, Thiruvakkarai, Villupuram .............................................................. 113

ANNEXURE I : FORMAT FOR RECORDING GEOSITES FOR INCLUSION IN GEOSITE DATABASE ................................................................................................................................. 119
ANNEXURE II : DRAFT GEOHERITAGE LAW ........................................................................ 122
ANNEXURE III : GLOSSARY ........................................................................................................ 135
ANNEXURE IV: SELECTED REFERENCES ............................................................................. 145
SOME POTENTIAL GEO-SITES AND GEOPARKS IN INDIA

A Marvel Of Weathering And Erosion On The Rock Formations Leh Manali, Himachal Pradesh
(Source: flicker.com)

A Natural Gateway Near Lachung La, Himachal Pradesh
(Source: flicker.com)
Kolodyne Castle, Mizoram
(Source: mizoramjourney.wordpress.com)

Marble Rocks, Bhedaghat, Jabalpur, Madhya Pradesh
(Source: tripadvisor.com)
Yana Rocks, Yana Village, Karnataka
(Source: natgeotraveller.in)

Natural Coral Bridge At Neil Island, Andamans
(Source: Retina Charmer)
Gongoni, Grand Canyon Of West Bengal
(Source: youtube.com)

Belum Caves, Kurnool District (Andhra Pradesh)
(Source: tumblr.com)
Mahabaleshwar Hill Range, Mahabaleshwar, Maharashtra
(Source: maharashtraplanet.com)

Gandikota, Andhra Pradesh
(Source: trekkerpedia.com)
Oravakallu-Rock-Garden, Andhra Pradesh
(Source: nandeyalonline.com)

Floating Rock, Meghalaya
(Source: loupiote.com)
Ratangad, Kalsubai Trek, Maharashtra
(Source: nonegram.com)

Zanskar Valley, Kargil District, Jammu & Kashmir
(Source: journeymart.com)
Pawar Pinnacle, Raigad, Maharashtra
(Source: Flickr)

Pandavula Gutta, Warangal District, Telangana
(Source: alltrails.com)
Akka Mahadevi Caves, Mahbubnagar District, Telangana
(Source: cpreenvis.com)

Krishna's Butter Cup, Balancing Rock, Mahabalipuram, Tamil Nadu
(Source: mhallizey.wordpress.com)
Zawar, Rajasthan – The Treasure Trove of Geology, Ancient Mining & Metallurgy, Archaeology, History
*(A potential Geopark Site that has all the needed parameters outlined by UNESCO)*

Mounds of Discarded Retorts and Slag of Ancient (430±100 BCE) Zinc, Lead, Silver Mining and Smelting

The ASM Plaque at Zawar, Rajasthan

A Close-Up of Clay Retorts used by Ancient Metallurgists
Introduction

I. Nature is endowed with unique geological features, significant in tracing the expression of earth’s history through ages. The chronicles of the earth (4.5 billion years old) are inscribed in these unusual physical formations providing an insight into earth science. These unique treasures are evidences of past narratives of geology, formation of earth systems and are part of earth evolution.

II. Societies and cultures have always been influenced by the geology and landscape of a specific region. For example Indian Subcontinent is blessed with captivating landforms which have played a key role in shaping its civilization and rich cultural diversity.

III. The diversified territory of India comprises of rocks and formations of various geological periods over the entire span of geological time scale. It extends right from oldest Eoarchean era to Cenozoic era, including evidences of rock fossils records from plants, vertebrates, invertebrates and stromatolites. The richness of various rocks, geological forms, and structural events has lead to occurrence of diverse geosites offering both scientific and aesthetic interest.

IV. Unique geological landscapes have faced millions of years of formation and witnessed the downfall of several civilizations. In the present age, many anthropogenic activities, natural hazards and climate changes have rendered them vulnerable to rapid deterioration. As a result, much of our landscapes have already been destroyed and many more are likely to be modified beyond recognition in the course of development. In recent decades the protection of geological and geomorphic natural resources (or the living world) has received appropriate attention globally. This has led to newly coined concepts such as geo-sites, geo-monuments, geo-parks and geo-diversity.

V. A number of agencies are working for the protection of geo-heritage sites across globe. One of them is GGN (Global Geoparks Network) which works under the aegis of UNESCO. It provides developmental framework which integrates conservation of geological heritage sites with sustainable economic development. The IUCN WCPA (World Commission on Protected Areas) has a specialised group (Geo-heritage Specialist Group) which assists the conservation and management of protected geo-heritage sites. A European agency ProGEO, in association with IUGS & UNESCO is focused on the conservation of the Geological Heritage in Europe.

VI. The major milestone in the field of geo-conservation was in the fourth world conservation Conference (2008) held in Spain where a resolution was passed by IUCN regarding conservation of Geodiversity and Geoheritage. Later, in June 2015, IUCN WCPA organised its first international Geoheritage conference in China which focused on conservation and management of geoheritage sites.
Fig. No. 1: Geological Time Scale

Source: Geology.com

Geodiversity

I. The diversity found in geological formations of the earth such as rocks, fossils, minerals and geological processes that create distinctive formations is known as Geodiversity. It is the major abiotic component supporting landscapes, biodiversity, and ecosystems.

II. The geological expression holds enormous potential with environmental, economic, social, cultural and aesthetic significance. Studying these formations allow us to trace the evolutionary history and understand its natural environment for better resource management.
III. Geodiversity is entitled to as Geoheritage when a certain uniqueness or value is attributed to it. The Geoheritage sites encompass significant elements which possess educational, scientific, aesthetic and cultural value. These features are vulnerable as once destroyed cannot be recreated.

IV. Geoheritage and Geoconservation, both are terms bound together by geodiversity. Geoconservation is preservation for heritage, science, or educational purposes. It involves a series of actions pertaining to identification, protection, and management of valuable elements of geodiversity.

V. Geoheritage sites hold enormous potential for education and recreation which can be connected for raising public awareness. The holistic approach towards such sites will sensitize common people and will promote geotourism as well as geoconservation together.

VI. Within the three macro geographic regions of India— the Himalayas, the Indo-Gangetic Plain, & the Peninsula, the meso geographic regions of Deccan Trap, Vindhyan and the Gondwana are of special interest. The formation of Deccan trap took place due to igneous volcanic activity during shifting of Gondwana Land. This flood basalt igneous region is exposed in parts of Gujarat, Maharashtra, Madhya Pradesh to Karnataka and parts of Andhra Pradesh. The Gondwana and Vindhyan include within its fold the prominent sedimentary formations in parts of Madhya Pradesh, Chhattisgarh, Odisha, Bihar, Jharkhand, West Bengal, Andhra Pradesh, Maharashtra, Jammu and Kashmir, Punjab, Himachal Pradesh, Rajasthan and Uttarakhand.

VII. A number of magnificent Geoheritage sites are found in India which extends over the entire span of geological time scale. The natural exquisite land sculptures are presently of interest mainly to the geological community but have the potential to interest the public at
large enabling promotion of Geotourism in the country. Some of these geosites have been declared as National Geological Monuments of India by Geological Survey of India (GSI).

VIII. Geological Survey of India (GSI) – one of the oldest in the world founded on 1851, is the parent body which is making efforts towards identification and protection of such rare and unique geological sites in India. This report examines the fate of these sites subsequently.

In 2001, to commemorate 150th anniversary of its foundation, GSI launched a special publication (#61) on National Geological Monuments (NGM) that it had recognised over the years. In this publication, GSI has concisely described twenty six unique geological sites across India which gives detail account of locations, geology, palaeontology and stratigraphy of all the monuments supported by pictorial illustrations.
National Geological Monuments

Andhra Pradesh
1. Natural Arch, Tirumala Hills, Chittoor District
2. Eparchean Unconformity, Tirumala-Tirupati road, Chittoor District
3. Bedded Barytes, Mangampeta, Cuddapah District

Chhattisgarh
4. Marine Gondwana Fossil Park, Manendragarh, Sarguja District

Gujarat
5. Eddy Current Markings, Panchmahal District

Himachal Pradesh
6. Siwalik Fossil Park, Saketi, Sirmur District

Karnataka
7. Peninsular Gneiss, Lalbagh, Bangalore
8. Columnar Basaltic Lava, Coconut Island (St. Mary's island), Udupi District
9. Pillow Lava, Maradihalli, Chitradurga District
10. Pyroclastic Rocks, Peddapalli, Kolar District

Kerala
11. Laterite, Angadipuram, Malappuram District

Maharashtra
12. Lonar Lake, Buldhana District

Orissa
13. Pillow Lava, Iron Ore Belt, Nomira, Keonjhar District

Rajasthan
14. Nepheline Syenite, Kishangarh, Ajmer District
15. Sendra Granite, Pali District
16. Bar Conglomerate, Pali District
17. Jodhpur Group- Malani Igneous Suite Contact, Jodhpur District
18. Welded Tuff, Jodhpur District
19. Akal Fossil Wood Park, Jaisalmer District
20. Great Boundary Fault at Satur, Bundi District
21. Stromatolite Park, Bhojunda, Chittaurgarh District
22. Gossan, Rajpura- Dariba, Rajsamand District
23. Stromatolite Park, Jhamarkotra, Udaipur District

Tamil Nadu
24. Charnockite, St. Thomas Mount, Chennai
25. National Fossil Wood Park, Thiruvavkarai, Villupuram District

IX. The above mentioned NGMs have been classified into four categories namely Fossil Parks, Rock Monuments, Geological Marvels and other monuments based on Stratigraphic and Economic importance.

X. Sadly, beyond declaration little else has been done to protect and conserve this inheritance. The Natural Heritage Division of INTACH started a Geoheritage Initiative with an endeavour to conserve, spread awareness and identify such geoheritage sites across India. As a part of this initiative, a study was carried out on each (26) National Geological Monuments.
XI. Each site was surveyed upon its current status of upkeep, threats and conservation measures. An important aspect of geotourism was also looked upon to suggest a holistic approach in conservation. During the surveys, it was established that geosites are mostly ill-kept and are facing severe pressure from the aggressive development activity. Apparently, awareness and significance of geoheritage sites is absent from the idea of public and decision makers. At the same time the threat to geo-sites is growing proportionately with the physical development and interventions in the landscape creating urgency for protection.

Map No. 2: Location Map of 26 National Geological Monuments of India

Source: Geological Survey Of India
ANDHRA PRADESH

1. Natural Arch, Tirumala Hills

[Text & Photographs by Dr. D. Rajasekhar Reddy]

Fig. No. 2: Natural Arch at Tirumala Hills

1.1. Natural Arch, Tirumala Hills is one of the rare geological features present in Andhra Pradesh. Unique to landscapes of Asia, the arch is said to be carved out of Nagari quartzite of Cuddapah Super Group of Middle to Upper Proterozoic (1600 to 570 Ma). The age of arch is estimated to be 1500 million years old.

Map No. 3: Location Map of Natural Arch at Tirumala Hills
1.2. **Geographical Coordinates**: Latitude -13° 40’ 54” N; Longitude -79° 20’ 46”E

1.3. **Location**: Near the Chakra Teertham, 1 km north of Tirumala hills temple.

1.4. **Elevation**: About 860m above mean sea level.

1.5. **Representative Features**: The dimension of geoheritage site is about 50m x 10 m x 3 m. The Arch is popularly known as ‘Silathoranam’ in Telugu language. ‘Sila’ means ‘rock’ and ‘thoranam’ means a garland string above which connects two vertical columns or an arch. The rock structure is 8 meters in width and 3 meters in height. It is carved out of quartzite of Cuddapah Supergroup of Middle to Upper Proterozoic period (1600 to 570 Ma).

1.6. **Geology**: Natural arches commonly form where cliffs are subject to erosion from the sea, rivers or weathering (sub-aerial processes); the processes find weakness in rocks and work on them, making them larger until they break through. The Natural Arch at Tirumala has been carved out of quartzites by the collective action of weathering agents like water and wind over a long period of several thousands of years.

1.7. **Accessibility**: The Natural Arch is well connected by roads, rails and air routes. Tirumala is situated 19 km away from Tirupati railway station by road.

Some examples of such formations are the Rainbow Arch of Utah (USA) and the Dalradian Quartzite. Similar arch is being carved out from the Eastern Ghat Khondalite Group of rocks by the waves and currents of sea water from Bay of Bengal at Visakhapatnam, which proves the geological dictum.

*“Present is the key to the past and past is a window to the future”.*

1.8. **Status**: GSI declared the site as a National Geological Monument in 1981. The area is well protected and maintained by Tirumala Tirupati Devasthanam. The site is fenced with a buffer zone, gated and locked so that the visitors cannot reach the out crop. The signages provide information about the site. It is properly fenced and receives visitors from pilgrims visiting Tirupati. In fact, it is one of the popular attractions in the area. The site is not ticketed and there are no guides available.

1.9. **Threats**: There are no major threats to the site except natural degradation.
1.10. **Conservation Measures**: The Natural Arch site needs to be conserved through regular maintenance by cleaning the premises and protect it from natural degradation.

1.11. The quality of signage, graphics, quality and adequacy of information can be greatly improved for making the site attractive. Night lighting can greatly augment the dramatic impact of the Arch and attract more visitors to this unique geological feature.
2. Eparchean Unconformity, Tirumala Hills, Chittoor District

[Text & Photographs by Dr. D. Rajasekhar Reddy]

Fig. No. 5 : Nagari Quartzite, Cap Rock of Tirumala Hills overlaid by Archean Granite

2.1. Eparchean Unconformity, Tirumala Hills, a regional feature, is a geological marvel with stratigraphic significance. The geological stratigraphy represents the unconformity with time gap of 800 Ma. The site is close to the Natural Arch.

Map No. 4 : Location Map of Eparchean Unconformity, Tirumala Hills
2.2. **Geographical Coordinates**: Latitude -13° 39’ 24” N; Longitude -79° 20’ 05” E.

2.3. **Elevation**: About 850m above mean sea level.

2.4. **Location**: The Geoheritage site is located in Tirupati Valley which is enclosed between Palakonda - Velikonda and Sanainbatla –Srikalahasti and Nagari range of the Eastern Ghats. It is 600 m before the main entrance of Tirumala temple on the left side.

2.5. **Representative Features**: Eparchean Unconformity (period of no rock deposition) in Tirumala hills separates the Nagari Quartzites of Proterozoic Kadapa Supergroup (about 1600 million year) from the oldest Archaen Peninsular Gneissic complex consisting of granites, gneisses and dolerite dykes (more than 2300 million years old). The unconformity represents a time gap of over 800 Ma. It also marks a period of remarkable quiescence without much structural disturbance and igneous activity in geological history.

2.6. **Geology**: The evolutionary history of earth is marked with various geological events (for e.g. weathering, geodynamic processes including periodic convulsions in the earth’s crust, generation and intrusion of magma, volcanic eruptions) and formation of corresponding rocks viz. sedimentary, igneous and metamorphic followed by different geological era.

![Fig. No. 6 : An Example of Eparchean Unconformity at Tirumala Hill*](image)

2.7. **Accessibility**: The site is located 12 km away on Tirupati to Tirmuala ghat road, Chitoor district, Andhra Pradesh. The nearest railway station is Tirupati and nearest airport is Renigunta.

*Please note the Fig. No. 6 is slightly modified and replaced*
2.8. Between these geological eras, at times there were gaps in the accumulation of rock masses or occasionally the pre-existing rocks were subjected to weathering and denudation. This resulted in a boundary between the older and the younger rocks which therefore indicate a period of non-deposition/erosion demonstrating an unconformity. After Archean Era, there was no deposition of rocks and the land mass was subjected to erosion for millions of years. The geological process was followed by formation of Proterozoic rocks. This time gap between the Archean and Proterozoic rocks is known as Eparchean unconformity.

Fig. No. 7: Eparchean Unconformity - Archean Granite in lower part overlaid by Proterozoic Nagari Quartzite in upper part

Fig. No. 8: Conglomerate formed between Archean Granite & Proterozoic Rocks
Fig. No. 9: Dark Coloured Dyke rock (left side of the photo) in the light coloured Archean Granite rocks

2.9. **Status**: GSI declared the site as a National Geological Monument [NGM] in 1976. It is under the ownership of Tirumala Tirupati Devasthanam. The signages which provide information about the site are in deteriorating condition. The site is in a state of neglect and the NGM is being ignored by thousands of pilgrims visiting Tirumala temple. No pilgrim is visiting the site. There is no much scope for the visitors to stop the vehicles as the site is just adjacent to the very busy one way Tirupati – Tirumala ghat road. There is no space for the vehicles to stop at the site.

Fig. No. 10: Rusted Signages in English & Telugu language

2.10. **Threats**: Road carriageway has been built right adjacent the site with no buffer zone. In future road expansion could encroach upon the site.

2.11. **Conservation Measures**: The site needs to be properly demarcated and protected and highlighted for its significance. Proper explanatory signages, entrance gate and lighting needs to be implemented to make the site interesting to visitors.

2.12. Practically there is not much scope for developing the area for visitors as the site is just adjacent to the very busy Tirupati – Tirumala Ghat road. Since the Eparchean Unconformity is a regional feature, it is advisable to identify an alternative out crop nearer to the present site so that the site can be visited by many people as the large number of pilgrims comes to Tirumala regularly.
3. Bedded Barytes, Mangampeta, YSR District

[Text & Photographs by Dr. D. Rajasekhar Reddy]

Fig. No. 11: Barytes Deposits in Mangampeta

3.1. **Bedded Barytes in Mangampeta** is the largest barytes deposit in the world. It constitutes about 98% of India’s barytes reserves and 28% of world’s barites reserves which occur as pure Barium Sulphate. It is situated in the crescent shaped Cudddapah basin of Proterozoic era.

Map No. 5: Location Map of Bedded Barytes, Mangampeta
3.2. **Geographical Coordinates** : Latitude -14° 01’ 14” N ; Longitude 79° 19’ 06” E.

3.3. **Elevation** : About 165 m above mean sea level.

3.4. **Location** : It is located in mining area of Mangampeta village, Obulavari pally Mandal, YSR District.

3.5. **Accessibility** : The geological site can be approached through Kurnool Renigunta state highway which passes from Mangampeta mines area. The nearest Railway station is about 10 km away at Koduru on the Kurnool – Tirupati line of the South Central Railway.

3.6. **Geology & Representative Features** : Barytes is naturally occurring barium sulphate. Barytes deposits have formed over time due to precipitation of volcanic vapours under submarine conditions, sub-aerial showering of ash and molten baryte lapilli. The deposits occur as Pullampet Formation of the Nallamalai Group of the Cuddapah Supergroup). The lower bed has Mangampeta Barytes which is considered as the highest grade of Barium Sulphate.

3.7. **Status** : The site was declared a National Geological Monument [NGM] in 1982. Presently, the ownership is with APDMC Ltd. (Andhra Pradesh Mineral Development Corporation Limited). The maintenance is conspicuously absent.. The signages are concealed with vegetation overgrowth. A single rusted signage in Telugu language is present and does not provide the adequate information about the site.

3.8. **Threats** : The site falls under the area which is actively mined and vulnerable to the threat of mining.

3.9. **Conservation Measures** : The site should be demarcated with a boundary and notified as a protected area. Signages need to be bigger, informative and properly sited for visibility. Proper site planning to incorporate visitors’ movement and facilities, parking area and conveniences, can make the site visitor friendly and protected. The site can be made popular by including it in the regional tourist circuit along with other two NGM sites present in Andhra Pradesh.

---

The term ‘barite’ is mineralogical term for pure barium sulphate mineral, while the term ‘barytes’, (always in plural) refers to an ore that is essentially barite bearing but other impurities like quartz, calcite, clay etc. are present.
Fig. No. 14: Mining Benches on the left side of NGM at Mangampeta
4. Marine Gondwana Fossil Park, Manendragarh, Sarguja District

[Text & Photographs by Mr. Sukhanandi Pratik Jawaharbhai]

Fig. No. 15: Field specimen of Bivalve Molluscs with coin as scale

4.1. **Marine Gondwana Fossil Park** is located in the Manendragarh, Sarguja district of Chattisgarh. Spread across an area of 16,200 sq m, the park is characterized by the unique exposure of fossiliferous marine Permian (280 – 240 Ma) Carbonaceous Shale rocks of Talchir Formation belonging to Gondwana Supergroup.

Map No. 6: Location Map of Marine Gondwana Fossil Park, Chattisgarh
4.2. **Geographical Coordinates**: Latitude -23° 12’ 23.46” N; Longitude - 82° 13’ 12.27” E

4.3. **Elevation**: About 432m above mean sea level.

4.4. **Location**: The park is located in Ammakherwa village of Sarguja District in the Satpura Range. It is exposed for a length of about one km upstream up to the confluence of Hasdeo River and Hasia nala.

Satpura Range extends from Madhya Pradesh to Maharashtra and Chhattisgarh. The mountain range stretch across a distance of 900 km and separates the Deccan plateau in the south from the Indo- Gangetic plain in the north.

4.5. **Representative Features**: The site was first discovered in 1954. It preserves and displays a rich collection of marine invertebrate fossils recovered from the fossiliferous bed of Satpura Range. The fossil faunal assemblage is indicative of transgression of sea in this part of India about 200 m.y of years ago (Permian). The fossiliferous bed exhibits dominant invertebrates of pelecypods/lamellibranches like Eurydesma and Aviculopecten within shale, besides Bryozoans, Crinoids and Foraminifers.

4.6. **Geology**: There are number of postulates and theories that describes the geology of the area. During Talichar Formation, two arms of Tethys Sea used to reach central India. Jhingran (1967) postulated there could be a wide inlet from the north (i.e. Tethys shore) which used to cover all the present fossilised areas. Mukhopadhyay et al. (2010) have given the route map of Tethys incursion during the Permian. Another hypothesis by Dasgupta (2006) suggested that the marine incursion in central India was due to rise of the mean sea level of Tethys followed by phases of deglaciations till the isostatic equilibrium was achieved. The sea receded just after the continental blocks recouped the isostatic equilibrium.

Similar Fossiliferous beds are found in Rajhara (Jharkhand), Darjeeling (West Bangal), Khemgaon (Sikkim) and Subansiri (Arunachal Pradesh).

**Granite** - an igneous rock which is granular and formed due to slow crystallisation of magma below earth’s surface. It is composed of quartz, feldspar with some traces of mica, amphiboles and other minerals. Granitic blocks of as much as 200 meters are found within the Marine Fossil Park, Manendragarh.
4.7. **Accessibility**: The area can be approached by road from Nagpur via Jabalpur (NH-7), Katni, Shahdol, Burhar, Anupur and Kotma (SH-14). It is located on the right bank of Hasdeo River, near the railway bridge between kilometre stone 937 and 938 of the Anuppur – Chirmiri branch of South-eastern Railway and about 2.5 km southeast of Manendragarh railway station near Ammakherwa village.

4.8. **Status**: The fossiliferous marine bed at Manendragarh was declared a National Geological Monument [NGM] by G.S.I. in 1982. The park is looked after by the State Government and Forest Department since 2013. It is spread across an area of 16,200 sq meters. The park holds great potential for scientific, educational and recreational attraction. Many researchers visit the area to study the site.

4.9. **Threats**: The fossiliferous bed exposed near Hasdeo River is poorly protected and poorly maintained.

4.10. **Conservation Measures**: Park needs to be protected with a proper site management plan which organizes visitors movement and provides necessary facilities. Adequate and properly located signages would assist visitors in grasping the significance of the park. A field museum could be of great help in understanding the complex geology of the area. The site can also be popularized by integrating with the tourism circuit.

*Fig. No. 16: Vegetation markings on the Granitic Rocks*
Fig. No. 17: Granitic Outcrop exposed towards the bank of Hasdeo River

Fig. No. 18: Poorly maintained Fossiliferous Bed in Marine Fossil Park, Chattisgarh
5. Eddy Current Markings, Kadana Village, Panchmahal District  
[Text & Photographs by Dr. Digvijay Parmar]

5.1. **Eddy Current Markings at Panchmahal District, Gujarat** consists of petrified markings on sandstone-quartzite surface from Upper Aravalli Lunavada Group (Precambrian-Proterozoic). It is one of rarest geological marvel representing the geology and evolution of Aravalli.

**Map No. 7 : Location Map of Eddy Current Markings, Kadana, Gujarat**
5.2. **Geographical Coordinates**: Latitude - 23°18’17.93” N; Longitude - 73°50’21.29” E.

5.3. **Elevation**: About 213 m above mean sea level.

5.4. **Location**: The site is located on the left bank of the Kadana Dam, at about 600 m downstream (southeast) on the right side of the approach road to the quarry sites.

5.5. **Representative Features**: The geological features are exposed in sedimentary (sandstone) surface of Upper Aravalli Lunavada Group of rock. The radiating circular markings are preserved on rock from Precambrian era. The site very well represents the geological evolution of the Upper Aravalli Lunavada Group.

5.6. **Geology**: During Aravalli Orogeny the incompetent (soft & fragmented) sedimentary rock got transformed into metamorphic rock. The orogeny movements of metamorphism in incompetent rocks produced large amount of shearing stress. This resulted into cross stratification, horizontal stratification, planar cross bedding, flute and groove marks on the rocks. In case of Eddy Current Marking, a pebble or gravel got trapped during this pressurised process and resulted in radiating circular marking (shearing, torsion, compression) on rocks.

---

**Orogeny (Greek - Mountain building)** – the process of formation of mountain through tectonic movement of Earth’s Crust or Volcanic activity.

5.7. **Accessibility**: The Kadana Dam is linked to the main towns of Gujarat and Rajasthan by roads and can be approached via Kherwara (National Highway -8). The nearest railheads are Dungarpur and Lunavada via Godhra.

---

5.8. **Status**: The site belongs to State Government and there has been no significant development after its declaration as NGM In 1976 by GSI.
5.9. **Threats**: The infrastructural developments around the area have threatened the site. Recently two markings have been destroyed by the construction of roads around the area. Earlier site was also marked with fencing which had fallen into a state of disrepair. Lack of signage makes it difficult to locate the site or provide information about the site significance.

5.10. **Conservation Measures**: The NGM site is exposed on quartzite-sandstone rocks which are under ownership of state Government. About 10-20 ha of area can be marked for conservation by means of fencings, boards, signages. Also, locals and tourists can be made more aware about the site highlighting its scientific, geological and recreational importance.
6. Siwalik Fossil Park, Saketi

[Text by Mr. L.N Aggarwal]

6.1. Siwalik Fossil Park, also known as Saketi Fossil Park, is nestled in the picturesque Siwalik foothills. It covers an area of about 15 sq.km. at in the Markanda Valley of Sirmaur district, Himachal Pradesh. In the year 1969, the Geological Survey of India (GSI) made numerous fossil finds in the Saketi area and decided to establish a fossil park. The idea was mooted to preserve the geologically interesting site.
6.2. The Siwalik Hills are the southernmost and geologically youngest east-west mountain chain of the Himalayas. The Siwaliks have many sub-ranges. They extend west from Arunachal Pradesh through Bhutan to West Bengal, and further westward through Nepal and Uttarakhand, continuing into Himachal Pradesh and Kashmir. The Siwalik Hills are chiefly composed of mudstone, sandstone and conglomerate rock formations, which are the solidified detritus of the great range in their rear, but often poorly consolidated.

6.3. **Geographical Coordinates**: Latitude - 30° 30´ 18.9" N; Longitude - 77° 14´ 34.08" E.

6.4. **Elevation**: About 410 above mean sea level.

6.5. **Location**: The park is located on the rocks belonging to Saketi Formation (Verma, 1989) forming the lower part of Upper Siwalik subgroup. These rocks may belong to Upper Pliocene (circa 5.3 to 2.6 million years ago) Tatrot Formation of the Middle Siwalik sequence (Srivastva and Patnaik, 2002).

6.6. **Representative Features**: The park preserves and displays a rich collection of vertebrate fossils recovered from the Siwalik rocks of the area. The park also displays large life-size fiberglass models of rare prehistoric animals that lived in the area about 1 to 1.5 million years ago. The animal exhibits include a gharial, a four horned giraffe and a sabre-toothed tiger.

6.7. **Geology**: The centre is situated amidst 10 to 1.5 million year old (Middle Miocene - Early Pleistocene) rocks of the Siwalik Group with rich assemblage of vertebrate fossils.

6.8. Three major structural discontinuities, the Himalayan Frontal Thrust (HFT), at the contact of the Siwalik and the Indo-Gangetic plain sediments; the Nahan Thrust, within the Siwalik Group of rocks and the Main Boundary Fault (MBF) at the contact of the Palaeogene and Neogene sediments, are located in the near vicinity.

6.9. A large and rare collection of vertebrate fossils recovered from Siwalik hills in Saketi and adjacent areas has been displayed in a field museum in the park. The site has been developed to provide a panoramic view of Plio-Pleistocene period (circa 5 million years ago) through massive afforestation.

6.10. The presence of remains of hippopotamuses, elephants, giraffes from the Pinjore area, fishes from the Shivalik region, amphibians and reptiles from Mumbai, Kota as well as Kashmir make the museum a microcosm of prehistoric fauna. The museum also displays fossils of some prehistoric plants. A large collection of stone objects, which are also among the oldest ones used by the Early Paleolithic Man, have been displayed at the museum. They are known to be some 2.5 million years old and recovered from the Indian subcontinent.
Fig. No. 22: Geological Map of Saketi area showing fossil locality

Fig. No. 23: Life size model of Four Horned Giraffe (*Sivatherium giganteum*)
(Source: teamBHP.com)
6.11. The lone fossil park in the whole Asia was inaugurated in 1974 to preserve and display the remains of prehistoric animals. In May 2014, Siwalik Fossil Museum was inaugurated by the Director General of GSI within the premises of the park.

Fig. No. 24: Life size model of Gharial. Remains of Crocodiles & Gharials are indicative of their presence in the region

(Source: team-BHP.com)

Fig. No. 25: Frontal View of museum at Shivalik Fossil Park, Saketi
6.12. **Accessibility** : The NGM is about 5 km northeast of Kala Amb on Kala Amb - Bikramabad road and 22 km south-west of Nahan, the district headquarter of Sirmaur. Kala Amb is connected to nearest rail station Ambala through a metalled road. The nearest airport is Chandigarh with daily flights to Delhi and Mumbai.

6.13. **Status** : GSI declared the site as Fossil park on 23rd March 1974, along with efforts of Government of Himachal Pradesh. Growth of bushes, grass and trees is noticed all around. There are no pathways to various models displayed in the park. Models displayed in the park tell a tale of negligence. At present there are only three chowkidaars to look after the models displayed in the area.

6.14. **Threats** : The road after the Markanda bridge is an inhospitable stretch of 12 km. Lack of funds and skeletal staff has affected the maintenance of the park. There is no fencing of the park area and it is highly vulnerable to encroachment.

6.15. **Conservation Measures** : The Park was developed by the Geological Survey of India in collaboration with the Government of Himachal Pradesh. It is supposed to be looked after by State Government along with its maintenance. There is urgent need to protect the area by fence. The park needs to be preserved by ensuring availability of adequate funds and staff, who can take proper care of this historic site. The construction and maintenance of the link road will also go a long way in promoting this place of historical eminence.

6.16. **Potential For Information and Tourist Centre** : There is likelihood that GSI might establish a training centre at the site in future. Management of site will be done by Himachal Pradesh Government. There is a tourism information centre at the park, which only displays pamphlets on HP tourism. Tourism potential is likely to boost up because of its geological importance, location and nearby tourist attractions [such as Sirmaur, Renuka and Habban Valley]
Fig. No. 27: Poorly maintained road leading to Saketi Fossil Park

(Source: www.tribuneindia.com).
KARNATAKA

7. Peninsular Gneiss, Lalbagh Botanical Garden, Bengaluru

[Text & Photographs by Dr. D. Rajasekhar Reddy]

Fig. No. 28: Peninsular Gneiss Exposed In Lalbagh Botanical Gardens

7.1. **Peninsular Gneiss, Lalbagh Botanical Garden**, is one of the prominent exposures of rock masses of Gneiss. Initially started as a private garden in an area of 40 acres in 1760 by Hyder Ali, a famous ruler of Mysore, Lalbagh was given the status of a Government Botanical Garden in 1856. Since then, it has been internationally renowned for scientific study of plants and botanical artwork. It should now be renamed as “Geobotanical Garden” because of the famous rock exposures that are prominent in the park.(cf. 7.6 below)

Map No. 9: Location of Peninsular Gneiss, Bengaluru
7.2. **Geographical Coordinates** : Latitude -12° 56´ 55" N ; Longitude -77° 35´ 21" E

7.3. **Elevation** : About 909m above mean sea level.

7.4. **Location** : Lalbagh Botanical Gardens are located in the heart of the city, about 4 km from the State Legislature - the Vidhana Soudha. Most parts of the garden are surrounded by different blocks of the beautiful residential layout - Jayanagar.

7.5. **Representative Features** : The Lalbagh hill is composed of dark biotite gneiss of granitic to granodioritic composition containing streaks of biotite. Vestiges of older rocks are seen in the form of enclaves within the gneiss. A common enclave is a dark grey to black amphibolite rock which was converted into grey biotite gneiss during migmatization which in turn was intruded first by grey porphyritic granite and later by pink granite. Granitization of the older sedimentary - volcanogenic sequence are reported as sources of the peninsular gneisses made up of polyphase migmatites, gneisses and granites ranging in composition from granodiorite to tonalite.

7.6. **Geology** : The Geological Survey of India declared the rock mass protruding as hillock above the ground as a National Geological Monument to propagate the knowledge of the rock formation among the public. It is also known as the Lalbagh Hill.

7.7. Peninsular Gneiss of the region is dated 2.5 to 3.4 billion years that accreted in three major episodes, i.e. 3.4 Ga, 3.3-3.2 Ga and 3.0-2.9 Ga. The antiquity of these rocks has attracted the attention of geologists from all over the world. The rocks continue to be material source for research in the various branches of earth science to understand the evolution of earth’s crust.

---

The term “*Peninsular Gneiss*” was coined by W.F. Smeeth of Mysore Geological Department in 1916 to highlight the older gneissic complex metaphoric rock formation found all over the Indian Peninsula.

---

**Gneiss** is a coarse-grained high grade metamorphic rock formed at high temperatures and pressures in which light and dark mineral constituents are segregated into visible bands. Gneisses and related granitoids constitute one of the most abundant rock types exposed on the continents of the earth. They form an essential part of geologically stable areas of the earth called shields.
7.8. **Accessibility**: The garden is accessible through four gates. The city buses plying to Jayanagar and localities beyond stop at one or other approach gates of Lalbagh. Vehicles are allowed only through the East gate towards the Double Road. There is ample parking space on entering through this gate. Vehicular movement inside the garden is restricted.

![Fig. No. 29: A closer view of exposed Peninsular Gneiss in Lalbagh Botanical Gardens](image)

7.9. **Status**: GSI declared the site as a National Geological Monument in 1975. The site is in a well-protected and the most celebrated botanical gardens in Lalbagh area of Bengaluru city, which is being maintained by the Directorate of Horticulture, Government of Karnataka. One of the four cardinal towers of Bangalore was erected above the Lalbagh Hill (Peninsular Gneiss) which forms the bedrock of whole of Southern India.

**Lalbagh Botanical Garden** is considered as one of the most diverse botanical garden with largest collection of rare flora around South Asia. The garden holds a picturesque view with over 100 year old trees and has India's first lawn-clock. The foundation of the garden was laid by Hyder Ali and later was completed by his son Tipu Sultan. The origin of its name is due to blooming red roses in the garden, (known as Rose or Cypress Garden till 1856). The garden holds a number of exhibitions showcasing various varieties of blooming flowers. The Glass House, modelled on London's Crystal Palace is the centre of attraction. Nearly 673 genera and 1,854 species of plants are found in Lalbagh. The collection of the plants has made it a veritable treasure house.
7.10. **Threats**: The site is located in a well-protected botanical garden and is a famous tourist place. Waste and its disposal is a serious problem within the area. It has many visitors throwing all kinds of trash all around. The makeshift stalls on the site make for a shoddy appearance. The water body towards the southern side is not being maintained.
7.11. **Conservation Measures**: The site requires:

- Site Management Plan
- Visitor Management Plan
- Garbage Management Plan
- Lake Management Plan
- Informative and well located signages
- Interpretation centre

![Temporary Food Stall on the exposed rock](image-url)
8. Columnar Basalt, Coconut Island (St. Mary’s Island), Udupi District

[Text & Photographs by Dr. D. Rajasekhar Reddy]

![Image of Columnar Basalt, St. Mary's Island, Udupi](topyaps.com)

Fig. No. 33: Columnar Basalt, St. Mary's Island, Udupi

[Source: topyaps.com]

8.1. **Columnar Basalt, Coconut Island (St. Mary’s Island)** is geometric rock sculpture of basaltic columns developed in Deccan Traps. These rock structures are called as “**Columnar Joints**” and are impending out of sea near Malpe over an area of 5.26 acres. It is believed that in 1498 “Vasco Da Gama” landed on this island during his voyage from Portugal to India and named these islands as “**El Padron de Santa Maria**”

Map No. 10: Location of Columnar Basalt at St. Mary’s Island
8.2. **Geographical Coordinates**: Latitude -13° 22' 41" N; Longitude -74° 40' 26" E

8.3. **Elevation**: About 10 m above mean sea level.

8.4. **Location**: St. Mary’s Islands are a tiny group of four picturesque islands situated off the west coast of India near Malpe, about 6 km west of Udupi, the district headquarters.

8.5. **Representative Features**: Spread across an area of 5.46 acres, the island has unique arrangement of basaltic rocks which have crystallised into columns and split into hexagonal mosaic. It is the only spot in India which displays these characteristic structures of basaltic rock.

8.6. **Geology**: Basalt is a dark coloured igneous rock rich in iron and magnesium. It is formed by the rapid cooling of volcanic lava. The Deccan Trap evolved due to vast outpouring of hot molten basaltic lava in the western part of India during Cretaceous – Eocene time (about 60 million years ago). They are now present as flat topped hills and step like terraces.

8.7. St. Mary’s Islands also known as Coconut Island are a set of four islands in the Arabian Sea off the Coast of Malpe in Udupi District, Karnataka. The northern most island has a basaltic rock formation in hexagonal shape. Columnar Basalt, Coconut Island (St. Mary’s Islands), Karnataka, displays majestic array of multi-faced columns developed in the basalts of Deccan Trap. The St. Mary’s volcanic and the Madagascar flood basalt province may well represent volcanic activity associated with the breakup of Greater India and Madagascar in the Upper Cretaceous at 88 Ma.

8.8. **Accessibility**: The site is easily accessible from Malpe situated near district headquarters from Udupi. The Town of Udupi is about 60 km from Mangalore City (nearest Airport). It is also linked to Mumbai and Thiruvananthapuram by the West Coast Railway. The site is closed to the visitors from 15 May to 15 September every year due to monsoon.

![Fig. No. 34: Well developed Columnar Joints in Basalts on St. Mary’s Island](image-url)
Columnar Jointing

A structure that forms in rocks (most commonly in basalt) that consists of columns (mostly hexagonal in shape) that are separated by joints or fractures in the rock that formed when the rock contracted, most often during cooling.

As the lava erupts onto the earth’s surface, it cools slowly. Thus it creates a temperature gradient. Generally, the top of the lava flow is cooler than the bottom of the lava flow. As the lava cools it contracts and creates a crack or fracture. A hexagonal fracture happens when contraction occurs at centres which are equally spaced.

Contraction may not be equally spaced if, for example, the thickness or composition of the lava flow varies. The fracture pattern that forms at the cooling surface will tend to be propagated down the lava as it cools, forming long, geometric columns. Thus, as lava cools to form basalt, it may crack in a hexagonal shape and form columns.

8.9. **Status**: GSI declared the site as a National Geological Monument in 1979. No special arrangements and worthwhile developments have been done by GSI for the maintenance of the site. The site is very popular and receives regular tourists. State Government has arranged boats to the visitors at Malpe Beach to St. Mary’s Island. The site is not maintained by the respective authority.
Fig. No. 36: Poor condition of rain shelters for visitors

Fig. No. 37: The Plastic waste dumped by visitors at the NGM site, St. Mary Island

8.10. **Threats**: The island gets submerged into the sea during high tides. The major threat to site is human interventions. The plastic litter and other waste destroy the aesthetics and hinders in site maintenance.
8.11. **Conservation Measures**: The following measures are suggested:

- Well sited explanatory signages
- Interpretation centre on island
- Visitor management plan including safety arrangements
- Garbage disposal plan
- Lighting arrangements to highlight the dramatic site in evening hours
- Adequate publicity
- Revenue stream [through ticketing]
9. Pillow Lavas, Maradihalli, Chitradurga District

[Text & Photographs by Dr. D. Rajasekhar Reddy]

Fig. No. 39: Major Outcrop of the Pillow lava of Maradihalli

9.1. Pillow Lava, Maradihalli, Chitradurga District, Karnataka, hosted within Chitradurga schist belt of Dharwar Group, is one of the best of its kind in the world. This small rocky hillock has been dated 2.5 billion years providing an important clue to the evolution of Precambrian peninsular India.

Map No. 11: Location of Pillow Lava at Maradihalli, Karnataka

Google Maps
9.2. **Geographical Coordinates**: Latitude -14°07' 49" N; Longitude -76°31' 34" E

9.3. **Elevation**: About 711m above mean sea level

9.4. **Location**: Maradihalli hills are a part of the north-south trending hills of the Chitradurga greenstone belt that mimics a back arc submarine basin.

9.5. **Representative Features**: The Maradihalli lava flow is exposed as a small elongated mound in the basin and consists of a massive core that is draped by lava pillows along the flow crest and flanks. The age of these basaltic pillow lavas is 2500 million years. The Chitradurga schist belt which hosts the Maradihalli pillow lavas is a schist belt of Dharwar type and is bound on the east and west by the older gneissic rocks of 3000 million years.

9.6. **Geology**: Lava erupts from the depths of the earth resulting in the formation of volcanic rocks. There are evidences to show that some volcanic rocks, presently occurring on land were actually formed under water. The most significant among them are what has been described as pillow lavas. They are known as Pillow Lava due to nearly roughly spherical or rounded pillow shaped forms. As the hot molten rock matter comes in contact with cold water, it suddenly gets chilled and part of the flow separates in to discrete rounded bodies a few feet or less in size. Pillows have flat bottom and rounded top. Due to their shape and associated features, the pillows are very useful in determining the order of superposition in deformed strata. The rock is basaltic in nature.

The pillows from Maradihalli occur as spheroid to elongate units with smooth, spalled, or wrinkled surfaces with vesicular interiors. Repeated budding of larger pillows have produced a series of interconnected pillow units indicating fluid lava that was emplaced on steeply dipping flanks, under submarine conditions.

9.7. **Accessibility**: Maradihalli is a small hamlet situated in Chitradurga district, Karnataka. It can be approached by a metalled road via Aiyamangala, about 180 km from Banguluru. Maradihalli is 16 km southeast of Chitradurga town and 4 km north of Aiyamangala village along NH-4 (Banguluru - Pune highway).

Formation of pillow lava:
- Hot Lava Spills out like globules of oil,
- Contact with cold sea water freezes the lava,
- Resulting into the globular shape

*Source*: classroom@sea.net
9.8. **Status**: GSI declared the site as National Geological Monument [NGM] in 1979 when the Government of Karnataka granted 100m x 100m land. The GSI took over nearly two-acre land to preserve the rock structure for the study. There has been no worthwhile development after the recognition of the site as NGM.

9.9. **Threats**: Since the site is not protected or fenced, it is vulnerable to human activities.

9.10. **Conservation Measures**: Protection and preservation of this geologically important site calls for management. The site should be fenced and protected. Creating awareness about its importance and conservation among local villagers can also aid in management of the site. Directional boards on the State Highway can improve visitor footfall. Proper explanatory signages should be provided.
10. Pyroclastic Rocks, Peddapalli, Kolar District

[Text & Photographs by Dr. D. Rajasekhar Reddy]

10.1. **Pyroclastic Rocks in Peddapalli** is a welded agglomerate of large fragments of granite, granite gneiss, basalt and banded ferruginous quartzite set in a matrix of ignimbrite. While many rock fragments are angular some of them appear to be well rounded. Some rock fragments of granite gneiss measure up to 80 cm in diameter.

**Fig. No. 42**: Pyroclastic Rock Formation at Peddapalli Village, Kolar District

**Map No. 12**: Location of Pyroclastic Rock, Peddapalli Village, Kolar District
A pyroclastic rock is a hardened, solidified or compressed version of an originally loose pyroclastic deposit that was thrown up in the air and fell in a heap on ground and solidified subsequently. The particles ejected from a volcano during explosive activity vary considerably in size and composition. All these ejected material consolidate to form pyroclastic rocks.

10.2. **Geographical Coordinates** : Latitude -12° 58´ 36" N ; Longitude -78° 16´ 06" E

10.3. **Elevation** : About 835 m above mean sea level.

10.4. **Location** : The Pyroclastic Rocks of Peddapalli near Kolar, are little more than 75 kms away from Bengaluru.

10.5. **Representative Feature** : Pyroclastic rocks at Peddapalli form part of the Kolar schist belt which houses the world famous Kolar gold field nearby. They formed around 2900 million years ago during the Dharwarian times in a submarine volcanic arc set up. Such pyroclastic rocks and pillow structures are commonly seen in all the green stones of Dharwar Super Group. The outcrop is reported as welded agglomerate consisting rounded to angular, large fragments of granite, granite gneiss, basalt and banded ferruginous quartzite set in a matrix of ignimbrite. The acidic fragments are ripped off from the country rocks during violent eruptions. The rock characteristics indicate ignimbritic pyromagma which has contributed to the glowing avalanche type of volcanic eruption.

10.6. **Geology** : Pyroclastic rocks are volcanic rocks formed by accumulation of material generated by explosive fragmentation of magma or previously solid rock, during the course of a volcanic eruption. They are hard or soft rocks, composed of rock fragment (pyroclasts).
The fragments are from older rocks (mostly volcanic, plutonic, but also sedimentary, or metamorphic ones) from the surrounding basement or solidified lava fragments. The volcanic products of acid and intermediate magmas are largely pyroclastic and comprise a significant proportion of volcanic deposits and edifices such as stratovolcanoes, they are typical products of plinian and sub-plinian eruption styles.

10.7. Pyroclastic rocks are, however, also produced by basic magmas in particular those that interact with water to produce phreatomagmatic surtseyan and strombolian eruptions. Alkaline magmas may also be associated with voluminous pyroclastic products. Pyroclastic rocks are classified according to the size and abundance of their pyroclasts. Tuffs are pyroclastic rocks dominated by ash (pyroclasts <2 mm), lapillistones are dominated by lapilli (pyroclasts 2-64 mm in size), and pyroclastic breccias and agglomerates are dominated by blocks and bombs (pyroclasts >64 mm in size). Deposits consisting of a mixture of ash and lapilli are termed lapilli tuffs, whilst high unsorted pyroclastics containing ash, lapilli and blocks are termed tuff breccias. The general term tephra is used to describe the fragmental materials produced by volcanic eruptions.

10.8. Accessibility: The Peddapalli village is about 700 m east of the road connecting Kolar Gold Field (KGF) with the Bangarpet-Betmangala road. The outcrop lies to the north west of the village and is best approached by this road and taking the southerly diversion near the 10 km stone for about one km. It is quiet near to the Peddapalli Gangamma Temple.

10.9. Status: On the occasion of 125th anniversary of GSI, these rocks were declared as National Geological Monument in 1976 due to their rarity. There has been no worthwhile development after the recognition of the site as NGM. The site has poor status of upkeep.

Fig. No. 44: Closer view of Pyroclastic rock exposed at Peddapalli village
10.10. **Threats**: The site is ill-maintained. The sign board is poorly located. The area is polluted as the local villagers use it for public defecation. The water body near the NGM is also polluted. Therefore, anthropogenic activity and lack of maintenance can be termed as a major threat to the site.

**Fig. No. 45**: Poorly maintained NGM site at Peddapalli

**Fig. No. 46**: Pollution caused by local villagers at the NGM site
Conservation Measures: The following measures are suggested:

- Protection and fencing of the site
- Well sited explanatory signages
- Visitor management plan
- Garbage disposal plan
- Lighting arrangements to highlight the dramatic site in evening hours
- Adequate publicity
- Creating awareness amongst local residents

Pillow lavas at Mysore mine area and pillow lavas and pyroclastic rocks at Virupaksha - Lakkanayakahalli section of KGF: In addition to the pyroclastic rocks of Peddapalli, GSI has included in this National Geological Monuments a few occurrences of pillow lava and pyroclastic rocks in the KGF viz. pillow lavas near Mysore mine area, and pillow lavas and pyroclastic rocks at Virupakshapura - Lakkanayakahalli section of KGF. However, no specific site has been earmarked, protected and maintained as National Geological Monument in this area. In the records Lat. 12° 55’ 05” - Long. 78° 15’ 50” is mentioned as the area containing pillow lavas. During the field visit is realized that the location given is of the area at Marikuppam railway station. Since the GSI has not earmarked any particular site as the NGM in these two areas, it is not possible to evaluate the ground status of these two sites.
KERALA

11. Laterite Deposits, Angadipuram, Mallapuram District

[Text & Photographs by Dr. D. Rajasekhar Reddy]

Fig. No. 48: Quarrying of Laterite deposits at Angadipuram

11.1. **Laterite deposits, Angadipuram** epitaph giving details of the laterite over a pedestal made of laterite bricks. In 1807, Dr. Francis Buchanan-Hamilton, a professional surgeon, gave the first account of this rock type in his report, as “indurated clay”. Generally this rock type falls outside the general classification of rocks and is a mixture of pyroxene granulite, charnockite and migmatite.

Map No. 13: Location Map of Laterite Deposits, Angadipuram
11.2. **Geographical Coordinates**: Latitude -10° 58’ 39” N ; Longitude - 79° 12’ 26” E

11.3. **Elevation**: About 60 m above mean sea level.

11.4. **Location**: Angadipuram is a small town located in Malapuram District of Kerala. It is bounded by Arabian Sea on west and in the north by Wayanad and Kozhikode Districts.

11.5. **Representative features**: The National Geological Monument plaque at Angadipuram is kept in the PWD Rest house on a hillock on which the granulite rocks are exposed. The crystalline rocks of this region are combination of pyroxene granulite, charnockite and migmatite.

11.6. **Geology**: The term laterite was christened in India for the highly weathered red subsoil or material found around Angadipuram in the year 1800. These rocks are cut into blocks and used as bricks for construction. Hence the term laterite based on the Latin word ‘lateritis’ which means brick in general.

11.7. Laterite is a secondary residual product resulting from the chemical weathering of widely varied rock types. In general the mineralogical and chemical characteristics of laterite are controlled by the intensity of chemical weathering of the parent rocks. Angadipuram Laterites are derived from acid charnockite rocks. Laterites have economic significance as mineral deposits of aluminium (bauxite), iron and nickel ores are associated with them.

![Fig. No. 49: Laterite Blocks used as bricks for construction](image)

11.8. **Accessibility**: The NGM is about 16 km from Malappuram on the road to Palghat and lies on the Shoranur – Nilambur railway line. The monument is located within the premises of the PWD rest house.
11.9. **Status**: The site was declared a National Geological Monument in 1979 on the occasion of the International seminar on “Lateritization Process”. The site is under the ownership of State Government.

11.10. **Threats**: There is no specific threat to the NGM site. No such threat to the site where the epitaph is located. The laterites extensively developed in and around Angadipuram are being extensively quarried. Laterites are widely being used as bricks for construction. Mining is a great threat to these deposits.

11.11. **Conservation Measures**: Angadipuram area holds widespread deposits of Laterites. It is suggested that a suitable laterite site nearby should be selected and declared as the protected area. The area can be preserved and maintained as the Monument site.

![Fig. No. 50: Laterites being cut into blocks with block cutting machine](image-url)
MAHARASHTRA

12. Lonar Lake, Buldhana District

12.1. **Lonar Lake** is a saline Crater Lake located in the Deccan Plateau of Buldhana District. It is believed to form due to collision of hypervelocity meteorite in Deccan basaltic rock of Cretaceous period. The Lonar Crater was first discovered in 1823 by J.E. Alexander, a British officer. The antiquity of lake is justified by its mention in ancient scripts like the Skanda Puran, the Padma Puran and the Aaina-i-Akbari. It has its genesis nearly 50,000 years ago, when a 2 million-ton meteorite impacted the earth to create a depression 1.83 kilometers in diameter and 150 meters deep.
12.2. **Geographical Coordinates**: Latitude -19° 58' 31. 93" N; Longitude -76° 30' 24. 92 "E

12.3. **Elevation**: About 480 m from mean sea level.

12.4. **Location**: The lake is situated in small town of Lonar in Buldhana district, which is 140 km east from Aurangabad.

12.5. **Representative Features**: Lonar Crater, India, is one of the youngest and best preserved impact structures on Earth. The lake is circular except on the north-eastern side, where siltation has created small mud flats. The diameter of the crater at the surface is about 1300m. The lake is confined from all sides by the walls of the crater and there is not a single channel of water draining away from it. The lake within the crater is both saline and alkaline in nature. The lake water contains various salts or sodas. When the water level reduces due to evaporation during dry weather, large quantities of sodas are collected.

12.6. **Geology**: The site belongs to Deccan Basalts of late Cretaceous to early Eocene period. The origin of the Lonar Crater, some believed that, it might have been formed by some phase of volcanic activity, but the evidence of glassy objects near the Lonar Crater suggested that the Lonar Crater was formed by the impact of a meteorite. The rocks observed in the lake are compact, vesicular and amygdaloidal basalt. At places the red bole beds separate the two lava flows. The basalt flows dip away from the depression.

**EJECTA BLANKET**

The impact crater is surrounded by layer of debris known as ejecta blanket. It is layered thickly at the crater's rim and thin to discontinuous at the blanket's outer edge. The extent of an ejecta blanket is determined by a number of factors including the size and mass of the impacting body (meteorite, asteroid, or comet), the surface gravity, and the atmospheric pressure.

*Source: daviddarling.info*
12.7. The impact origin of the Lonar Crater has been well established based on the evidence of shock-metamorphosed material. Coarse breccia with shatter cones and maskelynite-bearing micro breccia have been reported in drill core samples from the crater floor indicating the impact origin of the crater (Fredrickson et al, 1973). Glassy objects of varying sizes, up to 50 mm in diameter and resembling impact melts, have been recovered from the surrounding ejecta blanket (Nayak 1972).

12.8. Unlike at Barringer Crater, no significant vertical displacement of the basalt flows in the crater walls was observed along identifiable tear zones. Layer-parallel slip between the two upper most flows in the crater wall near Dhar Canyon was observed, consistent with slip along a weak contact during recumbent folding of the crater rim.
12.9. **Accessibility** : The site is well connected by regular bus services from Malkapur, Khamgaon, Aurangabad, Ajanta, Buldhana, Jalgaon & Mumbai. The nearest railway head is Malkapur on the Mumbai Bhusawal Line or Jalna. The nearest airport is Aurangabad (122 km).

12.10. **Status** : The crater cavity and rim are protected by the state from new construction. But not the ejecta blanket. Presence of rare areas where an impact spherule-rich layer suggests that the original ejecta surface (of fine debris and impact glass) has been unaltered by human activity or mass wasting.

12.11. **Threats** : The ejecta blanket is not protected and is vulnerable to activities of surrounding residents. Increases anthropogenic activities such as construction and overcrowding of slums is affecting the crater. Many streams in the rim area are polluted from regular domestic requirements such as bathing and washing using non-biodegradable detergents were dumping in these pollutants previously in the lake (e.g. Nabbi Nala stream). The path down to the lake is slippery, the quicksand on the banks making this a truly treacherous trek.

12.12. **Conservation Measures** : The polluted water streams are now diverted from the lake. The crater ecosystem can retain its unique character with immediate controls put in place through an integrated plan. For detailing the conservation and management plan the following steps need to considered:

- identification of the geographical area to be conserved
- appropriate legal status to be accorded to the defined area
- ensuring pollution free water flow into the lake
- site management plan
- visitor management plan
- interpretation centre
- revenue streams

![Fig. No. 56: Lake reduces to only a few inches depth during summers](image-url)
ODISHA

13. Pillow Lava, Iron Ore Belt, Nomira, Keonjhar District

[Text & Photographs by Dr. D. Rajasekhar Reddy]

13.1. **Pillow Lava, Iron Ore Belt, Nomira, Keonjhar District, Odisha** is consisted of well-preserved pillow structures exposed in the face of low hillock. The site serves as a geological evidence of Archean submarine volcanism and represents one of the old green stone sequences in India.

Map No. 15 : Location Map of Pillow Lava, Naimara, Odisha

Fig. No. 57 : Outcrop of Pillow Lava at Nomira

Map data ©2016 Google 2 km
13.2. **Geographical Coordinates** : Latitude -21° 54’ 13. 5”N ; Longitude -85° 26’ 17.8”E

13.3. **Elevation** : About 500 m above means sea level.

13.4. **Location** : The area is located about 18 km south of Joda town lying on Keonjhar – Barbil – Lahunipada state highway.

13.5. **Representative Features** : The pillow structure represents Archaean basaltic volcanic element, belonging to one of the known oldest greenstone sequences in India. Individual pillows in the sheet are nearly spherical and firmly packed with maximum thickness of 2m x 0.6 m. The lavas and the associated pyroclastics tuffs are externally covered by shale, chart – shale and banded hematite jasper and intrinsically lined by quartzite.

13.6. **Geology** : Pillow lavas at Nomira are the rocks that contain pillow-shaped, bulbous, spherical or tubular lobe structures, commonly up to one meter in diameter. They are formed due to the extrusion of the lava under water with low effusion rates. In other words, when hot molten magma flows into the water surface, due to extreme temperature difference, the emergent tongue cools very quickly forming a skin.

13.7. The crust cools at a faster rate and is very fine grained with a glassy texture. The material below skin cools more slowly and is slightly coarser grained. Slow extrusion gives enough time for a thick crust to form on all sides of a pillow lobe and prevents individual pillows from combine into a sheet. Pillow flows are produced by the piling up of individual pillow lava lobes. As a pillow flow forms, the newest pillows are erupted from the top of the stack and flow outward a limited distance before freezing, a process which tends to produce steep-sided mounds or ridges. Pillows often have lineations or scrape marks on their sides that form during extrusion.

### Chronostratigraphy

*Study of Rock Strata with relation to time*

The generalized stratigraphy of the region as per Tait et.al (2011) is as follows:

<table>
<thead>
<tr>
<th>Age</th>
<th>Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 Ma</td>
<td>Craton Cover sequences (e.g. Kolhan Group)</td>
</tr>
<tr>
<td>3100-3300 Ma</td>
<td>Singhbhum Batholith</td>
</tr>
<tr>
<td>3290 Ma</td>
<td>Keonjargarh – Bhaunra pluton</td>
</tr>
<tr>
<td>3510 Ma</td>
<td>Iron Ore Group (tuff, dolomite, BIF, basalt, dacite, rhyolite)</td>
</tr>
<tr>
<td>&gt;3600 Ma</td>
<td>Old Metamorphic Group</td>
</tr>
<tr>
<td></td>
<td>Old Metamorphic Tonalite Gneiss</td>
</tr>
</tbody>
</table>

13.8. **Accessibility** : The monument can be approached from road by following Joda Nayagar road upto Bamebari and then following a 2 km unmetalled road leading eastward up to Nomira.
13.9. **Status**: GSI has declared the site as a National Geological Monument in 1976 during its 125 years celebrations. TISCO (Tata Iron and Steel Company Limited) and GSI have taken initial care and made effort to put up the marble plaque for public information. The features of scientific/educational/tourist interest may lose their value unless persistent interest is shown by an identified authority (may be TISCO if the area is in their lease jurisdiction) in its maintenance. There is need for enhanced effort for the preservation and upkeep of the present exhibit.

13.10. **Threats**: The site is adjoining the road and may face destruction during widening of road or railway. There are no signages and information boards except a marble plaque showing that it’s a National Geological Monument. The site is poorly maintained and lacks protection, both physical as well as legal.

13.11. **Conservation Measures**: The following measures can be adopted:
- Physical protection of the site through fencing
- Highlighting the significance through appropriate signages
- Sensitizing local authorities about the NGM

13.12. Keeping in view the threat to the site, and as there are reported occurrences of pillow lavas in the nearby areas, there is also a need for finding a better substitute having similar/comparable feature and scientific/educational value elsewhere in the region.

13.13. **Potential For Developing A Geopark**: The National Geological Monument at Nomira, Keonjhar District can be clubbed with other nearby sites such as Sukinda & Talchir which are of geological importance. Sukinda holds about 97% of country’s chromite
resources. Talchir is consisted of boulder bed of Glacial Origin (age 250 million years). It forms a base of well-known coal bearing Gondwana Formation, an important stratigraphic horizon in India. Also,

i. To its northwest in its proximity lies one of the largest iron and manganese ore mining provinces of the country and is well known globally for its importance in Archaean geological set up.

ii. Recent researches in its vicinity have led to the identification of (a) the oldest greenstone lithopackages (eg. in the Daitari region in a comparable geological setting), (b) one of the oldest palaeosols revealing the enigmatic nature of Archaean atmosphere, (c) the Archaean gneisses and granites and (d) one of the largest Precambrian mafic dyke (the Palaspanga dyke) and the related dyke swarm (Newer Dolerite).

Fig. No. 59 : Plaque at the NGM site, Pillow Lava at Nomiara, Keojhar District
RAJASTHAN

14. Nepheline Syenite, Kishangarh, Ajmer District

[Text & Photographs by Dr. Pushpendra Singh Ranawat]

Fig. No. 60 : View of the NGM area camera facing north. Scattered outcrops of Nepheline Syenite are present in the area.

14.1. Nepheline Syenite, Kishangarh, Ajmer District, Rajasthan is a pluton emplaced along the core of an antiform of metamorphites in Aravalli craton of Rajasthan. Kishangarh syenite, by which the unit is also called, has been dated 1590 million years to 1910 million years.

Map No. 16 : Location Map of Nepheline Syenite, Kishangarh
14.2. **Geographical Coordinates**: Latitude -26° 33’ 2” N; Longitude -74° 53’ 18.6” E

14.3. **Elevation**: About 436.2± 5.2m above mean sea level.

14.4. **Location**: The NGM site is located near Kishangarh town in Ajmer District of Rajasthan.

14.5. **Representative Features**: The site is characterized by the presence of rare igneous plutonic rock emplaced in 1590 to 1910 million years in the Precambrian Aravalli metamorphic rocks. Nepheline bearing syenite is very rare rock in India.

14.6. **Geology**: An interesting suite of igneous rocks occurs close to the lineament which is also a trace of fault - cum - unconformity plane occurs at Kishangarh. Rocks occurring around Kishangarh belong to four lithostratigraphic units. The Nepheline Syenite occur as an intrusive pluton in the Kishangarh group which overlies a granite paragneiss, leucogranite and minor bodies of amphibolite and underlies unconformably a sequence of conglomerate, arkose and quartzite belonging to the Alwar Group of Delhi Supergroup. The Kishangarh Group is a sequence of meta-volcanics and metasediments correlatable with the Lower Aravalli Group of the Udaipur region. The nepheline syenite which is dominantly gneissic in appearance includes mafic enclaves of different sizes, and is also intruded by a number of dykes.

14.7. Granite is silica-rich course grained igneous rock that slowly cooled deep down the surface of the earth. While syenite is a similar rock but deficient in silica and containing rare feldspathoid minerals especially “nepheline” a silica-undersaturated aluminosilicate of soda and potash.

14.8. **Accessibility**: The designated NGM (GSI Board) is located south of the road on a small hillock about 2 km east of Kishangarh town on NH-8 coming from Jaipur to Ajmer extending further south up to the lake- Gundolav Sagar.

Fig. No. 61: Large exfoliated boulders of Syenite are strewn around the area
Fig. No. 62: Nepheline Syenite Specimen - Sample shows signs of weathering of feldspars and Feldspathoids on the exposed surface – on breaking it a fresh unaltered rock emerges, as seen in the rock piece to right. (Scale in Cms)

14.9. **Status**: GSI has declared the site as a National Geological Monument in 1976. Nepheline syenite has a fairly large exposure and occurs in state government land. There have been no worthwhile developments after the recognition of the site as NGM.

14.10. **Threats**: Kishangarh has fast developing marble and stone industries which are located away from the NGM. The NGM is located on a highway and in an area that has potential of residential and commercial constructions in future.

14.11. **Conservation Measures**: Nepheline syenite has a fairly large exposure and occurs in state government land. But people and administration need to be made aware of NGM’s existence, which they are presently unaware of, so that this area may be left undisturbed. An area of at least 10 ha should be earmarked for the NGM. The following measures should be taken:

- identification of the geographical area to be conserved
- appropriate legal status to be accorded to the defined area
- raising awareness with local people and administration
- providing appropriate signages
- fencing the area of NGM [say 10 ha]
- visitor management plan
15. Sendra Granite, Pali District

Sendra Granite, Pali District is a picturesque geological marvel displaying an array of eye-catching nature-sculpted exposures. It consists of old granite (~1200 million year) intruded into Beawer Formation of Delhi Supergroup of rocks (~1500 Mya) at depth, which was followed by its uplifting to the surface and denudation by weathering agencies for past ~ 600 million years.

Map No. 17: Location of Sendra Granite, Pali District
15.2. **Geographical Coordinates**: Latitude -26° 05’ 3.6” N; Longitude -74° 13’ 17.8” E

15.3. **Elevation**: About 429.6 ± 5.7 m above mean sea level

15.4. **Location**: It is located on the Beawar-Barr section of National Highway # 14. Sendra is a railway station on Ajmer-Ahmedabad section of North-western Railways. Presently the area is under the jurisdiction of Pali district but it is located near Beawar town.

15.5. **Representative Features & Geology**: Wind and water aided by fluctuations in temperatures, acting over millions of years, sculpt rocks into marvellous shapes that have fascinated humans for ages. They carve fancy forms some of which have uncanny resemblance to living beings.

A silica rich magma deep down the earth may cool gradually at depth from the surface of earth to form a granite (as at Sendra) or come out on the surface of the earth (as at Jodhpur and adjoining area) to form rhyolite/welded tuff, ignimbrite (fire rain).

15.6. **Younger Erinpura Granite (~640 Mya)**, on which Rajasthan’s only hill station Mt. Abu is located, also displays similar weathering characteristics. But Sendra granites display a wider variation of appealing nature’s architecture. The area is suitable for trekking and rock-climbing - hence it is also suitable for adventure tourism.

15.7. **Status**: GSI has declared the site as a National Geological Monument in 1977(?). There have been no worthwhile developments after the recognition of the site as NGM. The rocks are popular among local scouts and NCC cadets for adventure sports.

15.8. **Threats**: Being a large stretch of hard granitic terrain, the area hardly needs any protection and presently there is scarcely any scope of encroachment or construction activity in the area.
15.9. **Conservation Measures**: Sendra Granite has a large exposure but for the ease of accessibility the outcrops worth a visit along the road should be marked. Appropriate signages are needed that should be maintained by a suitable authority. Suitable treks and rock climbing spots too should be marked and composite printed folder should be available at Beawer, Sendra, and Barr. Following measures should be considered:

- identification of the geographical area to be conserved
- appropriate legal status to be accorded to the defined area
- site management plan
- visitor management plan
- interpretation centre
- revenue streams

15.10. **Potential For Information & Tourist Centre**: A small area of government land should be allotted adjacent to the road, for the ease of approach, to be developed as a “representative” of the monument where entry should be restricted. Display boards describing emplacement of granites, uplift, its weathering should be explained.

15.11. Brochures could be made available at the RTDC Mid-Way restaurant at Barr for the NGM. No RTDC facility is presently available at Sendra or Beawar. Both the neighbouring NGMs of Barr and Sendra and along with satellite site of the Bichardi Geothermal Well (Latitude 26° 03' 02.7" N; Longitude 073° 58’ 59.6” E. 331.7 ± 4.6 m) could be promoted through the RTDC Midway, Barr.
16. Barr Conglomerate, Pali District

[Text & Photographs by Dr. Pushpendra Singh Ranawat]

Fig. No. 65: Typical Exposure of Conglomerate Displaying Steep Foliation of Mica Schistose Rock Containing Stretched Pebbles of Grey Quartzite (Hammer for Scale).

16.1. Barr Conglomerate, Pali District, Rajasthan composed of pebbles of quartzite and rarely granite gneiss, set up in a fine grained pelitic matrix. It rests unconformably above the basement gneiss near the Barr.

Map No. 18: Location of Bar Conglomerate, Pali District, Rajasthan
Conglomerate is a rock consisting of individual clasts within a finer-grained matrix that have become cemented together. Conglomerates are sedimentary rocks consisting of rounded fragments and are thus differentiated from breccias, which consist of angular clasts. Conglomerates are important in geology as they aid in subdividing geological history based on sedimentary rock.

16.2. **Geographical Coordinates**: Latitude: 26° 04' 28.8" N; Longitude: 074° 06' 10.8" E.

16.3. **Elevation**: 389.1 ± 5.5 m above mean sea level.

16.4. **Location**: Barr is in Pali district close to Beawar town (which could become a district headquarters in near future) located on Ajmer-Pali section of the National Highway 14.

16.5. **Representative Features**: The unusual feature of fairly uniform lithology and exceptional stretching of pebbles in the conglomerate at Barr makes it different from typical conglomerate. More variety of rounded rock pieces (polymictic) conglomerates are also present elsewhere in Rajasthan, e.g., those at Rajnagar, Sindreth (near Sirohi), near Debari, east of Udaipur city and even atop the hill on which Roothi-Rani Mahal is constructed at Jaisamand, south of Udaipur.

16.6. **Geology**: This site shows unusual stretching (7-20 times its thickness) of pebbles of quartzite and rare aplite (fine-grained granite-like igneous rock), set in a matrix of fine grained mica schist. It rests unconformably above the basement gneiss near village Barr on Beawar-Pali section of the NH 14. The long axis of the pebbles is oriented along the foliation plane of the schistose rock.

16.7. It is interesting to observe how hard brittle rock pieces (pebble: 3.2-6.4 cm, cobble: 6.4-25.6 cm) can be flattened and elongated, like plastic clay without being fractured or fragmented.

16.8. Earlier geologists (1950s) considered this as sedimentary conglomerate. This sedimentary rock containing rolled ~spherical rock pebbles were pushed down to a depth of >20 km where under high temperature and pressure conditions they became pliable from their original brittle state. The rocks were folded due to which the original horizontal beds became nearly vertical, original sedimentary minerals were transformed to more stable (metamorphic) minerals. All this happened some 1500 million years ago. They were again uplifted and suffered weathering due to the action of water, air, and changing temperatures.

16.9. Later workers noted that the rock lacks the wide variety of cobbles that is expected of such a rock and owing to near uniform nature of the stretched pebbles it is now believed that they are autoelastic in origin - i.e., thin bands of sandstone beds (later metamorphosed to quartzite) were first stretched and split into long rods (mullions and boudins) which were detached into elongated pieces (cobbles) that ultimately assumed these rare and characteristic shapes-all in a pliable PT setting. They were again uplifted and suffered weathering due to
the action of water, air, and changing temperatures. Geologically, the rock belongs to Delhi Supergroup, Kumbhalgarh Group, Barr Formation.

![Fig. No. 66: Close-Up look at conglomerate showing stretched steeply inclined pebbles in a Mica Schist Matrix (Ruler For Scale- 5 cm)](image)

16.10. **Accessibility**: The conglomerate is best exposed on either side of the Beawar-Sendra-Barr-Pali road just before the Barr-Pali cross road towards Sendra.

16.11. **Status**: GSI has declared the site as a National Geological Monument in 1977. There have been no worthwhile developments after the recognition of the site as NGM.

16.12. **Threats**: The conglomerate bed is extending North-North East and South-South West for a very long distance. No major threat is recognised.

16.14 **Conservation Measures**: The following measures are proposed:
- identification of the geographical area to be conserved
- appropriate legal status to be accorded to the defined area
- site management plan
- visitor management plan
- interpretation centre
- revenue streams

16.13. **Potential For Information & Tourist Centre**: A small area of government land should be allotted adjacent to the road, for the ease of approach, to be developed as a “representative” of the monument where entry should be restricted. No RTDC/State Tourism Department facility is presently available at Sendra or Beawar. Both the neighbouring NGMs of Barr and Sendra along with satellite site of the Bichardi Geothermal Well, could be promoted through the RTDC Midway, Barr. Printed folders could be made available at the RTDC Mid-Way restaurant at Barr.
Fig. No. 67: Rarely smooth stretched pebbles of Aplite; Fine-Grained granitic rock
(Ruler for scale: 5 cm)

Fig. No. 68: Block of Conglomerate used in construction of wall shows smooth cavity from which a stretched pebble has been dislodged
17. Jodhpur Group- Malani Igneous Suite Contact, Jodhpur District

Fig. No. 69: The Sharp Contact-Nonconformity Between The Older Malani Welded Tuff (Igneous) Overlain By Younger Sedimentary Sandstone At Mehrangarh.

17.1. **Jodhpur Group- Malani Igneous Suite Contact** is situated in Trans-Aravalli-the area west of the Aravalli Hill Range (Trans = "across", "beyond" or "on the opposite side" of). The igneous suite represents the last phase of igneous activity of Precambrian age in the Indian Subcontinent.

Map No. 19: Location Of Malani Igneous Suite Contact
17.2. **Geographical Coordinates**: Latitude: 26° 17´ 58.6˝ N Longitude: 073° 01´ 09.7˝ E

17.3. **Elevation**: 338.3± 7.8 m above mean sea level

17.4. **Location**: Malani Igneous Suite Contact, Jodhpur District, Rajasthan lies at the foot of the picturesque Mehrangarh Fort within the Jodhpur city.

17.5. **Representative Features**: NGM site demonstrates in striking fashion the last phase of igneous activity during Precambrian age of Indian Subcontinent. The rock is characterised by purple to red and ash coloured laminated tuff with chocolate coloured chalcedony, dark red obsidian, purple, reddish, buff, whitish and greyish coloured rhyolitic tuff related to ignimbrite. The contact is enhanced by the multi-coloured igneous suite in contact with light coloured Jodhpur sandstone.

17.6. **Geology**: Trans-Aravalli area has entirely different geological set up compared with rest of Rajasthan. This is acknowledged by a “twin” NGM at Jodhpur. The above unique siliceous volcanic rocks that are overlain by a thick pile of sedimentary undeformed rocks that were deposited in a Trans-Aravalli Vindhyan or Marwar Super Group basin formed at the close of Proterozoic and early Cambrian Period (~540Mya). Each of these groups of rocks has their own extensive exposures in western Rajasthan, but at rare places the junction of two are noted that help in understanding their mutual age and genetic relationships. The “type/representative” area also happens to be at the hill on which Mehrangarh is built in Jodhpur. Here a sharp contact of volcanic base rock and overlying sedimentary rock, also known as “nonconformity”, is visible

17.7. **Accessibility**: Jodhpur is situated SW of Jaipur and is well connected by State Highways. The Northern Railway Main Line and Northern Railway Phalodi Branch passes through Jodhpur Town. Jodhpur is also approachable by air.

17.8. **Status and Threats**: There have been no worthwhile developments after the recognition of the site as NGM, and it is lying in highly neglected state, which needs proper boards, printed description folders and other attention drawing features. This site has TWO NGMs hence it is essential that an **Interpretation Centre** explaining volcanism followed by sedimentation witnessed by this area, its unique igneous and sedimentary structures in undeformed rocks, palaeogeography of the area since Precambrian times would certainly be of interest to technical as well as non-technical visitors. (Local administration and hospitality industry are unaware of these national monuments) Department of Rajasthan Tourism should also be made stakeholder of the site.
Fig. No. 70: Another famous & conveniently accessible spot showing contact of older volcanic & Younger Sandstone near the lift leading up to Mehrangarh Fort
18. Welded Tuff, Jodhpur District

[Text & Photographs by Dr. Pushpendra Singh Ranawat]

Fig. No. 71: Angular fragments of silicic volcanic rock and glass fused into an ignimbrite (welded tuff) as seen in the cleaned up lake feeding canal in the Rao Jodha Desert Rock Park, Mehrangarh

18.1. **Welded Tuff, Jodhpur District, Rajasthan**: In the Jodhpur Fort hill area, occurs terrace-like weathered Malani volcanic rocks. The welded tuff is a product of ejecta that spurted out from volcanic vents and were carried away by air to settle down. They are composed of glass, quartz and feldspar. On cooling they develop joints which give rise to columns and terraces. GSI has declared the site as a National Geological Monument in 1976.

Map No. 20: Location of Welded Tuff, Jodhpur, Rajasthan
18.2. **Geographical Coordinates**: Latitude -26° 18´ 9 ˝ N; Longitude -73° 01´ 13.7˝ E

18.3. **Elevation**: 304± 5.2 m above mean sea level

18.4. **Location**: The demarcated NGM is at the base of the hill on which Mehrangarh is built. The area is mostly owned by the Municipality and State Forest Department (govt. land) as also private property of the Mehrangarh Fort.

18.5. **Representative Features**: The Malani rhyolites comprise pink, maroon, brown, purple, grey and green rhyolite separated by tuff, welded tuff and pyroclastic rocks. The columnar joints developed are rectangular to hexagonal, attaining a length of 30m or more at places. It is overlain by deep purple coloured porphyritic rhyolite. The pyroclastics are intermixed with lava representing the final phase of emanations.

18.6. **Geology**: Western Rajasthan has one of the world’s largest silicic volcanic rock exposures covering an area of ~45,000 square km, which was the product of violent volcanic activity in Late Precambrian (Late Proterozoic) times (~750 Mya) for extended period of times spewing out nearly 3500 m thick rhyolite (siliceous volcanic flow) and welded tuff/ignimbrite (fire-rain)-the fused volcanic vent ejected igneous material. This group of rocks is classified under “Malani Igneous Suite of Rocks”, named after the Malani area of western Rajasthan (western Barmer district). Again for the convenience of accessibility, the “representative-area” selected for the NGM is at the *Bhaureeria* hill (the hill of birds) on which the famous historic fort-Mehrangarh Fort is built. Such a wide spread and extensive siliceous volcanic rock exposure is not seen anywhere else on the Indian peninsula, or rather anywhere on the earth.

18.7. The Deccan Traps (step-like hills) basalt, a silica deficient mafic volcanic rock, has equally significant presence is west-central India. Unlike its siliceous counterpart rhyolite, which is highly viscous and therefore has restricted flow area, basalts have high “fluidity” and hence it flows easily on the surface of the earth. These solidified flood basalts are spread over...
an area of ~0.5 million square km with a thickness of ~2000m (refer to the earlier sections above). On the other hand, equally wide spread aerial spread of Malani volcanic rocks has been explained by fusion/welding of air-fall volcanic ejecta. Deccan basalts poured out of long fissures on the surface of earth some 60 million years ago (at the end of Cretaceous Period) while the Malani rhyolites/welded tuffs witnessed violent/explosive ejections from volcanic cones, some of which as those near Bhinmal at Karda (N 24° 53´ 39.7 ˝; E 72° 08´ 14.9˝; 205.9± 5. m), which can be seen on satellite images.
19. Akal Fossil Wood Park, Jaisalmer District

[Text & Photographs by Dr. Pushpendra Singh Ranawat]

**Fig. No. 75**: Petrified Tree Fossil, about a metre in diameter, with visible tree rings

(Source: thatandthisinmumbai.wordpress.com)

19.1. **Akal Fossil Wood Park, Jaisalmer District** is a wonder for the tourists who know Jaisalmer as a part of the great Thar Desert. It consists of petrified wood carrying signature of the luxuriant forests in a warm and humid climate, bordering the sea some 180 million years ago.

**Map No. 21**: Location Map of Akal Fossil Wood Park, Jaisalmer, Rajasthan
19.2. **Geographical Coordinates** : Latitude - 26° 49' 30.4" N ; Longitude - 71° 02' 24.4" E

19.3. **Elevation** : 247.6 ± 6.3 m above mean sea level

19.4. **Location** : The area is located near Akal, 18 km South East of Jaisalmer.

19.5. **Representative Features** : The 21 ha Fossil Park contains about a dozen fossil wood logs lying horizontal in random orientation. The longest specimen is 13.4 m x 0.9 m. The fossils are of *petrophyllum*, *ptyllophyllum*, *equisetitis* species and dicotyledonous wood and gastropod shells of Lower Jurassic period.

19.6. **Geology** : The desert city of Jaisalmer has rare exposure of 180 million year old rock (Lathi Formation of Lower Jurassic age) that contains fossilized tree trunks lying scattered in an area of 21 ha in the company of invertebrate life remains (gastropods, ammonites for example). The longest specimen of the tree trunk preserved here is 13.4 m long and 0.9 m wide. Most of the fossilized logs are now protected with an iron grill protective cages with metal sheet roofing. Presence of such life forms indicates that the area at that period had lush growth of forest in humid climate. Quick burial of life in sediments of the then sea ensured their preservation and subsequent molecular replacement by silica to preserve the original shape and pattern of the life forms.

![Fig. No. 76 : Wood Fossils protected in their indigenous state at the Akal Wood Fossil Park](image)

19.7. Very attractive fossilized limestones of Jaisalmer area are famous decorative stones that find ready use in construction works and fancy items. The quality of wood fossils of Akal are not as appealing to eyes as are the cherty wood fossils of Cretaceous period (~145Ma) of Bagh and Chirakan areas of Madhya Pradesh (Fig. below).
Fig. No. 77: Sample of wood fossil displaying growth rings & internal structure under the former bark. Sample is placed over a polished Fossiliferous golden limestone of Jaisalmer Area that is a popular decorative stone.

Fig. No. 78: Wood Fossil (Well-preserved tree-knot with Paleo Resin) of Bhagh-Chirakan area of MP in Cretaceous Formations - These are better quality fossils compared to those of Jaisalmer area.

Desert National Park, is situated in the West Indian state of Rajasthan near the town of Jaisalmer. This is one of the largest national parks, covering an area of 3162 km². The Desert National Park is an excellent example of the ecosystem of the Thar Desert. Sand dunes form around 20% of the park. The major landform consists of craggy rocks and compact salt lake bottoms, intermedial areas and fixed dunes.
19.8. **Accessibility**: The site is 18 km SE from Jaisalmer and can be approached through National Highway #15 on Barmer road.

19.9. **Status**: GSI declared the site as a National Geological Monument in 1972. The Akal Fossil Wood Park was maintained by GSI till 1985 before being handed over to the State government’s Forest Department. This park is now being maintained by the authorities of Desert Nation Park (DNP) under the control of Chief Wildlife Warden, Government of Rajasthan. This is the best maintained NGM in the state of Rajasthan. It is fairly well maintained with road-side sign boards, boundary, printed folder, staff, and nominal entry fee.

19.10. **Threats**: The monument has no threat to developments as it forms part of the protected Thar Desert National Park in the care of the Forest Department of the state government.

19.11. **Conservation Measures**: Well located, easy to maintain, explanatory signages, in Hindi as well as in English, on both sides of the road are put up at the NGM (Photo below). However, directional signboards to guide a visitor starting from Jaisalmer should also be added along the road.

19.12. **Potential Information & Tourist Centre**: A nominal entrance fee is charged at the entry gate, a printed folder is available for visitors at the main gate (though a better one should be produced). Description signages at fossil sites should also be put up. An interpretation centre could be added. The exposed tree-trunks fossils have been protected by iron grill cages with overhead tin-shed in a make do fashion – a more aesthetic arrangement is required. Being a National Park, local wildlife (fauna) like deers / chinkaras, hares, partridges, peacock *etc.* should be introduced in the “Park” as added attraction for a fossil admiring sightseer.

19.13. The RTDC Hotel and private hotels are not well informed about the NGM; brochures should be made available at “Tourist Reception & Information Center” of RTDC as well as at the prominent hotels.
20. Great Boundary Fault at Satur, Bundi District

[Text & Photographs by Dr. Pushpendra Singh Ranawat]

Fig. No. 79: Upright Folds in the Vindhyan Limestone in a stone Quarry between the main road & Silica Sand Project

Figure 80: GBF (yellow line) & Aravalli Hill Range—the two prominent linear features of Rajasthan as seen on Google Earth satellite image.
20.1. **Great Boundary Fault [GBF] at Satur, Bundi district, Rajasthan** is characterised by a faulted boundary between Pre-Arvallis and Upper Vindhys having NNW-SSE trend. It 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 holds visual interest.

20.2. **Geographical Coordinates**: Latitude - 25° 28´ 41.5" N ; Longitude - 075° 33´ 32.2" E  
(Exposure in the Sathur village) Latitude - 25° 28´ 02.4" N ; Longitude - 075° 34´ 10.1" E  
(Exposure between the main road (NH 12) and silica sand mine)

20.3. **Elevation**: 298±11.6 m above mean sea level

20.4. **Location**: Sathur village is located nearly 11 km NW of Bundi on the new NH#12 connecting Kotah-Bundi-Deoli-Tonk-Jaipur passes through the GBF and to the east of the road is a conspicuous white debris of silica sand open-cast mine. There are no NGM sign boards hence no specific demarcated area could be located.

20.5. **Representative Features**: The area is designated by a faulted boundary between Upper Vindhys and Pre-Arvallis. It displays a zone of disruption consisting of a number of parallel and oblique faults resulting in step like features.

20.6. **Geology**: Great Boundary Fault (GBF) of Rajasthan (Bundi Lineament) separates younger Vindhyan sedimentary rocks (~900Ma) to its east that have characteristic escarped plateau geomorphology from the more deformed and metamorphosed pre-Vindhyan rocks of 1500-3500 Ma (Delhi/Aravalli/BGC rocks). GBF extends from eastern border of Rajasthan (south of Agra, Bharatpur) and extends up to west of Chittaurgarh town. With the improved remote sensing techniques at the command of geologists, the extent of GBF is believed to extend further southwest.
20.7. On a satellite image the ~North East - South West trending Aravalli Hill Range is conspicuous topographic feature, so is the East - North East and West - South West trending lineament in eastern part of Rajasthan that is the Great Boundary Fault. The otherwise horizontal, undeformed Vindhyan rocks of eastern Rajasthan are moderately dipping (~45°), folded, faulted, and brecciated (cemented angular fragments) along the GBF.

20.8. A dry-bed stream in Sathur village has exposure of inclined limestone which also shows folding. The area around the silica sand open cast mine is suitable to see deformed Vindhyan limestone with brecciated contacts with rocks of the Aravalli Supergroup. The feldspathic silica sand with clay impurities and its washing plant are added attraction for a visit to this NGM. Silica sand is product of GBF activity. Such extensive dislocation zones are rare, though smaller thrust and fault zone are reported from several places in India. “Main Boundary Faults” are common in Himalayan region.

20.9. **Accessibility**: The representative area selected for this important geologic feature is at Sathur (Satur) about 10 km North-West of Bundi on Jaipur Road.

20.10. **Status**: GSI has declared the site as a National Geological Monument in 1976(?). There have been no worthwhile developments after the recognition of the site as NGM.

20.11. **Threats**: Not being specific location feature, there is hardly any threat to this NGM. However a specific area showed be allotted that can be taken as representative of the GBF activity where representative samples should be placed for viewing.

20.12. **Conservation Measures**: Protection and preservation of this geologically important site calls for a management plan. The site should be fenced and protected. Alternatively, any other suitable site could also be selected and developed along the new Kota-Chittaurgarh section of the Highway.
20.13. **Potential Information & Tourist Centre**: A non-technical tourist would hardly be interested in such a feature, though people interested in science and economic minerals would find it worth a visit. The area will need to be promoted with imaginative management plan. This could mean adding a clutch of activities for the regular tourist, highlighting it on the tourism circuit and bringing in Tourism Department as a stakeholder. Appropriate signages should be installed and appropriate literature should be made available.

![Fig. No. 82](image1.png)

**Fig. No. 82**: A Water-Filled Silica Sand Pit, an economically significant aspect of GBF. This water is used for washing of silica sand (Removing Clay)

![Fig. No. 83](image2.png)

**Fig. No. 83**: Folded Vindhyan Limestone as seen in the Sathur Village Stream-Bed
21. Stromatolite Park, Bhojunda, Chittaurgarh District

[Text & Photographs by Dr. Pushpendra Singh Ranawat]

Fig. No. 84: Columns of Stromatolite rising across the bedding plane of Limestone, (Scale - 5 cm)

21.1. **Stromatolite Park, Bhojunda, Chittaurgarh District, Rajasthan** is an exposure within the massive Bhagwanpura Limestone of the Lower Vindhyan age.

Map No. 23: Location Map of Stromatolite Park, Bhojunda, Chittaurgarh
21.2. **Geographical Coordinates**: Latitude - 24° 50' 20.5'' N; Longitude - 074° 35' 00.8'' E.

21.3. **Elevation**: 436.5 ± 5.4 m

21.4. **Location**: The Bhojunda Stromatolite Park is located east of Chittaurgarh town near the village Bhojunda which is 110 km east of Udaipur, the NGM is located favourably at the junction of NH#79 (linking Ajmer and Indore) and NH# 76 (Udaipur-Kotah) in a state government land west of the conspicuous SARAS Dairy Plant.

21.5. **Representative Features**: Stromatolites are stratiform, columnar and nodular structures in carbonate rocks resulting from the combination of life activity and sediment trapping and binding ability of algal assemblages and preying bacteria. They form generally in shallow water where tides bring floating sedimentary material continuously and make it flow through carbonate particles.

21.6. **Geology**: Stromatolites are structures produced by blue-green algae, which through their filaments, attract and bond carbonate particles forming a mat. Stromatolites are known as impression of one of the earliest form of life on earth. In Indian geology, the Vindhyan Formations (~900 Mya) were vigorously but unsuccessfully searched for life, but the discovery of these life forms in still older rocks was the happiest moment of 1970s. Stromatolites- are the indisputable proof that life existed in these Precambrian rocks of Rajasthan.

---

**Fig. No. 85**: Weathering has enhanced circular cross section of stromatolite along bedding plane of limestone that has dissolved more than the less-soluble jutting out stromatolite (Hammer for Scale)
21.7. **Accessibility**: The best exposures of the stromatolites in Stromatolite Park are near Bhojunda village, about 6 km SW of Chittaurgarh city on either side of the Chittaurgarh – Udaipur State Highway to the west of Saras Dairy Plant and east of the Ajmer-Indore National Highway-NH79. The original park has an area of about ~3.5 ha.

21.8. **Status**: GSI has declared the site as a National Geological Monument in 1976. The park is in a state of neglect and lacks protection.

21.9. **Threats**: Stromatolites occur in a large area which is now vulnerable to fast urbanization. Hence the Park area should be demarcated, protected, and popularized, lest it becomes victim of unconcerned developers and district administrators.

21.10. **Conservation Measures**: The former village of Bhojunda is now part of expanding Chittaurgarh town therefore this monument should be renamed as “Chittaur Stromatolite Park”. The stromatolite bearing limestone has a very convenient accessibility and is a state government land; therefore the area beside the highway, west of the Saras Dairy Plant, should be protected so that no further encroachment takes place. Chittaur is an important tourist destination but tourists (as also the locals) are unaware of this monument of international significance. Therefore not just the sign boards and printed brochure but a well-thought out Interpretation Centre can be built at the location in which the significance of stromatolites, geologic and economic significance of the Vindhyan rocks should be highlighted. Appropriate signages should be provided and site should be properly fenced and gated.

*Fig. 86: Limestone Block In Which (Due To Weathering) The Stromatolites Are Conspicuous, They Are Growing Across The Bedding Plane Parallel To The Hammer Handle, While Circular Cross Section Can Be Seen On The Bedding Plane At Right Angles To It (White Scale Is 5cm Long)*
Fig. No. 87: A Smaller 3-Dimensional Block Weathered On All Sides Clearly Displaying The Shapes Of Columnar Growth Of Stromatolite Across The Bedding Plane (*Coin Diameter=2.5 Cm*)
22. Gossan, Rajpura-Dariba, Rajsamand District

Fig. No. 88: A unique sample of Gossan with Silica Iron Oxide (Brown) & Recrystallized “Comb” of Barite Crystals. The host rock contains fine Grained Barite (Heavy Spar, A Sulfate Of Barium) which was dissolved by oxidizing solutions producing Gossan & Barite was deposited in open spaces as crystals. Their shape & size indicates that they were formed from dilute solutions under slowly crystallizing environment.

22.1. **Gossan, Rajpura – Dariba, Rajsamand District**: The mineralised zone has formed due to extensive chemical weathering and pervasive oxidation of the sulphides – sulphosalts ores through prolonged geological periods under favourable climatic condition.

*Map No. 24: Location Of Gossan- Dariba, Rajsamand District, Rajasthan*
22.2. **Geographical Coordinates:** Latitude - 24° 56´ 33.3˝N ; Longitude - 074° 07´ 46.3˝E

22.3. **Elevation** : 510.5± 11 m above mean sea level

22.4. **Location** : Rajpura-Dariba is about 77 km NE of Udaipur city connected with newly constructed wide tar road via Dabok, Naharmagra, Mavli, Fatehnagar, Sanvaad.

22.5. **Representative Feature** : The secondary minerals of *gossan* show a variety of colours including reddish brown, brown, dark brown, bluish green, white and grey and also different type of boxwork structures. At Rajpura-Dariba a rare and rich multi-metal sulphide (and sulphosalts) ore deposit occurs over which a thick gossan is present. In fact the Rajpura-Dariba multi-metal deposit was discovered because of this *gossan*, which is a favourable “guide” to search an underground ore deposit. The chief primary ore minerals at this deposit are sphalerite, galena and chalcopyrite with minor quantities of several are minerals. *Arthashastra* authored by *Chankya* (~350–283 BCE) also makes mention of such ore guides and how mineral wealth is essential for state treasury.

22.6. Large heaps of slag and numerous underground old-workings indicate a thriving ancient mining activity. Carbon dating indicates an age of 3040 ± 150 years before present (BP) for Rajpura-Dariba. Ayad, east of Udaipur is an archeologically established chalcolithic (copper) site, the village was earlier also know by the name “Tambavati Nagri” the “Copper-Town”, this site is considered contemporary of Mohenjo-Daro & Harappa (~3000 BCE).

22.7. **Geology** : The importance of a “gossan” lies in its diagnostic characteristics, which help in the recognition and location of sulphide minerals beneath the surface. Evidently the ancient miners and prospectors realized the importance of *gossans* and utilized them as a clue to the location of hidden metallic deposits. The *Gossans* show a variety of colours including reddish brown, brown, dark brown, bluish green, white and grey and also different type of boxworks. The chief ore minerals are sphalerite, galena and chalcopyrite. Zinc is the dominant base metal followed by lead and copper.

---

*Fig. No. 89 : Panoramic View of lake & agriculture fields from the Gossan Hill*
Fig. No. 90: The Western Face of the Gossan Hill on which the Rajpura-Dariba Project name is written in masonry.

Fig. No. 91: Sample of smelting generated black glass slag that resembles Obsidian-The Volcanic glass formed due to rapid cooling of Felsic Lava.
GOSSAN

“Gossan” is a Cornish word designating a capping of oxidized cellular mass of limonite and gangue over the aggregated sulphide-sulphosalt material. The limonitic minerals, forming the predominant constituent of the gossan, impart the capping a typical reddish brown or yellow colour and serve as a very useful guide in reconstructing the mineralogical composition of the material from which they have been derived. The limonitic products derived from different sulphide and sulphosalts minerals usually differ in their minute physical characteristics such as structure, texture, size and arrangement of grains. The form and quality of limonitic matter may also help in an approximate determination of the original metal content. Other associated oxidized materials, such as carbonates and sulphates, also indicate the nature of the sulphides and sulphosalts.

22.8. **Accessibility**: The gossan is located between Dariba and Rajpura villages in Rajsamand district over a length of 4.5 km with 2 to 40 m width and 15 km NNE of Fatehnagar Railway station on Chittaurgarh – Udaipur section of North-western Railways.

22.9. **Status**: GSI has declared the site as a National Geological Monument in 1977. The area has a ~ 4.5km long and 2 - 40m thick gossan zone - an indicator of a rich base metal deposit under it - which was prospected (searched) and explored (shape, size, and grade) by GSI during the period 1963-1973. Thereafter it was handed over to Hindustan Zinc Ltd. for its utilization which is still going on which includes its underground mining, milling, and smelting. An explanatory engraved marble slab (Shilalekh) is installed at the site that has geologic map, name and composition of primary and secondary minerals present in the area.

22.10. **Threats**: The area falls in the lease of M/s Hindustan Zinc Ltd. which is employing underground mining by cut-and-fill method; hence any chance of damage through subsidence of gossan zone is minimal. No other development can take place as long as the mining activity is going on.

22.11. **Conservation Measures**: The monument will have to be taken care of by GSI and Rajasthan Department of Mines and Geology. Promotional measures and explanatory signages need to be added.
23. Stromatolite Park, Jhamarkotra, Udaipur District

[Text & Photographs by Dr. Pushpendra Singh Ranawat]

Fig. No. 92: One of the open cast mines of Jhamarkotra Stromatolitic Rock Phosphate.

23.1. Stromatolite Park, Jhamarkotra, Udaipur District, Rajasthan provides geological evidences to early life on earth. It holds the largest deposits of phosphorite associated with stromatolite.

Map No. 25: Location Of Stromatolite Park, Jhamarkotra, Udaipur District, Rajasthan
23.2. **Geographical Coordinates**: Latitude - 24° 28´ 29.7˝ N ; Longitude - 073° 52´ 02.3˝ E

23.3. **Elevation**: 512.1± 5.2 m (on the hillock)
490.9± 4.5m (at the base of the hillock)

23.4. **Location**: The site is located in Jhamarkotra which is ~25 km southeast of Udaipur city on Udaipur–Jagat road linking the famous Jhamerashwar cave temple.

23.5. **Representative Features**: Association of phosphorite with stromatolites showing typical surface manifestation has been of great value in stratigraphic correlation and as guide for phosphate prospecting in areas with similar litho-associations. Some of the features of stromatolites, like growth at right angles to beds and convexity towards top, have offered valuable field guidance for correct structural interpretation. The following types of phosphorite are reported from Jhamarkotra:

- 1. Laminated Phosphorite
- 2. Columnar Phosphorite
- 3. Fragmental Phosphorite
- 4. Brecciated Phosphorite
- 5. Vesicular Phosphorite
- 6. Botryoidal Phosphorite
- 7. Loose & Powdery Phosphorite

In-situ exposures of stromatolitic limestone are also present in the park.

23.6. **Geology**: Unique algal stromatolite fossils in the Proterozoic Aravalli dolomitic limestone (~1800 Ma) were found at Jhamarkotra. While the presence of life in Vindhyan Formations (~750 Ma) was being debated, the well-preserved, undoubted algal life in Proterozoic was a dazzling discovery. Diverse varieties, shapes, & sizes of stromatolites are present in the Fossil Park; characteristic “crocodile-skin” weathering due to differential weathering of stromatolitic and surrounding material is of special interest.

23.7. Stratiform stromatolites are seen in Block H comprising inter-bedded laminae. In high grade phosphorite, the brecciated fragments of stromatolites are welded together with calcareous and cherty matrix and were probably formed by tectonic activity causing brecciation and subsequent leaching and re-crystallization of detrital stromatolites which have upgraded the low-grade ore. In the low-grade phosphorite, stromatolitic structure are better seen with intervening carbonate matrix.

23.8. **Accessibility**: Undoubtedly the best stromatolites in India suitably located with easy approach to the site by air, railways or roads. The area can be approached from Udaipur, via Udaipur – Salumbar road linking Jhamerashwar temple which is about 500 m left side of the road. The NGM is located on a hillock east of the local village-connecting road.

23.9. **Status**: GSI has declared the site as a National Geological Monument in 1976. This NGM was inaugurated on 12th January 1978 with an aim to preserve these rare fossils for the future generations and for the earth scientists who visit Udaipur every year in large numbers.
Fig. No. 93 : Samples of the primary rock phosphate ore (Right) & secondary Fine-Grained Apatite (A calcium phosphate mineral) which was leached by dilute (Humic) acid bearing surface water & mineral in colloidal form is deposited as “Cherty” looking secondary apatite displaying eye-pleasing colour & delicate banding

Fig. No. 94 : Darker grey colour & differential weathering has enhanced the shapes of stromatolites that are growing across the bedding plane of host Dolomitic Limestone
23.10. **Status**: The site selected for the monument is well outside the mine area so the mining of rock phosphate does not affect the monument. There are no signboards on the road leading to NGM. A cement-concrete pathway branches out from the road, which was constructed for approach to a temple thereafter an unpaved path (*pagdandi*) approaches the hillock-top fossil park. The gate between the cement pillars is absent and the monument is lying in an utter state of neglect. Printed brochures or descriptive boards are not available now.

![Fig. No. 95: The entry gate to the NGM is in sorry state, there no signboards either.](image)

23.11. **Threats**: The site is both neglected and unprotected. It can easily be lost in the course of developmental activity. RSMML (Rajasthan State Mines & Minerals Limited), the state government agency that is mining the area, does not favour development of this NGM lest some organization launches a campaign to ban the mining activity thereby affecting the economy of the area and loss of an import-substitute natural resource.

23.12. **Conservation Measures**: The site should be fenced, protected and properly managed. The local government agencies are not aware of the monument; therefore the *Panchayat Samiti* and such local bodies should be sensitized and made responsible. The popular cave temple of Jhameshwar Mahadev is located at the southern base of the monument hill; the development activity of it should take into account the existence of the NGM and should not adversely affect it. The NGM area needs to be protected and the lease holders should be assured that popularizing this site will not have any adverse effect on mining activity which is well taken care of under the watchful eyes of State Pollution Control Board.

23.13. **Potential Information & Tourist Centre**: The locality deserves to be a UNESCO approved *Geopark* of international significance, for which an Interpretation Centre should be developed explaining the palaeogeography of this region, how it evolved over the geologic past and details of stromatolites and how it could also be used as a decorative stone—a possibility not yet examined.
TAMIL NADU

24. Charonockite, St. Thomas Mount, Chennai

24.1. The name Charnockite originated from the use of the same rock as tombstone of Job Charnock, the founder of Kolkata. The name charnockite has now gained worldwide usage. It is therefore unique that the name of an important rock type in the world – charnockite is derived out of a tomb stone of a person.
24.2. **Geographical Coordinates** : Latitude - 13° 00' 08" N ; Longitude - 80° 11' 45" E

24.3. **Elevation** : About 60m above mean sea level.

24.4. **Location** : St. Thomas Mount is located in the southern part of Chennai city, in the Pallavaram suburb, at the junction of Bengaluru-Chennai highway and is 3 km east to the Chennai International Airport.

24.5. **Representative Features** : Charnockite of St. Thomas Mount is a quartz – feldspar – hypersthene bearing metamorphosed igneous rock characterized by the presence of two pyroxene facies metamorphism. The constituents of the rock suggest of its origin in particularly dry and high temperature condition and believed to have important bearing in elucidating primordial crustal evolution of the earth. It received worldwide attention and evoked considerable interest amongst the earth scientists engaged in the study of Precambrian research.

24.6. **Geology** : Several petrographic varieties within the charnockites–enderbites such as the granulites and gneisses corresponding to adamellite, monzonite, granite and other have been found in the area. The rocks are in general bluish gray or darkish in colour and extremely fresh in appearance with an even grained granular texture. The mineral composition shows an unvarying presence of pleochroic rhombic pyroxene. The other feric minerals noted are augite and hornblende with minute grains of opaque iron ores and these minerals have been noted to cluster together. Plagioclase feldspars, alkali feldspars and quartz are the salic minerals present in this series of rocks.

24.7. **Accessibility** : Chennai is fourth largest metropolitan city in the country, well connected by road, railway and air network.

24.8. **Status** : Government of Tamil Nadu granted the land and the GSI has declared the site as National Geological Monument in 1975. The site is not protected and poorly maintained.

24.9. **Threats** : Several constructions related to the church have come up on the hill. The outcrop of the NGM is also in the compound wall of church and is vulnerable to further damages. There is no way to approach to the site as it is in a compound of a building. The concerned authorities of the building object to visitors and make it difficult for visiting scholars. If proper fencing and an approach road is not made available, in due course of time it is likely to be destroyed by construction and other developmental activities and will not serve the intended purpose of declaring the site as NGM.

24.10. **Conservation Measures** : The site needs to be fenced, an approach road should be developed and proper care needs to be taken to protect and preserve it. Awareness needs to be created amongst the public about its importance and need for conservation. Alternative outcrops of typical charnockites on the same hill/nearby areas should be identified and developed as NGM besides the existing outcrop.
Fig. No. 97: Typical exposure of the Charnockite (Pen For Scale)

Fig. No. 98: Portuguese Chapel of St. Thomas who was killed on December 21, 72 CE and buried on top of the Mount made up of Charnockite Rock Formation
25. National Fossil Woodpark, Thiruvakkarai, Villupuram

[Text & Photographs by Dr. D. Rajasekhar Reddy]

Fig. No. 99: Petrified Wood Of Mio-Pliocene Age In National Wood Fossil Park, Thiruvakkarai

25.1. National Fossil Woodpark, Thiruvakkarai, Villupuram is a nature wonder consisting of petrified wood fossils horizontally embedded in Cuddalore Sandstone of Mio-Pliocene age (Ca 20 m.y.)

Map No. 27: Location Of National Fossil Woodpark, Thiruvakkarai, Villupuram
25.2. **Geographical Coordinates**: Latitude - 12° 01.163 N; Longitude - 79° 39.340 E

25.3. **Elevation**: About 30-54 m above mean sea level.

25.4. **Location**: It is located 1 km east of village and lies 155 km SSW of Chennai following N.H. 45 up to via Tindivanam Kooteripattu via Tindivanam.

25.5. **Representative Features**: The park has about 200 fossil trees ranging in length from 3-15 m and up to 5 m in girth which are lying horizontally embedded in Cuddalore Sandstone of Mio-Pliocene age. Fossil woods are classified as *Mesembrioxylon schmidianum* (gymnosperm) and *Pence schmidiana* (angiosperms). The modern families like *Guttiferae*, *leguminosae*, *anacrdiaceae*, *sonnaratiaceae* and *euphorbiaceae* are likely to be represented in them. Some of them belong to genera *palmoxylon*, *albizzia*, *mangifera*, *shorea*, *terminalia*. Some fossil woods resemble the modern species of *tamarindus*.

25.6. **Geology**: The National Fossil Wood Park contains some of the most spectacularly preserved fossil trees in rocks that are of Mio-Pliocene age (20 m.y.). The trees belong to several rare species of conifers and palms. The trees are believed to have been transported by rivers to their present sites of deposition in inland seas. They were later petrified during which the woody matter was replaced by silica and the water expelled due to compaction of the overlying sediments. The fine woody structure, the annular rings, the pit structure and the knots are intricately preserved.

![Fig. No. 100: A Well Preserved Fossil of *Mesembrioxylon Schmidianum* - A Gymnosperm](image)

25.7. **Accessibility**: The village lies 155 km SSW of Chennai and can be approached by N.H. 45 from Chennai up to Kooteripattu via Tindivanam and from there by the Pondicherry road via Mailam. From Puducherry the park is about 35 km away and can be approached by
Pondicherry - Kooteripattu road. The nearest railway station is at Tindivanam which lies on the Chennai – Villupuram line of the Southern Railway.

Fig. No. 101 : Presence Of Annual Rings In Petrified Tree Trunk

25.8. **Status** : The site was declared as NGM in 1951 by Geological Survey of India. In total there are nine sites which are closer to each other and are looked after by GSI. Enclosure B with more fossil woods (60) is popular and reasonably well maintained by GSI. All other eight properties, though are fenced, the fencing and pillars are in bad shape due to aging. The fossil wood objects are not being maintained properly and they are dumped at places as heaps.

25.9. **Threats** : There is no major natural threat to the site. Except property B, other properties are not being maintained as they are not popular. As the upkeep and maintenance of the objects are not proper, they are likely to face deterioration over time.

25.10. **Conservation Measures** : The petrified objects should be kept dust free and protected in enclosure in order to preserve them for longer duration. A field museum can be developed around the area displaying specimens, explanatory charts, and field microscope with thin sections.

25.11. It appears that there were some signs to shift the objects from less popular properties to property B. The value of the objects are seen, studied and understood better in their natural settings. Therefore the objects should be kept in their natural settings to a possible extent. The site should be promoted within the public especially among the students of Geology.

[Text & Photographs by Dr. D. Rajasekhar Reddy]

Fig. No. 102: Part Of 18 M Long 100 M.Y. Old Fossil Wood At Sathanur National Geological Monument Site

26.1. **National Fossil Woodpark, Sathanur, Perambalur District** contains geological evidences of Upper Cretaceous age (100 m.y) in form of petrified woods. This Pediplain formed due to erosion of Cretaceous rocks exposed east to the pediments and is isolated erosional hills of crystalline rocks belonging to Southern Granulites.
Map No. 28 : Location Of National Fossil Woodpark, Sathanur, Perambalur

26.2. **Geographical Coordinates** : Latitude - 11° 09’.12” N ; Longitude - 78° 58’.33” E

26.3. **Elevation** : About 70-110 m above mean sea level.

26.4. **Location** : The Fossil Wood Park at Sathanur is located at 700 m north of Sathanur village located in Perambalur District of Tamil Nadu. Sathanur is about 12 km away west of Ariyalur.

26.5. **Representative Features** : The petrified trees belong to conifers (non-flowering) that dominated the land vegetation during the period. The fossilised tree trunk at Sathanur measures over 18 m in length. The petrified trees at Sathanur are embedded in Kulakkalnattam Formation of marine sedimentary rock sequence belonging to Upper Cretaceous period. These rocks are interpreted to have been formed under high energy wave regime and sub-tidal to intertidal coastal regime.

26.6. **Geology** : The Upper Cretaceous (100 m.y ago) period is marked significantly by the marine transgression in earth’s geological timescale. The imprints of transgression are evident in major River Basin like Krishna, Godavari and Cauvery in India. The Sathanur village is located within the Ariyalur area of the Cauvery basin. Exceptionally shallow marine sequences with very rich faunal assemblages occur in the Ariyalur area. It has been globally recognized as a reference sequence for the Upper Cretaceous.

26.7. National Fossil Wood Park in Sathanur, Perambalur District contains large trunks of petrified trees of Upper Cretaceous age (100 m.y).
26.8. **Accessibility** : The site can be approached by NH-45, which connects Chennai with Tiruchirappalli, up to Siruvachur village (about 6 km. South of Perambalur Town). From Siruvachur village an unmetalled road connects Sathanur Village which is about 14 km towards east. It can also be approached by Ariyalur – Alathur Gate road via Iluppaikudi which intersects NH45 at Alathur Gate. The nearest railway station to the NGM site is at Ariyalur, which lies on the Chennai – Tiruchirappalli section of Southern Railway.

26.9. **Status** : Geological Survey of India declared the site as the National Geological Monument in 1951. GSI is making an effort to maintain the site properly in a gated enclosure with watch and ward.

26.10. **Threats** : There is no major natural threat to the site. The main problem is the lack of proper protection to the objects in the site. As the objects are not kept and maintained properly they are likely to deteriorate over a period of time.

26.11. **Conservation Measures** : The fossilised trunk should be kept dust free and protected in a casing or wire mesh to avoid further damages. A field museum can be developed along the site including objects from places such as Thiruvakkarai etc.

26.12. The approach road to Sathanur is quiet damage and needs to be improved. Signages can be kept at the bifurcation road towards Sathanur along Perambalur – Ariyalur Road. The sign boards which are kept by GSI at different places are too small to be noticed by the public while passing through the area. The site can be made popular study among the students and researcher as well as the public.
ANNEXURE I

FORMAT FOR RECORDING GEOSITES FOR INCLUSION IN GEOSITES DATABASE

Primary Identifying Data

1. GEOSITE accession number
2. *National site accession number
3. *Geosite name (synonyms)
4. *State, District/town (or equivalent)
5. *Geographical coordinate: latitude and longitude
6. Approach to the site: How to reach the site from the nearby known place/s giving the distances and directions with a map
7. Character of site (e.g. crag/tor, quarry, sea cliff, river terrace, mine adit, reef, cirque, cave, drumlin, esker)

Primary Geological Data

8. Type of site (e.g. landform, stratigraphic profile - site may for instance be a cave, with a profile)
9. *Primary geo(morpho)logical interest (qualifying for GEOSITES status)
10. *Framework element or context represented (theme, region/province or age, e.g. ice front, time unit, fossil/mineral group)
11. *Chronostratigraphy
12. *Description of primary interest
   - Level and type of importance: (Regional/ National/ International; Scientific / Educational)
13. *Comparative assessment/justification (site justified as part of theme, province or age)
14. Qualities in relation to other sites

Secondary Supporting Data

15. Map sheet (at least at scale of 1 : 50,000)
16. Elevation
17. Geosite area (km$^2$)
18. Ownership: (public / private) Whether the geosite is in public domain or in the land owned by private individual / organization with the details of the owner
19. Protection status (assurances of integrity), accessibility
   - What are the perceived problems / threats both natural / human induced for the maintenance of the site and the possible solutions including whether any agency is interested in taking care of the maintenance
20. Priority of geoconservation: Whether it should be attended immediately or can be taken up in due course
21. Scope of being a part of Geopark: Can this geosite be clubbed with other important nearby geosites to group them to be a Geopark. If known give the details. If not known say Not sure.
22. Literature, key references
23. Sources of data, collections
24. Illustrations including photographs
25. *Proposer(s)
* Essential data required at the first stage of GEOSITES proposal. The rest can be filled in later.
PRINCIPLES FOR ASSESSMENT OF THE SCIENTIFIC MERITS OF PROPOSED GEOSITES

A proposer of a GEOSITE should ask themselves the following questions with regard to the potential candidate site or area:

i) what is its significance for an understanding of geological evolution (inorganic and organic)?)

ii) What is its significance for an understanding of geological/geomorphologic mechanisms and processes?

iii) How complete are the phenomena present: are all relevant features covered, e.g. in a volcano, how complete is the magmatic series, how many effusive rocks and types, or periods of eruption, etc, are there?

iv) How well has the object been studied, how sizable is its literature, how well are key parameters measured (absolute’/radiometric age determinations, identification of minerals, fossils etc)?

v) What is the special, typical or unique feature of the site in time and/or in space? How are its rock/deposit/landform and its time/areal relationships significant?

vi) What is the quality of material which is the particular focus of interest at the site?

vii) For what part of the geological column or which geological phenomenon is this site representative?

viii) Categories (e.g. stratigraphic, mineralogical, volcanic etc) are not significant in terms of quotas. The types of site a country selects are to be determined by the nature of its geo(morpho)logical make-up, [its outstanding features and their contribution to geodiversity].

ix) In what selection network (time or thematic) does this locality fall, and make a vital part?

GUIDELINES FOR SELECTION OF GEOSITES

Justification of the outstanding value of a proposed geosite should be demonstrated: this means that its position nationally and regionally has to be made clear. Its validated place as an example of, or part of, for instance, a regional structure, a vital stratigraphic interval, tectonic episode or glacial phase depends on the essential part it plays in elucidating such a theme, structure, event or epoch.

i) Size of an individual site is of no significance. Larger areas may contain multiple core areas’ each independently of special’ interest: interest, significance and representativeness should be demonstrated for each of these.

ii) Integrity is important, and any site proposed should be conservable, and protected [effectively] from damage.

iii) Geological conservation principles should apply, i.e. conservation means protection for use, including, where appropriate, collecting, [not preservation].

iv) As far as possible, inappropriate collecting, by both professionals and amateurs, should be discouraged (except, particularly, in areas of appreciable material loss through natural processes.

v) Sites should not be worked out’, with all good and representative material removed to remote museums, other collections or private establishments. If specimens are not readily visible, then there should be good potential for further collecting.

vi) Museums on sites, with collections, may be a satisfactory alternative.

vii) The provision of sites for education, recreation, training and research may be a desirable factor.

viii) The integrity and conservation of a proposed site should be subject to monitoring, where possible and appropriate.
ix) Geo(morpho)logical sites are best considered singly, each significant interest being assessed: but synergistically, it may be desirable to group like sites as clusters or within larger entities such as national parks. However, all sites must be judged individually and be capable of standing alone for the purposes of assessment and justification.

x) Equal concentration of sites by area is not feasible (relative to size of country or other area): this must be the case, to avoid the charge of subjectivity.

xi) In selecting sites for Geosites, it is more important to assess candidates comparatively within a context, to make informed comparisons with other possible candidates: this involves some further research.

xii) Size (the largest’) and age (the first’ or oldest’) are only some of the relevant factors, they cannot automatically be equated with the best’.

xiii) Sites with a complex record, subject to multidisciplinary studies, or with a long history of research, or a substantial bibliography are likely to be better candidate sites. But this does not rule out new or unexploited sites.

xiv) Nomination of a Geosite should be in the form of a concise and focused well-argued case. The Geosite documentation format should be used.
ANNEXURE II

DRAFT GEOHERITAGE LAW
(Authored by GSI)

THE NATIONAL GEOLOGICAL SITES (CONSERVATION, PROTECTION AND MAINTENANCE ACT. 2013

No.----------------------OF 2013

ARRANGEMENT OF SECTIONS

I. PREAMBLE

1. Short title, extent and commencement.
2. Definitions.

II. GEOLOGICAL SITES OF NATIONAL IMPORTANCE

3. Certain sites of geological and related significance etc. deemed to be of national importance.
4. Power of Central Government to declare sites of geological and related significance etc., to be of national importance.
5. Power to direct on issue related to conservation/ protection/maintenance of sites of geological and related significance etc. deemed to be of national importance.
6. Power to authorize.

III. CONSERVATION, PROTECTION, MAINTENANCE OF GEOLOGICAL SITES, RELATED FEATURES ETC. OF NATIONAL IMPORTANCE

7. Acquisition of rights in geological sites for conservation, protection and maintenance.
8. Conservation, protection and maintenance of Geological site by agreement.
9. Owners under disability or not in possession.

10. Failure or refusal to enter into an agreement.
11. Power to make order prohibiting contravention of agreement under section 6.
12. Enforcement of agreement
13. Purchasers at certain sales and persons claiming through owner bound by instrument executed by owner
14. Acquisition of protected site.
15. Maintenance of certain protected site.
16. Voluntary contributions
17. Protection of place of worship from misuse, pollution or desecration
18. Relinquishment of Government rights in a site
19. Right of access to protected site.
IV. PROTECTED AREAS INCLUDING THE SITES AND THE RELATED FEATURES

20. General
21. Power to acquire a protected area

V. GEOLOGICAL INVESTIGATION AND EXCAVATIONS

22. Investigations and excavations in protected areas
23. Excavations in areas other than protected areas.
24. Compulsory purchase of antiquities, etc., discovered during excavation operations.
25. Excavations, etc., for geological purposes.

VI. PRINCIPLES OF COMPENSATION

26. Compensation for loss or damage
27. Assessment of market value or compensation

VII. MISCELLANEOUS

28. Delegation of powers
29. Penalties
30. Jurisdiction to try offences
31. Certain offences to be cognizable
32. Special provision regarding fine
33. Recovery of amounts due to Government
34. Geological sites, etc., which have ceased to be of national importance
35. Power to correct mistakes, etc.
36. Protection of action taken under the Act.
37. Power to make rule.
THE NATIONAL GEOLOGICAL SITES (CONSERVATION, PROTECTION AND MAINTENANCE) ACT. 2013.

No.----------------------OF 2013

An Act to provide for the conservation, protection and maintenance of geological sites and related features of national importance.

Be it enacted by Parliament in the sixty fourth year of the Republic of India as follows:-

I.  PREAMBLE

1. (i) This Act may be called the National Geological Sites (Conservation, Protection and Maintenance) Act, 2013.

(ii) It extends to all the states of India.

(iii) It shall come into force on such date as the Central Government may, by notification in the Official Gazette, appoint.

2. In this Act, unless the context otherwise requires:

   (a) 'Geological site' means any area/place located inland and offshore within the territorial water limits of the country containing illustrative examples of geological/geoenvironmental feature/phenomena/specimen etc. which is of national interest and includes

      (i) The feature/phenomena/specimen as exposed on surface of land or water or in excavations beneath the surface.

      (ii) The site on/in which the above is located.

      (iii) Such portions of land/body of water and joining the above site, as may be required for fencing, covering, extension or for conserving/protecting the feature/phenomena/natural specimen, and

      (iv) The means/path of access to and convenient inspection of the site and its contents.

   (b) (i) "geological" means as related to 'Geology' which is defined as the Science of Earth.

      (ii) "geoenvironmental" means the geological factors as related to "environment" which includes water, air, land and the life and their interrelationships.

      (iii) "mining site" means the area/land/spot from where minerals are extracted from surface/below surface

   (c) "fossil" as defined in geological parlance means an organic trace buried by natural processes and subsequently permanently preserved. The term "organic trace" is here used to include skeletal material, impressions of organisms, experimental material, tracks, trails and borings. Human artefacts are not regarded as fossils.

   (d) "rock" as defined in geological parlance means any mass of mineral matter, whether consolidated or not, which forms part of the Earth’s crust. Rock is also something hard, consolidated and or load-bearing which, where necessary, has to be removed by blasting.

   (e) "Mineral" as defined in geological parlance means a structurally homogenous solid of definite chemical Composition, formed by the inorganic processes of nature. This definition includes ice as a mineral, but excludes Coal, natural oil and gas. The only allowable exception to the rule that a mineral must be a solid is native mercury (quick silver) which is a liquid.

   (f) "landslide" as defined in geological parlance means rock material which moves under the influence of gravity as mass movement of rocks along definite plane most common form involves movements along a lubricated
planes, often at the interface of permeable and impermeable rock types.

(g) “soil creep”/“talus creep” as defined in geological parlance means slow downhill movement of the soil or talus cover resulting in the displacement of objects supported by the soil.

(h) “mud flow/earth flow/soil flow” as defined in geological parlance means mud/soil movements that generally take place suddenly and involve a large quantity of water. The high ratio of water to soil or clay particles cause the material to behave as a liquid and earth flows, mud flows and soil flows result.

(i) “Inspecting Officer” means an officer authorized by the Central Govt. to inspect the sites of geological and related significance deemed to be of national importance.

(j) “owner includes:
   (i) a joint owner invested with powers or management on behalf of himself and other joint owners and the successor-in-title of any such owner; and
   (ii) Any manager or trustee exercising powers of management and the successor-in-office of any such manager or trustee.

(k) “Director General” means the Director General of Geological Survey of India and includes any officer authorized by the Central Govt. to perform the duties of Director General and/or in his behalf.

(l) “Conservation” means the act of conserving the geological site/area of national importance.

(m) “Protection” means the act of protecting the geological site/area of national importance.

(n) “Maintenance” means the act of maintaining the geological site/area of national importance.

(o) “Protected site/area” means any site/area of geological interest which is declared to be of national importance by or under this act.

II. GEOLOGICAL SITES OF NATIONAL IMPORTANCE

3. Certain sites of geological and related significance etc., deemed of national importance.

   All sites of geological and related significance, identified selected, categorized and Centra inventoried by the Central Govt. shall be deemed to be of notational importance for the purpose of this Act.

4. Power of Central Govt. to declare sites of geological and related significance etc. to be of national importance.

   i. Where the Central Govt. is of the opinion that any site of geological and related significance is of national importance, it may, by notification in the Official Gazette, give two months’ notice of its intention to declare such site of geological and related significance to be of national importance, and a copy of every such notification shall be affixed in a conspicuous place on or near the site as the case may be.

   ii. Any person interested in any such site of geological and related significance may, within two months after the issue
of the notification, object to the declaration of the site of geological and related significance.

iii. On the expiry of the said period of two months, the Central Govt. may, after considering the objections, if any, received by it, declare by notification in the “Official Gazette”, the site of geological and related significance, as the case may be to be of national importance.

iv. A notification published under sub-section (3) shall, unless and until it is withdrawn, be conclusive evidence of the fact that the site of geological and related significance to which it relates is of national importance for the purposes of this Act.

5. **Power to direct on issue related to conservation/protection/maintenance of sites of geological and related significance etc. deemed to be of national importance.**

Where it is deemed necessary, the Central Government, in terms of Sub-Sections(3) & (4) shall direct all Government Departs/Authorities/Institutes/Organisations/Bodies/Officers/on all issues related to conservation/protection/maintenance of sites of geological and related significance etc. deemed to be of national importance.

6. **Power to authorise**

Where it is deemed necessary, the Central Government shall authorize Government Departments/Authorities/Institutions/Organisations/Bodies/Officers to act on all or selected issues related to the conservation/protection/maintenance of sites of geological and related significance etc., deemed to be of national importance.

### III. CONSERVATION, PROTECTION AND MAINTENANCE OF GEOLOGICAL SITES, RELATED FEATURES ETC., OF NATIONAL IMPORTANCE.

### 7. Acquisition of rights in geological sites for conservation, protection and maintenance.

1. The Director General may with the sanction of the Central Govt., purchase, or take a lease of, or accept as a gift or bequest of, any sites containing its geological and related features of national importance and its extension/adjoining areas.

2. Where a site is without an owner, the Director General may, by notifications in the Official Gazette, assume the ownership/guardianship of the same.

3. The owner of any site may, by written instrument, constitute the Director General the guardian of the site and the Director General may, with the sanction of the Central Govt., accept such guardianship.

4. When the Director General has accepted the guardianship of a site under sub-section(3), the owner shall, except as expressly provided in the Act, have the same estate, right, title and interest in and to the site as if the
Director General had not been constituted a guardian thereof.

(5) When the Director General has accepted the guardianship of a site under sub-section(3), the provisions of this Act relating to agreements executed under Section 6 shall apply to the written instrument executed under the said sub-section.

(6) Nothing in this section shall affect the use of any protected site for customary religious observations.

8. Conservation, Protection and maintenance of Geological site by agreement

(1) The Collector, or Head of any identified Dept./Organisation (State/Central) when so directed by the Central Govt., shall propose to the owner of a protected site to enter into an agreement with the Central Govt. within a specified period for the maintenance of the site.

(2) An agreement under this section may provide for all or any of the following matters, namely:

   (i) Maintenance of the site and the related features
   (ii) Periodic inspections/checks, repairs and development of the site and the related features, and also in its extension/adjoining areas.
   (iii) The custody of the site and related features, and the duties and responsibilities of personnel deployed to be in-charge of it and for watch and ward.
   (iv) The restriction of the owner’s right:
       (a) to use the site for any purpose
       (b) to charge any fee for entry into, or inspection of, the site
       (c) to destroy, remove, alter or deface the site and related features
       (d) to build on or near the site.
   (v) The facilities of access to be permitted to the public or any section thereof or to State/Central Govt. officials of identified Organisations, departments or to persons depend by the owner or any scientific officer of Geological Survey of India/State Directorates of Geology & Mining or the Collector to inspect or maintain the site.
   (vi) The notice to be given to the Central Govt. in case the land which contains the geological site and its related features is situated or any adjoining land is offered for sale by the owner, and the right to be reserved to the Central Govt. to purchase such land, or any specified portion of such land, at its market value.
   (vii) The payment of any expenses incurred by the owner or by the Central Govt. in connection with the maintenance of the site and the related features.
   (viii) The proprietary or other rights which are to vest in the Central Govt. in respect of the site and the related features when any expenses are incurred by the Central Govt., in connection with the maintenance of the site and the related features.
   (ix) The appointment of an authority to decide any dispute arising out of the agreement; and
   (x) Any matter connected with the maintenance of the site and the related features which is a proper subject of agreement between the owner and the Central Govt.

(3) The Central Govt. or the owner may, at any time after the expiration of five years from the date of execution of an agreement under this section,
terminate it on giving six months’ notice in writing to the other party.

Provided that where the agreement is terminated by the owner, he shall pay to the Central Govt. the expenses, if any, incurred by it on the maintenance of the site during the five years immediately preceding the termination of the agreement or, if the agreement has been in force for a shorter period, during the period the agreement was in force.

(4) An agreement under this section shall be binding on any person claiming to be the owner of the site to which it relates, from, through or under a party by whom or on whose behalf the agreement was executed.

9. Owners under disability or not in possession

(1) If the owner of a protected site and its related features is unable, any reason of infancy or other disability, to act for himself, the person legally competent to act on his behalf may exercise the powers conferred upon the owner by Section 8.

(2) In the case of Village property, the headman or other village officer exercising powers of management over such property may exercise the powers conferred upon any owner by Section 8.

(3) Nothing in this section will be deemed to empower any person not being of the same religion as the person on whose behalf he is acting to make or execute an agreement relating to a protected site which or any part which is periodically used for religious worship or observance of that religion.

10. Failure or refusal to enter into an engagement.

(1) If any owner or other person competent to enter into an agreement under Section 8 for the maintenance of a protected site refuses or fails to enter into such an agreement, the Central Govt. may make an order providing for all or any of the matters specified in sub-section (2) of Section 8 such order shall be binding on the owner or such other person and on every person claiming title to the site from, through or under, the owner or such other person.

(2) Where an order made under sub-section (1) provides the site shall be maintained by the owner or other person competent to enter into an agreement, all reasonable expenses for the maintenance of the site shall be payable the Central Govt.

(3) No order under sub-section (1) shall be made unless the owner or other person has been given an opportunity of making a representation in writing against proposed order.

11. Power to make order prohibiting contravention of agreement under Section 6.

(1) If the Director General apprehends that the owner or occupier of a protected site intends to destroy, remove, alter, deface, imperil or misuse or act in a manner detrimental to site or to build on or near it in contravention of the terms of an agreement under Section 8, the Director General may, after giving the owner or occupier an opportunity of making a representation in writing, make an order prohibiting any such contravention of the agreement: Provided that no such opportunity may be given in any case where the Director General, for reasons to be recorded, is satisfied that it is not expedient or practicable to do so.

(2) Any person aggrieved by an order under this section may appeal to the Central Govt. within such time and in such manner as may be prescribed and the decision of the Central Govt. shall be final.

12. Enforcement of agreement.
(1) If an owner or other person who is bound by an agreement for the maintenance of a site under Section 8 refuses or fails within such reasonable time as the Director General may fix, to do any act which in the opinion of the Director General is necessary for the maintenance of the site and its related features, the Director General may authorize any person to do any such act, and the owner or other person shall be liable to pay the expenses of doing any such act or such portion of the expenses as the owner may be liable to pay under the agreement.

(2) If any dispute arises regarding the amount of expenses payable by the owner or other person under sub-section (1), it shall be referred to the Central Govt. whose decision shall be final.

13. Purchases at certain sales and persons claiming through owner bound by instrument executed by owner.

Every person who purchases, at a sale for arrears of land revenue or any other public demand, any land on which is situated a site and related features in respect of which any instrument has been executed by the owner for the time being under action 7 or section 8, and every person claiming any title a site from, through or under, an owner who executed any such instrument, shall be bound by such instrument.

14. Acquisition of protected site

If the Central Government apprehends that a protected site and the related features are in danger of being destroyed, injured, misused, or allowed to fall into decay, it may acquire the protected site under the provisions of the Land Acquisition Act, 1894, as if the maintenance of the protected site and related features were a public purpose within the meaning of that Act.

15. Maintenance of certain protected site

(1) The Central Government shall maintain every site and the related features which have been acquired under section 14 or in respect of which any of the rights mentioned in section 7 have been acquired.

(2) When the Director General has assumed the guardianship of a site and the related features under section 7, he shall, for the purpose of maintaining such site, have access of the site at all reasonable times, by himself and by his agents, subordinates and workmen, for the purpose of inspecting the site and for the purpose of bringing such materials and doing such acts as he may consider necessary or desirable for the maintenance, repairs and development thereof.

16. Voluntary contributions.

(1) The Director General may receive voluntary contributions towards the cost of maintaining a protected site and related features and may give orders as the management and application of any funds so received by him:
Provided that no contribution received under this section shall be applied to any purpose other than the purpose for which it was contributed.

(2) The Director General may engage Voluntary services offered by the Research Institution/Universities/Distinguished scientists in connection with the development/protection/conservation/maintenance of a protected site and the related features.
17. Protection of place of worship from misuse, pollution or desecration.

(1) A protected site maintained by the Central Government under this Act which is or includes a place of worship shrine shall not be used for any purpose inconsistent with its character.

(2) Where the Central Government has acquired a protected site under section 14 or where the Director General has purchased, or taken a lease or accepted a gift or bequest or assumed Guardianship of a protected site under section 7 and site or any part thereof is used for religious worship or similar purpose by any community, the Collector shall make due provision for the protection of such site or part thereof, from pollution or desecration-

(a) by prohibiting the entry therein, except in accordance with the conditions prescribed with the concurrence of the persons, if any, in religious charge of the said site or part thereof, of any person not entitled so to enter by the religious usages of the community by which the site or part thereof is used, or

(b) by taking such other action as he may think necessary on this behalf.

18. Relinquishment of Government rights in a site

With the sanction of the Central Govt., the Director General may,-

a. Where rights have been acquired by Director General in respect of any site under this Act by virtue of any sale, lease, gift or will, relinquish, by notification in the Official Gazette, the rights so acquired to the person who would for the time being be the owner of site if such rights had not been acquired: or

b. Relinquish any guardianship of a site which he has assumed under this Act.

19. Right of access in protected site

Subject to any rules made under this Act, the public shall have a right of access to any protected site and the related features.

IV. PROTECTED AREAS INCLUDING THE SITES AND THE RELATED FEATURES

20. General

(1) No person, including the owner or occupier of a protected area shall construct any building within the protected area or carry on any mining, quarrying, excavating, blasting or any operation of a like nature in such area, or utilize such area or any part thereof in any other manner without the permission of the Central Government: Provided that nothing in this sub-section shall be deemed to prohibit the use of any such area or part thereof for purpose of cultivation if such cultivation does not involve the digging of not more than one foot of soil from the surface.

(2) The Central Government may, by order, direct that any building constructed by any person within a protected area in contravention of the provisions of sub-section (1) shall be removed within a specified period and, if the person refuses or fails to comply with the order, the
Collector or authority duly authorized by him may cause the building to be removed and the person shall be liable to pay the cost of such removal.

21. Power to acquire a protected area.

If the Central Government is of opinion that any protected area contains a rare geological feature of national interest and value, it may acquire such area under the provisions of the Land Acquisition Act, 1894, as if the acquisition were for a public purpose within the making of that Act.

V. GEOLOGICAL INVESTIGATIONS AND EXCAVATIONS

22. Investigations and excavations in protected areas

Geological Survey of India officer or an officer authorized by him in this behalf or any person holding a licence granted in this behalf under this Act (hereinafter referred to as the licensee) may, after giving notice in writing to the Collector and the owner, enter upon and make investigations and excavations in any protected area.

23. Excavations in areas other than protected areas.

Where a Geological Survey of India officer has reason to believe that any area not being a protected area contains remains /fossils /specimens /features of geological importance, he or an officer authorized by him in this behalf may, after giving notice in writing to the Collector and the owner, enter upon and make excavations in the area.

24. Compulsory purchase of antiquities, etc. discovered during excavation operations

(1) Where, as a result of any excavations made in any area under section 22 or section 23, any remains/ fossils/ specimens/ features are discovered, the Geological Survey of India officer or the licensee, as the case may be, shall, -

(a) as soon as practicable, examine such remains/ fossils/ specimens/ features and submit a report to the Central Govt. as such manner and containing such particulars as may be prescribed;

(b) At the conclusion of the excavation operations, give notice in writing to the owner of the site from which such remains, fossils, specimens, features have been discovered, of the nature of same.

(2) Until an order for the compulsory purchase of any such site is made under sub-section (3), the Geological Survey of India officer or the licensee, as the case may be, shall keep them in such safe custody or care as he may deem fit.

(3) On receipt of a report under sub-section (1) the Central Government may make an order for the compulsory acquisition of any such site at market value or under the provision of the Land Acquisition Act, 1984 in the national interest.

(4) When an order for the compulsory purchase of any site is made under sub-section (3) such remains/ fossils/ specimens/ features shall rest in the Central Government with effect from the date of the order.

25. Excavations, etc., for geological purposes

No State Government shall undertake or authorise any person to undertake any investigation/excavation or other like operation for geological purposes in any area which is
not a protected area except with the prior approval of the Central Government and in accordance with the rules or directions, if any, as the Central Government may decide or give in this behalf.

VI. PRINCIPLES OF COMPENSATION.

26. Compensation for loss or damage.
Any owner or occupier of land who has sustained any loss or damage or any diminution of profits form the land by reason of any entry on, or investigation/excavations in, such land or the exercise of any other power conferred by this Act shall be paid compensation by the Central Government for such loss, damage or diminution of profits.

27. Assessment of market value or compensation.
(1) The market value of any property which the Central Government is empowered to purchase at such value under this Act or the compensation to be paid by the Central Government in respect of anything done under this Act shall, where any dispute arises in respect of such market value or compensation, be ascertained in the manner provided in sections 3, 5, 8 to 34, 45 to 47, 51 and 52 of the Land Acquisition Act, 1894, so far as they can be made applicable:
Provided that, when making an enquiry under the said Land Acquisition Act, the Collector shall be assisted by two assessors, one of whom shall be a competent person nominated by the Central Government and one a person nominated by the owner, or, in case the owner fails to nominate as assessor within such reasonable time as may be fixed by the Collector on this behalf, by the Collector.
(2) Notwithstanding anything contained in sub-section (1) or in the Land Acquisition Act, 1894, in determining the market value of any antiquity in respect of which an order for compulsory purchase is made under sub-section (3) of section 24 or under sub-section (1) of section 27, any increase in the value of the antiquity by reason of its being of geological importance shall not be taken into consideration.

VII. MISCELLANEOUS


The Central Government may, by notification in the official Gazette, direct that any powers conferred on it by or under this Act shall, subject to such conditions as may be specified in the direction, be exercisable also by—
(a) Such officer or authority subordinate to the Central Government— or
(b) Such State Govt. or such officer or authority subordinate to State Govt.

29. Penalties

Whoever
(i) destroys, removes, inquires, alters, defaces, imperils or misuse a protected site, or
(ii) Being the owner or occupier of a protected site, contravenes an order made under sub-section (1) of section 10 or sub-section (1) of section 11, or
(iii) Removes from a protected site any remains/fossils/specimens/features other like objects, or
(iv) Does any act in contravention of sub-section (1) of section 20, shall be punishable with imprisonment which may extend to three months, or with fine which may extend to five thousand rupees, or with both.

30. Jurisdiction to try offences

No court inferior to that of a presidency magistrate or a magistrate of the first class shall try any offence under this Act.
31. **Certain offences to be cognizable.**
Notwithstanding anything contained in the Code of Criminal Procedure, 1898, an offence under clause (i) or clause (iii) of sub-section (1) of section 29, shall be deemed to be a cognizable offence within the meaning of that Code.

32. **Special provision regarding fine**
Notwithstanding anything contained in section 31 of the Code of Criminal Procedure; 1898, it shall be lawful for any magistrate of the first class specially empowered by the State Government in this behalf and for any presidency magistrate to pass a sentence of fine exceeding two thousand rupees on any person convicted of an offence which under this Act is punishable with fine exceeding two thousand rupees.

33. **Recovery of amounts due to the Govt.**

Any amount due to the Government from any person under this Act may, on a certificate issued by the Director General or officer authorized by him in this behalf be recovered in the same manner as an arrear of land revenue.

34. **Geological sites, etc., which have ceased to be of national importance**

If the Central Government is of opinion that any site and the related features declared to be of national importance by or under this Act has ceased to the of national importance, it may, by notification in the Official Gazette, declare that the site and the related features as the case may be, has ceased to be of national importance for the purposes of this Act.

35. **Power to correct mistakes, etc.**

Any clerical mistake, patent error or error arising from accidental slip or omission in the description of any site and the related features declared to be of national importance by or under this Act may, at any time, be corrected by the Central Government by notification in the Official Gazette.

36. **Protection of action taken under the Act**

No suit for compensation and no criminal proceeding shall lie against any public servant in respect of any act done or in good faith intended to be done in the exercise of any power conferred by this Act.

37. **Power to make rules**

(1) The Central Government may, by notification in the Official Gazette and subject to the condition of previous publication, make rules for carrying out the purposes of this Act.

(2) In Particular, and without prejudice to the generality of the foregoing power, such rules may provide for all or any of the following matters, namely:-

- the prohibition or regulation by licensing or otherwise of mining, quarrying, excavating, blasting or any operation of a like nature near a protected site or the construction of buildings on land adjoining such site and the removal of unauthorized erections.

- The grant of licences and permissions to make investigation/excavations for geological purposes in protected sites, the authorities by whom, and the restrictions and conditions subject to which, such licences may be granted the taking of securities from
licensees and the fees that may be charged for such licences;
(e) The right of access of the public to a protected site and the fee, if any, to be charged therefor;
(f) The form and contents of the report of a Geological Survey of India officer or a licensee under clause (a) of sub-section (1) of section 24.
(g) The form in which applications for permission under section 20 may be made and the particulars which they should contain;
(h) The form and manner of preferring appeals under this Act and the time within which they may be preferred;
(i) The manner of service of any order or notice under this Act;
(j) The manner in which investigation/ excavations and other like operations for geological purposes may be carried on;
(k) Any other matter which is to be or may be prescribed.

(3) Any rule made under this section may provide that a breach thereof shall be punishable,-

(i) in the case of a rule made with reference to clause (a) of sub-section (2), with imprisonment which may extend to three months, or with fine which may extend to five thousand rupees, or with both;

(ii) in the case of a rule made with reference to clause (b) of sub-section (2), with fine which may extend to five thousand rupees;

(iii) in the case of a rule made with reference to clause (c) of sub-section (2), with fine which may extend to five hundred rupees.

(4) All rules made under this section shall be laid for not less than thirty days before each House of Parliament as soon as possible after they are made, and shall be subject to such modifications as Parliament may make, during monsoon 2013? Session in which they are so laid or the session immediately following.
ANNEXURE III

GLOSSARY

Age of the Earth: Based on the radiometric dating of oldest exposed rocks, meteorites, lunar samples, the age of the earth is estimated at $4.54 \pm 0.05 \text{ Ga}$ ($\text{giga-annus}$, giga year age, $1 \text{ Giga} = \text{one thousand million.}$ $4.54 \times 10^9$ years $\pm 1\%$).

Agglomerate: Coarse-grained volcanic rock with rounded to subangular fragments. These fragments are mainly larger than 2 cm in size, but the mixture of fragments is typically ill sorted and the matrix may be fine grained.

Aravalli Hill Range: [Rajasthani word “Adavali” (आदवली + कला) meaning oblique pillar or some believe “obstruction”]. This nearly NE-SW trending oldest folded hill range of India, runs across the western Indian state of Rajasthan, discontinuously extending through Haryana and Delhi in the north and extending below the soil cover up to Himalayas. The magnificent Rashtrapati Bhawan- the President of India Palace in New Delhi - is built on the Raisina Hill a northern termination of Aravalli Hills. To the south, this prominent geomorphic feature of Rajasthan extends into Gujarat. The highest peak is Guru Shikhar (=Knowledge-provider’s-Peak, 1722m) at Mount Abu. This range is the source of several streams and rivers; it supports a thick forest providing safe habitat for diverse wild life. These hill ranges rose in Precambrian times (Aravalli-Delhi Orogen) and were mighty hill ranges having glaciers but stopped rising and were eroded to present “eroded stub range” (Residual Hills)! The “young” Himalayan mountain range is still rising.

Barytes: An orthorhombic mineral form of barium sulphate, $\text{BaSO}_4$, the chief ore of barium. It is usually white but may also be yellow, grey, or brown.

Basalt: A dark-colored fine-grained extrusive igneous rock composed largely of plagioclase feldspar and pyroxene. Similar in composition to gabbro, basalt is thought to be one of the main components of oceanic crust.

Batholith: A very large intrusive igneous rock mass that has been exposed by erosion and with an exposed surface area of over 100 square kilometers. A batholith has no known floor.

Bedding Plane: It is a well defined plane separating one layer of sedimentary rock from the other, bed is the smallest unit of rock of the same composition-a bed of shale (clay rock) may rest over a bed of sandstone (a silica grain rock) each of these rocks will have their own bedding planes, which if not deformed would be horizontal.

Breccia: Coarse, clastic, sedimentary rock, the constituent clasts of which are angular. ‘Breccia’ literally means ‘rubble’ and implies a rock deposited very close to the source area. The term may also be applied to angular volcanic rocks from a volcanic vent.

Cap Rock: The hard, impervious layer of rock that overlies and seals a source of water, crude oil, or natural gas.

Charnockite: A light-coloured, medium- to coarse-grained igneous rock containing quartz and microcline feldspar as major components with, in order of decreasing abundance, oligoclase feldspar, hypersthene, biotite, and magnetite. Despite its low abundance, hypersthene (a calcium-poor, iron-rich pyroxene) is a distinctive feature of this rock. Rocks with charnockite mineralogy
can also be formed by the metamorphism of quartz feldspathic rock under dry granulite facies conditions.

**Chronostratigraphy**: Branch of stratigraphy that studies the age of rock strata in relation to time. The ultimate aim of chronostratigraphy is to arrange the sequence of deposition and the time of deposition of all rocks within a geological region, and eventually, the entire geologic record of the Earth.

**Conglomerate**: Conglomerate is a clastic sedimentary rock that contains large (greater than two millimeters in diameter) rounded clasts. The space between the clasts is generally filled with smaller particles and/or chemical cement that bind the rock together.

**Core**: The central zone or unit of the Earth. It is composed of iron, with a lighter element, probably sulphur, and accounts for 16% of the Earth's volume and 32% of its mass. The core is separated into inner and outer units. The inner core is a solid while the outer core is liquid.

**Chitradurga Schist Belt**: Chitradurga schist belt is a 450 km long linear feature of Archaean age and composed of several types of volcanic and sedimentary rocks.

**Craton**: Craton (shield, platform) are geologically ancient (Precambrian) stable part of earth’s crust that reach deep down into the interior of the earth, which are made up of metamorphosed / recrystallized rocks that form the basement on which younger sedimentary rocks are deposited. Important cratons of India are shown in the following map

**Dharwar Super Group**: The term Dharwaar Supergroup is now used as synonymous with metamorphosed Archaean sediments and including all the schistose series below the eparchaean unconformity. The Dharwarian rocks are mostly unfossiliferous.
Dolerite: A dark-coloured, medium-grained igneous rock which contains plagioclase feldspar of labradorite composition and pyroxene of augite or titanaugite composition as essential minerals, and magnetite, titanomagnetite, or ilmenite as accessory minerals. Dolerites are the medium-grained equivalents of basalts.

Dyke: Discordant, or cross-cutting, tabular intrusion. Most dykes are vertical or near vertical, having pushed their way through the overlying country rock.

Earth Crust: Crust is the outer hard layer of the Earth, and is less than 1% of Earth's volume. The crust is made up of different types of rocks; igneous, metamorphic, and sedimentary rocks. Below the crust is the mantle. The upper part of the mantle is made up of peridotite, a rock denser than rocks common in the crust.

Eastern Ghats: The Eastern Ghats also known as Mahendra Parvatam, is a discontinuous range of mountains along India's eastern coast. The Eastern Ghats run from West Bengal state in the north, through Odisha and Andhra Pradesh to Tamil Nadu in the south passing some parts of Karnataka. The Eastern Ghats are older than the Western Ghats, and have a complex geologic history related to ~1500 m.y to ~800 m.y.

Erosion: A general term applied to the wearing away and movement of earth materials by gravity, wind, water and ice.

Fault & Great Boundary Fault: “In geology, a fault is a planar fracture or discontinuity in a volume of rock, across which there has been significant displacement along the fractures as a result of earth movement. Large faults within the Earth's crust result from the action of plate tectonic forces, with the largest forming the boundaries between the plates, such as subduction zones or transform faults. Energy release associated with rapid movement on active faults is the cause of most earthquakes. A fault line is the surface trace of a fault, the line of intersection between the fault plane and the Earth's surface. Since faults do not usually consist of a single, clean fracture, geologists use the term fault zone when referring to the zone of complex deformation associated with the fault plane. The two sides of a non-vertical fault are known as the hanging wall and footwall. By definition, the hanging wall occurs above the fault plane and the footwall occurs below the fault.

Great Boundary Fault (GBF) is a major dislocation zone that traverses across a large area and is marked by presence of two distinctly different physiographic and geological terrains. Such mega-features are product of intense crustal movement that throws up deep seated rocks that formed at different times and usually have dissimilar modes of formation.

Feldspar: A group of common aluminium silicate minerals (the most common minerals in the world) that contain potassium, sodium, or calcium, and that form rocks.

Fossil: Fossil ("obtained by digging") is a preserved precise form of a life, animal or plant, occurring in sedimentary (or an originally sedimentary) rock. The necessary conditions for fossil formation are quick burial by layers of sediments in an oxygen-free (anaerobic) environment, their replacement by minerals followed by uplift of the rock to the surface of earth for us to see them. The fossil record helps in knowing the lot many aspects of the past, “Index fossils” (Guide or Indicator fossils, e.g. Ammonites) are helpful in dating a rock. The study of fossils is called Paleontology. Oldest fossil record goes back to 3.48 Ga, though richest fossil record occurs in “younger” rocks-650 Mya through the recent!
Fossil Wood: The wood that is preserved in the fossil record is known as fossil wood. Over time the wood will usually be the part of a plant that is best preserved (and most easily found). Fossil wood may or may not be petrified. The study of fossil wood is sometimes called palaeoxylology.

Geodiversity: The variety of the rocks, fossils, minerals, natural processes and soils that underlie and determine the character of our landscape and environment is defined as 'geodiversity', and the most widely used term for the conservation of geodiversity is 'geoconservation'.

Geoheritage: Geoheritage encompasses all the components of geodiversity that are important to humans for purposes other than resource exploitation; things we would wish to retain for present and future generations.

Geologic Structures: Geologic structures are usually the result of the powerful tectonic forces that occur within the earth. These forces fold and break rocks, form deep faults, and build mountains.

Geological Survey of India (GSI): A Government of India organization founded in 1851 by the then East India Company to assess coal resources of India for setting up of the Indian Railways. As the Capital of India at that time was located at Calcutta (now Kolkata) GSI too was based there as most of the coal, iron and other mineral resources were occurring in eastern India. Over the years GSI has systematically mapped and described in details the geology of the entire country and their color maps in various scales and publications as Memoirs, Records, Special Publications, journals etc are available to one and all. With the help of these the knowledge of India’s rock types, age relationships, economic minerals and rocks has become clear. After prospecting (search for ore) for economic resources, GSI also undertook their exploration (determining the shape, size, and grade of valuable rocks and minerals) which aspect was later on separated from it through the formation of Mineral Exploration Corporation of India (MECL) in 1972 with headquarters at Nagpur, Maharashtra. GSI was restructured in 2009 through S. Vijay Kumar Committee following fulfillment of the original objective and to look for future challenges and opportunities. In the present scenario the emphasis is on “advancement of the cause of Geosciences by documentation, propagation, archiving, and education, including creation and management of Monuments and Parks for use of the public, students, and researchers, and future generations. The purpose is to popularize geosciences for public...”
GSI is headed by a Director General (DG) at the Kolkata HQ assisted additional officials, but broadly and mainly by the Regional Deputy Director Generals (DDGs/Dy DGs) comprising the Northeastern Region at Shillong, Eastern Region at Kolkata, Northern Region at Lucknow, Western Region at Jaipur which has the jurisdictions of the states of Rajasthan and Gujarat. Central Region at Nagpur, and Southern Region at Hyderabad, besides these there are theme-specific offices too.

**Geologic Time Scale**: The geological time scale (GTS) is a system of chronological measurement that relates stratigraphy to time, and is used to describe the timing and relationships between events that have occurred throughout Earth’s history. The largest defined unit of time is the super eons, composed of eons. Eons are divided into eras, which are in turn divided into periods, epochs and ages.

**Geopark**: A Geopark is a unified area that advances the protection and use of geological heritage in a sustainable way, and promotes the economic well-being of the people who live there.

**Geotourism**: Defined as tourism that sustains or enhances the distinctive geographical character of a place—its environment, heritage, aesthetics, culture, and the well-being of its residents.

**Global Geoparks Network** (GGN) (also known as the Global Network of National Geoparks) is a UNESCO assisted network established in 1998. Managed under the body’s Ecological and Earth Sciences Division, the GGN seeks the promotion and conservation of the planet’s geological heritage, as well as encourages the sustainable research and development by the concerned communities.

**Gneiss**: A coarse-grained, foliated rock produced by regional metamorphism. The mineral grains within gneiss are elongated due to pressure and the rock has a compositional banding due to chemical activity.

**Granite**: Granite refers to a group of coarse grained silica-rich (>70% SiO2) igneous rock which gradually cooled much below the surface of the earth to give it a homogenous granular texture. They are essentially composed of grains of light colored feldspars (~60%) along with quartz (>20%) with a variety of minor quantity of micas and amphiboles and a few dark colored minerals. At times feldspars or other minerals could be of coarser than the surrounding minerals (phenocrysts) producing the porphyritic texture. Granite is nearly always massive (lacking any internal structures), hard and compact making it an ideal rock for decorative and construction works. Its volcanic (extrusive) equivalent is rhyolite.

**Granodiorite**: A coarse-grained igneous rock consisting of essential quartz, plagioclase feldspar, alkali feldspar, biotite, and hornblende, with accessory sphene, apatite, and magnetite.

**Granulite**: A coarse-grained, equigranular metamorphic rock, consisting of quartz, feldspar, and the anhydrous ferromagnesium minerals pyroxene and garnet.

**Greenstone Belts**: Greenstone belts are zones of variably metamorphosed mafic to ultramafic volcanic sequences with associated sedimentary rocks that occur within Archaean and Proterozoic cratons between granite and gneiss bodies. The name comes from the green hue imparted by the colour of the metamorphic minerals within the mafic rocks.
Group: A group in stratigraphy is a lithostratigraphic unit, a part of the geologic record or rock column that consists of defined rock strata. Groups are generally divided into individual formations. Groups may sometimes be divided into "subgroups" and are themselves sometimes grouped into "super groups".

Hypomagma: defined as relatively immobile, viscous lava that forms at depth beneath a shield volcano, and which is under saturated with gases, and initiates volcanic activity.

Igneous Rock: A rock formed by the crystallization of magma or lava.

Ignimbrite: A pyroclastic flow deposit that contains material varying in size from ash to pumice clasts; it may be unconsolidated or cemented.

Lapilli: Volcanic rock materials which are formed when magma is ejected by a volcano. Typically used for material that ranges between 2 and 64 millimeters in diameter.

Laterite: Weathering product of rock, composed mainly of hydrated iron and aluminium oxides and hydroxides, and clay minerals, but also containing some silica. It is related to bauxites and is formed in humid, tropical settings by the weathering of such rocks as basalts.

Lava: Magma which has flowed over the earth's surface. The viscosity of lava depends on its silica content, pressure, and temperature. Temperature is the most important factor.

Magma: Molten rock material that occurs below Earth's surface.

Mantle: A major subdivision of Earth's internal structure. Located between the base of the crust and overlying the core. Earth's mantle is a silicate rocky shell with an average thickness of 2,886 kilometres. The mantle makes up about 84% of Earth's volume. It is predominantly solid but in geological time it behaves as a very viscous fluid.

Marine Transgression: An advance of the sea to cover land areas, caused by a rise in the sea level relative to the land.

Matrix: The matrix or groundmass of rock is the finer grained mass of material in which larger grains, crystals or clasts are embedded.

Metamorphic Rock: Any rock that has been altered by metamorphism, involving heating and pressure. Also known as tertiary rock because metamorphic rock is derived from primary igneous rocks and secondary sedimentary rocks.

Meteorite: An extraterrestrial mass (fragment of rock or iron) which has reached the Earth from outer space, without burning up in the atmosphere. A meteorite’s size can range from small to extremely large.

Migmatite: A coarse-grained, heterogeneous mixed rock consisting of: (a) a high-grade metamorphic component with a gneissose texture; and (b) an igneous component with a granite mineralogy. Migmatites are found in high-grade metamorphic terrains where a sequence from high-grade metamorphic rocks through migmatites to granite bodies is often seen in the field. The granite component is thought to form by partial melting of the rock during extreme metamorphism.
Ministries of Geologic Resources: Because of their significance for the modern humans, else we shall have to go back to cave-dwelling-food-gathering days, the geologic resources (rocks, minerals, ground water) are managed by the Union Government through the offices of: Ministry of Coal; Ministry of Earth Sciences; Ministry of Mines; Ministry of Petroleum and Natural Gas; Ministry of Steel; Atomic Minerals Directorate for Exploration and Research (AMD) under Atomic Energy Commission (AEC) / Department of Atomic Energy (DEA), directly under the Prime Minister; Central Ground Water Board (CGWB) of the Ministry of Water Resources. Likewise, each of the states of the Union of India too has its own ministries to manage the geo-resources.

Natural Arch: A natural arch, natural bridge or, less commonly, a rock arch is a natural rock formation where a rock arch forms, with an opening underneath

Nepheline Syenite: A medium- to coarse-grained igneous rock consisting of essential alkali feldspar, nepheline, pyroxene and amphibole, which is essentially a sodic, iron-rich hornblende, with accessory sphene, apatite, titanomagnetite, ilmenite, and zircon. The rock is, in effect, a syenite which is undersaturated in silica

Pediplain: Extensive plain, best developed in arid and semi-arid regions, showing gently concave or straight-slope profiles and terminated abruptly by uplands. A result of scarp recession rather than of surface lowering, it consists of coalesced pediments

Peninsular Gneiss: Peninsular Gneiss is a term coined to highlight the older gneissic complex of the metamorphics found all over the Indian Peninsula. This term was first fashioned by W.F. Smeeth of the Mysore Geological Department in 1916 based on the first scientific study of this rock exposure.

Petrified Wood: Petrified wood is a fossil. It forms when plant material is buried by sediment and protected from decay by oxygen and organisms. Then, groundwater rich in dissolved solids flows through the sediment replacing the original plant material with silica, calcite, pyrite or another inorganic material such as opal.

Pillow Lava: Characteristic pillow-shaped structures that are attributed to the extrusion of the lava under water, or subaqueous extrusion. Pillow lavas in volcanic rock are characterized by thick sequences of discontinuous pillow-shaped masses, commonly up to one metre in diameter.

Pleochroism: In optical microscopy, the differential absorption of light in different crystallographic orientations by a coloured mineral when it is rotated on the stage in plane-polarized light. The mineral may show variations in shade of the same colour or even a different colour.

ProGeo: ProGeo is the European Association for the conservation of Geological heritage. The Association is open to all and most of the Europe’s nations are represented by members.

Pyroclastic Rock: A rock that is formed by the accumulation of fragments of volcanic rock scattered by a volcanic explosion.

Pyromagma: Highly mobile lava over saturated with gases that exists at lower depths than hypomagma.
Pyroxene: A group of ferromagnesian rock-forming silicate minerals. They are common in basic igneous rocks but may also be developed by metamorphic processes in gneisses, schists, and marbles.

Quartzite: Metamorphosed sandstone that has been crystallized into a hard compact rock due to heat and pressure below the surface of the earth during tectonic activity. Due to their hard compact nature, sandstones and quartzites form high hills and plateaus on which most of the “Hill-Forts” of Rajasthan are built.

Rhyolite Ignimbrite, welded tuff: Rhyolite is an igneous volcanic rock having high silica content (~ or >65% SiO2) that has erupted on the surface of earth through a volcanic vent. It is very hard and compact rock. Due to the viscous nature of high silica lavas (that cools as rhyolite rock), rhyolite has limited aerial extent compared to its mafic silica poor equivalent-basalt, which literally “floods” the surface when it comes to the surface of earth usually through long fissures. Rhyolite and similar rocks in western Rajasthan (Malani लालणी Volcanism) have one of the world’s largest surface exposures, which cannot be explained through a flow of viscous lava. They are thought to have been formed through violent volcanic activity that spewed hot siliceous dust far-and-wide which settles down on the surface of earth around the volcanic craters and due to its high temperature in a hot gas environment gets welded into a hard compact rock called welded tuff or ignimbrite. In hand specimen and in thin sections under microscope, such rocks will show presence of small fine-grained igneous rocks. Volcanic vents are seen near Karada village (Karara N24° 53’ 40”: E 072° 08’ 15”, 205.9± 5.1m) near Bhinmal, other vents are buried under the desert sands.

Salic Minerals: Those minerals of the norm which are rich in silicon and aluminium, including quartz, feldspars and feldspathoids.

Sandstone: A sedimentary rock essentially made up of quartz grains (0.6-2mm) with minor quantities of feldspars, mica or small rock fragments transported and deposited by moving water. Rajasthan has a rich deposits and wide variety of this rock which is very popular building material. When sandstone contains ~ 10% feldspar it is called “feldspathic sandstone” – the famous pink/red Dholpur sandstone of eastern Rajasthan has been extensively been used for constructions of several famous buildings at Delhi, Agra, Lucknow.

Sedimentary Rock: A rock formed from the accumulation and consolidation of sediment, usually in layered deposits.

Shale, Slate, Schist: A fine grained clastic sedimentary rock essentially made up of clay mineral grains that are less than 0.06mm in size. It breaks easily along its bedding plane. This rock may be metamorphosed to slate or schist. Shale is much softer than weather resistant sandstone and when shale underlies sandstone it produces (differential) erosion escarpment topography, typically represented at the Chittaurgarh (Vindhyan Shale underlying Vindhyan Sandstone).

Slag: The solidified oxidized non-metallic impurities that float over molten metal in a furnace during its smelting is called SLAG. It is mostly silicon dioxide with other oxides. Slag displays a variety of textures and structures typical of quick solidification of a melt. (Refer to Figures at Rajpura-Dariba section above).

Stratigraphy: The study of sedimentary rock units, including their geographic extent, age, classification, characteristics and formation.
**Stromatolite:** A mound-shaped fossil that forms from the repetitious layering of algal mat covered by trapped sediment particles.

**Stromatolite:** Stromatolites are biochemical colonies formed in shallow waters (inter-tidal zone) by multilayered sheets of micro-organisms (single-celled organisms, bacteria, blue-green algae). Their significance is in providing us a clue as to the start of life on earth some 3500 million years ago; they can still be seen forming as at the Shark Bay, Western Australia! Their other major importance is in the fact that they enriched the primordial earth’s oxygen-free (anaerobic), carbon dioxide-rich atmosphere with oxygen through photosynthesis. So the stromatolites—the fossils of filamentous oxygen-producing microbes that formed columnar colonies—should be credited with a useful “pollution” that resulted in our birth and existence.

Jhamarkotra stromatolites in Rajasthan, an NGM, are phosphate rich and the major source of phosphatic fertilizer for our agriculture-based economy. Their occurrence in a rock that is 1800 million old conclusively proves existence of life at that time in what is now India! This discovery pushed back the existence of life that was recorded in the invertebrate (without backbone) fossil record found in rocks ~600 million years old (Cambrian Period of Paleozoic Era).

**Strombolian Volcanic Eruption:** A type of volcanic activity which produces frequent, moderate eruptions. The lava is basaltic, but sufficiently viscous for entrapped gases to build up a pressure which is released in continuous small explosions. Lava, flung into the air, falls back to build up a steep-sided cone of interbedded lava and tephra. Lava flows are commonly erupted through breaches in the flanks of the cone.

**Surtseyan Volcanic Eruption:** A Surtseyan eruption is a type of volcanic eruption that takes place in shallow seas or lakes. It is named after the island of Surtsey off the southern coast of Iceland. These eruptions are commonly phreatomagmatic eruptions, representing violent explosions caused by rising basaltic or andesitic magma coming into contact with abundant, shallow groundwater or surface water. Tuff rings, pyroclastic cones of primarily ash, are built by explosive disruption of rapidly cooled magma.

**Syenite:** Granitic-like rock that is deficient in free quartz (0-5%) and is essentially composed of feldspars with minor quantity of a related silica-deficient group of minerals called felspathoids (of our relevance is nepheline, a soda-potash-aluminosilicate, in that case the rock is called nepheline syenite). Presence of this rock indicates its formation in a thick continental crust due to fairly low degree of partial melting.

**Tonalite:** An oversaturated, coarse-grained, igneous rock consisting of essential sodic plagioclase, quartz, hornblende, and/or biotite, with accessoryapatite, zircon, and iron oxide.

**Transit Compass:** A small survey instrument usually carried by geologist in the field to accurately measure the directions and inclinations of planer and orientation of linear geologic features (strike and dip directions of bedding, foliation, joints, and lineations etc.), land gradients, etc. The pocket transit made by Brunton Inc., a USA (Wyoming) company are universally used, hence the instrument is commonly referred to as “Brunton Compass”, even if it is made by some other manufacturer, say Tudor, Answorth etc.! Just like the company name “Xerox” that has become synonym for photocopying, Brunton too is synonym for transit compass.

**Tufa:** The surface water dissolves a carbonate rock [limestone (calcium rich)/dolomite (magnesium rich)] – which is transported on surface, or at times in ground and when the water gets saturated, it precipitates its dissolved load as secondary terrestrial carbonate deposit which
may at times trap leaves and twigs too. Such carbonates are very fine grained (colloidal) and display a typical structures and textures. Larger deposits have been used for making burnt lime—a popular construction material.

At times the carbonate loaded water drips from ceiling of a cave (which itself may be a product of dissolution!) the dissolved carbonates (calcite, dolomite, aragonite…) get precipitated as secondary deposition. These “dripstones” while dripping from ceiling wall of caves form cones or columns giving rise to stalactites (hanging from ceiling, stalaGtites ) or stalagmites (rising from the ground/floor of a cave, stalaGmites). At times a continuous pillar-like feature develops between the floor and roof of a cave forming a Column.

**Tuff**: Tuff is a type of rock made of volcanic ash ejected from a vent during a volcanic eruption. Following ejection and deposition, the ash is compacted into a solid rock in a process called consolidation. Tuff is a relatively soft rock, so it has been used for construction since ancient times.

**Unconformity**: “An unconformity is a buried erosional or non-depositional surface separating two rock masses or strata of different ages, indicating that sediment deposition was not continuous. In general, the older layer was exposed to erosion for an interval of time before deposition of the younger, but the term is used to describe any break in the sedimentary geologic record…The interval of geologic time not represented is called a hiatus. There are various types of unconformities, the ones of our interest are: **Disconformity**—period of erosion between two sedimentary sequences of rocks, soil preserved by burial under the younger rocks is called “paleosol”. **Nonconformity** is break in deposition over a metamorphic or igneous rock overlain by a sedimentary sequence (as at the Meharangarh, Jodhpur amongst other locations). **Angular unconformity** results when a younger rock has deposited over earlier sedimentary sequence that is tilted.

**Vindhyan Plateau**: Highlands, escarpment plateaus of eastern Rajasthan and beyond made up of a thick sedimentary sequence comprising sandstone, limestone, and shale, lying between the Indo-Gangetic Plain (soil and alluvium) and Deccan Plateau (basalts). The Vindhyan Plateau east of Chittaurgarh is locally called “Ooppermaal उपरमाल”—the upper fertile tableland. Vindhyan Sandstone, especially the Bijoliya Sandstone, is renowned building material, while the limestone, besides being build popular building material is also source for numerous cement plants and lime kilns.

**Weathering of rocks**: Rocks on the surface of earth are subjected to mechanical as well as chemical actions of atmospheric agencies that result in their breaking &/or formation of new stable material. They involve the actions of air (mechanical as well as chemical, oxidation for example), water, ice, and organic fluids (humic acid for example, product of biodegradation of dead leaves, wood…), freezing & thawing, Erosion is movement of these materials that gives rise to new landforms.
ANNEXURE IV

SELECTED REFERENCES


Geological society of America GSA position statement Adopted April 2012 , Geoheritage


http://geo.msu.edu/extra/geogmich/Precambrian.html

Wadia, D.N. "Geology of India." Macmillan and Co. Limited.

Ezzoura Errami. Margaret Brocx, Vic Semeniuk. "From Heritage to Geoparks : Case Studies from Africa & Beyond."

https://earthlandwaterbodies.wordpress.com/2010/04/08/geological-history-of-india/
http://www.portal.gsi.gov.in/portal/

Anon: Wood Fossils of Akal, Jaiselmer. Folder of the NGM


Jodhpur NGM
http://en.wikipedia.org/wiki/Jodhpur_Group_%E2%80%93_Malani_Igneous_Suite_Con...Contact

National Geological Monuments, Special Publication # 61 of Geological Survey of India, 2001, now out of print, soft copy at the website:
http://www.portal.gsi.gov.in/portal/page?_pageid=127,529542&_dad=portal&_schema=PORTAL

National parks & sanctuaries http://rajforest.nic.in/?q=national-parks-and-sanctuaries-in-rajasthan

Rajasthan http://www.rajasthan.gov.in/Pages/Home.aspx


UNESCO World Heritage sites of Rajasthan
http://en.wikipedia.org/wiki/List_of_World_Heritage_Sites_in_India