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A Geological and Paleontological Study on Petrified Wood in Western Rajasthan, INDIA.

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Abstract

Western Rajasthan is a globally significant repository of petrified wood, offering crucial paleontological and geological insights into the Earth's deep past. The region contains ancient fossilized forests – predominantly found in the Jaisalmer and Barmer basins – that document the climatic transitions and shifting depositional environments of the Indian subcontinent over millions of years.

The petrified wood of western Rajasthan is deeply tied to the geological history of the Thar Desert and surrounding sedimentary basins. The petrified wood of western Rajasthan is deeply tied to the geological history of the Thar Desert and surrounding sedimentary basins.

The fossils are preserved within the Mesozoic strata (specifically the Lathi and Jaisalmer formations) and the Cenozoic Barmer Hill Formation. The ancient trees were swept into deltaic or marine environments, rapidly buried under thick sediments, and subjected to groundwater rich in silica. Over millions of years, organic plant matter was replaced with silicate minerals like quartz via permineralization, cell by cell.

Akal Wood Fossil Park (Jaisalmer): Designated as a National Geological Monument, this 21-hectare park is the most famous site for petrified wood. It houses 25 petrified tree trunks (including extinct gymnosperms) dating back to the Early Jurassic period (~180 million years ago).

Key Words : petrified wood, Jurassic period, Palaeocene, wood-boring trace fossils, sedimentary basins

Introduction

Petrified wood (from the Greek root petro meaning "rock" or "stone"; literally "wood turned into stone") is the name given to a special type of fossilized remains of terrestrial vegetation. It is the result of a tree or tree-like plants having completely transitioned to stone by the process of permineralization. All the organic materials have been replaced with minerals (mostly a silicate, such as quartz), while retaining the original structure of the stem tissue. Unlike other types of fossils which are typically impressions or compressions, petrified wood is a three-dimensional representation of the original organic material. The petrification process occurs underground, when wood becomes buried under sediment is initially preserved due to a lack of oxygen which inhibits aerobic decomposition. Mineral-laden water flowing through the covering material deposits minerals in the plant's cells; as the plant's lignin and cellulose decay, a stone mold forms in its place (*Campbell and Baxter , 1979*).

Petrified wood refers to a fossil formed when the organic components of woody plant material are gradually replaced by minerals, predominantly silica, via a process called permineralization. This process can only take place under the right set of circumstances.

When an organism dies, it usually decomposes. Such is the circle of life. The process that most people call "rotting" is a type of decay which sets in as microorganisms break down organic matter. Usually, a dead, fallen tree will be subjected to this process.

Once in a while, though, a newly deceased tree (or some other kind of woody plant) gets rapidly buried by mud, silt or volcanic ash. This blanketing material, or sediment, then shields the dead tree from oxygen. Because oxygen is the main driving force behind the decaying process, the smothered plant will begin to decompose far more slowly than it normally would.

Meanwhile, mineral-laden water or mud seeps into the dead tree's pores and other openings. As our plant's internal structure gradually breaks down, its organic material (wood fibers) gets replaced by silica and other minerals.

Over several million years, the minerals that replace the organic material gradually crystallize, forming a rock-like structure. This resulting structure may closely mimic the shape and internal features of the original tree, effectively preserving its essence in stone for geological and scientific study.

Petrification often conjures images of a painstakingly slow geological journey, typically spanning millions of years. However, this is not always the case — sometimes petrified wood forms much more quickly.

While it's true that crafting the detailed and vibrantly hued specimens of petrified wood we often admire can stretch across long geological epochs, the inception of petrification can happen relatively quickly under the right conditions.

The speed of this process can vary significantly, depending on environmental factors. In some instances, it can happen relatively quickly, within decades or centuries, particularly when optimal conditions exist, such as the presence of abundant minerals and rapid burial.

The level of detail seen in some fossilized specimens is downright astonishing. Petrified logs with well-preserved knots, branches and leaves have been found.

Fossil-hunters have also come across the occasional log with root structures attached to its base. In certain petrified log segments, it's possible to count the growth rings.

There's also the matter of coloration. Cross-sections of petrified wood often showcase a glistening rainbow of colors, which is why the fossils are so beloved by artists. The different hues are produced by different minerals. For example, some petrified logs have a red or pink tint. Internal hematite is responsible for this hue.

Now if there's a greenish color in your favorite hunk of wood, that means a mineral called "native iron" is inside the fossil. And shades of black are associated with "fool's gold" — also known as pyrite. Polishing petrified wood helps bring out the vibrance of these colors and patterns.

Over 200 million years ago, it was the site of a dense forest loaded with conifers and about a dozen other tree species. Log jams were often created when deceased trees fell into the prehistoric rivers that ran across the landscape. Scores of these plants were then buried rapidly in sediment and silica-rich volcanic ash.

Once that lava touched the lake water, it hardened into pillow basalt (an igneous rock formed by the cooling of molten magma or lava). This encased the logs, shielding them from oxygen and allowing the petrification process to occur.

Geology of Western Rajasthan

Extensive geological and paleontological research on petrified wood in western Rajasthan centers around the Akal Fossil Wood Park (Jaisalmer district) and the Barmer Basin. Studies focus on identifying extinct gymnospermous species, paleoenvironmental conditions, and unique wood-boring trace fossils.

Western Rajasthan, located in northwestern India, represents a pivotal component of the Indian Shield, preserving an extensive geological record that extends from the Archaean era to contemporary times. The area's supracrustal formations encompass the Banded Gneissic Complex (BGC), along with the Aravalli, Delhi, and Vindhyan Supergroups, covering a temporal span of approximately 3500–800 million years ago (Ma), delineated by significant regional unconformities. During the late Proterozoic, the region experienced the voluminous Malani Igneous Suite, a prominent felsic volcanic episode featuring rhyolites, tuffs, and granitic intrusions across an expanse of roughly 55,000 km². Overlying this suite is the Marwar Supergroup (Neoproterozoic to Cambrian), composed of sandstones, limestones, and evaporites, with ichnofossils suggesting a Lower Cambrian affinity. Paleozoic deposits are sparse, highlighted by the Carboniferous Bap Boulder Bed and Permian Badhaura Formation, which document limited glacial and marine sedimentation. Mesozoic strata, predominantly Jurassic, include the Lathi and Jaisalmer Formations, exhibiting fluvial and marine deposits enriched with fossilized wood and trace fossils. Tertiary sequences in the Jaisalmer, Barmer, and Palana-Ganganagar basins illustrate transitions from marine to continental environments, represented by formations such as Sanu, Khuiala, and Bandha. The Quaternary deposits of the Thar Desert, influenced by Neogene tectonic activities, comprise fluvial, fluvio-lacustrine, and aeolian sediments, alongside calcretes and soils reflective of persistent arid conditions. This multifaceted geological tapestry, shaped by multiple orogenic cycles, tectonic upheavals, and climatic fluctuations, highlights the critical role of western Rajasthan in elucidating India's geodynamic history.

Recent investigations, including paleomagnetic analyses and geochemical studies have refined the timing and petrogenetic models of the Malani Igneous Suite, linking it more robustly to global Neoproterozoic tectonic events such as Rodinia's fragmentation. Furthermore, contemporary climate studies reveal ongoing greening trends in the Thar Desert due to enhanced monsoon precipitation and anthropogenic groundwater extraction, increasing vegetation cover by up to 38% since 2000. These developments underscore the interplay between ancient geology and modern environmental dynamics, with implications for sustainable resource management in arid zones.

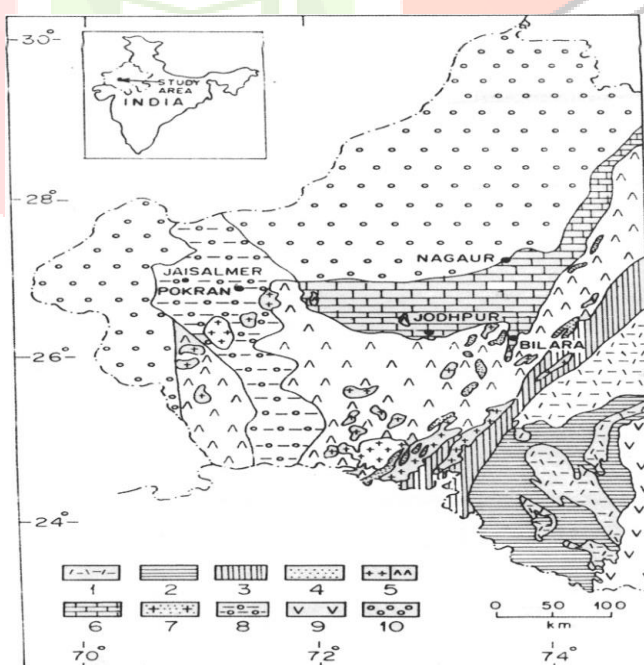


Fig. 1 : Regional geological map of western Rajasthan, India. (1) Banded Gneissic Complex, (2) Aravalli Supergroup, (3) Delhi Supergroup, (4) Proterozoic sediments of uncertain age, (5) Neoproterozoic igneous activity, (6) Marwar Supergroup, (7) Jalore and Siwana granite, (8) Mesozoic sediments, (9) Deccan Traps, (10) Tertiary sediments.

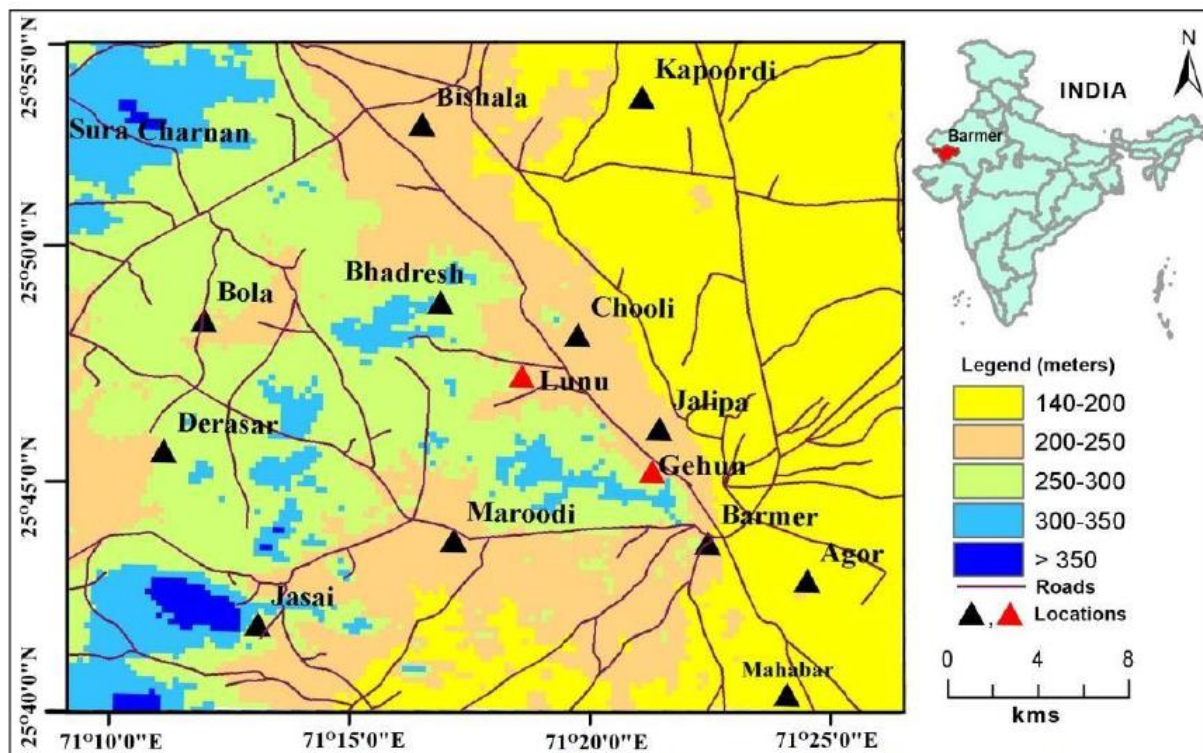


Figure 2. DEM of Barmer Area showing location of fossil-bearing Gehun and Lunu sections of Barmer Hill Formation of Barmer area, Western Rajasthan, India

Methodology

In BHF the petrified wood occur in fine grained sandstone in lower cycle are mostly silicified and jasperified (Plate-1-a and 2-Z-b) while petrified wood occur in fine grained sandstone in upper cycle are mostly either ferruginized or coalified or carbonaceous (Plate-2-Y: b and 2-Z:a).

In BHF the petrified wood occur in fine grained sandstone of all six fining upward cycles. It has been found that in this rock Petrified wood clasts, plant leaves, and its veinlets are also preserved (Plate-2-Y: a) The dominant presence are in lower cycle where they occur in situ and as drifted and transported in upper cycles at Lunu section as small fragments and pecies indicating they have been derived from lower cycles of Gehun section (Plate 1a; 2-Y and 2-Z). It is also controlled by preservation of *Asthenopodichnium* in large tree log in cycle 1 of lower facies.



Plate 1-a

Plate-2 : Y-a,b, Z-a,b



2 Y-a. The fine grained silty sandstone preserved network of veinlets of leave in top part of wood log.

2-y: b. A fragment of petrified wood showing partly coalification.





2 Z-a. A fragment of petrified wood showing partly coalification and partly ferruginization.



2 Z-b. A fragment of petrified wood in fine grained sandstone showing coalification in lower part while upper part is highly jasperified.

Well preserved, few centimeters to few meter sized wood logs (Plate-3a) and petrified wood (Plate-3b) occur in fine grained sandstones of all cycles in BHF. *Petrified wood* at Gehun section is probably formed by tree and plants which completely transformed to rock by the process of permineralization. Under this process, organic material has been replaced with silicate minerals, mainly quartz and Jasper which retained the original structure of the stem tissues. Not being impressions or compressions, petrified wood is simply a three-dimensional representation of original organic material. The petrification process commences when wood is buried under fluvial sediments which are initially passes through the environment with lack of oxygen. Subsequently, mineral-laden water start flowing through the covering material in plantcells; as the plant's lignin and cellulose decay, a stonemould of silica forms in its place *to form petrified wood* (*c.f.* Campbell & Baxter, 1979). It has been found that petrified wood occurring in fine grained sandstone in the lower cycle are partially coalified, silicified and jasperified. This imparts them a beautiful and attractive colors (Plate3c). Wood logs with *Asthenopodichnium* and petrified wood indicate the process of terrestrial fluvial environment. This represents that presently Barmer area which has arid-semi arid climatic conditions presently, was a luxuriant forest during the Paleocene time and a big riverine system was operated here.



Plate-3a



Plate-3b



Plate-3c

Conclusion

The present study explore and analyse that the discovery of these fossils indicates that the arid expanse of western Rajasthan was once a lush, humid, or sub-humid tropical/subtropical forest. The presence of non-flowering plants (such as early gymnosperms) and intermingled marine fossils (like gastropods and foraminifera) suggests that ancient oceans transgressed and regressed across the region, heavily influencing the sedimentation and preservation of these ancient forests.

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