XXII INQUA INDIA 2027

QUATERNARY SCIENCE AS SOCIETAL SERVICES



XXII INQUA INDIA 2027

FIELD GUIDE

INMID - 07

ARCHITECTURAL AND GEOMORPHOLOGICAL SIGNIFICANCE OF SHAAN-E-AWADH: IMAMBARA, BHULBHULIYA, AND TILEWALI MASJID ON THE T2 GEOMORPHOLOGICAL SURFACE OF LUCKNOW







Nawaz Ali and Mayank Shekhar

बीरबल साहनी पुराविज्ञान संस्थान
Birbal Sahni Institute of Palaeosciences
विज्ञान एवं प्रौद्योगिकी विभाग के अंतर्गत स्वायत्त संस्थान, भारत सरकार
An autonomous institute under the Department of Science and Technology, Government of India

विज्ञान एवं प्रौद्योगिकी मंत्रालय MINISTRY OF SCIENCE AND TECHNOLOGY
पृथ्वी विज्ञान मंत्रालय Ministry of Earth Sciences
NCPOR
INQUA International Union for Quaternary Research
ASSOCIATION OF QUATERNARY RESEARCHERS

Published in 2026 by

XXII INQUA Congress, India
Birbal Sahni Institute of Palaeosciences (BSIP)
53, University Road
Lucknow – 226007, Uttar Pradesh
India

Website: www.inquaindia2027.in
Email: inqua.india@bsip.res.in

© 2026 BSIP, Lucknow

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the publisher.

Published under the overall supervision of:
Mahesh. G. Thakkar, Director, Birbal Sahni Institute of Palaeosciences, Lucknow
Binita Phartiyal, Organising Secretary, INQUA India 2027
Pradeep Srivastava, President, INQUA India 2027
Rahul Mohan, Vice-President, INQUA India 2027

Field Trips Committee
Chairperson: Malay Mukul
Convener: Anupam Sharma
Members: Vimal Singh, Y. P. Sundriyal, Navin Juyal, Pradeep Srivastava, R. J. Perumal, U. K. Shukla, Shanti Pappu, Yogesh Ray

Compilation and editing: Field Trips Committee in collaboration with the INQUA 2027 Secretariat.

Design and Production:
XXII INQUA Congress 2027
Anupam Sharma, BSIP, Lucknow
Akhilesh K Yadava, BSIP, Lucknow
Rakesh Rao, Goa
Creative Team, Expression 360, New Delhi

INQUA INDIA 2027

Field Guide Book

INMID-07

Architectural and Geomorphological Significance of Shaan-e-Awadh: Imambara, Bhulbhuliya, and Tilewali Masjid on the T2 Geomorphological Surface of Lucknow

Principal Investigator

Dr. Nawaz Ali

Scientist-E

BSIP Lucknow

Co-Principal Investigator

Mayank Shekhar

Scientist-C

BSIP Lucknow,

Email of Contact Person

snawazali@bsip.res.in

Mobile No.

+91 9554955511

Table of Contents

1. Team Leaders 1
2. Introduction 2-3
3. Geological Setting of Lucknow 3-5
4. Climate of Lucknow 5-6
5. Site Visits During the Field Excursion 6-13
6. Excursion Synthesis 13-14
7. References 15
8. Annexure 16-17

Team Leaders



Dr. Sheikh Nawaz Ali

Scientist-E,
BSIP, Lucknow

Dr. Sheikh Nawaz Ali is a Scientist 'E' at the Birbal Sahni Institute of Palaeosciences and an Honorary Assistant Professor at AcSIR.
A leading Quaternary geologist and Himalayan cryosphere researcher, his work bridges past climate dynamics with contemporary cryospheric change. He integrates glacial geology, geomorphology, quantitative palaeoclimatology, luminescence dating, remote sensing, and hazard modelling to unravel glacier–climate interactions across centennial to millennial timescales. His research spans Late Quaternary glaciation, Indian Summer Monsoon variability, glacier–lake evolution, rock glaciers, permafrost, elevation-dependent warming, and GLOF hazards. He leads national and international research initiatives addressing Himalayan environmental change and its implications for high-mountain communities and infrastructure.



Dr. Mayank Shekhar

Scientist-C,
BSIP, Lucknow

Dr. Mayank Shekhar is a Scientist-C at the Birbal Sahni Institute of Palaeosciences, Lucknow, India. He is a dendrochronologist and palaeoclimate scientist specialising in Himalayan climate variability and Indian monsoon dynamics. His research integrates tree-ring analysis, sedimentary archives, and multi-proxy approaches to reconstruct past climate and environmental changes. His key research interests include droughts, floods, landslides, glacier fluctuations, forest dynamics, dendrochemistry, and climate modeling. He has published extensively in international scientific journals and contributed chapters to edited books. His recent work also incorporates machine learning and explainable artificial intelligence to investigate climate variability and improve understanding of climate–environment interactions.

Introduction

Welcome to Lucknow!!!

This field guide has been prepared for the "INQUA 2027" delegates participating in the "Lucknow Darshan" pre-conference field excursion, organized by the Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow. The one-day excursion introduces participants to the geological, geomorphological, historical, archeological, and cultural landscape of Lucknow, demonstrating the close relationship between Quaternary landscape evolution and the development of one of northern India's most significant heritage cities.

Situated within the Central Ganga Plain, Lucknow occupies a geomorphologically important region characterized by extensive Quaternary alluvial deposits laid down by the Ganga river system and its tributaries. These sediments preserve valuable archives of Late Quaternary environmental and climatic change, fluvial evolution, and landscape development. The region also forms part of the wider Middle Ganga cultural landscape, which has witnessed continuous human occupation from prehistoric times through the Early Historic, Medieval, and Colonial periods, making it an important setting for archaeological and geoarchaeological investigations. At the same time, they have profoundly influenced patterns of human settlement, the availability of construction materials, and the city's architectural evolution over several centuries. The excursion, therefore, provides an opportunity to examine how geological processes have shaped not only the physical landscape but also Lucknow's cultural and historical identity.

The field guide emphasizes the integration of Earth sciences with archaeology, architecture, and heritage studies, demonstrating how geological and geomorphological observations can provide valuable insights into the origin, development, and preservation of historic monuments and urban landscapes. Particular attention is given to the geomorphological setting of Lucknow, the characteristics of its Quaternary alluvial deposits, the provenance and properties of locally available construction materials, and the role of these natural resources in shaping architectural styles and engineering practices. The guide further explores how geological conditions influenced settlement patterns, monument siting, the selection of construction materials, and the long-term conservation of archaeological and architectural heritage, thereby highlighting the close interrelationship between the region's geological evolution and its rich cultural legacy.

The Central Ganga Plain represents one of India's most significant Quaternary sedimentary basins and serves as a natural archive of Late Quaternary environmental change, fluvial evolution, monsoonal variability, and human occupation. Owing to its rich geological and archaeological record, the region has been the focus of multidisciplinary research integrating Quaternary geology, palaeo-climatology, geoarchaeology, archaeology, and geomorphology. Consequently, this excursion extends beyond the geological framework of Lucknow, demonstrating how Quaternary science contributes to reconstructing landscape evolution, understanding the interactions between environmental change and human societies, and interpreting the development of cultural landscapes across the Indo-Gangetic Plains. The field guide also highlights the importance of geological knowledge in

geo-heritage conservation, archaeological site preservation, monument conservation, and sustainable urban planning. As the host institute for INQUA 2027, the Birbal Sahni Institute of Palaeosciences showcases its interdisciplinary research integrating Earth sciences with archaeology, palaeobiology, and heritage studies, reflecting the broad scientific objectives of the International Union for Quaternary Research (INQUA) in promoting an integrated understanding of Quaternary environments and their relationship with human history.

The excursion includes visits to four iconic heritage monuments of Lucknow—the Hussainabad Clock Tower, the Rumi Darwaza, the Bada Imambara complex (including the Bhool Bhulaiya labyrinth), and the British Residency. Together, these sites represent successive phases in the historical and architectural evolution of the city and provide an exceptional setting for examining the interactions between geology, geomorphology, archaeology, architecture, and cultural heritage. At each stop, participants will investigate the geological and geomorphological setting alongside the historical, archaeological, and architectural significance of the monuments, with discussions focusing on the provenance and properties of building materials, traditional construction techniques, monument engineering, landscape evolution, weathering processes, conservation challenges, and the influence of geological factors on the preservation of built heritage. The excursion also highlights how Quaternary landforms and alluvial sediments have influenced urban growth, resource availability, and the spatial development of Lucknow through time.

This field guide is intended to serve both as a companion during the excursion and as a reference for future research, encouraging participants to appreciate the role of Quaternary processes in shaping the landscapes of the Central Ganga Plain and their influence on the archaeological, historical, and cultural evolution of Lucknow. By integrating geological and geomorphological observations with archaeological, historical, and architectural perspectives, the guide demonstrates the value of interdisciplinary approaches for reconstructing past environments, understanding human–landscape interactions, and promoting the conservation of geoheritage and cultural heritage. It is hoped that this guide will stimulate further collaborative research on the links between Quaternary landscape evolution, geoarchaeology, and heritage conservation, in keeping with the interdisciplinary objectives of INQUA 2027.

Geological Setting of Lucknow

Lucknow, the capital of Uttar Pradesh, is situated in the central part of the Indo-Gangetic Plain at 26°51′ 00″ N latitude and 80°57′ 00″ E longitude, with an average elevation of approximately 123 m above mean sea level (amsl). The city occupies a strategic geomorphic position within the Central Ganga Plain, one of the world's largest Quaternary alluvial basins, formed through the long-term depositional activity of the Ganga River system and its tributaries during the Neogene and Quaternary (Singh, 1996). The Central Ganga Plain extends for nearly 300 km from the Himalayan foothills in the north to the Peninsular Craton in the south and constitutes the southern foreland basin of the Himalaya, preserving a

sedimentary succession exceeding 1,000 m in thickness that records the combined influence of Himalayan tectonics, monsoon variability, fluvial dynamics, and landscape evolution (Sinha et al., 2005).

Lucknow is located on the interfluve between the Gomti River to the east and the Sai River to the west. This geomorphic setting has strongly influenced the evolution of the city's landscape, drainage network, groundwater regime, and patterns of human settlement. The relatively stable interfluve surface provided favourable conditions for the establishment and expansion of settlements, while the proximity of the Gomti River ensured a reliable source of water, fertile soils, transportation routes, and construction materials. Consequently, the geological setting has played a fundamental role in shaping the archaeological, historical, and urban development of Lucknow.

The near-surface geology of Lucknow is dominated by Quaternary alluvial deposits represented by the Older Alluvium (Bhangar) and the Younger Alluvium (Khadar). The Older Alluvium, which forms the foundation beneath much of the historic city, consists predominantly of oxidised fine- to medium-grained sand, silt, and clay with abundant pedogenic calcareous concretions (kankar), representing Pleistocene fluvial deposits (Singh, 2004). Along the active floodplains of the Gomti River, these sediments are overlain by the Younger Alluvium, composed of unconsolidated Holocene sand, silt, and clay deposited during recent fluvial activity. Together, these deposits preserve valuable records of Late Quaternary environmental change, river migration, and floodplain evolution. Kankar nodules, characteristic of the older alluvium of the Ganga Plain, represent pedogenic calcium carbonate concretions formed during prolonged subaerial exposure and soil development (Singh, 1996).

The Gomti River, a major tributary of the Ganga, has been the principal geomorphic agent controlling the evolution of Lucknow. Meandering channel migration, floodplain aggradation, natural levee formation, abandoned channels, and oxbow lakes are characteristic geomorphic features associated with the river, reflecting the dynamic nature of the alluvial landscape. These fluvial processes have governed sediment distribution, groundwater recharge, and the availability of construction materials, and have also influenced the location and long-term stability of human settlements. The shallow alluvial aquifer system hosted within these sediments constitutes an important groundwater resource and has been extensively investigated for its hydrogeological characteristics (Saha et al., 2008). Fluctuating groundwater levels and the compressible nature of unconsolidated alluvial sediments have important implications for foundation engineering and the long-term preservation of historical monuments.

From a tectonic perspective, Lucknow lies within the relatively stable Indo-Gangetic foreland basin immediately south of the actively deforming Himalayan orogenic belt (Valdiya, 2016). Although the city is located away from active Himalayan faults, sedimentation within the basin has been fundamentally controlled by Himalayan uplift, foreland subsidence, and Quaternary climatic fluctuations associated with the Indian Summer Monsoon. The subsurface beneath Lucknow comprises a multi-layered aquifer system consisting of alternating sand bodies and clay-rich aquitards, a characteristic feature of the Quaternary fluvial deposits of the Central Ganga Plain (Khan, 2021).

The geology of Lucknow is inseparable from its archaeological and architectural heritage. The absence of shallow bedrock meant that historical builders relied almost entirely on locally available geomaterials, including alluvial clay for bricks, river sand, lime mortar, kankar, and timber. The engineering properties of these materials, together with the characteristics of the underlying alluvial sediments, influenced monument design, foundation construction, and long-term structural stability. Throughout this excursion, participants will observe how the geological framework of the Central Ganga Plain governed the selection of construction materials, the siting of monumental architecture, patterns of urban growth, and the conservation challenges faced by some of Lucknow's most important heritage monuments. Understanding this geological context provides an essential foundation for interpreting the close relationship between Quaternary landscape evolution, archaeology, architecture, and the cultural heritage of Lucknow.

Climate of Lucknow

Lucknow experiences a humid subtropical climate (Köppen classification: Cwa), characterized by three distinct seasons: a hot, dry summer (March–June), a southwest monsoon season (July–September), and a cool, dry winter (October–February). According to the India Meteorological Department's climatological normals (1991–2020), the city receives an average annual rainfall of approximately 990 mm, nearly 85% of which falls during the southwest monsoon, with the highest rainfall occurring in July and August (IMD, 2022). Mean maximum temperatures during May and June frequently exceed 40 °C, whereas minimum temperatures during December and January may fall to 3–5 °C during cold-wave conditions (IMD, 2022).

Each season imparts a distinct character to the landscape and cultural life of Lucknow. Summers are typically hot and dry, with occasional dust storms preceding the monsoon's arrival. The season is also associated with the flowering and subsequent ripening of the region's famous Dashehari mango, an important part of Awadh's cultural and horticultural heritage.

The southwest monsoon transforms the city into a lush green landscape as seasonal rainfall replenishes wetlands, parks, gardens, and the Gomti River. The monsoon sustains the fertile alluvial plains surrounding Lucknow, supports agricultural activities, and enhances the city's scenic beauty, and it also coincides with several important cultural and religious observances.

Winters are cool, dry, and generally pleasant, with clear skies, low humidity, and comfortable daytime temperatures. This season is considered the most favourable time for tourism and outdoor activities, when the city's monuments, gardens, and riverfront can be explored under ideal weather conditions. The pleasant climate also complements Lucknow's renowned cultural traditions, including its cuisine, markets, and festivals, offering visitors an opportunity to experience the city's unique Nawabi heritage.

The INQUA 2027 pre-conference excursion is scheduled for the last week of February, coinciding with the transition from winter to early spring. During this period, daytime temperatures typically range between 24 and 30°C, while mornings and evenings remain cool at 10–15°C, providing ideal conditions for walking tours and extended field observations. The landscape retains the freshness of winter, with flowering trees, well-maintained gardens, and pleasant weather enhancing the experience of visiting Lucknow's historic monuments and cultural precincts. Participants are advised to wear light clothing during the day and carry a light jacket or sweater for the cooler morning hours.

Site Visits During the Field Excursion

The Lucknow Darshan field excursion comprises four principal heritage sites that collectively illustrate the close relationship between the geological setting, archaeological heritage, architectural traditions, and cultural history of Lucknow. Each site has been selected to highlight different aspects of the city's evolution within the Quaternary landscape of the Central Ganga Plain.

At each stop, participants will examine the geological and geomorphological setting, the provenance and characteristics of the construction materials, and the architectural and engineering techniques employed in the monuments. Discussions will also focus on the historical and archaeological significance of each site, the influence of local environmental conditions on monument design, and the role of geology and climate in the long-term preservation and conservation of the built heritage. Together, these observations will provide an interdisciplinary perspective on the interactions between Quaternary landscape evolution, human settlement, architecture, and cultural heritage in one of northern India's most historically significant cities.

Hussainabad Clock Tower

The Hussainabad Clock Tower is one of the most recognizable landmarks of Lucknow and, at approximately 67 m in height, ranks among the tallest clock towers in India. Constructed in 1881 by the Hussainabad Trust during the British period, the tower commemorates the arrival of Sir George Couper, the first Lieutenant Governor of the North-Western Provinces and Chief Commissioner of Oudh. Designed in the Victorian Gothic style with Indo-Islamic influences, the monument forms an integral part of the historic Hussainabad heritage precinct and reflects the architectural transition of late nineteenth-century Lucknow.

The monument is founded on the Older Alluvium (Bhangar) of the Central Ganga Plain, comprising well-drained, oxidized sand, silt, and clay with abundant kankar (calcareous) concretions. These relatively stable Pleistocene deposits provided suitable bearing capacity for the construction of the massive masonry tower. The location on a slightly elevated alluvial surface, above the active floodplain of the Gomti River, has further contributed to the structure's long-term stability by reducing the impacts of seasonal flooding and prolonged waterlogging.

From a geological and architectural perspective, the Clock Tower illustrates the use of both local and imported geomaterials. The principal structural components comprise brick masonry bonded with lime mortar, while decorative elements incorporate red sandstone, most likely sourced from the Vindhyan sandstones exposed around Mirzapur in southeastern Uttar Pradesh. The combination of locally manufactured bricks, lime prepared from regional kankar, and transported building stone demonstrates the extensive material procurement networks that supported major public works during the nineteenth century. Participants should observe the contrasting weathering behaviour of brick, sandstone, and lime mortar, which reflects differences in mineral composition, porosity, and exposure to the humid subtropical climate of Lucknow.

Beyond its architectural significance, the Clock Tower occupies an important position within Lucknow's historic urban landscape. Together with the adjoining Rumi Darwaza, Bara Imambara, and Hussainabad precinct, it forms part of a remarkable ensemble that illustrates the evolution of the city from the Nawabi to the colonial period. The site provides an excellent example of how geology, locally available construction materials, engineering practices, and historical development are interwoven within the Quaternary landscape of the Central Ganga Plain.



Fig 1. Cultural and heritage landmarks within the Husainabad precinct, Lucknow: (a) Husainabad Clock Tower; (b) Husainabad Food Court, representing the city's renowned culinary heritage; and (c) Lucknow Museum of Heritage and Art, showcasing the historical and artistic legacy of Lucknow.

Immediately adjacent to the Clock Tower is the Hussainabad Food Court, developed as part of the city's heritage corridor to celebrate the celebrated culinary traditions of Awadh and enhance the visitor experience within the historic precinct. Nearby is the Lucknow Museum of Heritage and Art, which presents the history, architecture, crafts, literature, and composite Ganga–Jamuni Tehzeeb of Awadh through modern interpretative galleries. Its striking cantilevered structure, extending approximately 45 m without intermediate columns, represents a noteworthy example of contemporary structural engineering that complements the surrounding nineteenth-century heritage landscape while providing an engaging introduction to the cultural history of Lucknow.

Rumi Darwaza

The Rumi Darwaza (Rumi Gate), one of the defining landmarks of Lucknow, was commissioned by Nawab Asaf-ud-Daula in 1784 as part of an ambitious programme of public works undertaken during the severe famine of 1784. Serving as both an architectural gateway to the city and a symbol of the prosperity of the Awadh kingdom, the monument is one of the finest surviving examples of Awadhi architecture, blending Mughal, Persian, and regional traditions. The gateway forms an integral part of the historic ensemble that includes the Bara Imambara and Hussainabad precinct, illustrating the cultural and architectural achievements of eighteenth-century Lucknow (Government of Uttar Pradesh, 2025).

The Rumi Darwaza provides an excellent example of how the geology of the Central Ganga Plain influenced construction practices. Owing to the scarcity of durable building stone within the alluvial plains, the monument was constructed primarily from lakhauri bricks bonded with lime-surkhi mortar and finished with finely worked lime plaster (Singh & Rai, 2017). The bricks were manufactured from locally available fine-grained alluvial clays, while the lime used in the mortar and plaster was produced by calcining kankar (calcareous concretions) widely occurring within the Older Alluvium (Bhangar). These readily available geomaterials formed the foundation of traditional construction technology across the Gangetic Plain and contributed significantly to the distinctive architectural character of Awadh.

From both geological and engineering perspectives, the monument demonstrates the remarkable adaptability of eighteenth-century builders in their use of locally available materials. The lightweight lakhauri bricks, combined with lime-surkhi mortar, provided sufficient strength and flexibility to support the monumental central arch and the superimposed ornamental pavilion while reducing the overall structural load on the underlying alluvial foundation. The elaborate floral motifs, arabesques, and ornamental stucco decorations were executed using lime plaster, a material that allowed greater artistic freedom than stone carving and became a defining feature of Nawabi architecture (Asher, 1992).

Participants are encouraged to observe the fine brick masonry, lime-plastered surfaces, and ornamental stucco work, noting how the properties of local geomaterials influenced both the structure's engineering and its aesthetics. The monument also provides an opportunity to examine the effects of natural weathering, moisture, biological growth, and urban pollution on lime-based building materials. Ongoing conservation efforts aim to preserve the structural stability and artistic details of the gateway while maintaining the authenticity of

its historic fabric, making the Rumi Darwaza an outstanding example of the intersection between Quaternary geology, traditional construction materials, architecture, and cultural heritage conservation.



Fig 2. Rumi Darwaza (Turkish Gate), an eighteenth-century ceremonial gateway commissioned by Nawab Asaf-ud-Daula in 1784, representing one of the finest examples of Awadhi Indo-Islamic architecture and an enduring symbol of Lucknow's Nawabi heritage.

Bada Imambara and Bhool Bhulaiya

Imambara means 'House of Imam' and 'Bada' means big. The Bada Imambara, also known as the Asafi Imambara, is the architectural centerpiece of eighteenth-century Lucknow and one of the finest examples of Nawabi architecture in India. Commissioned by Nawab Asaf-ud-Daula in 1784, the monument was constructed as part of a large-scale famine relief programme that provided employment to thousands of people during the devastating famine of 1784 (Oldenburg, 1984). Beyond its historical importance, the complex stands as an exceptional achievement in engineering, architecture, and the use of locally available geomaterials within the Quaternary landscape of the Central Ganga Plain.

The monument is founded on the relatively stable Older Alluvium (Bhangar), whose compact sand, silt, clay, and kankar-rich horizons provide adequate bearing capacity for large masonry structures. In the absence of suitable building stone, the Imambara was constructed almost entirely from lakhauri bricks, bonded with lime-surkhi mortar and

finished with lime plaster prepared from locally available kankar. The extensive use of these indigenous materials reflects the close relationship between the geology of the Central Ganga Plain and the development of traditional construction technologies in northern India.

The central vaulted hall, measuring approximately 50 m in length, 15 m in width, and about 15m in height, is widely regarded as one of the largest arched halls in the world to be constructed without iron, steel, timber beams, or internal supporting pillars. Its remarkable structural stability is achieved through an ingenious system of interlocking arches, thick load-bearing masonry walls, and carefully distributed loads, demonstrating the sophisticated engineering knowledge of eighteenth-century builders. Participants are encouraged to observe how the geometry of the arches and the use of lightweight lakhauri bricks reduce structural loads while maintaining the integrity of the vast interior space.

Situated above the central hall is the famous Bhool Bhulaiya (literally meaning a labyrinth or maze), an intricate network of interconnected corridors, stairways, galleries, and concealed passages built into the thickness of the roof and surrounding walls. Originally conceived as part of the structural system to reduce the dead load of the massive roof while providing maintenance access, the labyrinth today stands as one of the most distinctive architectural features of the monument. The interconnected passages also create an efficient system of natural ventilation and passive cooling. During the field excursion, participants may experience noticeably cooler temperatures within the labyrinth than outside, illustrating the effectiveness of traditional climate-responsive architectural design in Lucknow's humid subtropical climate.

The Bada Imambara complex offers an outstanding opportunity to examine the interplay among Quaternary geology, locally available construction materials, architectural innovation, and cultural heritage. Participants should observe the lakhauri brick masonry, lime plaster, vaulted structural system, and evidence of weathering and conservation, while considering how the geological setting and indigenous building materials influenced both the engineering and long-term preservation of one of India's most celebrated heritage monuments.

The remarkable structural stability of the Bada Imambara for more than two centuries reflects the successful integration of traditional engineering with locally available geomaterials. The monument was constructed using lime-surkhi mortar, a mixture of slaked lime, finely powdered burnt clay (surkhi), and water, which gradually hardens through carbonation, forming a durable and resilient binding material. This mortar is highly compatible with historic brick masonry, accommodating minor structural movements while enhancing the monument's long-term durability.

Equally significant is the structure's response to its geological setting. The foundation rests on the relatively competent Older Alluvium (Bhangar), where compact sand, silt, clay, and kankar-rich horizons provide a stable bearing surface for the massive masonry. The broad foundation and substantial load-bearing walls effectively distribute structural loads, minimizing differential settlement that commonly affects monuments founded on unconsolidated alluvial sediments.



Fig 3. Views of the Bara Imambara–Bhul Bhulaiya heritage precinct, Lucknow, documented during the pre-INQUA 2027 field excursion. (a) Bara Imambara (Asafi Imambara), commissioned by Nawab Asaf-ud-Daula in 1784, is renowned for its monumental vaulted central hall and the celebrated Bhul Bhulaiya, an intricate labyrinth of interconnected corridors and passageways constructed within the massive load-bearing walls. (b) Teele Wali Masjid (Wazu Khana), the ablution courtyard and water reservoir associated with one of Lucknow's oldest and most prominent mosques, is situated on an elevated mound overlooking the Gomti River. (c) Traditional horse-drawn tongas, a historic mode of transport that continues to form part of Lucknow's cultural landscape. (d) Chhota Imambara (Imambara Hussainabad Mubarak), built by Nawab Muhammad Ali Shah in 1838, is distinguished by its richly ornamented façade, gilded dome, and Indo-Islamic architectural style.

The engineering of the central vaulted hall represents one of the most remarkable achievements of eighteenth-century Indian architecture. The roof is formed by a system of interlocking arches constructed from thousands of lightweight lakhauri bricks laid in lime-surkhi mortar. This arrangement efficiently transfers compressive forces through the masonry, eliminating the need for timber, iron, or steel supports while allowing the creation of an exceptionally large unobstructed interior space. Together, the geological setting, the judicious use of indigenous construction materials, and innovative structural design have contributed to the exceptional longevity of the Bada Imambara, making it an outstanding example of the interaction between Quaternary geology, traditional engineering, and cultural heritage.

The Residency

The Residency is one of Lucknow's most historically significant monuments and an enduring symbol of the Siege of Lucknow (1857) during the Indian Rebellion. Constructed between 1780 and 1800 during the reign of Nawab Asaf-ud-Daula, the complex served as the official residence of the British Resident and subsequently became the principal centre of the prolonged siege that shaped the course of the uprising in northern India. Today, the site is protected by the Archaeological Survey of India (ASI) and preserves an extensive complex of residential buildings, administrative offices, a banqueting hall, church remains, cemeteries,

and landscaped gardens, many of which still bear the scars of artillery and gunfire from the events of 1857 (Markovits, 2004).

The Residency occupies a gently elevated alluvial terrace overlooking the Gomti River floodplain. This geomorphic setting provided strategic advantages, including improved visibility, natural drainage, and relative protection from seasonal flooding. The stable Older Alluvium (Bhangar) underlying the site offered favourable foundation conditions for the construction of substantial masonry buildings while ensuring long-term structural stability within the Quaternary landscape of the Central Ganga Plain.



Fig 4. Representative views of the major heritage features within the Residency Complex, Lucknow, visited during the pre-INQUA 2027 field excursion. (a) The 1857 Memorial Museum, housed in the restored south-western annex of the Residency, displays artifacts, archival photographs, and paintings related to the Revolt of 1857. (b) Ruins of Dr. Fayrer's House, the former residence of Civil Surgeon Dr. Joseph Fayrer, where Sir Henry Lawrence succumbed to injuries sustained during the Siege of Lucknow. (c) The Sir Henry Lawrence Memorial (Residency High Cross) was erected in memory of Sir Henry Lawrence and the defenders of the Residency. (d) Memorial to Her Majesty's 32nd Regiment of Foot, commemorating the officers and soldiers who lost their lives during the 1857 siege. (e) Historic British artillery pieces displayed on the Residency lawns, representing the military landscape and intense bombardment endured during the 147-day Siege of Lucknow.

Architecturally, the Residency reflects a synthesis of European classical design and locally adapted construction techniques. The buildings were constructed primarily using lakhauri brick masonry bonded with lime-surkhi mortar and finished with lime plaster. Classical architectural features, including Doric and Ionic columns, cornices, arches, and pediments, were executed in finely modelled lime stucco over brick cores. The extensive use of brick and lime-based materials reflects the geological character of the Indo-Gangetic Plain, where durable building stone is scarce and construction traditionally relied on locally available alluvial clay, kankar-derived lime, and river sand.

From a geoarchaeological and conservation perspective, the Residency provides valuable insights into the long-term behaviour of historic masonry constructed on Quaternary alluvial deposits. Participants should observe the contrasting preservation of lime-plastered and exposed brick surfaces, which illustrates the protective role of traditional lime coatings against moisture ingress and weathering. Areas where the original plaster has been lost commonly exhibit accelerated deterioration of the underlying masonry due to prolonged exposure to rainfall, salt crystallization, biological colonization, and atmospheric pollution (Archaeological Survey of India, 2003; Vergès-Belmin, 2008). Equally significant are the preserved cannonball impacts and bullet marks, which constitute important archaeological evidence of the events of 1857 and contribute to the site's exceptional historical authenticity.

The Residency provides an excellent concluding stop for the excursion, demonstrating how geology, geomorphology, construction materials, military history, archaeology, and heritage conservation are closely interconnected within the Quaternary landscape of Lucknow. It illustrates the enduring relationship between the natural environment and the historical development of one of India's most significant colonial-period heritage sites.

Excursion Synthesis

The Lucknow Darshan field excursion has been designed to provide participants with an integrated understanding of the geological, geomorphological, archaeological, architectural, and cultural evolution of Lucknow within the Quaternary landscape of the Central Ganga Plain. Through visits to the Hussainabad Clock Tower, Rumi Darwaza, Bada Imambara, and Bhool Bhulaiya, and the Residency, participants gain first-hand insight into how geology has influenced human settlement, the selection of construction materials, architectural innovation, and the long-term preservation of one of India's most significant historic cities.

The excursion demonstrates that the Quaternary alluvial deposits of the Central Ganga Plain have served not only as the physical foundation for urban development but also as the primary source of the geomaterials that define Lucknow's architectural identity. The widespread use of lakhauri bricks, kankar-derived lime, river sand, and alluvial clay exemplifies the close relationship between the geological environment and traditional building technologies. Equally, the monuments illustrate how eighteenth- and nineteenth-century builders successfully adapted engineering practices to the region's

geological and climatic conditions, creating enduring structures that continue to inspire architects, engineers, geologists, archaeologists, and conservation professionals.

Throughout the excursion, participants are encouraged to adopt an interdisciplinary perspective by integrating observations from Quaternary geology, geomorphology, geoarchaeology, archaeology, architecture, engineering, and conservation science. Such an approach not only enriches our understanding of the evolution of cultural landscapes but also demonstrates the importance of Earth sciences in interpreting archaeological sites, conserving built heritage, and reconstructing past human–environment interactions. These themes closely reflect the scientific objectives of the International Union for Quaternary Research (INQUA) and highlight the growing importance of interdisciplinary research in addressing questions related to environmental change, landscape evolution, and cultural heritage conservation.

Beyond its scientific significance, the excursion offers participants an opportunity to experience the living heritage of Lucknow—its celebrated Ganga-Jamuni Tehzeeb, Nawabi architecture, gardens, cuisine, crafts, and traditions—which collectively contribute to the city's unique cultural identity. The monuments visited during the excursion should therefore be viewed not as isolated architectural landmarks, but as components of a dynamic cultural landscape that has evolved in response to changing environmental conditions, available natural resources, and centuries of human ingenuity.

It is hoped that this field guide will serve as both a practical companion during the excursion and a lasting reference for future studies in Quaternary science, geoarchaeology, heritage conservation, and cultural landscape research. More importantly, it is intended to encourage dialogue and collaboration among geologists, geomorphologists, archaeologists, architects, historians, conservation scientists, and heritage managers, reflecting the interdisciplinary spirit of INQUA 2027. We warmly welcome all participants to Lucknow and wish them an engaging, enjoyable, and scientifically rewarding field experience as they explore the remarkable geological and cultural heritage of the Central Ganga Plain.

References

Archaeological Survey of India. (2003). The Residency, Lucknow. Archaeological Survey of India.

Asher, C. B. (1992). Architecture of Mughal India. Cambridge University Press.

Government of Uttar Pradesh. (2025). Rumi Darwaza. District Lucknow. https://lucknow.nic.in/tourist-place/rumigate/

India Meteorological Department. (2022). Climatological tables of observatories in India (1991–2020). Ministry of Earth Sciences, Government of India. https://imdpune.gov.in/library/public/Climatological%20Tables%201991-2020.pdf

Khan, Nisar. (2019). Lime Stucco of Lucknow-Attributes, Issues and Conservation. 6. 936-941.

Khan, S. (2021). Aquifer mapping and management of ground water resources: Lucknow District, Uttar Pradesh (National Aquifer Mapping and Management Programme [NAQUIM]). Central Ground Water Board, Ministry of Jal Shakti, Department of Water Resources, River Development and Ganga Rejuvenation, Government of India.

Markovits, C. (2004). A history of modern India, 1480–1950. Anthem Press.

Oldenburg, V. T. (2014). The making of colonial Lucknow, 1856-1877.

Saha, D., Dhar, Y. R., & Vittala, S. S. (2010). Delineation of groundwater development potential zones in parts of marginal Ganga Alluvial Plain in South Bihar, Eastern India. Environmental monitoring and assessment, 165(1), 179-191.

Singh, A., & Rai, D. C. (2017). Dynamic characterization and seismic assessment of historic masonry structure of Rumi Darwaza. In Proceedings of the 13th Canadian Masonry Symposium, Halifax, Canada.

Singh, I. B. (1996). Geological evolution of Ganga Plain-an overview. Journal of the Palaeontological Society of India, 41(1), 99-137.

Singh, I. B. (2004). Late quaternary history of the Ganga plain. Journal of the Geological Society of India, 64(4), 431-454.

Sinha, R., Tandon, S. K., Gibling, M. R., Bhattacharjee, P. S., & Dasgupta, A. S. (2005). Late Quaternary geology and alluvial stratigraphy of the Ganga basin. Himalayan Geology, 26(1), 223-240.

Valdiya, K. S. (2015). The making of India: geodynamic evolution. Springer.

Vergès-Belmin, V. (2008). Illustrated glossary on stone deterioration patterns. Icomos.

Annexure

Field Excursion Guidelines: Do's and Don'ts

To ensure the safety of all participants and to promote responsible scientific field practices, all participants are requested to adhere to the following guidelines throughout the field excursions.

Keep a valid passport (for international participants) or a government-issued photo ID (for Indian participants) with you at all times during the field excursion.

Do's	Don'ts
1. Follow the instructions of the excursion leaders, coordinators, and local authorities at all times.	1. Do not collect rocks, fossils, archaeological artefacts, biological specimens, or any other materials without prior authorization.
2. Remain with the group and inform the excursion leader before leaving the designated route.	2. Do not damage, deface, or remove material from geological outcrops, caves, monuments, heritage structures, or other natural features.
3. Wear appropriate field attire, including sturdy closed-toe footwear, full-length trousers, a hat or cap, and weather-appropriate clothing.	3. Do not wander alone or separate from the excursion group without informing the field leaders.
4. Carry sufficient drinking water, personal medications, sunscreen, insect repellent, and other essential field supplies.	4. Do not climb unstable slopes, cliffs, rock formations, or enter hazardous areas unless specifically instructed or supervised.
5. Keep a valid photo identification and your excursion registration details with you during travel.	5. Do not swim or enter rivers, lakes, lagoons, or coastal waters unless expressly authorized by the excursion leaders.
6. Respect local customs, religious sites, cultural heritage, and private property.	6. Do not consume alcohol, recreational drugs, or engage in unsafe or irresponsible behaviour during the excursion.
7. Follow the Leave No Trace principles by carrying back all waste and helping to keep field sites clean.	7. Do not operate drones or other restricted equipment without obtaining the necessary permissions.
8. Use designated trails and approved observation areas to minimise environmental disturbance.	8. Do not photograph restricted installations, sensitive locations, or local residents without prior permission.
9. Observe geological, ecological, archaeological, and cultural features carefully without causing any damage.	

10. Record field observations systematically and collect samples only with prior permission from the excursion leaders and the relevant authorities.

11. Exercise caution near cliffs, riverbanks, caves, unstable slopes, road cuts, and other potentially hazardous terrain.

12. Respect wildlife by maintaining a safe distance from animals, birds, reptiles, insects, and their habitats.

13. Immediately report any illness, injury, emergency, or hazardous situation to the excursion organizers.

14. Be prepared for changing weather conditions and comply with all safety advisories issued by the excursion leaders.

9. Do not create excessive noise or disturb local communities, religious activities, wildlife, or natural habitats.

10. Do not leave valuables unattended or rely solely on mobile phone connectivity in remote areas.

11. Do not undertake any activity that may compromise your safety, the safety of fellow participants, or the conservation of the area's geological, ecological, archaeological, or cultural heritage.

Disclaimer

Participation in the field excursions is entirely at the participant's own risk. While the Organising Committee and excursion leaders will make every reasonable effort to ensure participant safety and provide appropriate guidance, they shall not be held responsible for any personal injury, illness, loss of personal belongings, property damage, delays, or unforeseen incidents arising during travel or field activities. Participants are expected to act responsibly, follow all instructions issued by the excursion leaders, and comply with applicable local laws and regulations throughout the excursion.













Scan for
Field Guide Book

Contact Details:

INQUA Secretariat
Birbal Sahni Institute of Palaeosciences (BSIP),
53, University Road, Lucknow-226 007 U.P, India

Email: inqua.india@gmail.com | inqua.india@bsip.res.in

Phone: +916386696896 | +916392507990