

**RETORTS – ANCIENT SMELTING SITE,  
Zawar, Udaipur**

**GOVERNMENT OF RAJASTHAN  
MINES AND GEOLOGY DEPARTMENT  
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**Timeless Treasures:  
The Geo-Heritage of Rajasthan**



**Meteor Impact - Ramgarh Crater, Baran: 165 Million Years Ago**



## Geo-Heritage Sites of Rajasthan

# Introduction

Heritage refers to something inherited from the past. This is natural and may be cultural, historical or religious. The term "Geoheritage" evolved from "Geological Heritage". The term applied to sites or areas of geological features with significant scientific, educational, cultural or aesthetic value.

Such geological sites have high potential for scientific studies, use as outdoor classrooms, enhancing public understanding of science and economic support to local communities through promotion of geotourism.

There is a need to develop and conserve with action plan to these geological identities and understanding the scientific value of the geological features and land forms. Geological Survey of India (GSI) has identified and declared few of sites of geological importance as National Geological Monuments (NGM) in the State.





### MESSAGE

Rajasthan is renowned for its majestic forts, palaces and cultural heritage. However, this book reveals another facet of our State's splendor – its incredible geo-heritage. From the ancient Aravalli range to the majestic sand dunes of the Thar Desert, Rajasthan's diverse geological formations have been shaped over millions of years.

My Government is committed to preserving our State's natural and cultural heritage for future generations. This book is a testament to our Government's efforts in promoting sustainable tourism and environmental conservation.

I commend the authors, photographers and contributors for their efforts in capturing the essence of Rajasthan's geo-heritage viz. Ramgarh Crater (Baran), Great Boundary Fault (Sathur), Akal Wood Fossil Park (Jaisalmer), Kishangarh Nepheline Syenite, Zawar-an Ancient Mining Site etc. amongst many others. This book is a fitting tribute to our State's natural beauty and will inspire readers to explore, appreciate and protect these precious sites.

I invite you to embark on this visual journey through Rajasthan's geo-heritage wonders and discover the untold stories of our State' fascinating geological history.

Bhajan Lal Sharma  
Chief Minister, Rajasthan



#### MESSAGE

We are excited to announce the publication of a richly illustrated coffee table book focused on the geo heritage sites of Rajasthan, a venture proudly undertaken by the Mines Department. This book highlights the geological diversity and historical significance of our state's natural treasures.

Among the prominent sites featured in this publication is the ancient mining landscape of the Zawar Mine. Known for its historic importance in mining activities, Zawar Mine not only showcases our rich mining heritage but also illustrates the advanced techniques utilized by ancient civilizations.

Additionally, the book emphasizes the Nepheline Syenite, an extraordinary geological formation that dates back an astonishing 1910 to 1590 million years. Recognized as the oldest geo heritage site in Rajasthan, it provides invaluable insight into our planet's geological history.

Furthermore, the Ramgarh Crater is highlighted for its astronomical significance, being an impressive geological formation created by a prehistoric meteorite impact. This site not only offers stunning views but also serves as a key point of interest for research and tourism, making it a must-visit for enthusiasts and scholars alike.

This remarkable publication is a culmination of collaborative efforts from dedicated professionals and we extend our sincere appreciation to Sh. Sandesh Nayak, IAS, former Director, Department of Mines & Geology, for his visionary leadership and Sh. NP Singh, CEO, RSMET for his contribution in initiating the collection of such vital geo heritage sites.

We invite everyone to explore this coffee table book, which will be available for public viewing and distribution at various locations across the state. Let us join together in appreciating the geological wonders that Rajasthan has to offer.

T. Ravikanth, IAS  
Principal Secretary  
Mines and Petroleum Department  
Government of Rajasthan



#### MESSAGE

Geological Heritage Sites have insights into the Earth's evolution, history, in the field of Earth science. These sites also serve as excellent educational resources for learning about our planet's geological processes and history.

These sites can encompass a wide range of geological features, such as rock formations, fossil beds, mineral deposits, or unique landforms, which provide a window into the Earth's past. They play a crucial role in enhancing geological literacy among the general people.

Preserving these sites offer valuable insights into geological phenomena, climate change, and the Earth's dynamic past, making them indispensable for scientific research, and education, among people of all ages. Geo Heritage Sites can also boost tourism, stimulate economic growth and promote environmental conservation for future generations.

I wish all the success to this Pictorial publication.

Bhagwati Prasad Kalal, IAS  
Director  
Mines and Geology Department  
Udaipur (Rajasthan)



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## **Zawar- An Ancient Mining Site**

# Zawar- An Ancient Mining Site

India is the first to produce zinc by distillation processes. The mines of Rajasthan have given definite evidence of zinc production going back to 6th Century BC. Distillation process however was being used only from the 12th century AD, Zinc is silvery white in colour, hard and brittle. Its boiling point is  $907^{\circ}\text{C}$ . The regular zinc production by distillation started in India around 12th century AD and in China it is not earlier than 16th century AD. As early as the 12th century AD, India produced the metallic zinc by the sophisticated distillation process at Zawar in Rajasthan. This technology of zinc manufacture is also described in several Indian alchemical works of the mediaeval period including the 13th century Rasa Ratna Samuccaya. Zinc smelting began in China in the Jiajung period (1552-1566 AD) of the Ming dynasty.





The ancient site of Lead(Pb) Zinc(Zn) Silver(Ag) Zawar deposit is located about 40 km. South of Udaipur Long and continued association. The globally relevant aspect of Zawar is the ancient mining smelting and global trading of the metals that were produced from the ores located at Zawar. It is only known ancient Zinc smelting site in India. Ancient mine openings are visible in almost all mines areas and are mostly in the form of open stops, trenches, chamber galleries, shafts, incline and open mines. The entire valley of Tiri at Zawar is marked by immense heaps of slag and retorts which indicate long tradition of Lead Zinc Smelting at Zawar.

The mappable litho-units in Zawar include dolomite, phyllite, greywacke and quartzite. The phyllites are often quartzose in nature and this particular variation is found to be very conducive for spectacular preservation of outcrop level structural features. The Zn-Pb ore deposits are hosted by dolomite and its variants that belong to Mochia Member of the Baroi Magra Formation. Minor hiatus is indicated by a thin band of polymictic dolomite that is exposed in the Balaria and eastern end of Mochia Hill. A prominent metadolerite dyke intrudes the rocks of the Mochia Member and its thermal effect has caused coarsening of ore lodes. The main ore mineral is Sphalerite (for Zinc), Galena (for Lead) and Pyrite, Arsenopyrite, Chalcopyrite & Pyrolusite occurs in minor amount.





# Ramgarh Crater

# Ramgarh Crater

**R**amgarh crater, also known as Ramgarh structure and Ramgarh Dome, situated near Ramgarh village in Kishanganj Tehsil of Baran district in southeast Rajasthan, India. Ramgarh crater was first discovered by the Geological Survey of India in 1869. Some of the studies carried out by geo-scientists support impact origin of the Ramgarh Crater. Shatter has collected near the centrally uplifted region of the Ramgarh structure, which is an ideal location as per the well-established and internationally accepted criteria for their presence. Although Crawford speculated about the impact origin for the Ramgarh structure way back in 1972, it took almost 70 years to confirm it as a meteorite impact structure.

Ramgarh Crater structure is the third meteorite impact structure from India, which have unique geomorphology and origin. Rising a 200-250 m high almost circular ridge, amidst the vast agricultural plains and horizontal strata of the Vindhyan Supergroup, it represents a conspicuous topographic high.





It is a domelike structure having peripheral circular ridges and a central depression having diameter of 3.2 km. while its rim rises prominently 200-250 m. above the surrounding plain and dips outward with angles between 20-40 degrees from the rim crest. The impact possibly occurred during middle-upper Jurassic Period, some 165 million years ago.

A rootless mass of sheared sandstone found near Bhand Dewara temple in the crater indicates a fallback material. Presently, most of the geological studies support impact origin of the Ramgarh Crater. Now "Ramgarh Crater is third impact structure" established as meteoritic impact crater in India after "Lonar crater of Maharashtra" and "Dhala Crater of Madhya Pradesh".





## Akal Wood Fossil Park Jaisalmer

संग्रहित काष्ठजीवारम  
प्राप्ति स्थल :- ग्राम हाडा त. जैसलमेर  
संग्रहण अवधि :- 2002-2003  
संग्रहणकर्ता :- उप वन संरक्षक  
वन्धु जीव, जैसलमेर

## Akal Wood Fossil Park Jaisalmer

The Akal Wood Fossil Park is 21 hectares in extent and is located in Akal village. 17-18 km from Jaisalmer city, and 1 km off the Jaisalmer - Barmer road, on a stretch of about 10 sq. km of bare hillside. The terrain is barren and rocky.

It is an interesting area of remains of ancient flora, in the form of fossils of trees belonging to a forest that existed almost 180 million years ago. The sheer fact stands out to be unbelievable and majestic. The tree trunks, and hence the wood is what remains of that ancient region of forests that used to cover this land, and probably got submerged under water of the sea. This region is one of the many awe inspiring corners of the grand mysteries that the great Thar Desert (Great Indian Desert) has to offer and reveal.





Geologically the Akal Wood Fossil Park belongs to the Lathi Formation the of Lower Jurassic Period. The part lies in Jaisalmer's fossil belt, a region noted to have the potential for geological parks. Fossils and footprints of pterosaurs have been found in the nearby Thaiyat area. The part contains fossils of Pterophyllum, Ptilophyllum, Equisetites species, and dicotyledonous wood and gastropod shells of the Early Jurassic period. There are about a dozen fossilized wood logs lying horizontally oriented in random directions, the largest of which is 13.4 m in length and 0.9m in width. There are a total of 25 petrified tree trunks. Fossils and footprints of pterosaurs have been found in the nearby Thaiyat area.





# Gossan

## Rajpura Dariba

# Gossan

## Rajpura Dariba

The Gossan ridge 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 Chittor- Udaipur section of Western Railway.

Gossans are the signposts that point to what lies beneath the surface. Gossans are exceedingly ferruginous rock, which is the product of oxidation by weathering and leaching of sulfide mineralization. The colors significantly depend on mineralogical composition of iron hydroxides and oxides phases, and vary between red (hematite), yellow (jarosite), brown, and black (galena) with stains of azure blue, malachite green, and peacock (copper). The texture can be brecciated, cleavaged, banded, diamond mesh, triangular, cellular, contour, sponge, and colloform with box work of primary sulfides. The texture assumes a honeycomb pattern (box work) of various colors that exist in capping as sulfide grains oxidize and residual limonite remains in cavities.





**G**ossan is primary indicator of sulfides in Rajpura Dariba below which the main ore body lies. In the field, several old workings were recorded in gossanized hill which also indicates the ancient mining occurred based on the presence of gossan. At Rajpura Dariba, the gossan is extended for approx. 4.5 km length and product of intensive chemical weathering of complex sulphide deposits.

Surface manifestation of mineralisation by the very well-developed gossan. The zone of oxidation extends up to a depth of 40-50m from the surface in Dariba area. The gossan here is intensely oxidized, weathered, decomposed rock consisting of erosion-resistant iron oxides and quartz, giving it a reddish-brown, orange or yellow color. The gossan shows dark brown, bright yellow, bright reddish yellow, vermilion, brick red, red, purple, yellow, pale grass green, bluish green, azure blue, black, grey and white colours indicating presence of several minerals like limonite, goethite, jarosite, jasper, malachite, azurite, tarquis, hematite, manganese-oxide, clay minerals etc.





# **Stromatolite Park**

## **Jhamarkotra**

# Stromatolite Park

## Jhamarkotra

**S**tromatolite Park Jhamarkotra has located about 25 km. southeast on Udaipur-Salumber road. It is the largest & richest deposits of phosphorite associated with stromatolite

Association of phosphorites with stromatolites showing typical surface manifestation has been of great value in stratigraphic correlation and as a guide for phosphate hunting in areas with similar litho-associations. Some of the features of Stromatolites, like growth at right angles to beds and convexity towards the top, have offered valuable field guidance for correct structural interpretation.





The phosphorite deposits extends continuously for a strike of 12 km and an additional 4 km in discontinuous patterns in a horse shoe shape with cumulative strike of 16 km with width of phosphorite verifying from 6 to 120 mts

The presence of unique stromatolite fossils in the Proterozoic Aravali dolomitic limestone 1800 Ma at the attention of Geologist all around the world. Stromatolite Park Jhamarkotra has various varieties, shapes & sizes of various stromatolites, It is characteristic by "crocodile-skin" weathering due to differential weathering of stromatolitic & surrounding material is of special interest.





# **Stromatolite Park**

## **Bhojunda**

# Stromatolite Park Bhojunda

The stromatolite park is well connected by road and rail on the Chittorgarh- Udaipur State Highway. Exposure of prolific development of stromatolites spread over extensive area. Stromatolites therefore, represent the only available fossil record of the earliest forms of life that are visible through naked eye. Their first appearance in Archaean sediments is a clear indication of organic activity.

Bhojunda Stromatolite fossil park is located near village Bhojunda, about 6 km SW of Chittorgarh, near Saras dairy plant & Government medical collage on Chittorgarh-Udaipur road.





**S**tromatolites are typically a layered, mostly with convex-up, biochemical, accretionary, organo-sedimentary structures formed through the action of certain microbial lifeforms, especially cyanobacteria like blue green algae. These algal stromatolites are known as impression of one of the earliest form of life on earth. The stromatolite rocks are structures that are come in existence when bluish-green algae attach itself to the carbonate particles. Stromatolites are found mainly as large bioherms in the cherty quartzite, limestones & dolomites

Stromatolites Bhojunda or stromatoliths are layered accretionary structures formed in shallow water by the trapping, binding and cementation of sedimentary grains by biofilms of microorganisms, especially cyanobacteria (commonly known as blue-green algae).

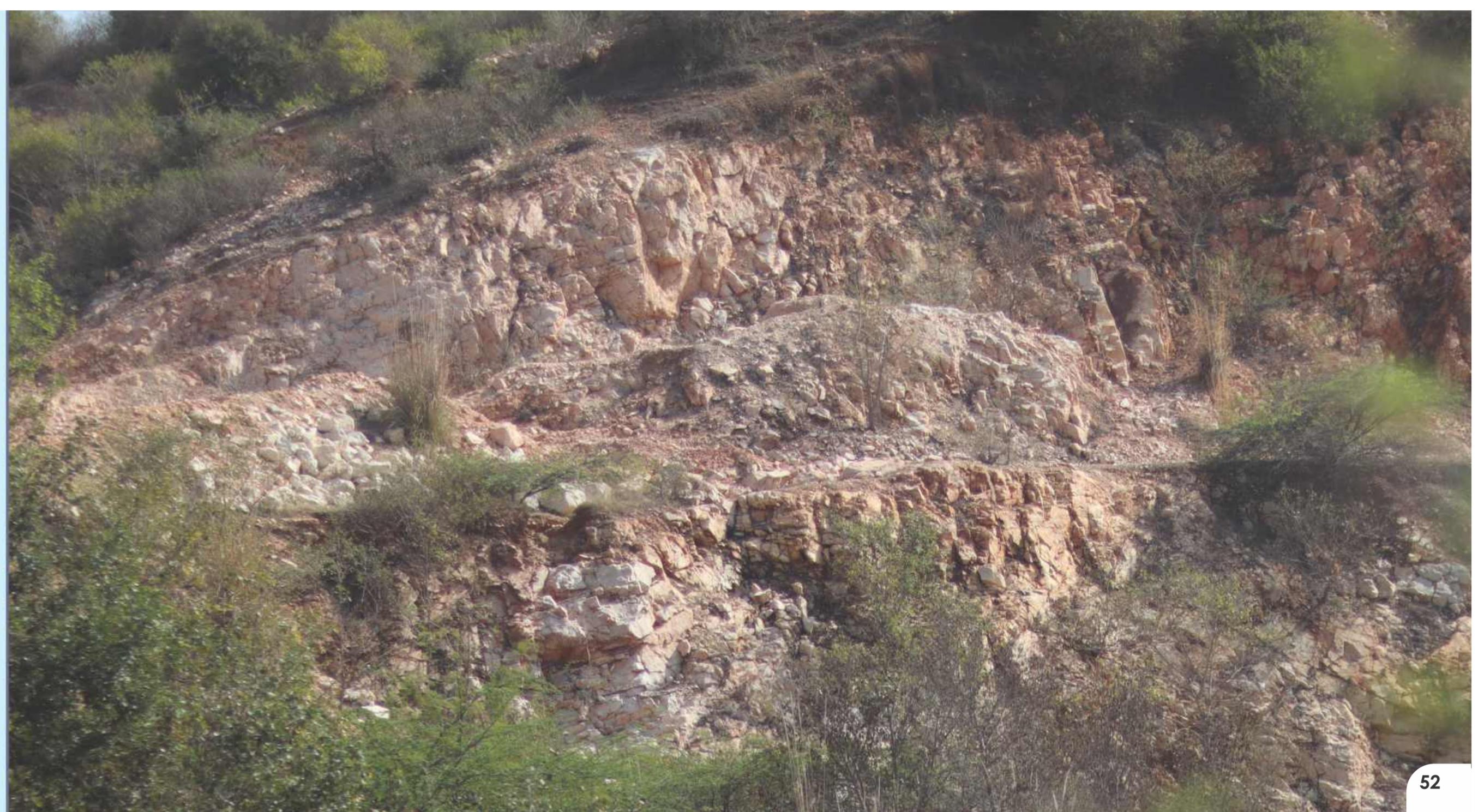


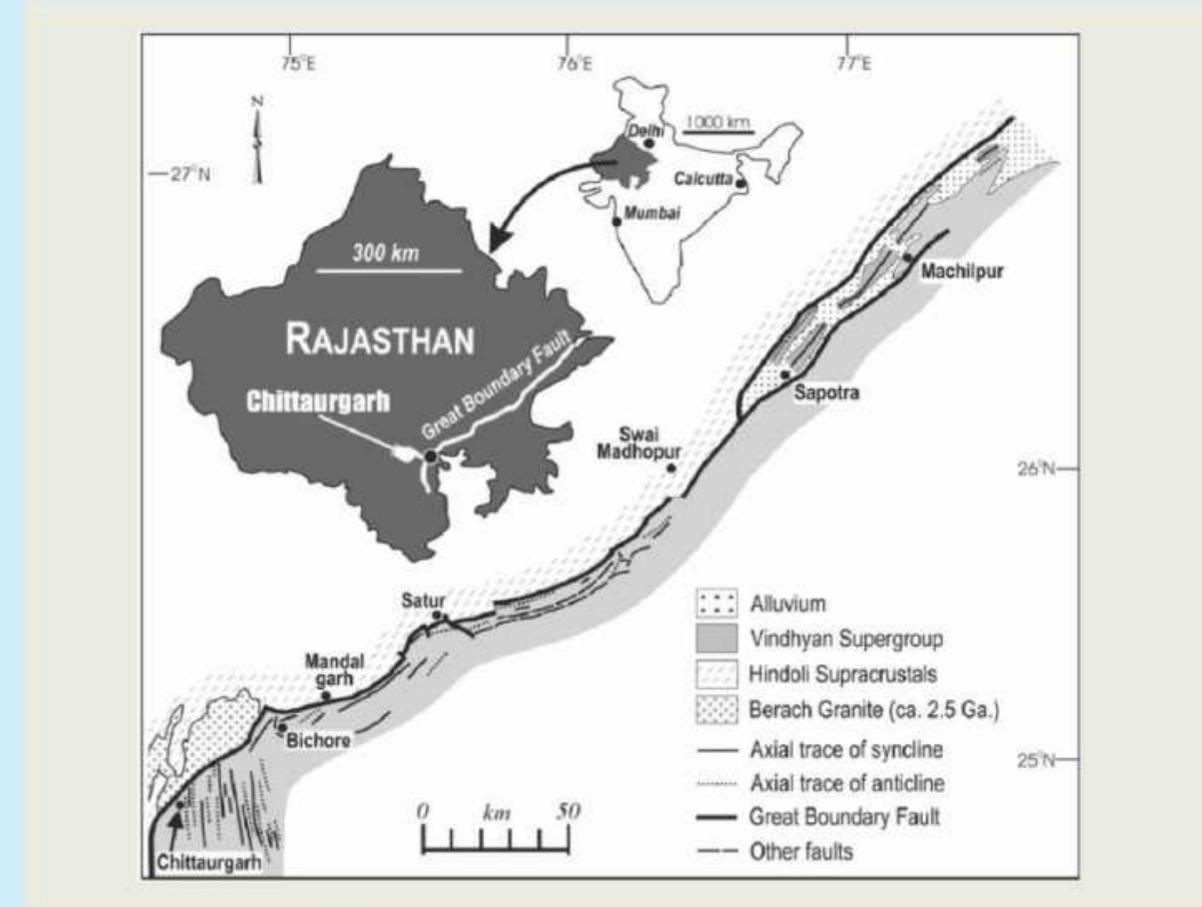


## The Great Boundary Fault Sathur

## The Great Boundary Fault Sathur

The Great Boundary Fault is a major tectonic lineament in the northwestern India that runs close to the contact between the Vindhyan sedimentary rocks (ca. 1400-600 Ma) and the pre-Vindhyan rocks. Great boundary fault extends for more than 400 km from Machilpur in the northeast to a little south of Chittorgarh in the southwest. The Great Boundary Fault is best studied at about 10 km NW of Bundi on N.H. No. 12 (Jaipur to Jabalpur) around village Sathur. Fault-related deformation zones developed in different parts of the Great Boundary Fault. The Great Boundary Fault (GBF) Sathur in southeastern Rajasthan originated as a thrust in a brittle-ductile/ductile regime and it is the one of the important faults and makes this as one of the most interesting geological sites in Rajasthan.





The low angle thrust faults represent the signatures of the first phase of reactivation on the Great Boundary Fault. The second group of brittle structures comprise striated fault/fractures, brittle-ductile shear zones and en-echelon veins. This group of structures is inferred to have developed during the second phase of reactivation on the Great Boundary Fault in a major strike-slip regime. The third group of structures include thrust and fault related kink folds that were developed during the third phase of reactivation on the Great Boundary fault in a thrust regime.



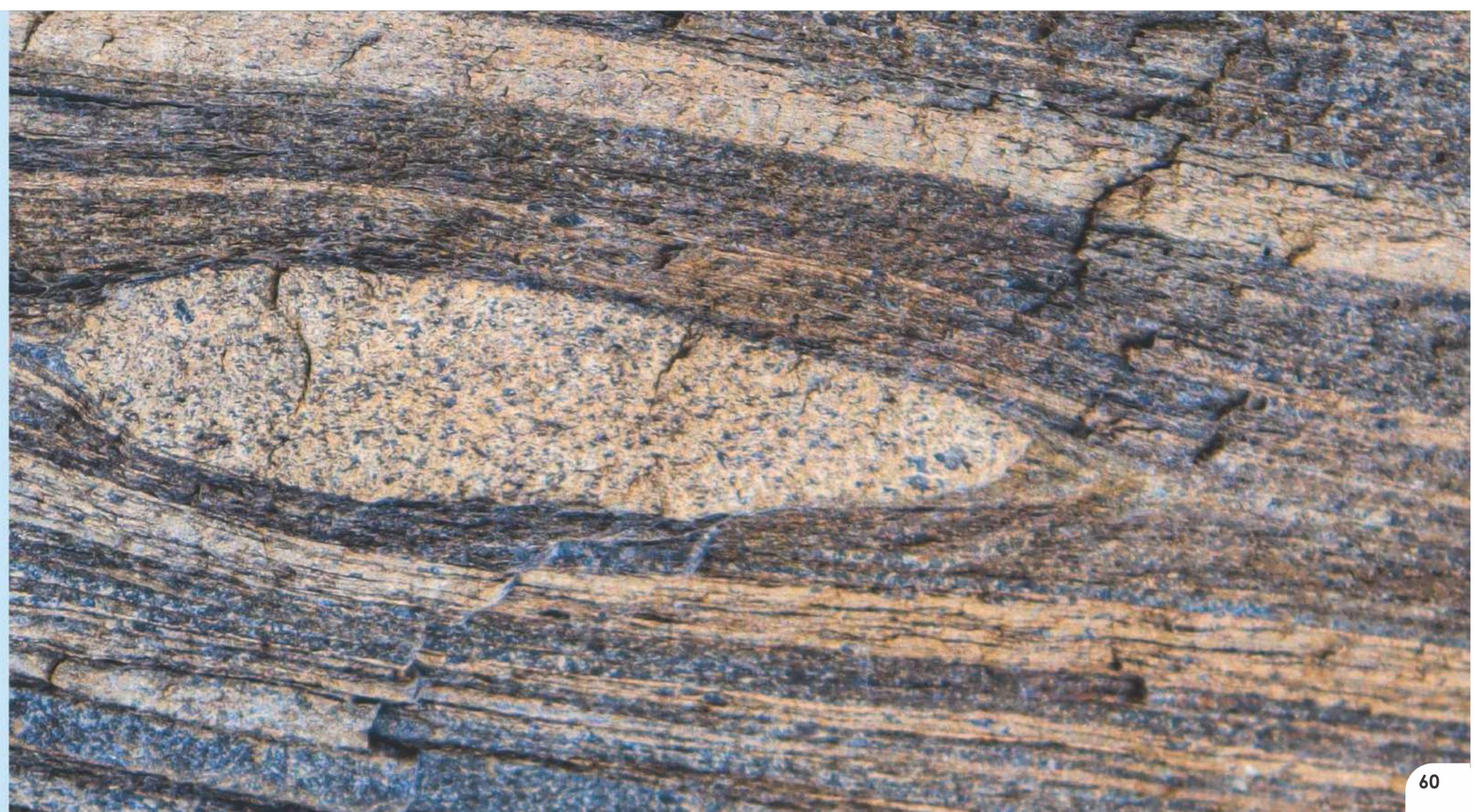


# Barr Conglomerate Pali

# Barr Conglomerate Pali

The Barr Conglomerate in Pali district, Rajasthan is a sedimentary rock that's been declared a National Geological Monument of India. The conglomerate is best exposed on either side of the Beawar- Sendra-Barr- Pali road but just before Barr- Pali crossroad towards Sendra. The Barr Conglomerate is a sedimentary rock made of pebbles and cobbles of quartzite, granite-gneiss, chert, and mica schist. It's located on the western flank of the Middle Proterozoic Delhi fold belt.

The Barr Conglomerate is important because it's deformed and can be used to study the nature of the Delhi-PreDelhi contact. The pebbles in the conglomerate are good strain markers that show how the shear strain has changed over time.





**Barr Conglomerate** indicate multiple deformation with compression and elongation due to deformation episode. The first deformation episode (D1) produced long-limbed isoclinal folds with axial planar schistosity or gneissosity which became asymmetrically folded with dextral vergence (Z-shaped folds) during the second deformation phase (D2). Here rocks of Aravalli Supergroup are missing.





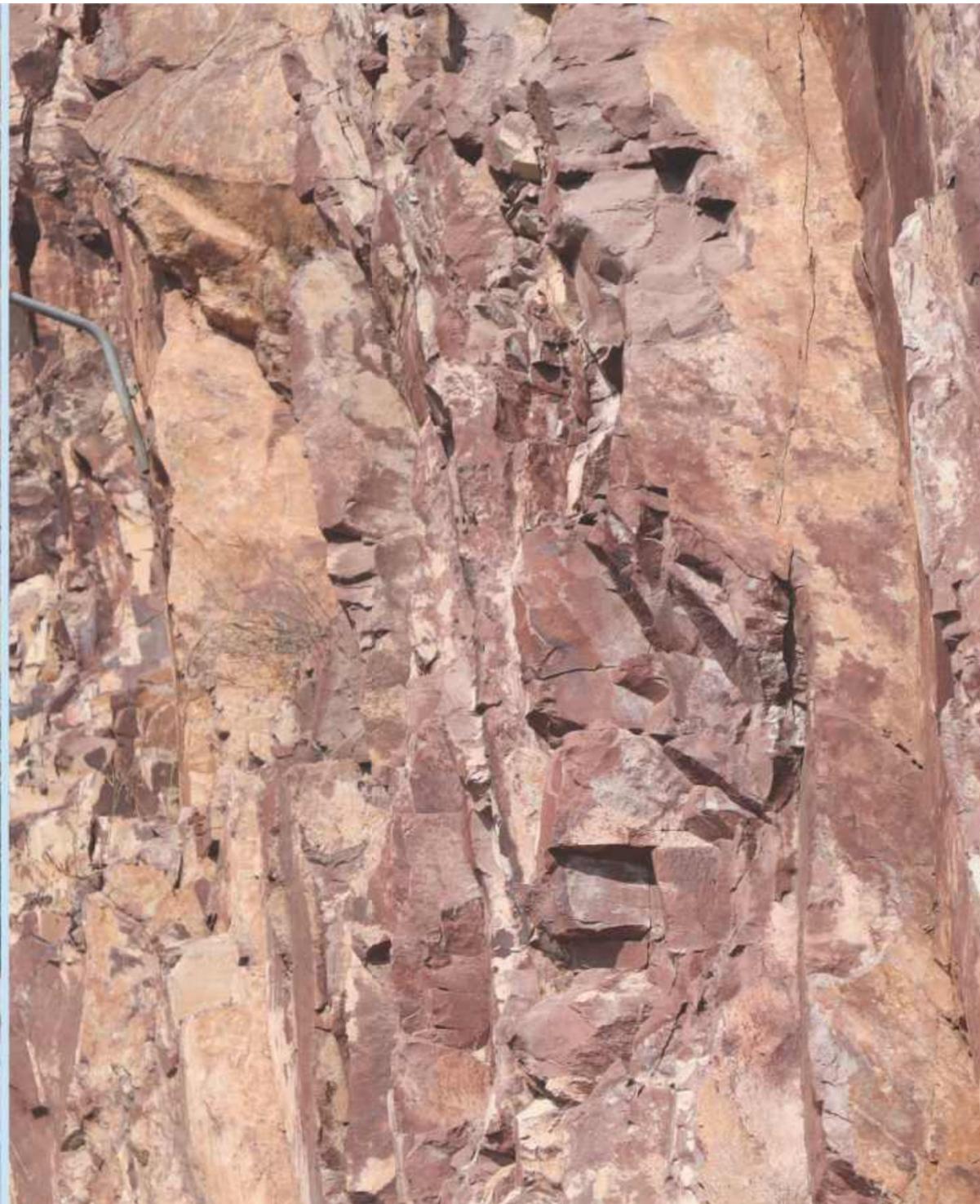
# Malani Igneous Suite

## Jodhpur

## Malani Igneous Suite Jodhpur

**M**alani volcanics, of the Thar Desert in Rajasthan, extends at the periphery of the desert and covers parts of Pali, Sirohi, Jodhpur, Barmer, Jaisalmer, and Jalore districts. The rock is characterized by purple to red and ash colored laminated tuff with chocolate-colored chalcedony, dark red obsidian, purple, reddish, buff, whitish, and greyish colored rhyolitic tuff. Sandstones of the Jodhpur Group form the basal part of the Marwar Supergroup and the upper boundary of these Malani volcanics is considerably eroded. This erosional contact is between the underlying youngest igneous suite of rocks of Precambrian age and the overlying oldest sedimentary sequence.





**D**ominant part of rhyolite at Mehrangarh Ridge display porphyritic nature, one of the excellent sections is selected near left side of the gate No.2 of Rao Jodha Desert Rock Park (RJDRP).

The geoheritage sites represented by the rocks of Malani Igneous Suite the world's third and India's largest acidic and terrestrial volcanism of 745 Million Years age, display two extrusive volcanic stages in Jodhpur. Lava phase (rhyolite and rhyolite porphyry) and Pyroclastic phase (welded tuff, ignimbrite, agglomerate, volcanic breccia and minor ash beds) Both these phases constitute an "igneous cycle" and are the reflection of the 'Pan-African Event' in India showing the international significance of great geoheritage value.





# Welded Tuff

## Jodhpur

# Welded Tuff

## Jodhpur

The pyroclastic rocks display many unique and rare features in welded tuff. It is characterized by its aphanitic to fine grained nature. It is dominantly composed of volcanic ash and fine sand which are mixed with hot gases that were ejected rapidly down from source vent to deposit massive welded tuffs. These features along columnar, volcanic terraces provide great geoheritage value to this rock.





**M**alani Igneous Suite at Mehrangarh Ridge has been evolved through three stages which are represented by I. subsurface basic volcanism, II. Acid lava flows, and III. Acidic inter Pyroclastic flows. The first phase comprises of the bimodal volcanism with initial basic lava (Basalt) which is followed by II phase of acid lava flows (rhyolite and rhyolite porphyry) and pyroclastic flow deposits (agglomerates, volcanic breccia, welded tuffs, ignimbrites with minor ash laminations) on the top (phase III) Sandstone of the Jodhpur Group.



# Sendra Granite



# Sendra Granite

It is located in Pali district lying in central part of Rajasthan state in NW India. But very near to Ajmer district boundary, nearest town is Beawar which is 15 kms away.

This term represents spread of Pre Cambrian granite group designated in geological literature as "Syn Orogenic Amba ji Granite there by making it one of the oldest such unit in geology of Rajasthan. The effects of wind and water erosion has converted part of granite in animal-like forms like Owl rock. Lion rock. This area is outside the boundary of desert so also has lot of plantation and greenery, and is ideal site for geology and other science students, environment-nature lovers and general enthusiasts who love outdoors. Sendra granite is an igneous batholith, covering roughly 11 kms X 5kms area where granite out crops is available for study. General trend is NE-SW. This area includes villages like Sendra, Shergarh, Chitar, Amarpura, Lalpura, Chang and Khera-Sagrotan.





**G**eologically Delhi Super Group is overlain by a sequence of unmetamorphosed sedimentary rocks consisting of sandstone, limestone, siltstone and gypsum beds. The Marwar Super Group is divided into Jodhpur and Bilara Group which consists of sandstone, shale and limestone rocks overlain by the thin alluvial cover of Sub-Recent to Recent period of Quaternary Era. The thickness of alluvium cover increases from east to west. The Delhi Super Group rocks are intruded by granites and rhyolite. Predominant intrusive is the Erinpura Granite. The Delhi Super Group is mainly exposed in NNE parts of the district while Marwar Super Group is exposed in northern part in Jaitaran and Sojat blocks. Erinpura granite & gneiss occupied almost 50% area of the district and exposed mainly in central. Southern and southeastern parts of the district.





## Kishangarh Nepheline Syenite

## Kishangarh Nepheline Syenite

The monument is about 500 meter after the bypass bifurcation of Kishangarh towards Jaipur on NH-8. The area of interests extends upto Gundu Rao Talav. Kishangarh is situated on NH-8 and is about 26 km northeast of Ajmer and is also connected by Western Railway Main line and the nearest airport is Kishangarh airport. The Syenite body extends for about 25 km long and 1-5 km wide.





**N**epheline syenite is an alkali intrusive rock, composed essentially of alkali feldspar, nepheline with sodalite and cancrinite. Sphene and apatite occur in less amounts. Nepheline syenite of Kishangarh is 1910 to 1590 million years old and has a unique position as it is the only known occurrence in the Aravalli craton. Hence the site located near Kishangarh was declared a National Geological Monument in 1976. The rock has three textural varieties namely granitoid, foliated, and banded, it is greyish white with a pitted surface due to the leaching of the nepheline crystals. The main body of nepheline syenite is associated with the metasedimentary-metavolcanic assemblages that occur between the Delhi Basin rocks in the west and the banded gneisses of the Sandmata Complex in the east.



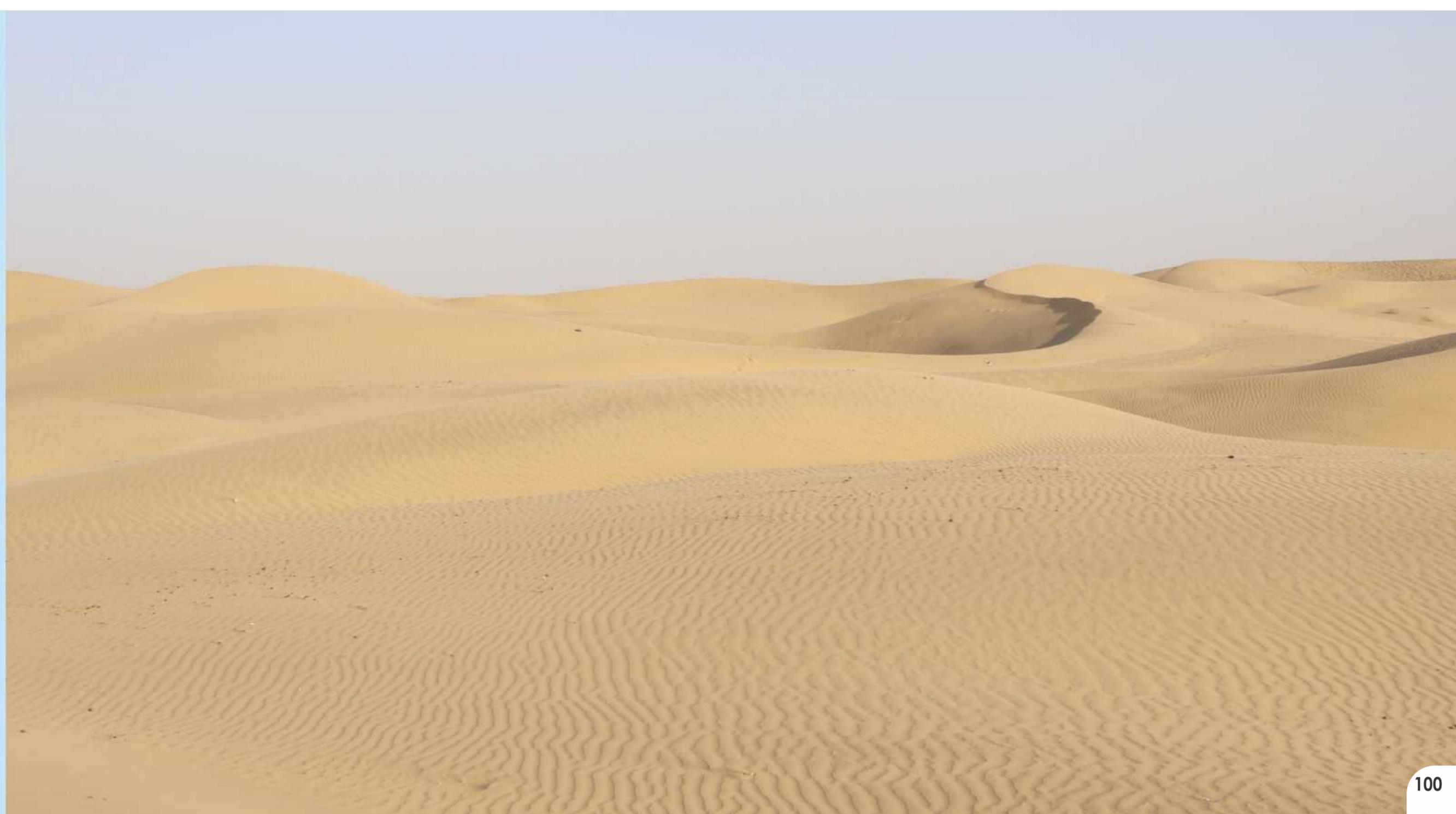


# Thar Desert of India

# Thar Desert of India

The sand dunes in Jaisalmer exposed along barren area from Barmer to upto Bikaner district along the international boundary of Pakistan. The main location of Sand dunes Jaisalmer district Sam Sand Dunes:- Located about 42 km West of Jaisalmer city & lies along Jaisalmer-Sam road, 3km before Sam village, Dimension of dunes about 1.5 -2 km NE-SW x 1 km NW-SE low to medium height dunes having about 3 to 10m height. The Sand dunes area of Sam lies in eco-sensitive zone of Desert National Park.

This site has immense educational, aesthetic, cultural and economic values through tourism, low-impact recreational and leisure activities. The scientifically researched robust details on several rare geosites are documented for their unique geoscientific significance, comprehensive geoconservation efforts and promotion of knowledge-based geotourism leading to the creation of suitably managed Jaisalmer Geopark and sustainable growth of the local communities.



## Fossils in Thar Desert



Jaisalmer Basin has established and well-documented depositional environments ranging from continental fluvial to nearshore and offshore deep marine Jaisalmer Basin in western India presently falls under the extreme hyper-arid dryland environment and typical desert conditions that define the core of the Thar Desert. The numerous characteristic landscapes of desert that are of immense educational and recreational values include a variety of sand dunes, hamada, gravel spreads and wind deflated residual rocky ridges. Erosion and depositional processes in both the current and historical climatic regions have produced desert landscapes. Desiccated stony plains, pebble-boulder dispersed as deflation lag deposits, salt lakes and a variety of stable and dynamic dune fields, including parabolic, linear, transverse and barchans of various sizes and generations, make up the desert landscape.