

# Unveiling the Ancient Saraswati: Tracing Paleochannels through Geological Signatures from foothills of Himalayas to Rann of Kutch

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**Abstract:** In ancient times, the glaciers of the Himalayas gave rise to numerous rivers, most of which contributed to the emergence of different civilizations. Among these rivers was the Saraswati River, whose journey spanned from the Himalayas to the Rann of Kutch in Gujarat, shaping the landscapes it traversed. To elucidate the historical course of rivers like the Saraswati, scientists have turned to surface features such as lineaments, faults and joints that provide evidence of deep faults in the Earth's crust. In regions like Haryana, Rajasthan, and Gujarat, several lineament structures have been identified, formed over epochs by processes like volcanism and plutonism. In particular, the Malani Igneous Formation (MIS), one of the largest felsic igneous formations in the world, extends across northwest Rajasthan and southwest Haryana. The formation's distribution is influenced by NE-SW trending lineaments, with notable examples like the Sirohi, Jhunjhunu, and Ganganagar lineaments marking its boundaries. These lineaments, extending from Rajasthan to Haryana, run northeast to southwest and help magma extrusion, facilitating the formation and expansion of the Malani rocks. Using advanced technology such as LANDSAT imagery, geoscientists have identified former river beds, including under the Thar Desert to the Rann of Kutch. This study revealed the existence of paleo-river valleys and important structural trends in the region. The geological structure along the course of the ancient Saraswati River contains important clues to the history of its paleochannels. By analyzing the size and connection to aquifers, researchers can gain insight into the river's evolution and its role in shaping the landscape. This holistic approach not only enriches our understanding of ancient river systems but also promises to influence the development of sustainable water management strategies today.

**Keywords:** Saraswati, Lineaments, Malani Rocks, Paleochannels, Geological significance.

## 1. Introduction

The Saraswati River flows through a long history, emerging as a symbol of cultural and geological importance. Emerging from the melting glaciers of the Bandapanch massif in the Garhwal Himalayas, this river meanders through the foothills, passing famous landmarks such as Adibadri, Bhavanipur, and Bharchapur. Its journey spanned the plains of Punjab, Haryana, Rajasthan, and Gujarat, culminating in a graceful descent into the Arabian Sea at the Great Ranch of Kutch (Validya.1996, Kalyanaraman. 1999).

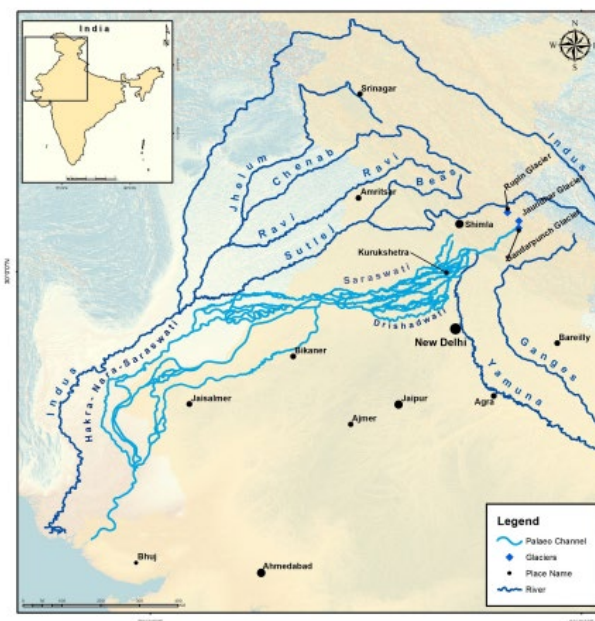


Fig. 1. Map of the Indian subcontinent showing the modern-day significant drainage channels and the Palaeo-Saraswati River system (Chaudhari et al. 2021)

However, Saraswati River flows are different, static, and influenced by the vagaries of geological forces and natural phenomena. Factors such as tectonic movements, earthquakes, and adverse climatic conditions change the course of the river, resulting in its disappearance or disintegration, river piracy, and steady decline of water and this phenomenon has been observed in various paleo-river valleys. These changes were often determined by large tectonic trends called lineaments, which greatly influenced river migration patterns in this region by several scholars (Subramanya.1996, Yashpal.1980, Rao.1999).

A lineament, created by Hobbes, represents a curved feature above the earth's surface that indicates tectonic behavior beneath the earth's surface. In modern times, advances in satellite and airborne technology have enabled comprehensive studies of these linear structures, especially in Rajasthan and Haryana. Here, the lineaments identified in association with the Malani Igneous Group (MIS) structures follow a predominantly

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northeast-to-southwest trend, demonstrating that they play an essential role in shaping the geological landscape of the region. (Hobbs. 1904, Sonder. 1947, Wilson, 1948, Kelley). (1955, Sharma et.al.1982 and Bakliwal.1983)

Several scholars attributed that the migration of the course of the Saraswati River happened because of the influence of tectonic uplifts such as the Delhi-Hardwar ridge and the Aravalli range (Kar and Ghosh. 1984, Bakliwal and Grover, 1999). The great Indian desert and adjacent parts of the western Rajasthan area are dissected by several lineaments, some of which (e.g., Luni–Sukri lineament) were reactivated during the Pleistocene–Holocene period bringing about the alignment of Saraswati with Ghaggar (Bakliwal and Ramaswamy.1983). Sirohi, Jhunjhunu, and Ganganagar lineaments are located at the Western boundary of MIS and these lineaments of Rajasthan are extended to Haryana and show NE-SW trends.

The purpose of this study is to address the complex relationship between linear structures and ancient river channels while highlighting the importance of exploiting these geological features for the study of paleo-fluvial channels. By drawing the attention of geoworkers to the application of linear structures in paleochannel studies, we aim to unravel the mysteries of the ancient channel of the Saraswati River and reveal its deep geological significance.

## 2. Discussion

Lineaments are subtle but influential features carved into the Earth's surface and are subject to global interpretation by geoworkers. These linear structures are also called "deflected drainages." This is because they have a significant impact on river channels and often create large diversions in the flow path. Along river channels, lineaments serve as notable markers, appearing as crests of ridges or defining boundaries of elevated areas, drainage lines, coastlines, and geological formations. The relationship between geomorphology, drainage patterns, and lineaments is discernible through satellite imagery and digital topography, offering valuable insights into the dynamic interplay between Earth's surface features and its hydrological systems.

## 3. Case Studies

### A. The Bighorn Mountains in the United States

This mountain range extends from north to south and towards the northwest. Within this region, there is a structural break between the Pyrope Mountains and the Bighorn Mountains, both of which are influenced by the Tongue River lineage (Hoppin and Jenninos, 1971). This particular line shows that the flow of natural forces is heading west along the way. As a result, the direction of some river channels may have changed from south to north areas, illustrating the complex ways in which geological features shape the landscape.

### B. Western Amazon Basin Near Manaus, South America

Here we encounter three different tectonic elements: the Ariau Trench, the Castaño-Mamori Trench, and the Manacapuru Basin. The Ariau and Castaño-Mamori grabens

form a unique rectangular asymmetric northeast-southwest landform characterized by faulting in several directions: northwest-southeast, northeast-southwest, and north-south. These faults are displayed as relief and drainage lines extending in the corresponding directions. On the other hand, the Manacapuru Basin consists of a depression bounded on the north and south by east-west strike-slip faults and on the east and west by northeast-southwest trending normal faults dipping to northwest and southeast. Interestingly, the abrupt changes in the Solimões River channel in this region can be attributed to the faults that limit the Manacapuru Basin. This case highlights the important role of neotectonics in shaping fluvial morphology and sedimentary processes in the western Amazon Basin and illustrates the complex relationship between geological forces and landscape evolution.

### C. The Flowing Pattern of the Chenab River Near Raoli in the Lahul-Spiti District of Himachal Pradesh, India

Here we can see that the river course is influenced by his two different set of lineaments (Sharma.2015). One set controls the flow of the major river, while the other set governs a smaller river channel known as Nallah. Additionally, the direction of lower order streams is influenced by lithology, resulting in a varied pattern of sub-parallel, parallel, and dendritic channels. By drawing parallels with these important features of the lineament, similar studies can be applied to understand the course of the Saraswati River. Flowing in the northeast-to-southwest direction, mirroring the lineaments of Haryana, Rajasthan, and Gujarat, the Saraswati River followed a path similar to that of the Ghaggar River in present-day Haryana, transitioning into the Hakra River in Rajasthan, and further into the Nara River in Sindh (Chauhan.1999). This comparison sheds light on the geological factors influencing ancient river courses and their relevance in understanding past civilizations.

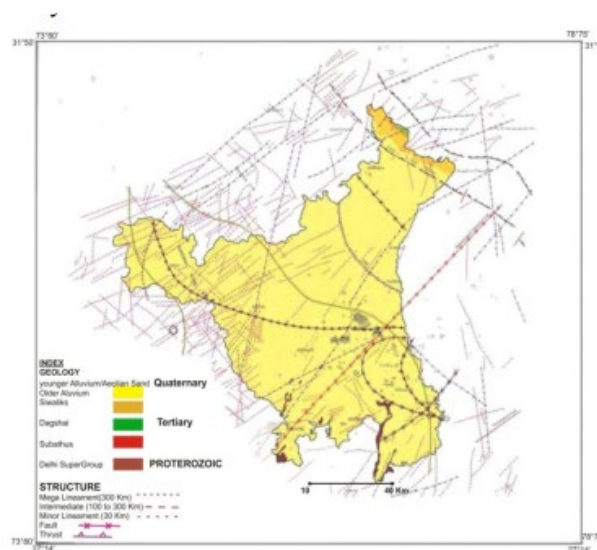


Fig. 2. Seismotectonic map of Haryana (GSI, 2016)

Lineaments observed in Haryana, Rajasthan, and Gujarat provide interesting insights into the geological features of different rock types of different ages. Figure 2 shows that these

lineaments mainly trend in an NNE-SSW to NE-SW direction and are consistent with the Aravalli fold axis. However, their length is relatively limited, typically up to 30 kilometers. In contrast, in Rajasthan and Gujarat, the characteristics of these lineaments exhibit both linear and curvilinear expressions, with lengths ranging from as short as 2 kilometers to well over 1000 kilometers. This variability in length and form highlights the complex geological processes at play in shaping the landscape of these regions.

After a comprehensive study of the geology, structure, magmatism, mineralization and deep geophysical features of the river, several lineaments have been identified and discussed by researchers such as Ray, Sharma, Bakliwal, and Ramasamy in Rajasthan and Gujarat. These lineaments exhibit alignments primarily in the NNE-SSW, NW-SE, and ENE-WSW directions, displaying systematic placement that significantly influences the regional geology and tectonic evolution of sedimentary basins from the Proterozoic to recent times (Bakliwal and Ramaswamy.1983).

Some notable lineaments in Rajasthan and Gujarat include Udaipur-Sardarpur, Rakhabdev Lineament, Kishangarh-Chhipri Lineament, Pisangan-Vadnagar Lineament, Sadri-Palanpur Lineament, Sirohi-Disa Lineament, Luni-Sukri Lineament, West Coast Lineament, Jaisalmer-Barwani Lineament, Ajmer-Sandia Lineament, and Raisinghanagar-Tonk Lineament (Bakliwal and Ramaswamy.1987). Around the world, paleochannel studies play an important role in identifying areas of productive freshwater areas, highlighting their importance for water resource management and geological research.

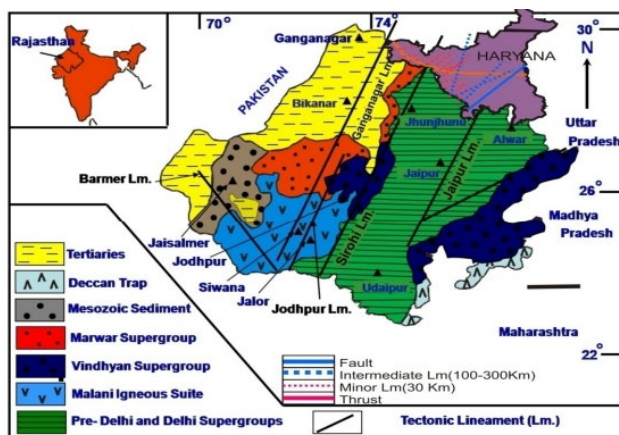


Fig. 3. Geological Map of Rajasthan and Haryana showing the aerial extent of the Malani Igneous Province. Also showing the major tectonic Lineaments (Lm.) (Modified after Pareek (Sharma, 2019)

Studies of the lineament along the Luni River have provided valuable insights into various aspects such as drainage patterns, tectonics, hydrogeology, groundwater potential, and gravity contours (Rajawat *et al.* 1999, Mitra and Balram 2012). Analysis using techniques such as Rose diagrams has further improved our understanding of these lineaments. In the Jaisalmer Basin, major lineament trends indicate the predominant direction of paleochannels of the Saraswati River system, primarily aligning with the NE-SW to ENE-WSW

directions (Figure 3). A multitude of intermediate and minor paleochannels are observed along these trends in Rajasthan and Gujarat. The river's linear course suggests its alignment with major deep-seated weak zones in the region.

Throughout its existence, the Saraswati River played an important role by causing floods, depositing large amounts of sediment, and forming deltas. Understanding the geological structure along the course of the ancient Saraswati River provides a deeper understanding of the history of the paleochannel, including its dimensions and connections to aquifers containing high-quality water.

Lineaments play an important role in identifying subsurface groundwater resources and identifying geological features such as alluvium fields, river terraces, and karst fields. Additionally, it provides valuable information for understanding drainage network patterns, identifying landslides, detecting levee failures, and selecting locations for civil engineering projects such as dams. Additionally, lineaments may be associated with seismic activity, providing insight into seismic phenomena and their potential impact on landforms.

#### 4. Concluding Remarks

Malani Magmatism, which straddles Haryana, Rajasthan and Gujarat, is influenced by northeast-southwest lineament structures that cut through rocks of various ages from Archean to Cenozoic periods. These lineaments have played an important role in the tectonic deformation of various sedimentary basins formed mainly by volcanic and plutonic activities. The extension of Malani rocks in Rajasthan and Haryana, along with major structural trends observed in Gujarat, underscores their significance in regional geology.

The alignment of the Saraswati River along these regions highlights the possibility of identifying paleochannels and provides valuable insights into groundwater balance and connectivity with aquifers containing high-quality water. Understanding the geological framework formed by these lineament structures is important for elucidating the history of river channels and their impact on groundwater resources.

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