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FIELD GUIDE

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LATE QUATERNARY LITHOLOGY AND PALAEOENVIRONMENTAL STRUCTURE OF THE KALPI SECTION ALONG THE YAMUNA RIVER

Ansuya Bhandari and Sabyasachi Mandal









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Field Guide Book

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Late Quaternary Lithology and Palaeoenvironmental structure of the Kalpi Section along the Yamuna River

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Abstract

The Ganga-Yamuna interfluve (doab) preserves one of the most complete Late Quaternary fluvial archives in South Asia, documenting the complex interplay of tectonics, climate, river dynamics, and human occupation. This field guide presents a comprehensive account of the Late Quaternary geology, fluvial geomorphology, geoarchaeology, and landscape evolution of the Ganga-Yamuna inetrfluve through a field transect extending from Lucknow to Kalpi and Dashan, with special emphasis on the cliff sections at Kalpi and Dhasan. These natural exposures provide exceptional opportunities to examine the stratigraphic architecture of the Yamuna and Betwa foreland basin, revealing stacked channel sands, overbank silts and clays, palaeosols, calcrete horizons, and terrace sequences (T0, T1, and T2) that record repeated phases of river aggradation and incision during the Late Quaternary. The field guide highlights the geomorphological evolution of the Kanpur–Kalpi region, including braided bars, natural levees, palaeochannels, badland topography, and active floodplains, and discusses their significance in reconstructing fluvial processes and landscape evolution under changing monsoon conditions. The field transect also emphasizes the geoarchaeological importance of the region. The Dhasan cliff sections preserve the fossil of Elephas, while Kalpi records evidence of prehistoric activity together with an outstanding sedimentary archive. The integration of geological, geomorphological, geochemical, chronological, and archaeological datasets offers a holistic understanding of landscape evolution and human–environment interactions within the Marginal Ganga Plain. In addition, the field guide provides information on regional geology, geomorphology, flora, fauna, climate, geoheritage, archaeological significance, local culture, field safety, and logistical considerations for scientific excursions. Collectively, the Kalpi– Dhasan transect represents a unique natural laboratory for investigating Late Quaternary environmental change and serves as an important reference section for interdisciplinary research in the Indo-Gangetic foreland basin.

Key words: Marginal Ganga Plain, Cliff section, Late Quaternary, Fluvial, River

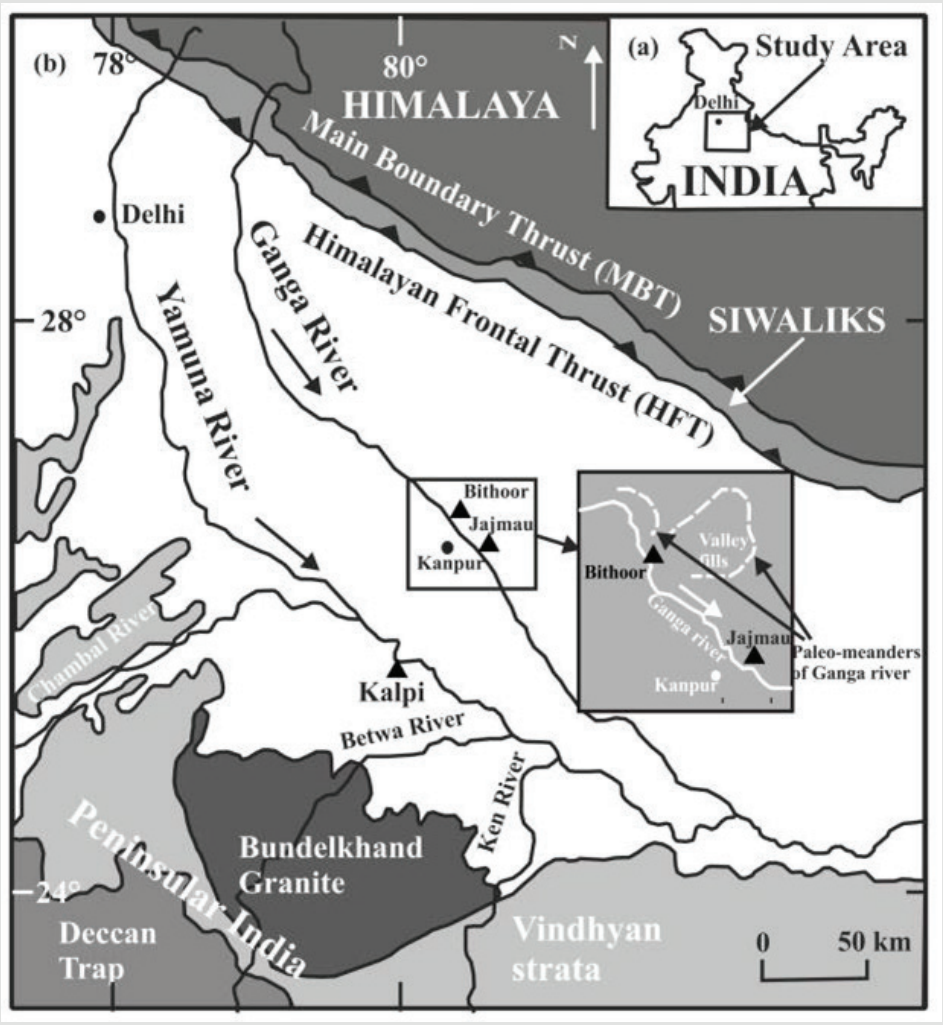
Preamble

The Ganga-Yamuna interfluve is one of the most significant Quaternary sedimentary basins of the Indian subcontinent. Formed through the long-term interaction of tectonic movements in the Himalayan foreland basin, climatic fluctuations, and fluvial processes, the region preserves an extensive archive of environmental and landscape evolution spanning the Late Quaternary Period. Thick alluvial deposits laid down by the Himalayan and Peninsular rivers record successive phases of sedimentation, channel migration, floodplain development, and soil formation, making the plain an ideal natural laboratory for studying Quaternary geology, fluvial geomorphology, palaeoenvironmental change, and geoarchaeology.

The Kalpi– Dhasan transect of the Ganga-Yamuna doab represents an exceptional natural archive for understanding Late Quaternary environmental evolution, fluvial dynamics, and landscape transformation in the Indo-Gangetic Foreland Basin. The Kalpi cliff, situated along the right bank of the Yamuna River near Kalpi town, Jalaun District, Uttar Pradesh, preserves one of the most significant and well-exposed Late Quaternary sedimentary successions in northern India. The alternating sequence of fluvial deposits, palaeosols, and calcrete horizons provides valuable evidence of repeated phases of river aggradation, floodplain stabilization, soil formation, and climatic variability. Extensive sedimentological, palaeopedological, geochronological, and archaeological investigations have established Kalpi as a key reference locality for reconstructing Late Quaternary palaeoenvironmental changes in the central Ganga Basin.

The Dhasan River section, located within the Marginal Ganga Plain along the eastern bank of the Dhasan River, a tributary system of the Betwa and Yamuna rivers, provides an important complementary record of Late Pleistocene fluvial processes. Situated near the peripheral bulge of the Ganga foredeep, the region exhibits deeply incised valleys, ravine development, and thick alluvial exposures. The sedimentary succession comprises sandy clayey silt, calcrete-rich conglomeratic horizons, and fining-upward channel deposits, preserving evidence of changing fluvial conditions and climatic influences. The occurrence of Elephas cf. namadicus fossils further enhances the significance of this section for understanding Late Pleistocene palaeoecology and biostratigraphy of the Ganga Plain.

Among the numerous Late Quaternary exposures preserved within the Marginal Ganga Plain, the cliff sections at Kalpi hold exceptional geological and geoarchaeological significance. These naturally exposed river-cut sections provide continuous stratigraphic records that document variations in sediment texture, depositional facies, pedogenic development, palaeosol formation, calcrete horizons, and changing fluvial processes through time. Their well-preserved sedimentary sequences and accessibility have established them as important reference sites for understanding Quaternary stratigraphy, fluvial evolution, palaeoenvironmental reconstruction, and landscape development within the Ganga Basin. Collectively, these sections preserve valuable archives of climatic fluctuations, river dynamics, sediment accumulation, and human–environment interactions during the Late Quaternary.



The map of India showing location of Kalpi Cliff section

The Kalpi Cliff situated along the right bank of the Yamuna River, near Kalpi town, Jalaun District in Uttar Pradesh, is internationally recognized for its well-exposed Late Quaternary sequence. The section records alternating fluvial deposits, and calcrete horizons, documenting repeated episodes of river aggradation, floodplain stability, soil formation, and climatic change during the Late Quaternary. Numerous sedimentological, palaeopedological, geochronological, and archaeological investigations have established Kalpi as a key locality for reconstructing environmental evolution in the Ganga basin.



Cliff section of the Kalpi (a, c , d & e) along the Yamuna River bank (b)

The Dhasan River Section: The study area constitutes the part of Marginal Ganga Plain (MGP). The main section exposed on the eastern bank of Dhasan river (25°44'41.3" N and 79°23'29" E) a tributary of Betwa river which in turn is tributary of Yamuna River. The area represents to the peripheral bulge of the Ganga foredeep and area slopes gently towards north and shows development of dense ravines with deeply incised rivers valley. The thickness of sections exposed along the incised rivers range from a few meters to more than 50 m in thickness. The section represents the late Pleistocene age and the sediments of the section contain fossils of Elephas cf. namadicus. The bottom part of the section (~3m thick) is consisting of brown coloured sandy clayed silt. On the other hand, the middle part is characterized by conglomerate dominantly of calcreate clast and subordinate lithic fragments with thickness of 1.5 to 2.5 m. The top most section consists of fining upward channelized unit.

Research problem

Late Quaternary geology is fundamentally concerned with understanding Earth's environmental and climatic history during the last ~2.58 million years through the study of sedimentary records, landforms, palaeosols, fossil assemblages, and archaeological evidence. Across the world, major river basins such as the Mississippi, Nile, Rhine, Danube, Yellow (Huang He), Yangtze, Amazon, and Ganga preserve extensive Late Quaternary deposits that record repeated episodes of climatic change, tectonic activity, river migration, and human occupation. These fluvial archives provide the basis for reconstructing past landscapes, understanding river evolution, and evaluating the response of sedimentary systems to global climatic fluctuations.

The Ganga foreland basin represents one of the largest active fluvial systems in the world and receives enormous quantities of sediment derived from Himalaya as well as peninsular India. Continuous sediment accumulation throughout the Late Quaternary has produced an alluvial succession several hundred metres thick, making the Marginal Ganga Plain. The geomorphic evolution of the Middle Ganga Plain has been influenced by variations in monsoonal intensity, sediment supply from Himalayan and Peninsular Indian Rivers, neotectonic activity, and changes in river dynamics during glacial and interglacial climatic cycles. These processes have resulted in a complex assemblage of river terraces, floodplains, abandoned channels, natural levees, palaeochannels, and cliff exposures that collectively preserve evidence of changing depositional environments and landscape evolution. Such sedimentary archives are invaluable for reconstructing the environmental history of northern India and understanding the interaction between climate, tectonics, river systems, and human occupation.

Regional Geology

The Kalpi region occupies a strategically important part of the Marginal Ganga Plain within the central sector of the Indo-Gangetic Foreland Basin. The area is characterized by thick Late Quaternary alluvial deposits derived principally from the Himalayan (Ganga and Yamuna river systems) and Cratonic rivers (Chambal and Betwa river systems). These sediments preserve an exceptional record of climatic oscillations, tectonic activity, fluvial processes, landscape evolution, and human occupation during the Late Quaternary Period. The river-cut cliff sections at Kalpi and Dhasan provide continuous natural exposures of these deposits and serve as important reference sections for geological, geomorphological, and geoarchaeological investigations. The exposed stratigraphy of the Kalpi-Dhasan area is dominated by Late Quaternary alluvial deposits of Pleistocene and Holocene age. These sediments consist of alternating sequences of gravel, sand, silt, clay, palaeosols, and calcrete horizons deposited under changing fluvial environments.

A generalized stratigraphic succession is as follows:

Stratigraphic Unit	Lithology	Environment
Recent Alluvium (Holocene)	Sand, silt, clay	Active floodplain (T0)
Older Alluvium (Late Pleistocene–Holocene)	Fine sand, silt, clay, palaeosols	Older floodplain (T1)
Upper Older Alluvium (Middle–Late Pleistocene)	Sand, gravel, calcrete, palaeosols	High terrace (T2)
Basement	Precambrian crystalline rocks (not exposed)	Indian Shield

Although the Kalpi-Dhasan region appears geomorphically stable, its evolution has been influenced by subtle neotectonic movements within the Ganga Foreland Basin. The basin continues to respond to compressional forces generated by the ongoing Himalayan orogeny. Numerous concealed basement faults and lineaments influence river gradients, channel migration, sediment thickness, and local drainage patterns.

Regional tectonic activity has contributed to differential uplift and subsidence, development of fluvial terraces (T0, T1, and T2), river incision and valley formation, localized preservation of thick alluvial sequences, rejuvenation of drainage systems. Several studies suggest that episodes of river incision during the Late Quaternary reflect the combined effects of climatic fluctuations and neotectonic adjustments within the foreland basin.

The Quaternary succession preserves a variety of palaeobiological evidence useful for environmental reconstruction. These include freshwater molluscan shells deposited in floodplain and oxbow lake environments, carbonized plant remains, fossil wood fragments, pollen and spores preserved within fine-grained sediments, and phytoliths derived from

The Quaternary geology of the Kalpi-Dhasan region records repeated cycles of sediment aggradation, floodplain stability, soil development, and river incision associated with glacial–interglacial climatic oscillations and variations in monsoonal intensity.

The principal lithological components include channel sands, gravel lenses, overbank silts and clays, palaeosols, calcrete horizons, organic-rich floodplain deposits etc.

Three geomorphic surfaces are well developed:

T0 Surface: Represents the active floodplain presently affected by seasonal flooding. It contains braided bars, point bars, natural levees, abandoned channels, and recent alluvium.

T1 Surface: Forms an older floodplain terrace characterized by mature soils, palaeosols, and relatively stable geomorphic conditions.

T2 Surface: Represents the oldest preserved terrace in the area and is extensively dissected by ravines and badlands, particularly along the Yamuna valley near Kalpi and near Dhasan river. Thick Quaternary sediments exposed in the Kalpi Cliff belong largely to this geomorphic level.

The Quaternary succession records repeated alternations between phases of river aggradation during humid climatic conditions and incision during periods of reduced discharge or tectonic uplift.

The area serves as an important natural laboratory for multidisciplinary studies involving Quaternary geology, sedimentology, fluvial geomorphology, palaeopedology, palaeoclimatology, geoarchaeology, and neotectonics. Its exceptional cliff exposures, well-preserved terrace sequence, and rich archaeological record make the Kalpi-Dhasan transect one of the most significant field areas for understanding the evolution of the Marginal Ganga Plain and the interaction between climate, tectonics, river systems, and human societies during the Quaternary.

Flora, Fauna, Climate and weather conditions

The Kalpi-Dhasan region lies within the subtropical monsoon climatic zone of northern India and experiences a continental climate characterized by hot summers, a humid monsoon season, and cool winters. The climate is primarily controlled by the southwest monsoon, which supplies nearly 80% of the annual rainfall. Seasonal variations in temperature and precipitation have played a major role in shaping the geomorphology, hydrology, soil development, and Quaternary sedimentation of the Marginal Ganga Plain.

The region experiences three principal seasons:

Summer (March–June): Summers are extremely hot and dry, with maximum temperatures commonly ranging from 40°C to 46°C during May and June. Hot, desiccating winds locally known as loo frequently blow across the plains, enhancing evaporation and reducing soil moisture. Dust storms are common before the onset of the monsoon.

Southwest Monsoon (Late June–September): The arrival of the southwest monsoon brings heavy rainfall and significantly lowers temperatures. Average annual rainfall ranges between 800 and 1,000 mm, most of which falls during this season. The Yamuna and Dhasan rivers experience increased discharge, resulting in flooding, channel migration, overbank sedimentation, and the formation of natural levees, braided bars, and flood basins. These seasonal floods are fundamental to the continued evolution of the floodplain.

Winter (November–February): Winters are generally cool and dry, with minimum temperatures occasionally falling below 5°C, while daytime temperatures remain between 18°C and 25°C. Dense fog commonly develops during December and January due to high humidity and temperature inversions. Winter precipitation associated with western disturbances occasionally contributes light rainfall.

The pronounced seasonal contrasts in temperature and rainfall have significantly influenced Late Quaternary landscape evolution by controlling river discharge, sediment transport, soil formation, and vegetation patterns.

Weather

Weather conditions in the Kalpi-Dhasan region are highly seasonal and directly influence geomorphic processes. During summer, prolonged dry conditions favour wind erosion, desiccation of exposed sediments, and stabilization of river bars. With the onset of the monsoon, intense rainfall generates surface runoff, bank erosion, channel migration, and large-scale sediment transport by the Ganga and Yamuna rivers. Winter weather is relatively stable, with low evaporation rates and frequent morning fog that influences local microclimatic conditions. Extreme weather events such as high-intensity rainfall, floods, droughts, and heat waves periodically affect the region and contribute to the dynamic evolution of the alluvial landscape.

Flora

Kalpi, located in the Jalaun district along the Yamuna River, lies in a semi-arid region of the Bundelkhand–Yamuna alluvial landscape. The natural vegetation is mainly characterized by tropical dry deciduous and thorny vegetation, adapted to seasonal rainfall and prolonged dry periods. Common plant species found in and around Kalpi-Dhasan include Neem (Azadirachta indica), Babul/Acacia (Vachellia nilotica), Peepal (Ficus religiosa), Banyan (Ficus benghalensis), Ber (Ziziphus mauritiana), Mahua (Madhuca longifolia), Tendu (Diospyros melanoxylon) and Palash (Butea monosperma)

The fertile alluvial plains along the Yamuna-Dhasan support extensive agricultural vegetation. Major cultivated crops include wheat, rice, pulses, mustard, cotton, and vegetables. Riverbanks contain grasses, reeds, and moisture-loving plants that contribute to the local riparian ecosystem.

Fauna (Animal Life)

The landscape around Kalpi supports a variety of wildlife typical of the Yamuna riverine ecosystem and the Bundelkhand plains. Although much of the area has been transformed by agriculture and settlement, several species continue to inhabit the region. Common fauna include Mammals, Nilgai (Boselaphus tragocamelus), Blackbuck (Antilope cervicapra) (in suitable habitats), Indian jackal (Canis aureus), Indian hare (Lepus nigricollis), Common mongoose, various rodents and small mammals, Birds, Peafowl (Pavo cristatus), Egrets and herons, Kingfishers, Parakeets, Doves and pigeons, Migratory water birds along the Yamuna during winter, Reptiles and Aquatic species ,snakes, lizards and turtles, freshwater fish species of the Yamuna River.

The region's prehistoric record also indicates a richer Pleistocene fauna, with animal remains associated with Middle Paleolithic archaeological deposits, reflecting ancient riverine grassland and woodland environments.

Literature review

Initial geological studies of the Marginal Ganga Plain were primarily concerned with describing the alluvial stratigraphy and geomorphology of the Indo-Gangetic Basin (Gibling et al. 2005; Singh 1996; Singh et al. 1999; Sinha et al. 2007; Sinha et al. 2005). Early workers recognized the distinction between Older Alluvium and Newer Alluvium and documented the occurrence of river terraces, palaeochannels, calcrete horizons, and floodplain deposits. These studies established that the Late Quaternary succession was closely related to Himalayan tectonics, monsoon-driven sediment supply, and repeated episodes of river aggradation and incision. Subsequent regional geomorphic mapping demonstrated that the southern Marginal Ganga Plain preserves multiple geomorphic surfaces (T0, T1, and T2) associated with different stages of Late Quaternary landscape evolution.

Kalpi Cliff Section: The Kalpi Cliff is the most extensively investigated Quaternary exposure in the Marginal Ganga Plain and is widely regarded as a reference section for Late Quaternary fluvial stratigraphy. Detailed sedimentological studies have documented alternating channel sands, floodplain muds, palaeosols, calcrete horizons, and erosional surfaces, indicating repeated transitions between active sedimentation and periods of landscape stability.

Photomosaic mapping, lithofacies analysis, and stratigraphic logging have identified several depositional environments within the Kalpi succession, including channel, floodplain facies etc. Carbonate nodules, rhizoconcretions, and calcrete horizons have been investigated using petrographic and stable isotope techniques to reconstruct palaeoclimate and palaeovegetation processes.

The Sr and Nd isotopic study of the Kalpi core provides important insights into the provenance and evolution of Quaternary sediments in the Marginal Ganga Plain. Analyses of radiogenic strontium (87Sr/86Sr) and neodymium (εNd) isotopic ratios from both silicate fractions and pedogenic carbonates reveal systematic temporal variations reflecting changes in sediment source contributions during the Late Quaternary.

Geochronological investigations employing luminescence dating have shown that the exposed sediments span much of the Late Pleistocene and Holocene. These studies indicate repeated episodes of floodplain aggradation interrupted by periods of incision, pedogenesis, and gully development that correspond broadly with changes in monsoon intensity.

Because of its exceptional exposure, the Kalpi Cliff has become a benchmark locality for studies of Quaternary sedimentology, palaeopedology, monsoon variability, and landscape evolution in the Himalayan foreland basin.

Major Scientific Contributions

Research conducted in the Kanpur region has significantly advanced understanding of:

- Quaternary stratigraphy of the Middle Ganga Plain.
- Fluvial architecture and sedimentary facies of large alluvial rivers.
- Evolution of floodplains and river terraces (T_0, T_1, and T_2).
- Monsoon-driven cycles of aggradation and incision.
- Development of palaeosols and calcrete under semi-arid climatic conditions.
- Late Quaternary palaeoenvironmental reconstruction.
- Relationships between geomorphology and archaeological settlement.
- The role of Himalayan tectonics and foreland basin evolution in controlling river behaviour.

The Kalpi-Dhasan transect therefore represents one of the most valuable natural laboratories in the Ganga foreland basin for advancing Late Quaternary geological research and provides considerable opportunities for future interdisciplinary investigations.

Dhasan River: The late Quaternary sedimentary sequence of Dhasan River, Ganga Plain provide critical insights into mammalian evolution and paleoclimatic fluctuations. The post-Siwalik proboscidean remains have historically been documented across Peninsular India (such as the Narmada and Godavari valleys), chronologically anchored records from the Ganga Plain have remained sparse. The well-preserved fossil elephant skull recovered from a late Pleistocene cliff section along the Dhasan River in the Marginal Ganga Plain. Detailed comparative analyses of cranial architecture and dental morphology reveal a very close affinity to Elephas namadicus (historically nested within Palaeoloxodon namadicus), a prominent extinct megaherbivore of the Indian subcontinent. However, given the isolated nature of the find, the specimen is provisionally assigned to Elephas cf. namadicus to

maintain taxonomic caution (Ghosh et al. 2016). Chronometric constraints derived from Optically Stimulated Luminescence (OSL) dating place the fossil horizon at ~56 ka BP. This discovery represents the first chronologically well-constrained, absolute-dated report of E. cf. namadicus from the Ganga Plain, providing crucial baseline data for Late Pleistocene megafaunal distribution and biostratigraphy in northern India

Field Transect

The Kalpi- Dhasan transect represents a classic north–south to northwest–southeast traverse across the Marginal Ganga Plain, crossing major geomorphic surfaces of the Ganga and Yamuna fluvial systems. The route provides an excellent exposure of Late Quaternary stratigraphy, fluvial geomorphology, and neotectonic landforms, transitioning from older interfluve surfaces near Lucknow to active floodplains and river-cut cliff sections near Kalpi. The transect broadly follows National and State Highways connecting Lucknow–Unnao–Kanpur–Bithoor–Kalpi, cutting across T2, T1, and T0 geomorphic surfaces and exposing representative sedimentary facies of the Ganga basin.

1. Kalpi Sector (Yamuna Valley and Incised Terrace Landscape)

This stretch transitions from the Ganga floodplain to the Yamuna incised valley system, where older geomorphic surfaces (T2) are strongly dissected into ravines and badlands.

Key Geological and Geomorphic Features are prominent T2 terrace surface forming uplands, deeply incised ravine (badland) topography, exposed calcrete-rich Late Quaternary sequences, channel sands and floodplain muds, strong evidence of river incision and neotectonic adjustment

Key Field Stop:

- Kalpi Cliff Section
- Thick Quaternary stratigraphy (~multi-storey exposure)
- Calcrete horizons, channel fills
- Classic record of monsoon-driven sedimentation cycles
- Excellent exposure of Late Pleistocene–Holocene evolution

Kalpi to Dhasan:

The Kalpi to Dhasan River transect cross-cuts the Southern Marginal Ganga Plain (MP), transitioning from the axial Yamuna River valley at Kalpi to the craton-derived fluvial systems draining the Bundelkhand Craton margin. This region acts as a crucial sediment-mixing zone where cratonic (peninsular) sediment pathways interface with broader Himalayan-driven foreland basin deposition. The regional landscape marks a transition from a highly incised, dynamically controlled alluvial plain into an undulatory, structurally confined cratonic boundary.

Deep River Incision & Cliff Topography: At Kalpi, the Yamuna River features iconic, highly incised vertical cliffs reaching 30–33 meters in height. Moving southwest toward the Dhasan River, the valleys remain sharply entrenched, indicating widespread regional uplift or climate-driven base-level changes during the Late Quaternary.

Badland Development: The interfluve along this transect is dissected by extensive gullies and badland topography, driven by episodic monsoonal runoff washing across highly erodible, fine-grained Pleistocene sediments.



Badland of the Kalpi along the Yamuna River bank

Structural and Tectonic Control: The drainage patterns transform along the transect. While the Kalpi domain is dominated by axial foreland basin pathways, the Dhasan River basin exhibits strong structural orientation (trellis and dendritic patterns) under strict morphotectonic control from the underlying Bundelkhand Craton basement faults.

Location(s) Description

a. Kalpi Cliff Section

Location: The Kalpi Cliff is located near Kalpi town in Jalaun District, Uttar Pradesh, along the right bank of the Yamuna River, approximately 90 km south of Kanpur (26°07'52.6" N and 79°44'52.5" E). It forms part of the southern margin of the Middle Ganga Plain and represents one of the most prominent natural exposures of Late Quaternary alluvium in the Yamuna valley.

Geomorphology: Kalpi lies on a well-developed T2 terrace surface, which is deeply dissected by gullies and ravines forming classic badland topography. The Yamuna River has incised into older alluvial deposits, exposing a continuous cliff section. The geomorphic setting reflects long-term river incision, terrace formation, and neotectonic uplift, coupled with monsoon-controlled fluvial dynamics.

Sedimentology: The exposed sequence consists of multi-storey channel sands, overbank silts and clays, and calcrete horizons. Channel deposits show cross-bedding and ripple structures, while floodplain facies are dominated by laminated silts and pedogenically modified horizons. Repeated fining-upward sequences indicate alternating phases of channel activity and floodplain stabilization.

Chronology: Optically Stimulated Luminescence (OSL) and associated geochronological studies suggest that the exposed succession ranges broadly from the Middle to Late Pleistocene into the Holocene. The sedimentary record reflects cyclic aggradation–incision phases linked to monsoon variability and climatic oscillations during the Late Quaternary.

Geochemistry: Geochemical and isotopic studies from the Kalpi succession highlight strong variations in Sr and Nd isotopic ratios, reflecting mixed sediment sources from the Himalayan belt and Bundelkhand Craton. Pedogenic carbonates show evidence of monsoon-driven soil formation processes, with calcrete development indicating seasonally dry phases.

b. Dhasan river Section

Geographic and Geological Location

The Dhasan River section is located in the Marginal Ganga Plain (MGP) of central-northern India.

- **Coordinates:** The primary studied site sits on the eastern bank of the Dhasan River at approximately 25°44'41.3" N and 79°23'29" E, near Jigni village.
- **Regional Context:** The Dhasan River is a major right-bank tributary of the Betwa River (part of the larger Yamuna-Ganga drainage system). It flows northward through the Bundelkhand upland region spanning Madhya Pradesh and Uttar Pradesh.
- **Tectonic Setting:** Geologically, this section is positioned over the peripheral bulge of the Ganga foredeep, serving as a boundary zone where the southern cratonic basement (Bundelkhand Granitic Complex) meets the alluvial foreland basin.

Geomorphology

- The geomorphological framework of the Dhasan River basin is characterised by a t ransition from rocky cratonic uplands to deeply incised alluvial corridors.
- Incised Cliff Stratigraphy: The area features vertical cliff sections exposing up to 13 metres of Quaternary sediments on its banks, indicating active base-level changes or regional uplift.
- Drainage Network & Pattern: The river exhibits a highly structured trellis to dendritic drainage pattern. Its orientation displays a polymodal distribution (primarily NE-SW, NW-SE, and E-W), which points to strong morphotectonic control governed by underlying basement lineaments and faults.
- **Terrain Profile:** The landscape functions as an undulatory topography featuring a steep stream gradient in upper sub-watersheds and severe badland/ravine development along the margins due to high seasonal monsoonal runoff washing over erodible sediments.

Sedimentology

The 13-metre-thick sedimentary sequence exposed at Jigni is divisible into three distinct lithofacies units that record shifting environmental dynamics.

- **Fluvial Channel Sand Facies (Lower Unit):** Composed of cross-bedded, gravelly-to-coarse quartzose sand with arkosic matrices. This package features abundant pink feldspar, quartz granules, and rock fragments derived directly from the weathering of the local Bundelkhand granite basement.

- **Overbank & Floodplain Fines (Middle Unit):** Comprising multi-metre thick bands of muddy silts, laminated fine sands, and variegated clayey silts. These reflect low-energy floodplains punctuated by episodic monsoonal sheet-wash events.

- **Pedogenic Calcrete & Mud Horizon (Upper Unit):** Showcases widespread development of nodular-to-massive calcrete horizons and mottled red-brown paleosols. These represent prolonged periods of subaerial exposure, low sedimentation rates, and landscape stability under semi-arid conditions.

Chronology

The Dhasan River section is a critically anchored chronology benchmark for the Late Pleistocene epoch.

- **Numerical Age:** The fossil-bearing horizon within this section is securely dated to ~56,000 years Before Present (~56 ka BP).
- **Dating Technique:** This constraint was determined using Optically Stimulated Luminescence (OSL) dating on quartz grains collected directly from the host sediment layer.
- **Stratigraphic Stage:** This temporal anchor places the deposition firmly within Marine Isotope Stage 3 (MIS 3), establishing it as the first chronologically well-constrained record of fossil megafauna (specifically Elephas cf. namadicus) in the Ganga Plain.

Geoheritage, UNESCO heritage, cuisines, and culture

The Kalpi–Dhasan corridor in the Marginal Ganga Plain represents one of the most significant fluvial geoheritage landscapes of northern India, where active river processes, Quaternary stratigraphy, and long-term landscape evolution are exceptionally well preserved in natural cliff exposures and terrace systems. The Kalpi Cliff (Yamuna River) is globally important as a reference exposure for Late Quaternary fluvial sedimentation, palaeosol development, and calcrete formation, recording repeated cycles of monsoon-driven aggradation and incision. The Bithoor and Jajmau cliffs (Ganga River system) complement this record by preserving floodplain architecture, channel migration histories, and terrace formation processes (T0–T1–T2 surfaces). Collectively, these sites form a continuous geoarchive of Himalayan-derived sedimentation in a foreland basin setting, making them highly valuable for Quaternary stratigraphy, palaeoclimatic reconstruction, and fluvial geomorphology.

Although not formally inscribed as UNESCO World Heritage Sites, the region forms part of the broader Ganga River cultural–geomorphic system, which has been recognized globally for its Outstanding Universal Value in terms of living cultural traditions, sacred geography, and river–civilization interaction. Sites like Varanasi's riverfront (a UNESCO tentative listing context) highlight the broader cultural landscape to which Kalpi–Dashan belongs.

Although no UNESCO World Heritage Site is located in the vicinity of Kalpi, and Dashan, several internationally significant heritage sites occur within the broader region. The nearest UNESCO World Heritage property is Fatehpur Sikri, Agra Fort and Taj Mahal, while the sacred city of Varanasi has long been considered for UNESCO recognition because of its exceptional cultural and religious importance. The Ganga Plain itself is recognized globally for its archaeological richness and long history of human occupation.

The Kalpi region of the Marginal Ganga Plain represents a culturally diverse landscape where riverine geography, historical trade routes, and agricultural abundance have significantly influenced local cuisine and cultural traditions. Situated along the fertile alluvial plains of the Ganga and Yamuna rivers, both settlements reflect a blend of Awadhi, Bundeli, and central Gangetic cultural elements, shaped by long-term human occupation and regional mobility.

a. Cultural Setting

In contrast, Kalpi retains a more traditional small river-town cultural identity, deeply rooted in historic riverine trade, agriculture, and regional folk traditions.

Despite this contrast, both regions share common cultural foundations based on:

- River-centric settlement patterns
- Agricultural cycles of the Ganga–Yamuna floodplain
- Religious festivals and seasonal rituals
- Strong oral and folk traditions

b. Cuisine of Kalpi and Dhasan area

Kalpi's cuisine reflects a more traditional Bundelkhand–Yamuna river valley food culture, closely linked to rural agrarian practices and seasonal availability of resources.

Key Features

- Simple, seasonal, and home-cooked meals
- Strong reliance on locally grown grains and pulses
- Use of mustard oil, spices, and dried preservation techniques
- Influence of rural Bundelkhand and lower Doab traditions

Common Foods

- Bajra and jowar roti
- Dal (lentils) with seasonal vegetables
- Litti-like preparations and rustic breads
- Pickles and sun-dried vegetables
- Traditional sweets such as peda and local jaggery-based items

Kalpi's food culture is closely tied to agricultural cycles of the Yamuna floodplain, with seasonal variation in ingredients and preparation methods.

c. Cultural Traditions and Festivals

Kalpi share a vibrant cultural calendar rooted in Hindu, Muslim, and folk traditions, reflecting regional diversity.

Major Festivals

- Diwali and Holi
- Eid celebrations
- Navratri and Durga Puja
- Chhath Puja (especially significant in river contexts)

Conclusion

The Kalpi and Dhasan cliff sections collectively represent a continuous and highly significant late Quaternary fluvial and geoarchaeological transect of the Marginal Ganga Plain, recording the interaction between fluvial dynamics, monsoon variability, sediment provenance, tectonic adjustment, and human occupation. These sites expose well-developed alluvial terrace systems (T0, T1, and T2 surfaces) and preserve thick successions of channel sands, overbank floodplain muds, palaeosols, and calcrete horizons, reflecting repeated cycles of river incision and aggradation under changing climatic conditions. Kalpi, located in the Yamuna valley, preserves a deeply incised badland and ravine-dominated T2 landscape with long stratigraphic records of floodplain sedimentation and pedogenesis. Geochemically, these sequences record mixed sediment provenance, with varying contributions from Himalayan and Peninsular sources, while isotopic and pedogenic signatures reflect monsoon-driven environmental fluctuations during the Late Quaternary. Chronologically, the deposits broadly span the Middle Pleistocene to Holocene, capturing multiple phases of climatic instability and landscape reorganization. Commonly, the Kalpi corridor represents an exceptional natural laboratory for investigating Quaternary geology, fluvial geomorphology, geoarchaeology, and landscape evolution. It preserves a rare and integrated record of Earth surface processes, climatic and tectonic influences, and human–environment interactions within the Indo-Gangetic foreland basin, making it an ideal setting for interdisciplinary research.

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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

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