
Artículo

Selected historical quarries of India: an account

Canteras históricas selectas de la India: un relato

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Abstract: Diverse stones and rocks have played a crucial role in shaping the monumental architectural heritage of India. Sourced from historical quarries scattered across the Indian subcontinent, these rocks have served as a vital link to our rich past cultures and traditions. Each stone narrates a story, reflecting the craftsmanship and creativity of previous eras. Acknowledging the significance of these stones and the quarries is essential for celebrating and preserving our cultural legacy. By recognizing these stones and qaurries, we ultimately nurture a deeper appreciation for the cultural identity that has evolved over centuries. Indian subcontinent is well endowed with rocks like marble, basalt, sandstone, charnockite, granite, limestone, laterite, to name a few. Some of these stones are inherent part of well-known UNESCO World Heritage Sites, such as the Taj Mahal (Makrana Marble), Jaisalmer Fort (Jaisalmer Limestone), Elephanta, Ajanta and Elora caves (Deccan Basalt), the Qutb Minar complex (Alwar Quartzite), Group of monuments at Hampi (Closepet granite) and Konark Sun temple (Khondalite), Mamallapuram Shore Temple (Indian Charnockite), Basilica of Bom Jesus (Western Ghats Laterite) so on and so forth. Recently, seven stones from India viz. the Makrana Marble, the Jaisalmer Limestone, the Deccan Basalt, the Alwar Quartzite, the Himachal Slate, the Indian Charnockite and the Western Ghats Laterite have been recognised as 'IUGS Heritage Stones'. This paper will focus on a few noteworthy stones and the ancient quarries that produced them. The significant architectural heritage crafted in these stones have experienced some deterioration as a result of anthropogenic and natural factors. As a result, it is crucial to retrieve stones from the historical quarries of these significant rocks for restoration work and to understand how quarrying practices have changed through time. It is important to conserve and preserve the historical quarries for posterity.

Keywords: stones; historical quarries; monuments; India

Key points:

This paper aims to explore the historical quarries associated with some of India's well acclaimed monuments.

By examining these ancient quarries, we can gain insights into the geology of the stones, cultures and traditions revealed through these stone-built structures, quarrying practices in the past and the impact of these practices on the preservation of our heritage sites.

Through this investigation we explore ongoing efforts to safeguard these stone quarries for future generations.

Resumen: Diversas piedras y rocas han desempeñado un papel crucial en la formación del monumental patrimonio arquitectónico de la India. Extraídas de canteras históricas dispersas a lo largo del subcontinente indio, estas rocas han servido como un vínculo vital con nuestras ricas culturas y tradiciones pasadas. Cada piedra narra una historia, reflejando la artesanía y la creatividad de eras previas. Reconocer la significancia de estas piedras y las canteras es esencial para celebrar y preservar nuestro legado cultural. Al reconocer estas piedras y canteras, finalmente nutrimos una apreciación más profunda por la identidad cultural que ha evolucionado a lo largo de los siglos. El subcontinente indio está bien dotado de rocas como mármol, basalto, arenisca, charnockita, granito, caliza, laterita, por nombrar algunas. Algunas de estas piedras son parte inherente de conocidos Sitios de Patrimonio Mundial de la UNESCO, tales como el Taj Mahal (Mármol de Makrana), el Fuerte de Jaisalmer (Caliza de Jaisalmer), las cuevas de Elephanta, Ajanta y Ellora (Basalto del Decán), el complejo del Qutb Minar

(Cuarcita de Alwar), el Grupo de monumentos en Hampi (Granito de Closepet) y el Templo del Sol de Konark (Khondalite), el Templo de la Orilla de Mamallapuram (Charnockita India), la Basílica del Bom Jesus (Laterita de los Ghats Occidentales) y así sucesivamente. Recientemente, siete piedras de la India, a saber, el Mármol de Makrana, la Caliza de Jaisalmer, el Basalto del Decán, la Cuarcita de Alwar, la Pizarra de Himachal, la Charnockita India y la Laterita de los Ghats Occidentales han sido reconocidas como 'Piedras de Patrimonio de la IUGS'. Este artículo se centrará en unas pocas piedras notables y las antiguas canteras que las produjeron. El significativo patrimonio arquitectónico elaborado en estas piedras ha experimentado cierto deterioro como resultado de factores antropogénicos y naturales. Como resultado, es crucial recuperar piedras de las canteras históricas de estas rocas significativas para trabajos de restauración y para entender cómo las prácticas de cantería han cambiado a través del tiempo. Es importante conservar y preservar las canteras históricas para la posteridad.

Palabras clave: piedras; canteras históricas; monumentos; India

Puntos clave:

Este artículo tiene como objetivo explorar las canteras históricas asociadas con algunos de los monumentos más destacados de la India.

Al examinar estas antiguas canteras, podemos obtener conocimientos sobre la geología de las piedras, las culturas y las tradiciones reveladas a través de estas estructuras construidas en piedra, las prácticas de extracción en el pasado y el impacto de estas prácticas en la preservación de nuestros sitios patrimoniales.

A través de esta investigación exploramos los esfuerzos en curso para salvaguardar estas canteras de piedra para las generaciones futuras.

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Supplementary information ↓

1. INTRODUCTION

The utilisation of stones in our monuments, abodes, infrastructure, antiquities, artwork, household equipment serves as a vital link to our heritage, culture and tradition capturing stories that span centuries (Kaur, 2022a, 2022b; Kaur *et al.*, 2021a; Ehling *et al.*, 2024). The aim of this article is to highlight the profound significance of the stones and the quarries that produced them. They are not merely resources, they are enduring symbols of our past, allowing us to connect with the civilizations that shaped our identity and continue to influence our cultural evolution.

When ancient monuments are examined, it often indicates that the stones used in their construction were quarried from specific locations. Typically, the provenance of these stones is found to be in close proximity to the monuments themselves. This practical approach allowed builders to utilize readily available resources, streamlining the construction process. However, there are intriguing exceptions that reveal the broader trade networks and the significance of certain materials. One of the most iconic examples is of Makrana Marble, well known for its utilization in Taj Mahal. This stunning marble of the Taj was sourced from Makrana, located approximately 400 kms west-southwest of Agra. This marble, celebrated for its beauty and quality, was transported to Agra using bullock carts, showcasing the remarkable logistical skills and dedication required for such a monumental undertaking. Another noteworthy example is the approximate 1700 Km transportation of a high grade metamorphic rock

(commonly known as charnockite) quarried from Saint Thomas Mount in Chennai (Tamil Nadu) to Calcutta (West Bengal) in the 17th century, to construct the tomb of Job Charnock (an English administrator of East India Company). This high-grade metamorphic rock was then named as Charnockite in honour of Job Charnock. This article will explore the historical quarries of significant stones that have played an essential role in our understanding of ancient quarrying practices. These quarries have not only supplied the materials for some of India's most iconic monuments but have given us insights into the geological record of the stone, our history, past cultures and traditions. As we examine these quarries, we uncover information about historical trade routes, local economies, and even cultural exchanges that would have otherwise remained obscured.

2. STONES OF INDIA

India's rock diversity and rich history of use of stones in architectural heritage provides a fascinating glimpse into its past cultures and traditions. The Indian subcontinent is home to various rock types viz. marble, granite, sandstone, basalt, laterite, charnockite, and limestone, and many more each contributing to the distinctive architecture seen throughout the country (Kaur *et al.*, 2019a, 2019b; Kaur *et al.*, 2020a, 2020b, 2020c, 2020d; Kaur *et al.*, 2021a, 2021b; Sreejith *et al.*, 2021; Garg *et al.*, 2019, 2022; Sen *et al.*, 2022; Kaur *et al.*, 2023; Ehling *et al.*, 2024). Recently, seven of the remarkable stones from India viz. Makrana Marble (Garg, 2019), Jaisalmer Limestone (Kaur *et al.*, 2020a), Deccan Basalt (Kaur *et al.*, 2019a), Alwar Quartzite (Kaur *et al.*, 2021b), Indian Charnockite (Sreejith *et al.*, 2021), Himachal Slate (Kaur *et al.*, 2020b), Western Ghats Laterite (Kaur *et al.*, 2023), have been recognized as 'IUGS Heritage Stones', underscoring their significance in both geological and cultural contexts (Kaur, 2022a, 2022b; Ehling *et al.*, 2024). Each stone contributes uniquely to the architectural style that define India's rich cultural heritage.

The famed white marble from Makrana is perhaps the most renowned globally for its use in the Taj Mahal. This architectural masterpiece, built during the Mughal era, epitomizes grandeur. Granite and granulite from southern India have been fundamental to temple architecture. The ancient city of Hampi, a UNESCO World Heritage site, exemplifies this with its breathtaking structures carved from Closepet Granite. Similarly, the Mamallapuram Shore Temples, another UNESCO site, are masterpieces of rock-cut architecture, carved from Indian Charnockite. The Khondalite is another interesting rock which has been quarried from the eastern Ghats region of India and has been ornately used in the Sun Temple of Konark. The Deccan Basalt from the Deccan plateau exhibits the most impressive rock-cut caves from western India. The Ajanta, Ellora and Elephanta cave monuments carved in basalt and decorated with intricate murals and sculptures narrate tales of Buddhist, Hindu, and Jain traditions. The rock cut caves and scores of forts and temples of basalt in this western part of India highlights the region's geological resources and the ingenuity of its creators. The laterite from the western Ghats region of India provides a unique architectural experience. Laterite has been widely used in constructing traditional houses and temples, cathedrals and forts. The use of laterite in Goa and vicinity exhibits a confluence of various architectural styles, showcasing the region's rich cultural diversity. The sandstone from the Vindhyan Basin has significantly shaped the architectural landscape of North and Central India. Commonly known as 'Vindhyan Sandstone', it is prominently featured in the Red Fort and the Taj Mahal complex in Agra, where its warm hues enhance the grandeur of these monumental sites. The temples of Khajuraho, with their intricate carvings and stunning sculptures, alongside the historic Chittorgarh Fort, further exemplify the versatility of sandstone from Vindhyan Basin, highlighting its ability to convey artistic expression and historical accounts. In the arid landscapes of Rajasthan, the distinctive yellow limestone of Jaisalmer, often referred to as "golden stone," has been skillfully crafted into temples, havelis, and forts, with intricate carvings and as common abodes that narrate the accounts of the past. The Alwar quartzite known for its durability and strength was mainly used in fortification and core structures in many forts in north India. In the hilly regions of Himachal Pradesh, slate is a natural choice of local architecture. Valued for its durability and aesthetic appeal, slate serves as an ideal roofing material, often combined with wood to create earthquake-resistant structures. This practical use reflects the region's adaptation to its geological environment, while also contributing to the unique character to the homes and temples cradled in the mountains.

3. HISTORICAL QUARRIES OF INDIA

The locations of some of the historical quarries that provided stones for the architectural heritage of India are given in Figure 1. A more detailed discussion follows in the ensuing text.

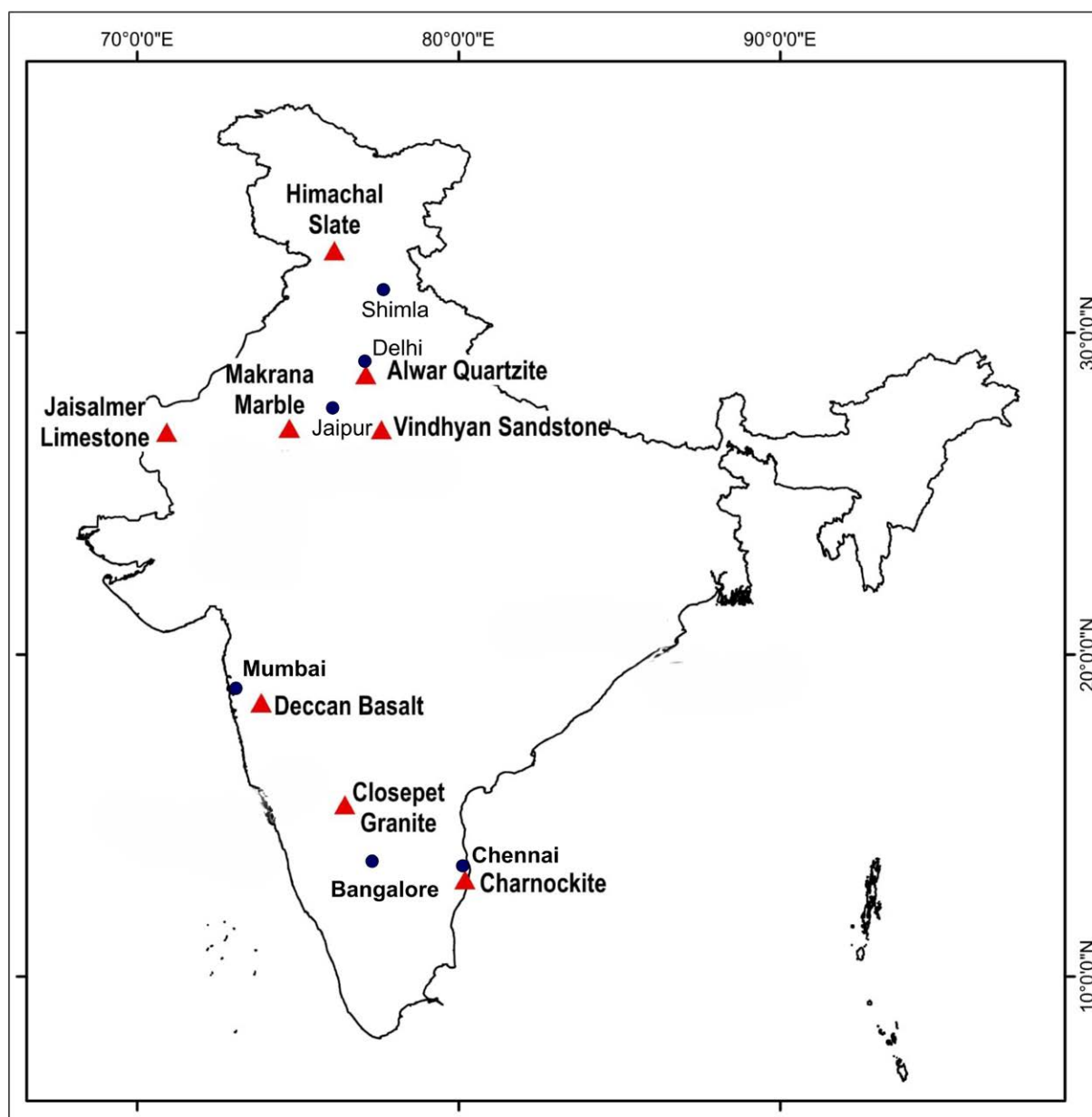


Figure 1. Map of India with historical quarry sites and major cities in vicinity.

Figura 1. Mapa de la India con canteras históricas y las principales ciudades cercanas.

3.1. Makrana Marble: The Glory of Taj Mahal

The famed white marble from Makrana which is also an IUGS designated 'IUGS Heritage Stone' is perhaps the most iconic of India's stones, renowned globally for its use in the Taj Mahal (Figure 2). Makrana Marble has been quarried near Makrana, Rajasthan, for over four hundred years. The town currently hosts around 800 odd quarries, ranging from small manual operations to larger semi-mechanical ones, employing mainly unskilled to semi-skilled workers, many of whom are descendants of Iranian families who migrated during Shah Jehan's reign. The marble sourced from these quarries has been used in UNESCO World Heritage sites like the Taj Mahal and the Agra Fort. Most quarries are smaller, with Bhadra *et al.* (2007) identifying about 550 operational quarries as of 2003, while a 2017 satellite image shows 745 functional sites. The best Makrana White marble is predominantly quarried

from the Devi-Gunawati range, with notable quarries at Chousira, Ulodi, and Pahad Kuan (Garg *et al.*, 2019; Kaur *et al.*, 2020d and references cited therein). However, continuous quarrying has led to deeper pits and safety concerns in the region. The marble's exquisite sheen, combined with the ease for engraving and the intricate inlay work using semi-precious stones, creates a profound effect that adds a magical charm to the monuments created using Makrana Marble (Kaur *et al.*, 2020d; Figure 2).

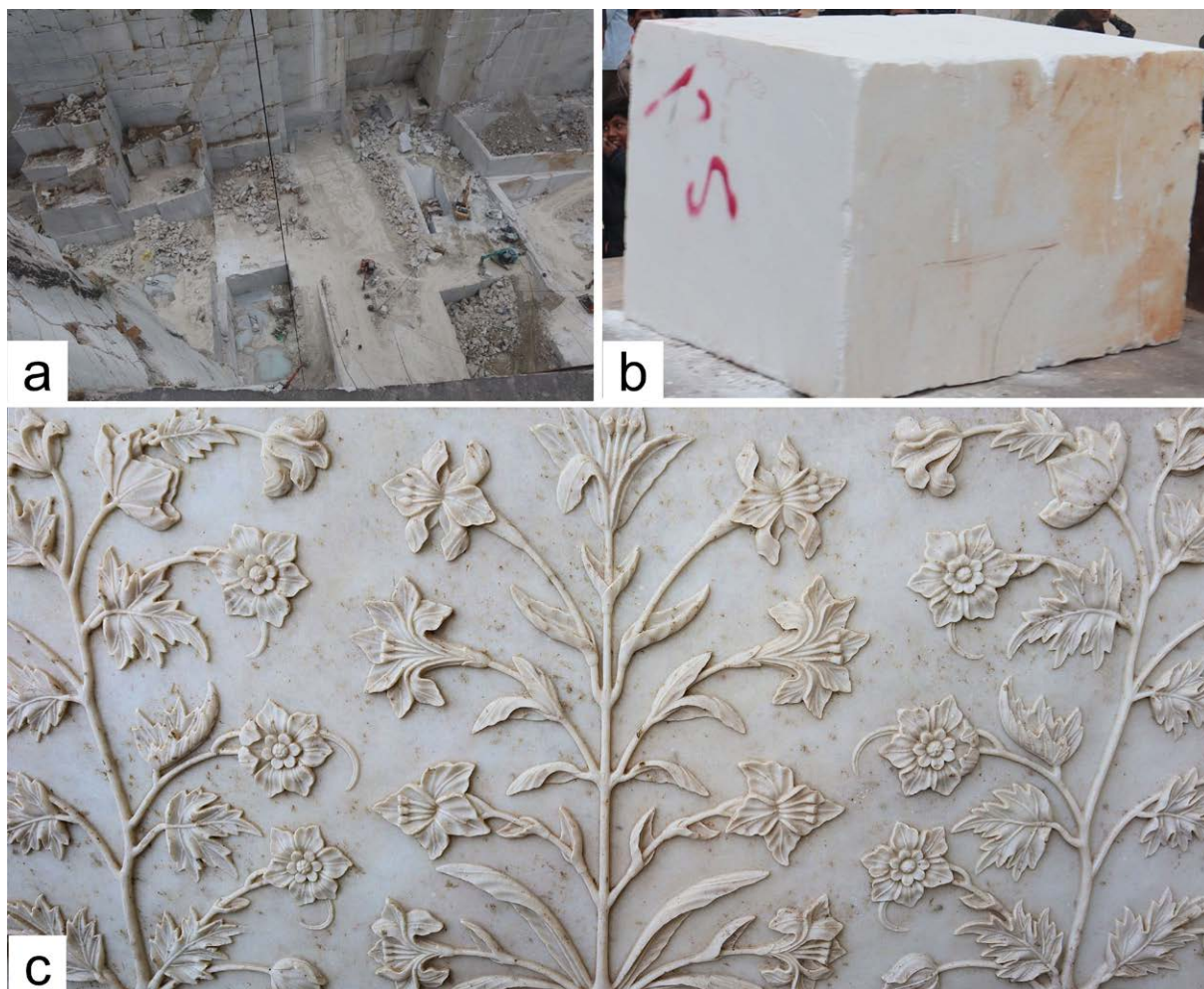


Figure 2. a. Makrana Marble quarry; b. Makrana Marble; c. Floral motif in Makrana Marble (photo credit: Luis Lopes).

Figura 2. a. una cantera de mármol Makrana; b. Mármol Makrana; do. Motivo floral en mármol Makrana (crédito de la foto: Luis Lopes).

The three “Imperial Firmans” issued by Emperor Shah Jahan addressed to Mirza Raja Jaisingh of Amer regarding marble supply from Makrana for the Taj Mahal are archived in the Bikaner Archives, Rajasthan, and cited in Nath (1985). These documents confirm that the marble used in the Taj Mahal came from Makrana quarries in the Ajmer province during the Mughal period and continued to be sourced from the region during the British period, now part of present-day Rajasthan (Kaur *et al.*, 2020d and references cited therein).

The first, second and third translated Firmans/imperial orders extracted from Nath (1985) are given below:

The first translated Firman/imperial order dated 21st January 1632 “As a great number of carts is required for transportation of marble needed for constructing buildings (at the Capital), a firman was previously sent (to you to procure them). It is, again, desired of you that as many carts on hire be arranged as possible at the earliest time, as has already been written to you, and be sent to Makrana for expediting the transport of marble to the Capital (Agra). Every assistance be given to Allāh-dād (Khan) who has been deputed to arrange transportation of marble to Akbarabad (Agra). Account (of the expenditure on carts) along with the previous account of amounts allocated for the purchase of marble be submitted to the (Mutasaddi) in-charge of payments.”

The second translated Firman dated 9th September 1632 “Malük Shäh has been deputed to Ambar (Amer) to bring marble from the new mines (of Makrana). It is commanded that carts on hire be arranged for transportation of marble, and Maluk Shah be assisted to purchase as much marble as he may desire to have. The purchase price of marble and cartage shall be paid by him from the Royal Treasury. Every other assistance be given to him to procure and bring marble and sculptors to the Capital expeditiously.”

The third translated Firman dated 21st June 1637 “We hear that your men retain the stone-cutters (sang-tarāsh) of the region at Ambar (Amer) and Rajnagar. This creates shortage of stone-cutters (miners) at Makrana and the work (of procuring marble) suffers. Hence, it is desired of you that no stone cutter be detained at Ambar and Rajnagar, and all available miners be sent to the Mutasaddis of Makrana (so that marble be procured in large quantities to be dispatched to the Capital for building purpose”.

Erskine (1908) further documented the quarries of Makrana Marble and its use in building the Victoria memorial of Calcutta in his accounts. The excerpt from Erskine (1908) is given below:

“Village in the Parbatsar district of the State of Jodhpur, Rajputana situated in 27° 3' N and 74° 44' E, on the Jodhpur-Bikaner Railway. Population (1901), 5, 157. The village derives its importance from its marble quarries, which have been noted for centuries, and from which the material used in the construction of the Taj Mahal at Agra was obtained. It has been proposed to use this marble for the Victoria Memorial Hall at Calcutta. The quarries vary in depth from 30 to 75 feet and the yearly out-turn averages about 900 or 1000 tons. The marble is excavated by blasting, and is then cut into required sizes by means of steel saws. The chips and dust left behind after the blocks have been hauled to the surface are burnt into lime and used for the finer kinds of plastering. There are now twenty-six quarries being worked, which give employment to about 100 labourers daily, mostly of the Silawat caste of Muhammadans” (Web Source: <https://archive.org/details/in.ernet.dli.2015.207013/page/n233>).

3.2. Vindhyan Sandstone: a legacy to architectural heritage

The Vindhyan sandstone of the Vindhyan Basin has significantly shaped the architectural landscape of North and Central India (Figure 3). This vibrant sandstone is prominently featured in scores of structures throughout the northern and central India. The Red Fort of Delhi and Agra, Fatehpur Sikri and the Taj Mahal complex in Agra invariably are known for the red variety of the Vindhyan Sandstone, where the warm hues of red enhance the grandeur of these monumental sites (Kaur *et al.*, 2019b). The temples of Khajuraho, with their intricate carvings and stunning sculptures, alongside the historic Chittorgarh Fort, further exemplify the versatility of beige to buff Vindhyan sandstone, highlighting its ability to convey artistic expression and historical account.

The historical quarries of Vindhyan Sandstone yielded high-quality sandstone from places like Bansi Paharpur, Dholpur, Bharatpur, Karauli, Sawai Madhopur, Bundi, Kota, Jhalawar, Baran, Bhilwara and Chittorgarh, characterized by varying hues of red, beige, buff, brown, and white spotted in red, making it both aesthetically pleasing and functional. The following excerpts from Eriksine (1908) explain further the supply of sandstone from the historical quarries of the Vindhyan Basin.

“Sandstone is plentiful almost everywhere, varying greatly in texture and colour. The most famous sandstone quarries are at Bansi Paharpur in Bharatpur State; they have furnished materials for the most celebrated monuments of the Mughal dynasty at Agra, Delhi, and Fatehpur Sikri, as well as for the beautiful palaces at Dig. There are two varieties of this stone: namely, a very fine-grained yellowish white and a dark red, speckled with yellow or white spots. The quarries give employment to 450 laborers, and the out-turn is about 14,000 tons a year.” (Web Source: <https://archive.org/details/in.ernet.dli.2015.207013/page/n87>).

“The famous sandstone quarries at Bansi Paharpur furnished materials for the most celebrated monuments of the Mughal dynasty at Agra, Delhi, and Fatehpur Sikri, as well as for the beautiful palaces at Dig. The stone is of two varieties: namely, dark red, generally speckled with yellowish white spots or patches; and a yellowish white, homogeneous in colour and texture, and very fine-grained. The red variety is inferior for architectural purposes to the white, but is remarkable for perfect parallel

lamination; and, as it readily splits into suitable flags, it is much used for roofs and floors. The annual outturn is about 14,000 tons, of which about two-thirds are sold to the public on payment of royalty, and the balance is utilized for State works. These quarries give employment to some 450 labourers who are mostly Ujhas (or carpenters) residing in the neighbourhood, and whose monthly earnings average Rs.6 to Rs.10 per head.’ (Web Source: <https://archive.org/details/in.ernet.dli.207013/page/n363>).

“The red sandstone of Dholpur is most valuable for building purposes; fine-grained and easily worked, it hardens by exposure, and does not deteriorate by lamination. The principal quarry is at Narpura, 4 miles north-west of the capital, with which they are connected by a railway siding, and near Bari; they are worked on the petty contract system, and in 1900-1 yielded a net profit of Rs. 13,300, which had increased to Rs. 21,300 in 1904-5.” (Web Source: <https://archive.org/details/in.ernet.dli.207013/page/n379>).

“Headquarters of a tehsil of the same name in the State of Bharatpur, Rajputana, situated in 26° 59’N and 77° 39’ E about 19 miles south-by-south-east of Bharatpur city..... In the vicinity of Rupbas are some enormous stone obelisks and images. The oldest is a sleeping figure of Baldeo cut in the rock, 22 ½ feet long, with a seven serpent-hooded canopy and an inscription dated A.D. 1609. About 8 miles to the south-west are the famous sandstone quarries of Bansi Paharpur, which have supplied material for the beautiful palaces at Dig and for many of the buildings at Agra and Fatehpur Sikri’ (Web Source: <https://archive.org/details/in.ernet.dli.207013/page/n373>).

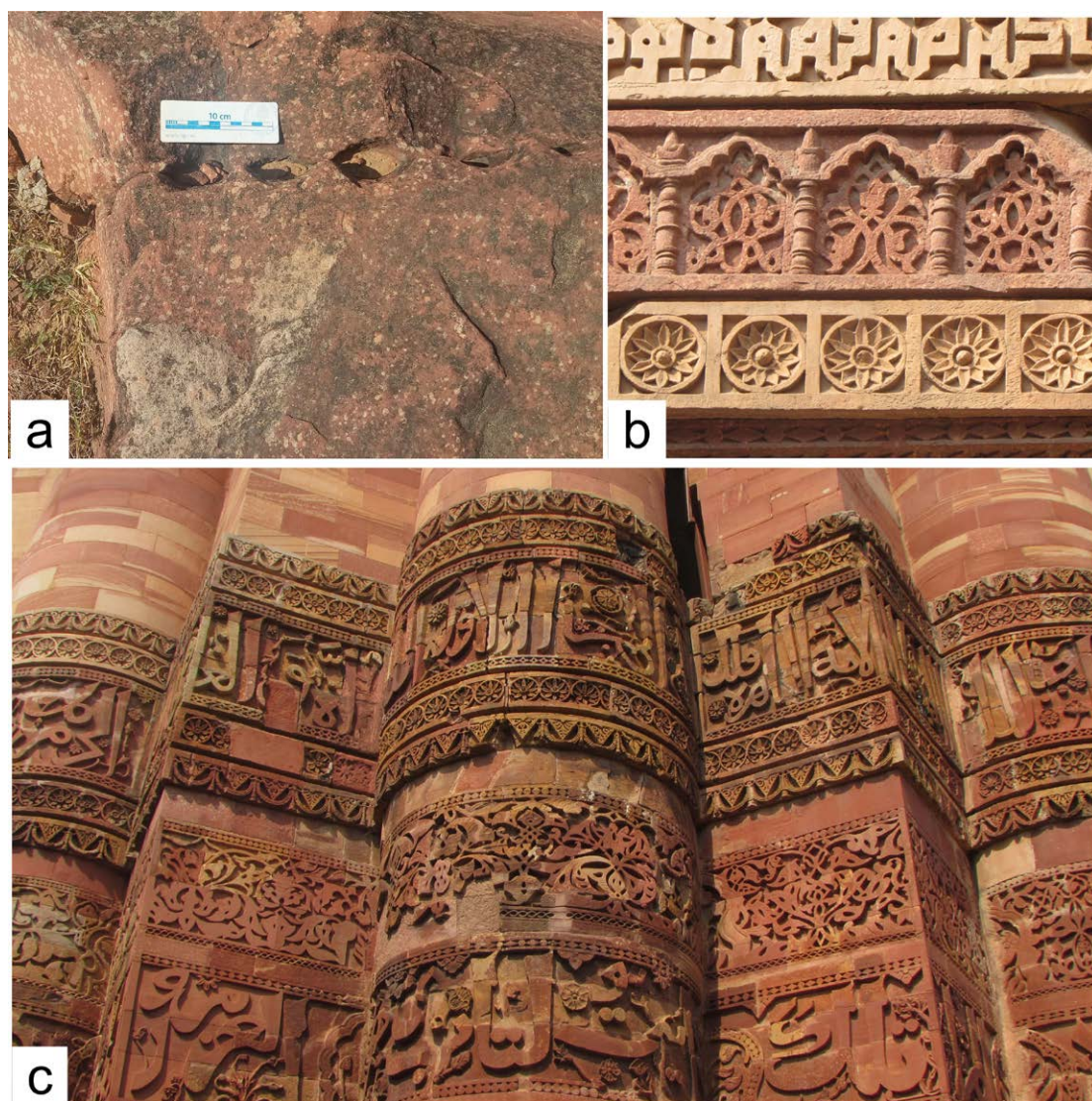


Figure 3. a Historical quarry of Vindhyan sandstone with quarry marks; b and c. Carved Vindhyan Sandstone with varying shades of colours.

Figura 3. a Cantera histórica de arenisca de Vindhyan con marcas de cantera; b y c. Arenisca de Vindhyan tallada con diferentes tonalidades de colores.

3.3. Alwar Quartzite: symbolic of robustness

Alwar Quartzite was extensively used in the core structures of the Qutb Minar and is featured in many buildings within the Qutb Complex and Humayun's Tomb Complex. It has also been a favored material for fortifications in many noted Indian forts such as Old Fort (Purnala Qila) and Red Fort of Delhi, Amer Fort and Bhangarh Fort of Rajasthan, to name a few (Figure 4). The Alwar Group quartzite formations in the Delhi region manifest as low-lying outcrops that rise above the surrounding Quaternary alluvium. The exposure of Alwar Quartzite in the Delhi Ridge also referred to as the Delhi Quartzite Ridge was once a continuous feature extending for kilometers, but urbanization has led to its current sporadic visibility. The general orientation of the Delhi Ridge trends NNE-SSW in the northern and central parts of Delhi, shifting to WNW-ESE and E-W in the southern and south-central areas. As the ridge broadens towards the south, particularly in the Surajkund area of Haryana, it merges with a larger quartzite plateau south of Tughlaqabad. In South Delhi, notable Alwar Quartzite outcrops can be found in locations such as Tughlaqabad, Noor Nagar, Jasola, Abul Fazal Enclave, Jaunapur, Okhla, the Bhatti mines area, Asola, Mandi, Greater Kailash, Aya Nagar, Vasant Vihar, Mahipal Pur, Ghitorni, Jawaharlal Nehru University, Vasant Kunj, Naraina, Pusa, Dhaula Kuan, and Nicolson Lines. Notable exposures within New Delhi include areas like Buddha Jayanti Park, the Raisina Hills, Birla Mandir, Mahavir Banasthali, and the American Embassy School. Historically, large-scale quartzite quarrying took place in the early twentieth century at sites such as Lal Kuan, Jhandewala, Paharganj, Rathia Lado Sarai, Kalkaji, and Mehrauli. However, this practice was later banned by the Supreme Court of India due to its significant environmental impact, threatening the natural habitats of numerous plants and wildlife (Kaur *et al.*, 2020d; Kaur *et al.*, 2021b and references cited therein). The Alwar Group quartzite is particularly well-developed in the Alwar-Jaipur sub-basin, where it has been identified by various names, including Mortalab Quartzite, Mohioni Conglomerate, Kanawar Quartzite, and Lakhanpur Sandstone. In the Alwar-Jaipur sub-basin, quartzite quarries are located along the steep ridges and hills that define the landscape.

3.4. Jaisalmer Limestone: the golden stone

The Jaisalmer limestone in the vicinity of Jaisalmer city was the source of numerous structures built in and around Jaisalmer (Figure 5). Some of the noteworthy historical quarries at Amarsagar, Lodurva, Bada Bag, Moolsagar, Cipala, Jethwai, and Hamira are still producing yellow limestone for consumption in local and international markets (Kaur *et al.*, 2020a; Ehling *et al.*, 2024). The following excerpts provide insights into the quality of the stone and kind of structures built in the past using this stone.

"Yellow Marble of excellent quality, easily polished and carved, is met with at Jaisalmir. The plateau on which the capital stands is principally composed of this yellow marble; it is very extensive, and from it most of the building stone used for carving and roofing is now taken. This stone is also exported" (Adams, 1899; p. 24).

"The houses have beautifully carved fronts, to which the yellow marble of hills in and around Jaisalmir lends itself, as it is easily chiseled when first quarried, and becomes harder on exposure. Some of the houses of the Seths have such beautifully carved fronts, that it is at first sight difficult to realize that work is in stone. Nearly every house of any importance in the city has a carved balcony, balustrade, or latticed window, and ornamented porches and columns supporting ornamented projections of stone are very common. The house of the notorious Dewan Salem Singh, who devastated the country nearly a hundred years ago with his extortion and cruelty, is magnificently carved, and towers above the rest of the city, it is a very grand edifice of six storeys of cut stone, with cupolas and much ornamentation, especially on the top storey. Nath Mal, the late Dewan, during his time of office, built himself a fine house, on the front of which much beautiful carving is displayed. The late Maharawal, Bairi Sal, built a new palace and erected a carved edifice on it in the form of a watch-tower, which displays some of the finest workmanship of Jaisalmir in stone. A new house for the present Maharawal is approaching completion; it is built of the yellow marble of the place, having its windows and chhatris handsomely carved and of beautiful design; when completed, it will add to the architectural beauty of the place. Around the city are many fine houses and chhatris of the same yellow stone, minutely worked into a great variety of designs". (Adams, 1899; p. 88–89).

“There are several quarries of limestone near the capital; the stone produced is very fine, even-grained, and compact, of a buff or light-brown colour, and admirably adapted for carving. It takes a fair polish, and was at time used for lithographic blocks.” (Erskine 1908; p. 212).

“The houses are all substantially built of stone and mortar and flat-roofed. Most of them have beautifully carved fronts of yellow limestone found locally, which is chiseled when first quarried, and becomes harder on exposure. The Jain Temples in the fort are very fine, the carving in them being exquisite; some of them are said to be 1,400 years old.” (Erskine 1908; p. 216)



Figure 4. a. Historical quarry of Alwar Quartzite; b. use of Alwar Quartzite in stone masonry; Alwar Quartzite as core structure clad by red sandstone.

Figura 4. a. Cantera histórica de cuarcita de Alwar; b. uso de la cuarcita de Alwar en mampostería; cuarcita de Alwar como estructura central revestida de arenisca roja.

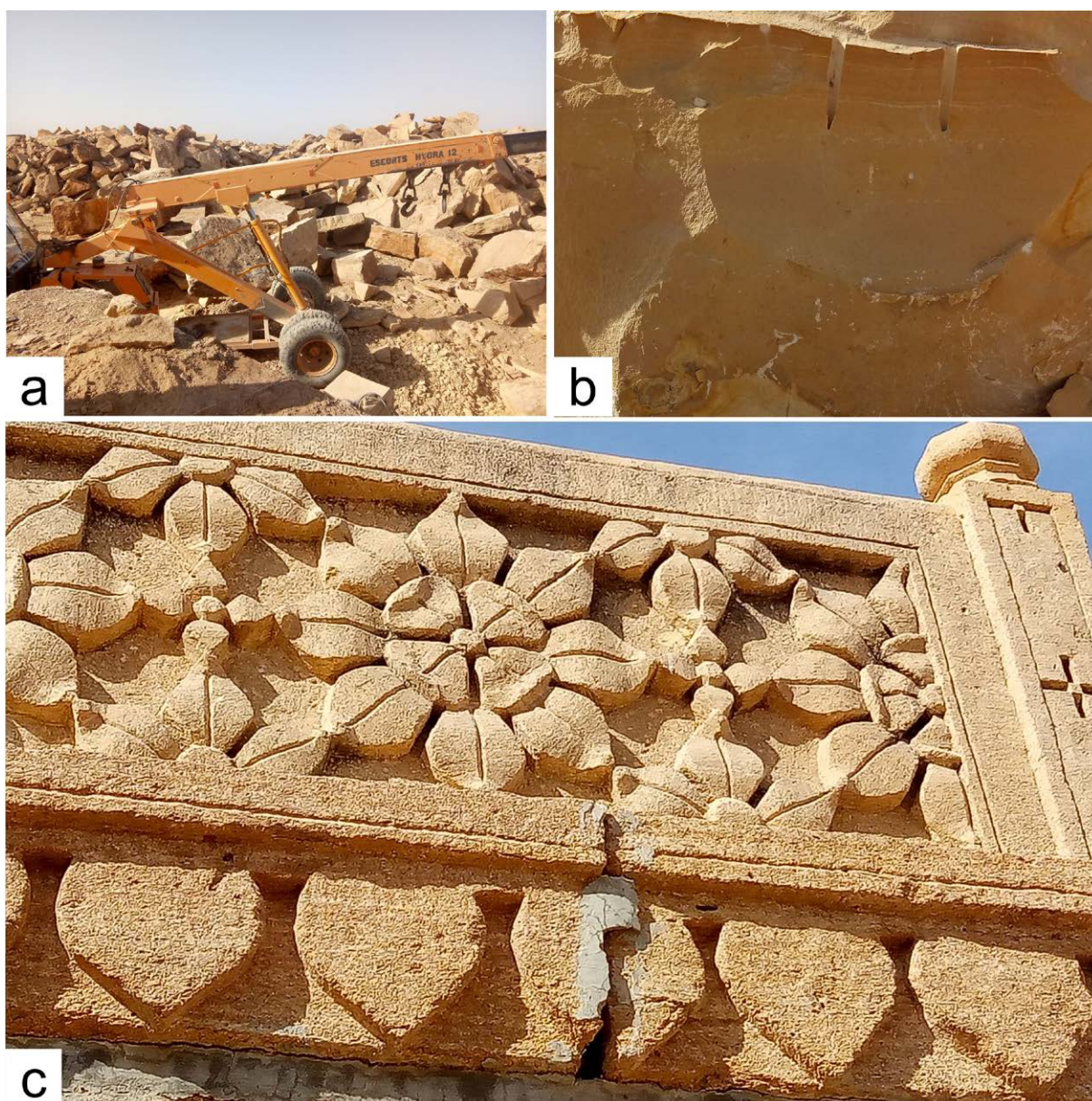


Figure 5. a. Jasalmer Limestone historical quarry in the vicinity of Jaisalmer; b. Golden Jaisalmer Limestone; c. Floral relief carved in Jaisalmer Limestone.

Figura 5. a. Cantera histórica de piedra caliza de Jaisalmer en las cercanías de Jaisalmer; b. Piedra caliza dorada de Jaisalmer; c. Relieve floral tallado en piedra caliza de Jaisalmer.

3.5. Himachal Slates: resilience in the hills

In the hilly regions of Himachal Pradesh, slate is a vital element of local architecture (Figure 6). Valued for its durability and aesthetic appeal, slate serves as an ideal roofing material, often combined with wood to create earthquake-resistant structures. This practical use reflects the region's adaptation to its geological environment, while also contributing to the unique character of the homes and other structures present in the mountains (Kaur *et al.*, 2020b).

Dark-gray slate and phyllite of Chamba Formation have been mined since historic times from Khaniyara and Dari. Mining practices in the region were haphazard and unscientific, primarily conducted by unskilled laborers. Extraction typically involved manual methods using chisels and digging tools, sometimes supplemented by blasting materials. Slate mining is banned at many places in Himachal Pradesh, although illegal mining is continuing at a few places. Below given are excerpts from Imperial gazetteer of India, "Provincial series, Punjab vol. I and Punjab District Gazetteers, Kangra District vol Xa Part A," highlighting slate quarrying from Himachal Pradesh in the past:

"The slate or quartz-mica-schist of the central zone (Sub- Himālayan zone) is fissile, and of considerable value for roofing purposes; it is quarried at and round Kaniāra" (Websource: <https://archive.org/details/in.ernet.dli.2015.120376/page/n393/mode/1up>; Geology, p. 354).

Kangra range of Kangra District 'In the schistose strata of the same range the well known slates of Dharmśāla and Narwāna are found. These are more siliceous and harder than Welsh slates, but are all that could be desired in point of feasibility. Being almost crystalline in structure, they are too coarse for many purposes to which slates are usually applied; but in point of durability they are superior to Welsh slates. European capital has been applied to working slates at Kaniāra, and the Kángra Valley Slate Company now carries on extensive operations under the management of Mr. Seale, and provides employment for a large number of labourers and pack animals. There are three other quarries being worked, one by Mr. W. Ballard, and the rest under native management, but their operations are as yet very restricted. The number of slates sold in 1902 were from the Kaniāra quarry 914,370, from the Dharmśāla 40,193, from the Narwāna 63,226, from the Kareri 800, and the receipts were, respectively, Rs 61,884, Rs. 1,600, Rs. 2,040, and Rs. 40. These receipts show a very considerable increase on those for 1883 which were for the same quarries, respectively, Rs. 12,178, Rs. 1,350, Rs. 1,000, and Rs. 40. These slates are largely used for roofing in the District, and large quantities are exported to Hoshiárpur, Jullundur and Gurdáspur Districts' (Government of Punjab 1906; Websource: <https://archive.org/details/dli.csl.2947/page/n180/mode/1up>; Building stones and slates, p. 170–171).

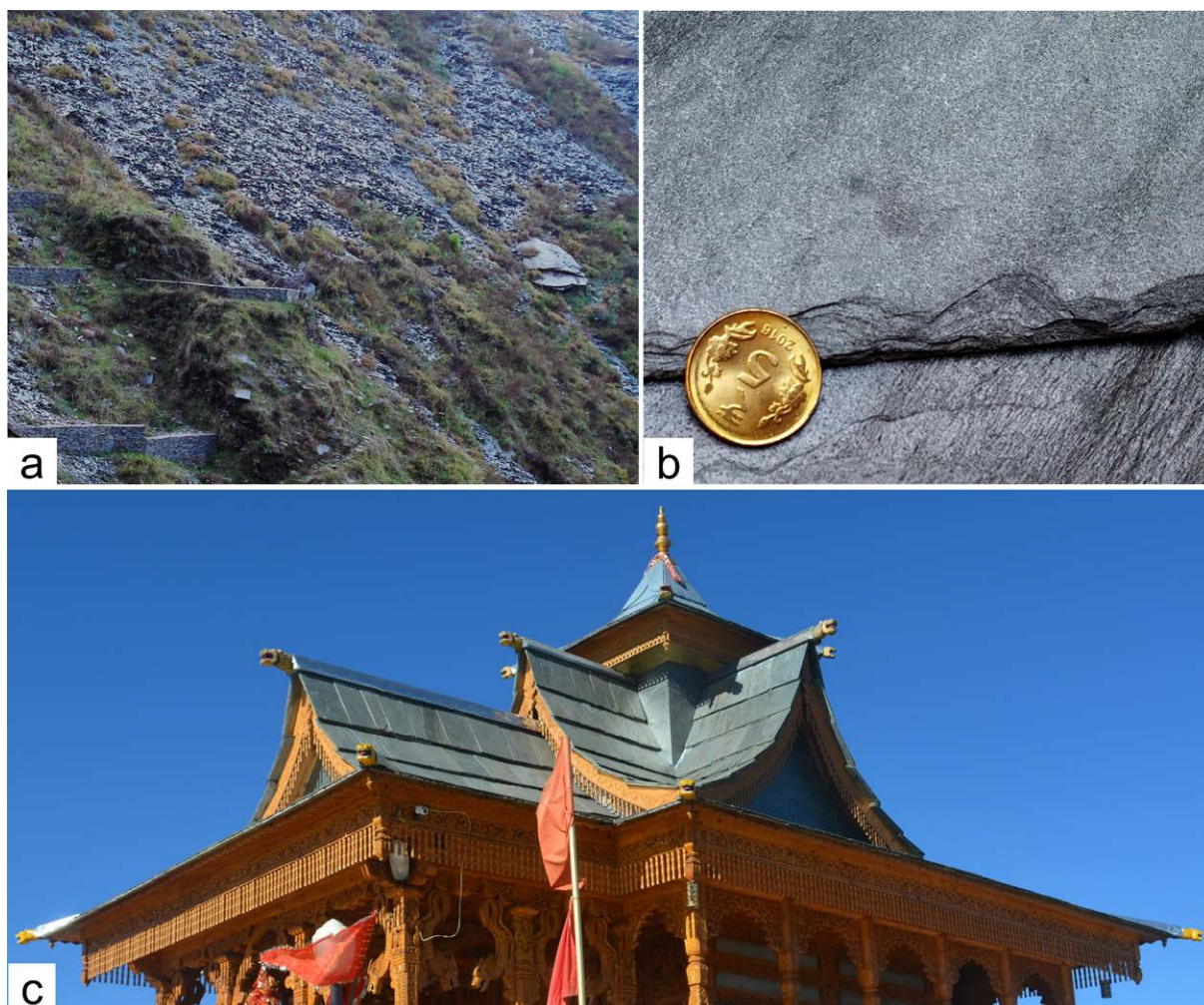


Figure 6. a. Himachal Slate historical quarry; b. grey coloured Himachal Slate (the Indian coin has 2 cm diameter); c. Himachal Slate roof.

Figura 6. a. Cantera histórica de pizarra de Himachal; b. Pizarra de Himachal de color gris (la moneda india tiene 2 cm de diámetro); c. Techo de pizarra de Himachal.

3.6. Closepet Granite and Charnockite: southern splendor

In southern India, granite and granulite dominate the landscape and have been fundamental to temple architecture. The ancient city of Hampi, a UNESCO World Heritage site, exemplifies this with its breathtaking structures carved from Closepet granite (Figure 7). The iconic stone chariot, a hallmark of Hampi, and the intricately adorned pillars of the Vitthala Temple demonstrate the architectural prowess of the Vijayanagara Empire. Similarly, the temples of Mamallapuram, another UNESCO site, are masterpieces of rock-cut architecture, carved from Indian charnockite. These structures not only reflect the skill of ancient artisans but also convey deep spiritual significance through their elaborate sculptures and reliefs.

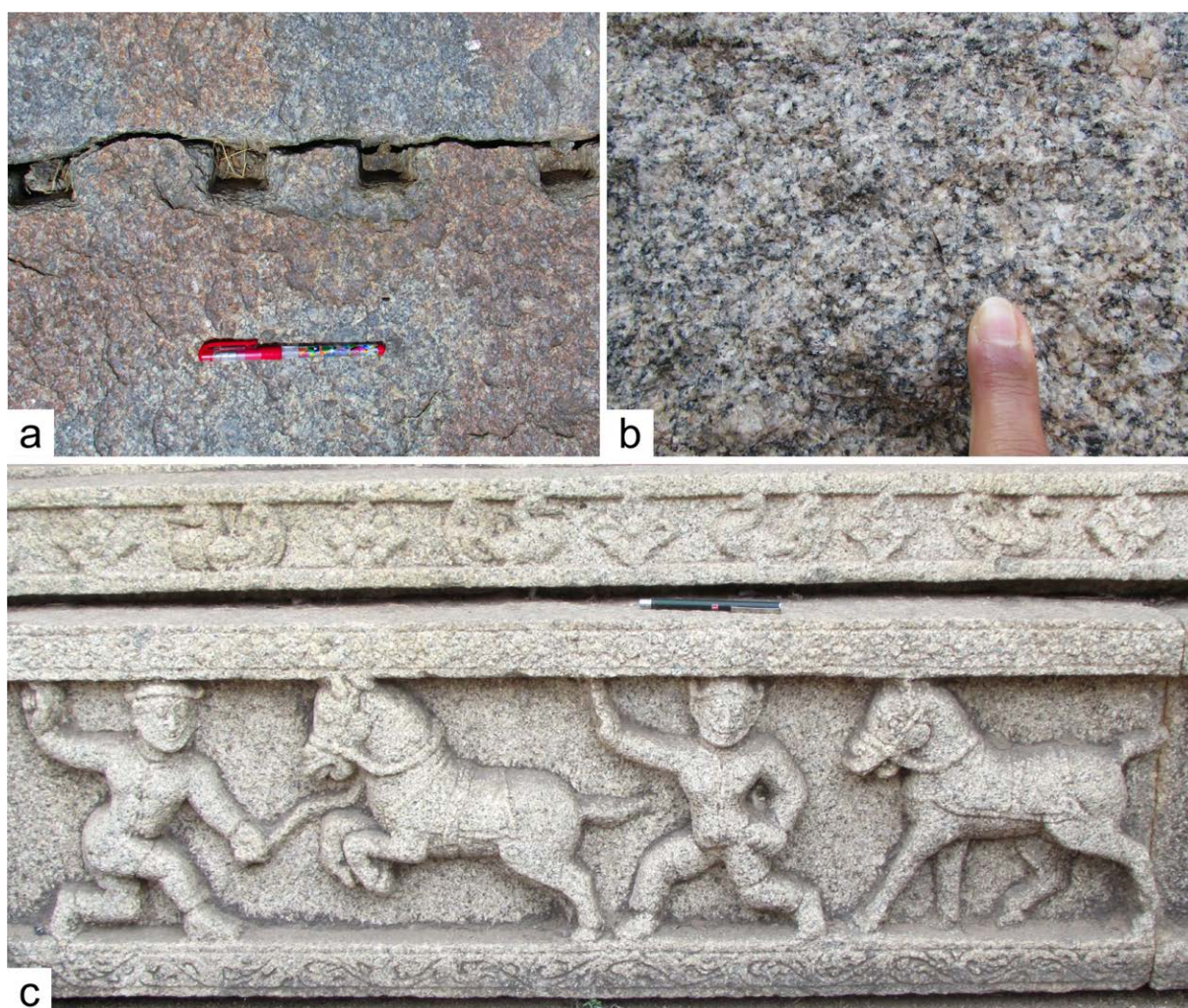


Figure 7. a. Quarry marks in a historical Closepet Granite quarry (the pen in the photograph is 15 cm in length); b. medium-to-coarse grained Closepet Granite; c. Carved Closepet Granite in Hampi.

Figura 7. a. Marcas de cantera en una cantera histórica de granito de Closepet (el bolígrafo en la fotografía mide 15 cm de largo); b. Granito de Closepet de grano medio a grueso; c. Granito de Closepet tallado en Hampi.

Closepet granite is the primary material used in town of Hampi. Granite used for construction of the Group of monuments at Hampi are locally sourced. Its durability has allowed many structures to withstand the test of time, while the skillful craftsmanship has resulted in intricate carvings and detailed sculptures, reflecting the artistic prowess of the era. The below excerpt elaborates the use of closepet granite in Hampi and vicinity.

‘The hills are of granite weathered to every shade of color from grey to brown and have hardly any vegetation on them. The alternate burning days and chilly nights of the Deccan climate have seamed and split in every direction the huge masses of solid rock of which they originally consisted..... The unlimited supply of splendid building material close at hand, laid a considerable influence on the architecture of

the city by rendering it possible, to acquire on the spot, huge blocks of stone of vast dimensions which otherwise would not have been so freely used owing to the difficulty of transporting them from a distance.’ (Source: <https://archive.org/details/in.gov.ignca.22748/page/n13/mode/2up?view=theater>).

In southern India, charnockite is extensively distributed across the Southern Granulite Terrain (SGT) and along the Eastern Ghats Mobile Belt (EGMB), collectively known as the Precambrian granulite belt. The massive-type charnockite, commonly quarried as dimension stone or rough blocks, is highly valued for construction purposes worldwide. The massive charnockite appears either as large, isolated hillocks or as bands and lenses, several meters thick, embedded within garnet-biotite and/or hornblende-biotite gneisses. Charnockite in this region exhibits a broad compositional spectrum, ranging from tonalitic-granodioritic to granitic types. The historically significant quarry that supplied the charnockite used for Job Charnock’s tombstone is located at St. Thomas Mount in Tamil Nadu (Sreejith *et al.*, 2021).

3.7. Basalt: The Heart of the Deccan Plateau

The Deccan Plateau, rich in basalt, is home to some of India’s most impressive architectural heritage (Figure 8). Historical quarries are spread throughout the Deccan Trap landscape. These quarries which supplied essential dimension stones for forts and significant buildings include the sites near Navi Mumbai, Aurangabad, Jalgaon, Nashik, and Kolhapur. The basalt from the Deccan Plateau was used to construct the iconic UNESCO-listed buildings in Bombay. In Pune, quarries like Yerwada and Pashan were active for 100-150 years, providing basalt for many iconic structures but are now abandoned due to urbanization and environmental concerns (Kaur *et al.*, 2019a).

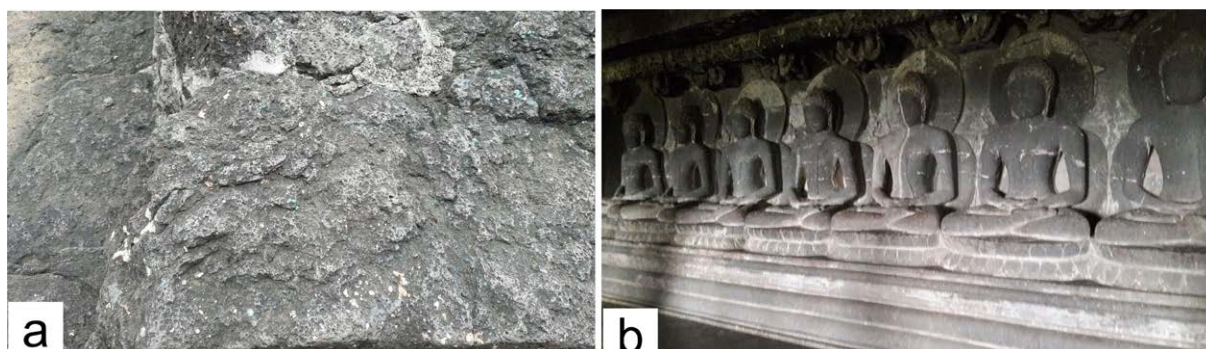


Figure 8. a. Deccan Basalt; b. Sculptured Deccan Basalt.

Figura 8. a. Basalto del Deccan; b. Basalto del Deccan esculpido.

CONCLUSIONS

India’s rich cultural heritage is profoundly expressed through its monumental architecture, which prominently features a diverse array of stones sourced from historical quarries across the subcontinent. Each type of stone not only showcases unique geological location, environment of formation, properties but also tells a story of the cultures, traditions and societies that shaped them. However, these stone built iconic structures face deterioration due to both anthropogenic and natural factors. Therefore, identifying historical quarries of these important stones is crucial for restoration efforts. To maintain the structural integrity of any monument the preservation of historical quarries must be executed in order to restore the cultural heritage for posterity.

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Not applicable.

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