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FIELD GUIDE

INPOST - 06

KAREWAS OF KASHMIR — DECODING QUATERNARY CLIMATE ARCHIVES OF THE WESTERN HIMALAYA

Rayees Ahmad Shah, Irfan Maqbool Bhat and Prof. Shakil Ahmad Romshoo



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Field Guide Book

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Karewas of Kashmir — Decoding Quaternary Climate Archives of the Western Himalaya

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Abstract

The Kashmir Valley, an intermontane basin in the western Himalaya, preserves an exceptional archive of Quaternary Karewa deposits that document major climatic, environmental, and tectonic changes spanning the past ~4.4 million years. These fluvio lacustrine and aeolian successions provide one of the most complete terrestrial records of Quaternary landscape evolution and paleoclimate in the Himalayan region. This field excursion is primarily designed to introduce participants to the diverse Quaternary archives of the Kashmir Valley, highlighting their stratigraphy, sedimentology, chronology, and paleoenvironmental significance, while showcasing their importance for understanding regional and global climate evolution.

Participants will visit key geological and archaeological sites, including Shankerpora, Makaibagh, Burzahama (Neolithic archaeological site), Hirpur, Palar, Khan Sahab, and Nagum, to examine representative sedimentary sequences, paleosols, neotectonic structures, and the diverse Quaternary deposits of the Kashmir Basin. The excursion will provide hands-on experience in field stratigraphy, sedimentological logging, geomorphic interpretation, and discussions on advanced chronological techniques, including infrared stimulated luminescence (IRSL) dating and isotope geochemistry.

Through field observations, scientific discussions, and knowledge exchange, participants will gain a comprehensive understanding of the Quaternary archives of the Kashmir Valley and their significance for reconstructing Himalayan paleoclimate, landscape evolution, and tectonic history. The excursion will also highlight current research challenges and opportunities for integrated, multi-proxy investigations, while fostering scientific exchange and future international collaborations in Quaternary science.

Preamble

Globally, Quaternary geology seeks to understand the timing, mechanisms, and impacts of climatic and environmental changes that have shaped Earth's landscapes over the past ~2.58 million years. A central research challenge is the development of high-resolution, well-dated continental records that can be correlated with global climate archives such as marine sediments and ice cores. While significant advances have been made in regions such as Europe, China, and North America, many key areas in the Himalayan region remain comparatively underexplored, resulting in major gaps in understanding regional climate responses to global forcing mechanisms. In particular, uncertainties persist regarding the chronology of terrestrial sequences, the interpretation of multi-proxy climate indicators, and the relationships among tectonics, atmospheric circulation, and sedimentation patterns.

The Kashmir Valley represents one of the few intermontane basins in the Himalayan region preserving a nearly continuous succession of fluvial, lacustrine, and aeolian deposits spanning several million years. Despite the presence of extensive Karewa deposits, including thick loess-paleosol sequences, discrepancies among age determinations obtained using different dating methods and the limited application of modern chronological techniques highlight a critical research gap. These limitations hinder robust correlation of Himalayan terrestrial records with global climatic events and restrict the integration of South Asian paleoclimate archives into broader Quaternary climate frameworks.

The proposed field transect is unique because it integrates multiple depositional environments within a single geographically confined basin, providing an exceptional natural laboratory for investigating long-term climate–tectonic–sedimentary interactions. The transect includes loess-paleosol sequences that record atmospheric dust dynamics and climatic variability, fluvial-lacustrine successions that preserve evidence of ancient lake systems and hydrological changes, and neotectonic exposures that document active deformation. The close spatial association of these complementary Quaternary archives provides a rare opportunity to compare depositional systems directly and develop an integrated understanding of regional paleoclimate evolution.

The excursion will introduce participants to these outstanding Quaternary archives while highlighting current scientific challenges in establishing robust chronological frameworks and refining paleoenvironmental reconstructions. It will provide opportunities to discuss the application of advanced analytical approaches, particularly infrared stimulated luminescence (IRSL) dating, Radiocarbon dating, other chronological methods, and isotope geochemistry, to improve the understanding of the Kashmir Valley's Quaternary record. The field excursion is also expected to serve as a platform for initiating future international collaborations, particularly in chronology and geochemistry, where further research is needed to strengthen regional datasets and their correlation with global paleoclimate records.

Regional Geology

The Kashmir Valley, located within the western Himalaya, represents a classic intermontane basin bounded by the Pir Panjal Range to the southwest and the Great Himalayan Range to the northeast (Burbank and Johnson, 1982; Burbank and Johnson, 1983). This elongated basin, trending NNW–SSE, is approximately 140 km long and 40 km wide, with an average elevation of about 1800 m above mean sea level. The region exposes lithologies ranging in age from Palaeozoic bedrock to Recent alluvium. The Paleozoic rocks form the structural basement and surrounding mountain ranges, whereas the central basin is occupied by Neogene-Quaternary Karewa deposits and Recent alluvial sediments. Together, these geological units provide an exceptional archive for investigating the tectonic evolution, landscape development, and Quaternary environmental history of the Kashmir Valley. The Quaternary Karewa deposits occupy the central parts of the valley, forming elevated plateaus above the present-day floodplains of the Jhelum River and its tributaries (Bhatt, 1982, 1989).

Stratigraphy

The stratigraphy of the Kashmir Valley is dominated by the Karewa Group, which consists of thick fluvio-lacustrine, glacial, and aeolian deposits that accumulated within the basin during the Late Neogene and Quaternary periods (Bhatt, 1982). These deposits rest unconformably over older basement rocks, including Triassic limestone and volcanic units. The Karewa succession is classically divided into three major formations: Hirpur, Nagum, and Dilpur (Table 1).

Table 1. Lithostratigraphic subdivisions of the Karewa (after Bhatt, 1982, 1989).

Epoch		Formation	Member	Lithology
Holocene		Alluvium	-	Alluvium deposits
Pleistocene	Late	Dilpur Formation	-	Loess-paleosol sediments
	Middle	Nagum Formation	Pampore Member	Sand, Silt, Clay and Sporadic Conglomerate
			Shopian Member	Conglomerate
		Angular Unconformity		
	Early	Hirpur Formation	Methawoin Member	Lignite, Silt, Sand, Sandy clay, Clay and Sporadic Conglomerate
Pliocene		Hirpur Formation	Rambiara Member	Conglomerate
			Dubjan Member	Clay, Sandy clay and Sand

According to Bhatt (1982, 1989) the Hirpur Formation, representing the lower part of the Karewa Group, primarily consists of lignite-bearing sediments composed of clay, sandy clay, sand, and sporadic conglomerates. These deposits indicate deposition in fluvial to lacustrine environments during the early stages of basin development. The Nagum Formation, overlying the Hirpur Formation, consists predominantly of sand, silt, clay, and conglomeratic units, reflecting dynamic fluvial and lacustrine depositional settings associated with glacial influences. The uppermost Dilpur Formation consists largely of aeolian deposits, particularly loess–paleosol sequences, representing repeated cycles of dust accumulation and soil formation linked to climatic oscillations during the Late Quaternary. These loess–paleosol sequences serve as high-resolution terrestrial archives of paleoclimate change and landscape evolution. Overlying the Karewa deposits are Recent alluvial sediments associated with the Jhelum River and its tributary systems. These younger sediments are derived largely from the erosion of loess-capped Karewa plateaus and surrounding mountainous terrain. The preserved stratigraphic record spanning several million years provides valuable insights into basin development, sedimentation patterns, and paleoclimatic fluctuations.

The Karewa deposits represent a continuous, multi-million-year terrestrial archive that records the evolution of the Kashmir Basin through transitioning depositional regimes driven by tectonic uplift and climatic oscillations. According to Bhatt (1982, 1989), the basal Hirpur Formation (Fluvial to Lacustrine Archive) documents the initial phase of basin evolution. Characterized by lignite-bearing clay, sandy clay, sand, and sporadic conglomerates, these sediments capture a low-energy fluvial-to-lacustrine setting under relatively warm and humid conditions, preserving organic-rich palynological and floral archives. Overlying the Hirpur Formation, the Nagum Formation (transition to Glacio Fluvial settings) consists of dynamic sand, silt, clay, and conglomeratic units. This unit marks a pivotal shift toward cold-climate regimes, where proglacial and meltwater dynamics combined fluvial and lacustrine processes. Glacial advances and retreats influenced sediment transport, recording the onset and amplification of Quaternary glaciations. The uppermost Dilpur Formation (Last Glacial Maximum to Aeolian Dominance) represents the transition to arid and cold conditions, notably capturing the Last Glacial Maximum (LGM) and late Quaternary climatic cycles. During intense glacial phases, reduced vegetation cover and strong wind regimes promoted dust deposition, giving rise to thick loess–paleosol sequences. Cold, dry glacial intervals (e.g., LGM) led to rapid aeolian dust accumulation (loess units), whereas warmer, moist interglacial/interstadial phases arrested dust fallout and favored soil development (paleosols). These sequences serve as high-resolution archives of high-frequency climate fluctuations. Capping the Karewa sequences are Recent alluvial sediments (Modern Reworking) associated with the Jhelum River and its tributaries. These deposits represent the modern fluvial phase, primarily derived from the denudation and erosion of loess-capped Karewa plateaus and surrounding high-altitude glaciated terrains.

Structural Geology

Structurally, the Kashmir Valley represents a tectonically active intermontane basin formed as a result of Himalayan orogeny associated with the ongoing convergence between the Indian and Eurasian plates (Thakur et al., 2010). The basin's formation and evolution have

been strongly influenced by thrusting, folding, and faulting along major Himalayan tectonic zones (Figure 1). These tectonic processes-controlled basin subsidence, sediment accumulation, and the development of accommodation space for thick Karewa deposits (Wadia, 1975).

Evidence of neotectonic activity is preserved in several sections across the valley, including the Palar Section, where soft-sediment deformation structures such as folds and faults are clearly observed (Agarwal et al., 2018). These structures indicate continued tectonic adjustments during sediment deposition. Uplift of surrounding mountain ranges has also influenced sediment supply, drainage evolution, and climatic patterns within the basin. Structural deformation has further contributed to changes in depositional environments, influencing transitions between lacustrine, fluvial, and aeolian regimes.

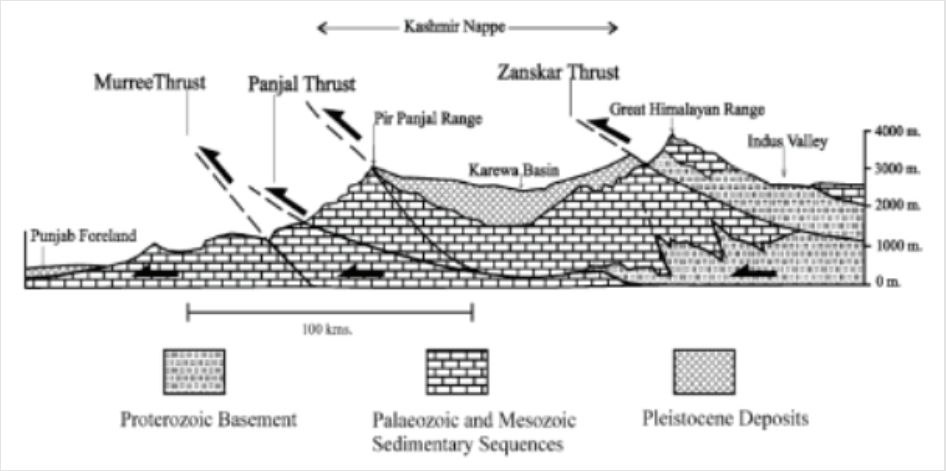


Figure 1. Cross section of the Kashmir Himalayas displaying the broad tectonic features (modified after Wadia, 1931).

Palaeontology

Palaeontological records from the Kashmir Valley provide valuable information regarding past environmental and climatic conditions. Fossil remains reported from the Hirpur Formation include plant remains such as cinnamon, oak, maple, walnut, and rose, along with fruit remains and spores (Kotlia, 1990). In addition to plant fossils, diatoms, land-shells, and other microfossils have been documented, indicating lacustrine and wetland depositional environments. These fossil assemblages provide evidence of climatic variability, vegetation changes, and ecological responses during different phases of basin evolution. The presence of temperate vegetation fossils suggests periods of relatively warm and humid climatic conditions, while changes in fossil assemblages reflect transitions to cooler and drier climates associated with glacial–interglacial cycles. Such palaeontological evidence forms an essential component of reconstructing paleoenvironments and understanding the ecological dynamics of the Quaternary Period (< 2.6 Ma) in the region.

Quaternary Geology

The Quaternary geology of the Kashmir Valley is particularly significant due to the preservation of diverse depositional systems representing fluvial, lacustrine, glacial, and aeolian environments. The valley is widely considered to have hosted a large paleo-lake during earlier phases of its evolution, within which extensive lacustrine sediments accumulated. Subsequent climatic changes and tectonic uplift led to fragmentation of the lake and the development of fluvial systems.

Loess-paleosol sequences within the Dilpur Formation represent one of the most important Quaternary archives in the region. These deposits reflect repeated cycles of dust deposition during cold and dry periods and soil formation during warmer and wetter intervals. Pedostratigraphic studies indicate multiple climatic cycles recorded in these sequences, providing evidence of long-term climate variability linked to glacial–interglacial oscillations.

Glacial features also form an important component of the Quaternary landscape in the region. These glaciers of the valley are characterized by U-shaped valleys, cirques, and well-preserved moraine ridges, records multiple stages of glacier advance and retreat. These landforms provide valuable insights into the timing and extent of past glaciations and their relationship with regional climate changes. Together, these Quaternary records provide a comprehensive framework for reconstructing the paleoclimate history of the western Himalaya.

The chronology of the Lower and Middle Karewa (i.e., Hirpur Formation) has received limited attention, with a few studies discussing sedimentation rate, paleontological evidence, and magneto-stratigraphy. Lydekker (1878) suggested the base of the Karewa sequence dates back to the beginning of the Pliocene, later supported by Wadia (1951), who extended it to encompass the Lower Pliocene (Pontian stage). Bhatt (1982, 1989) further corroborated this based on the tectonic and paleontological evidences. Magneto-stratigraphic studies revealed five normal and five reverse polarities (Burbank and Johnson, 1982), suggesting 4 Ma start to the Karewa deposits. However, Basavaiah et al. (2010) revised this chronology using the Romushi section, and identifying eight normal and eight reverse polarity magnetozones spanning from 4.40 to 0.77 Ma.

Unlike the extensive study of the Hirpur and Nagum Formations, the Dilpur Formation has received thorough attention from various researchers. Agrawal et al. (1979, 1988, 1989), Kusumgar et al. (1980), Pant and Dilli (1986), Singhvi et al. (1987), Bronger et al. (1987), Rendell et al. (1989), Gupta et al. (1991), Dar et al. (2015), Chandra et al. (2016), Babeesh et al. (2017), Meenakshi et al. (2020), Ali and Achyuthan (2020), and Shah et al. (2021) have contributed to this field. Agrawal et al. (1979) determined that the loess deposition occurred during the Brunhes chron, less than 780,000 years ago. Kusumgar et al. (1980) dated the last deglaciation in the Kashmir Himalaya to around 18,000 years ago. Singhvi et al. (1987) used thermo-luminescence dating to estimate the age of various sites in the valley, suggesting a span of at least 300 ka. Bronger et al. (1987) proposed a minimum age of 350 ka based on the pedostratigraphy. Agrawal et al. (1988, 1989) suggested that the loess deposits along the Valley's southwestern side deposited during the Late Quaternary, and is younger than 200 ka. Gupta et al. (1991) reinterpreted previous thermo-luminescence ages, and used mineral magnetic analysis, suggesting a start of loess deposition around 225 ka ago. Babeesh et al.

(2017) utilized optically stimulated luminescence (OSL) dating, determining a 40-ka age for an 8.7m loess-paleosol sequences (LPS) near Manasbal lake. Meenakshi et al. (2018) dated sections in Shankerpora and Burzahama, suggesting previous thermo-luminescence dates were less reliable. Ali and Achyuthan (2020) dated the Burzahama section to 52 ±2 ka and a loess section near Pattan town to 54 ±2 ka. Shah et al. (2021) dated the LPS of Makaibagh section from 65.8 ± 7.2 ka to 14.7 ± 5.4 ka using OSL dating. Tauseef et al., 2022 used AMS radiocarbon dating, reporting a range of >40 to 19.6 ka for the LPS deposits of Pattan section. The accuracy of reported ages for LPS deposits remains disputed, particularly for older sediments, highlighting a critical research gap in loess research in the Kashmir Valley.

Despite the extensive sedimentary records spanning approximately 4.4 Ma, derived from fluvial, glacial, lacustrine, and aeolian sediments, detailed climate studies are still scarce from this region. These sedimentary deposits offer valuable but largely untapped resource for understanding Quaternary climatic research, posing challenges for global correlation due to limited exploration compared to similar studies carried elsewhere. By analysing various proxies, such as radiometric and luminescence dating, magneto-stratigraphy, grain size distribution, geochemistry, and isotopic composition, we aim to shed light on the region's climatic history and its relationship with atmospheric processes.

Pedostratigraphic studies conducted by Agrawal et al. (1989) and Dar et al. (2015) have investigated loess sections across the Kashmir Valley. The most extensive and well preserved LPS deposits are found in Shankerpora section on the Pir Panjal Range, while the thickness and number of paleosol profiles decrease towards the Great Himalayan Range (GHR). Shankerpora section LPS, with nearly 12 paleosol sequences, reflects 12 climatic cycles from cold/dry to warm/wet. Other sections like Khansahib, Pattan, and Makaibagh have fewer profiles and are located centrally or towards the GHR. These variations reflect the gradual geomorphic evolution of the Kashmir Valley.

Understanding sedimentation processes, physical and chemical parameters, and biotic components helps reconstruct the regional paleoenvironments. Early references to the presence of the Karewa Lake dates back to Von Hugel (1840), with subsequent researchers suggesting that the Karewa deposits formed in that lake basin with occasional fluvial influences. Tandon et al. (1982) used sedimentological parameters to interpret the paleoenvironment, while Singh (1982) focused on sediment grain size to discuss the paleoenvironment in detail. The Lower Karewa was proposed to have been deposited in a fluvial environment (Lydekker, 1883). However, interpretations regarding the size and depositional environment of the Karewa Lake varied among researchers. Basavaiah et al. (2010) suggested that tectonic uplift restricted the Southwest monsoon from entering the valley, leading to dominance of mid-latitudinal western disturbances. This resulted in increased sedimentation rates between 1.95 and 1.77 Ma (Basavaiah et al., 2010).

Ali and Achyuthan (2020), and Shah et al. (2021) studied sections across the valley, thereby finding similar stratigraphic units. Meenakshi et al. (2020) noted chemical alterations in sediments under warm-humid and weak alterations under cold-dry climatic conditions. Shah et al. (2021) identified a significant loess deposition event around 44 to 43 ka ago, which is likely linked to global climate shifts. They also noted a Cambisol unit dating from approximately 43 to 34.7 ka ago, indicating a warm climate phase, followed by a weak paleosol during the last glacial maximum around 34.7 to 14.7 ka ago. Widespread

precipitation and glacial melting around 14.7 ka ago marked the end of loess deposition.

Relevance of the field trip within regional geology

The proposed field trip is strategically designed to integrate multiple geological components within the Kashmir Valley, providing participants with direct exposure to representative sections that illustrate the region's Quaternary evolution. Key field locations such as Shankerpora, Makaibagh, and Burzahama offer excellent exposures of loess–paleosol sequences that record atmospheric dust dynamics and climatic oscillations. The Hirpur and Khansahib Section provides insights into fluvial-lacustrine sedimentation and associated fossil records, while the Palar Section demonstrates neotectonic deformation features indicative of active structural processes.

By traversing these diverse geological settings, the field trip provides a unique opportunity to link stratigraphy, structure, palaeontology, and geomorphology within a single regional framework.

This integrated field-based approach places the Kashmir Valley within the broader context of global Quaternary geology by enabling comparisons with similar sedimentary basins worldwide. The field trip therefore serves as a critical platform for advancing understanding of Himalayan basin evolution, climate variability, and landscape response to tectonic and climatic forcing. It also facilitates collaborative research, promotes interdisciplinary learning, and strengthens the role of the Kashmir Valley as a globally significant archive of Quaternary environmental change.

Flora, Fauna, Climate, and Weather conditions during the field excursion

Flora

The Kashmir Valley supports diverse vegetation due to its varied topography, elevation gradients, and climatic conditions. The natural vegetation of the region is dominated by temperate forests, alpine meadows, cultivated agricultural landscapes, and riparian vegetation associated with river systems. In the lower elevations and Karewa plateaus, vegetation includes cultivated crops such as paddy, maize, and saffron, along with orchard plantations of apple, walnut, almond, and apricot. These cultivated landscapes reflect the long-term interaction between humans and the Quaternary landforms of the valley.

The mid-elevation slopes surrounding the basin are characterized by temperate broadleaf forests composed of species such as oak (Quercus spp.), maple (Acer spp.), walnut (Juglans regia), and poplar (Populus spp.). Coniferous forests are also common and include species such as deodar (Cedrus deodara), blue pine (Pinus wallichiana), and fir (Abies pindrow). These forest ecosystems are significant indicators of climatic variability and environmental change through time, as fossil remains of similar taxa have been reported from Quaternary deposits, suggesting past climatic conditions broadly comparable to present temperate environments.

At higher altitudes, especially in glacial valleys such as the Thajwas Glacier region, alpine meadows dominate during warmer months. These meadows support seasonal grasses, herbs, and flowering plants that thrive in short growing seasons. During winter months, however, much of the high-altitude vegetation remains dormant under snow cover.

Fauna

The Kashmir Valley supports a rich diversity of fauna characteristic of temperate Himalayan ecosystems. Mammalian fauna includes species such as the Himalayan black bear (Ursus thibetanus), Himalayan brown bear (Ursus arctos), red fox (Vulpes vulpes), musk deer (Moschus spp.), and various rodent species inhabiting forested and open terrains. In addition, domesticated livestock such as sheep, goats, and cattle are common in rural landscapes and often observed near field sections, particularly in Karewa plateau regions.

Avifauna in the valley is highly diverse and includes both resident and migratory species. Common birds include magpies, crows, pigeons, and various waterfowl species associated with wetlands and lakes. The presence of migratory birds in lacustrine environments provides important ecological indicators of environmental stability and seasonal hydrological conditions.

The fossil record from Quaternary Karewa deposits includes plant remains, pollen, diatoms, and molluscan shells, which provide critical information about past biodiversity and environmental conditions. These palaeobiological records demonstrate the existence of wetland, lacustrine, and forest ecosystems during different climatic phases, making the region particularly valuable for palaeoecological reconstructions.

Climate

The Kashmir Valley experiences a temperate climate influenced by both mid-latitude westerlies and the Indian monsoon system. Seasonal variations in temperature and precipitation are significant, with cold winters and mild to warm summers. Winter precipitation is primarily associated with western disturbances, which bring snowfall and rainfall across the valley and surrounding mountainous regions. These climatic systems play a critical role in shaping sedimentation processes, glacier dynamics, and hydrological regimes, all of which are central to Quaternary geological evolution.

Temperature variations across the valley depend strongly on altitude. Lower valley floors typically experience milder conditions compared to higher elevations, where temperatures remain significantly lower. Snowfall is common in winter months, particularly at higher elevations such as glacial valleys and mountain passes. Seasonal snow cover influences

erosion, sediment transport, and landscape stability, which are important considerations during geological fieldwork.

Long-term climatic fluctuations during the Quaternary have significantly influenced sediment deposition, soil formation, and glacial activity in the region. Loess–paleosol sequences record cycles of cold, dry dust deposition followed by warmer, wetter soil formation, reflecting repeated climatic oscillations. Similarly, glacial landforms such as moraines and cirques in the Thajwas region provide evidence of past glacial advances linked to colder climatic periods.

Weather conditions during the field excursion

The proposed field excursion is scheduled for early February, which falls within the winter season in the Kashmir Valley. During this period, weather conditions are typically cold, with temperatures commonly ranging between approximately -2°C to +10°C in the valley floor, and significantly lower at higher elevations such as glacial valleys. Night-time temperatures frequently fall below freezing, while daytime temperatures may remain cool but manageable for field activities.

Snowfall is possible during February due to the influence of western disturbances. Light to moderate snowfall events may affect accessibility to certain high-altitude locations, particularly glacier valleys and elevated Karewa sections. Fog and reduced visibility may occasionally occur during early morning hours, especially in low-lying areas. Participants should therefore be prepared for variable winter weather conditions, including cold winds and occasional precipitation in the form of snow or sleet.

Despite these challenges, winter conditions provide unique opportunities for geological observations. Snow cover may enhance the visibility of certain geomorphic features such as moraines and terrace boundaries, while reduced vegetation cover improves exposure of sedimentary sections. Field participants are advised to wear insulated clothing, waterproof footwear, gloves, and protective headgear suitable for cold environments.

Overall, the flora, fauna, and climate of the Kashmir Valley contribute to a dynamic environmental setting that reflects both present-day ecological processes and long-term Quaternary environmental evolution. Understanding these modern environmental conditions enhances the interpretation of geological records encountered during the field excursion and provides valuable context for reconstructing past climatic and ecological changes.

Literature Review

The Kashmir Valley has been the focus of geological and paleoclimatic investigations for more than a century, resulting in a substantial literature addressing its stratigraphy, paleoenvironments, tectonics, and Quaternary climate evolution. Early geological studies laid the foundation for understanding the basin evolution and depositional environments of the Karewa sediments. Initial observations by early workers identified the Kashmir Valley as an intermontane basin filled with thick fluvio-lacustrine deposits, interpreted as remnants of an ancient lake system. These early interpretations established the concept of a large Karewa lake and recognized the importance of sedimentological studies for reconstructing paleoenvironmental conditions.

Subsequent research focused on stratigraphic classification and lithological characterization of the Karewa Group. Detailed stratigraphic studies led to the subdivision of the Karewa succession into the Hirpur, Nagum, and Dilpur formations. These studies emphasized the fluvial, lacustrine, and aeolian origin of the sediments and provided the first systematic understanding of basin development. Investigations into sedimentology revealed the presence of alternating layers of clay, sand, silt, and conglomerate, reflecting changing depositional environments linked to climatic fluctuations and tectonic activity. These foundational works established the Kashmir Valley as a key site for studying Quaternary environmental change in the Himalayan region.

Chronological studies have played a central role in advancing the understanding of Quaternary deposits in the Kashmir Valley. Magnetostratigraphic investigations identified multiple normal and reverse polarity zones within Karewa sediments, suggesting that sedimentation began during the Pliocene (~ 5.3 Ma) and continued into the Quaternary (~ 1.8 Ma). Later studies refined these interpretations, proposing ages ranging from approximately 4.4 million years to < 1 Ma for various stratigraphic intervals. Radiocarbon dating, thermo-luminescence (TL), and optically stimulated luminescence (OSL) dating techniques have been applied to loess–paleosol sequences to constrain the timing of sediment deposition. These studies suggested that loess deposition in the valley occurred primarily during the Late Quaternary (~ 0.3 Ma), with several major depositional phases linked to glacial–interglacial climatic cycles.

Research on loess-paleosol sequences represents one of the most significant contributions to Quaternary Science in the Kashmir Valley. Pedostratigraphic investigations identified multiple paleosol horizons within loess deposits, indicating repeated cycles of soil formation under relatively warm and humid conditions followed by dust accumulation during colder and drier periods. These sequences have been widely interpreted as terrestrial equivalents of global climatic oscillations. Studies based on mineral magnetic properties, grain-size distribution, and geochemical composition have further enhanced the understanding of climatic variability recorded in these deposits. The Shankerpora and Makaibagh sections, in particular, have been recognized as key reference sites for reconstructing Late Quaternary climate variability in the region.

Palaeontological and palaeoecological studies have provided additional insights into environmental changes during the Quaternary. Fossil plant remains, including oak, maple, walnut, and other temperate species, have been reported from the Hirpur Formation,

indicating the presence of forested landscapes during specific climatic phases. Microfossils such as diatoms and molluscan shells have been used to infer lacustrine and wetland environments. These biological records complement sedimentological and geochemical data, enabling a more comprehensive reconstruction of past ecosystems and climatic conditions.

Glacial geomorphological studies have also contributed significantly to the understanding of Quaternary landscape evolution in the Kashmir Valley. Investigations of glacial valleys, moraine systems, and cirques, particularly in regions such as the Thajwas Glacier, have documented multiple phases of glacier advance and retreat. These studies have linked glacial activity to regional and global climatic fluctuations, providing important evidence for understanding the timing and magnitude of past glaciations in the western Himalaya.

More recent studies have focused on multi-proxy approaches combining sedimentology, geochemistry, isotopic analysis, and luminescence dating. These integrated investigations have revealed significant environmental changes associated with variations in monsoon intensity, mid-latitude westerlies, and tectonic uplift. Geochemical proxies such as Rb–Sr isotope ratios have been proposed as valuable tools for tracking changes in chemical weathering and continental hydrology. Similarly, luminescence dating methods such as IRSL and post-IRSL have been recommended for improving the reliability of chronological frameworks, particularly for older sedimentary sequences. Despite the extensive research conducted to date, several outstanding issues remain unresolved. One of the most significant challenges is the uncertainty in the chronology of older loess–paleosol sequences. Discrepancies among dating results obtained using different techniques highlight the need for improved methodological approaches and cross-validation of chronological data. In addition, the Lower and Middle Karewa formations have received comparatively less attention than the upper Dilpur Formation, resulting in gaps in understanding the early stages of basin evolution and environmental change. Another major outstanding issue concerns the correlation of terrestrial records from the Kashmir Valley with global climatic archives. While local records indicate multiple climatic cycles, precise alignment with marine and ice-core records remains challenging due to limited chronological resolution. Furthermore, the influence of tectonic processes on sedimentation patterns and climate evolution is not fully understood, particularly with respect to the role of uplift in modifying atmospheric circulation pathways. In summary, the available literature demonstrates that the Kashmir Valley is one of the most significant Quaternary geological archives in the Himalayan region. However, unresolved issues related to chronological precision, depositional environment interpretation, tectonic influences, and global correlation highlight the need for continued interdisciplinary research. The proposed field excursion provides an important opportunity to revisit key stratigraphic sections, evaluate existing interpretations, and identify new research directions aimed at resolving these outstanding challenges and advancing Quaternary science in the region.

Field Transect

Field programme

Day	Programme	Distance between stops (km)	Scientific Focus
Day 0	Arrival and check-in at the Guest House, University of Kashmir	-	Introductory briefing on the Quaternary geology and palaeoenvironmental evolution of the Kashmir Valley
Day 1	Interactive sessions followed by visits to Burzahama, Wanihama and Makaibagh (Upper Karewas, Dilpur Formation)	Guest House – 6.7 – Burzahama – 2 – Wanihama – 6 – Makaibagh	Late Quaternary stratigraphy, lacustrine and fluvio-lacustrine sediments, palaeosols, loess deposits, chronology and geochemical proxies
Day 2	Field excursion to Khansahib, Palar and Nagum sections	Guest House – 38 – Khansahib – 33 – Palar – 18 – Nagum	Examination of Lower and upper Karewa stratigraphy, fluvio-lacustrine sediments, Neotectonic structures and Angular Unconformity
Day 3	Field excursion to Pakharpora and Shankerpora sections	Guest House – 53 – Pakharpora – 6 – Shankerpora	Study of geomorphic surfaces, palaeosols, climatic oscillations and chronological frameworks
Day 4	Field visit to Hirpur and Dubjan section	Guest House – 63 – Hirpur – 14 – Dubjan	Examination of lower Karewa geomorphic features, fluvial deposits, tectonic controls and sediment geochemistry
Day 5	Field excursion to Manasbal Loess Section and Manasbal Lake followed	Guest House – 25 – Manasbal	Investigation of loess and lake archives, isotopes, and geochemistry
Day 6	Departure from the University of Kashmir	-	Concluding remarks and departure of participants

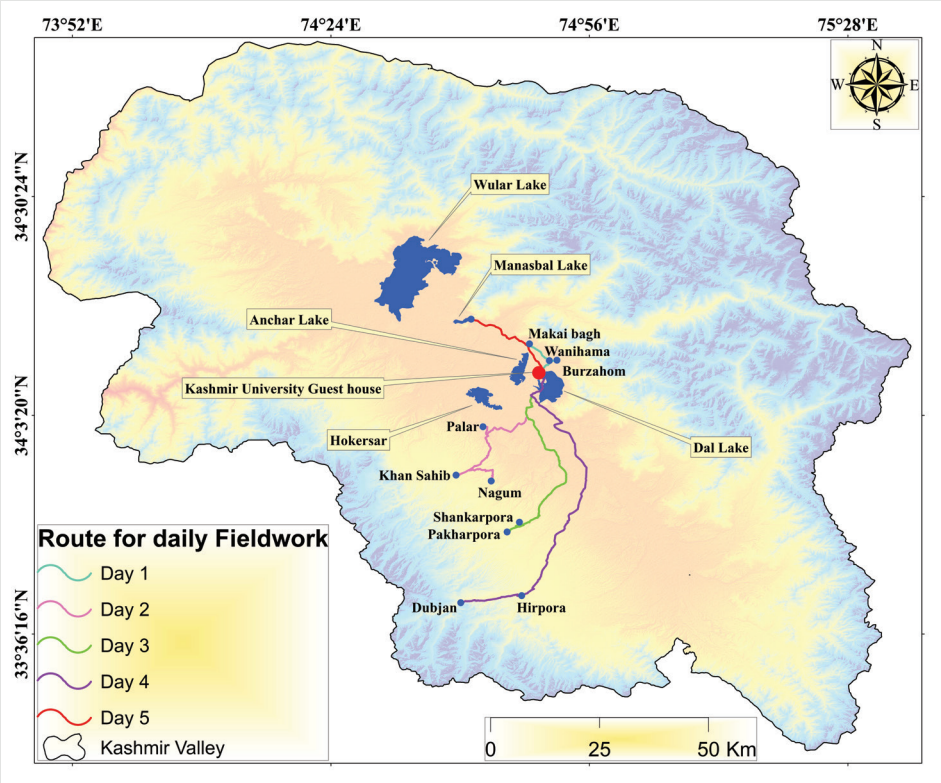


Fig. 2. Map showing locations to be visited in Kashmir Himalaya.

Location(s) description

Hirpur Section

The Hirpur section (Fig. 2) consists of fluvial-glacial and lacustrine sediments belonging to the lower Karewas (Table 1). Fossil leaves of cinnamon, oak, maple, fruit, and spores of rose, walnut, trapa; diatoms; land-shells, have been reported from the Hirpur Formation (Bhatia, 1968). Wadia (1966) recognized four stages of glaciation intervened by interglacial periods during the deposition of Hirpur and Nagum Formations. The best exposures are exposed

along the Rambiara, Ningli, and Vishav River sections (Fig. 3). This section is of immense importance to understand the sedimentation processes, physical and chemical parameters, during the depositional environment of this Formation.

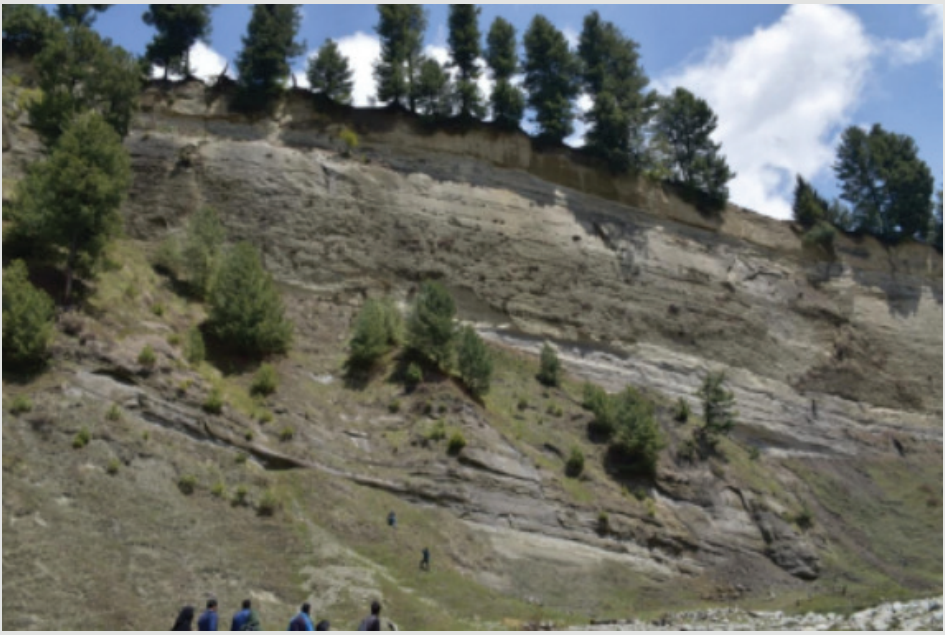


Fig. 3 : Field photograph of the Hirpur Section in Shopian District.

Khansahib Section

The Khansahib section of the Kashmir Karewas, located in the Khansahib area of Budgam district (Fig. 2), represents an important exposure of the Late Neogene–Quaternary lacustrine and fluvio-lacustrine sediments of the Kashmir intermontane basin (Fig. 4). The section is part of the Lower Karewa Formation and comprises alternating sequences of laminated silt, clay, sand, and gravel beds deposited under fluctuating lake and fluvial conditions. These sediments record the interplay of climatic oscillations, tectonic activity, and sediment supply associated with the uplift of the surrounding Himalayan ranges. The Khansahib section preserves evidence of repeated lake changes and environmental shifts during the Pleistocene, making them valuable archives for reconstructing palaeoclimate and basin evolution. The section has been extensively studied using sedimentological, geochemical, and chronological approaches to understand the Late Quaternary environmental history of the Kashmir Valley and its response to Himalayan tectonics.

Nagum Section

The Nagum section (Fig. 2) is a classic exposure of the Upper Karewa (Nagum Formation) and displays a ~20–30 m thick succession of fluvio-lacustrine sediments comprising sandy clays, silts, sands, gravels, and calcareous horizons (Fig. 5). The section exhibits distinct lithological variations, ferruginous bands, and gravelly unit's indicative of fluctuating depositional energy and lake-level changes. These sediments were deposited during the Pleistocene in the Kashmir intermontane basin and provide an important archive of Himalayan tectonics, palaeoclimate variability, and basin evolution.



Fig. 5 : Field photograph of Nagum Formation displaying ~20–30 m thick succession of fluvio-lacustrine sediments of the Nagum Section in Budgam District.

Pakharpora Section

The Pakharpora section (Fig. 2) contains the Middle to Late Pleistocene age Karewa deposits having well-preserved fossil assemblages, including freshwater molluscs, plant remains, and occasional vertebrate fragments, indicating its lacustrine to palustrine depositional environment (Fig. 6). Abundant diatoms and palynoflora recovered from its deposits, provide insights into past hydrological conditions and vegetation dynamics, reflecting shifts in monsoonal intensity and temperature. Distinct volcanic ash (tephra) layers are interbedded within this Formation, therefore serving a key chronostratigraphic marker across the Kashmir Basin. Geochemical fingerprinting of this tephra layers suggest correlation with major regional and extra-regional volcanic events, offering valuable time constraints for paleoclimate and tectonic studies.

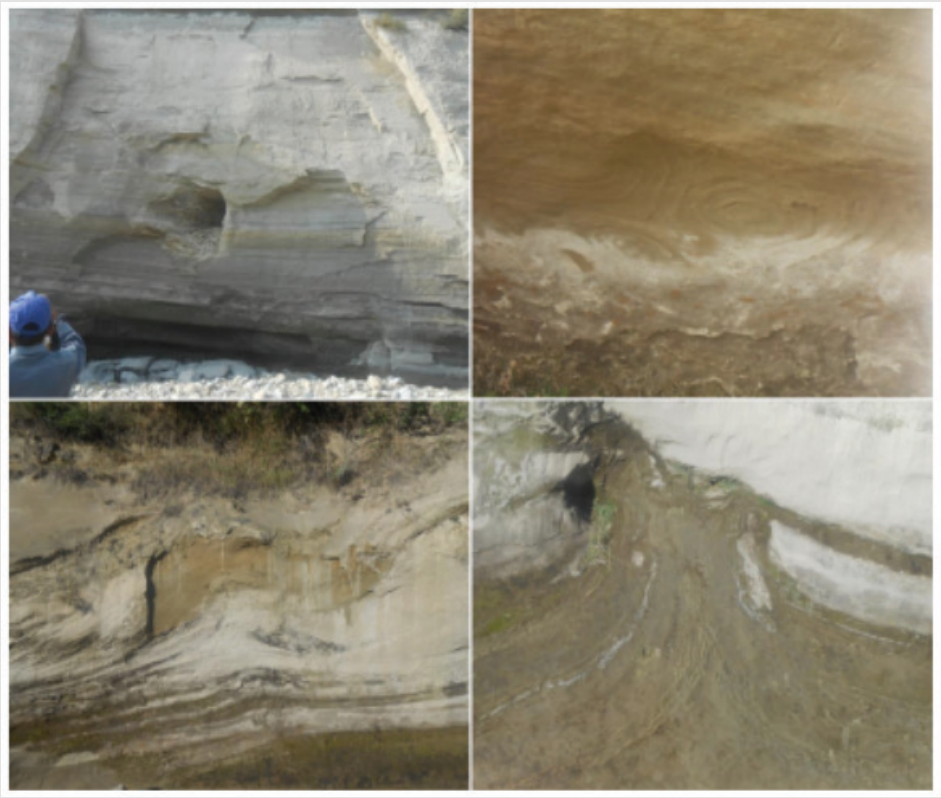


Fig. 6 : Field photographs of the Middle to Late Pleistocene Karewa deposits at Pakharpora Section, Pulwama District.

Palar Section

Palar section (Fig. 2), situated in Budgam district, comprising the Nagum Formation, and exemplifies a typical section showcasing significant neotectonic activity, with signatures of soft sediment deformation characterized by folds and faults, among other features (Fig. 7).

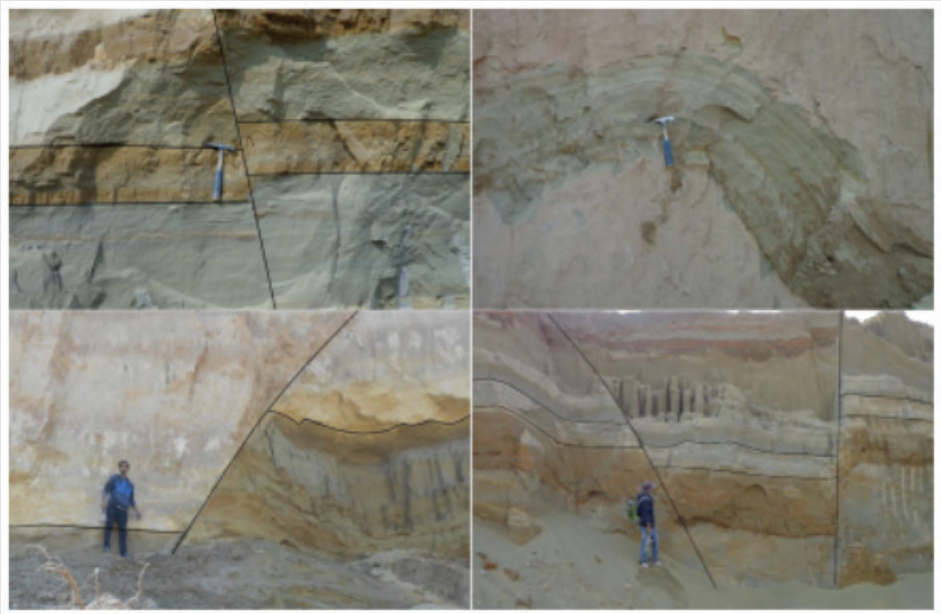


Figure 7. Field photographs of the Palar section, Budgam District, illustrating soft-sediment deformation structures characterized by folds and faults.

Shankerpora, Makaibagh, Burzahama & Manasbal Sections

Shankerpora, Makaibagh, and Burzahama sections (Fig. 2) primarily consists of aeolian origin deposition within the Dilpur Formation (Table 1). Located towards south of the Kashmir Valley, Shankerpora section features approximately 30 meters of vertical deposition of Loess-Palaeosol Sequences (LPS), with deposition believed to have commenced around 300 ka (Fig. 8a). Makaibagh section, situated in central Kashmir, comprises an 8-meter LPS section (Fig. 8b), with deposition dating back to around 65 ka (Shah et al., 2021). Moreover, the Makaibagh section exhibits a transition from aeolian to fluvial sedimentation in the upper 2 meters at around14 ka (Shah et al., 2021). In contrast, Burzahama section, akin to Makaibagh section and Manasbal section, holds significance as a heritage Neolithic site and is positioned ~6 kilometres away from the Makaibagh section towards east direction.

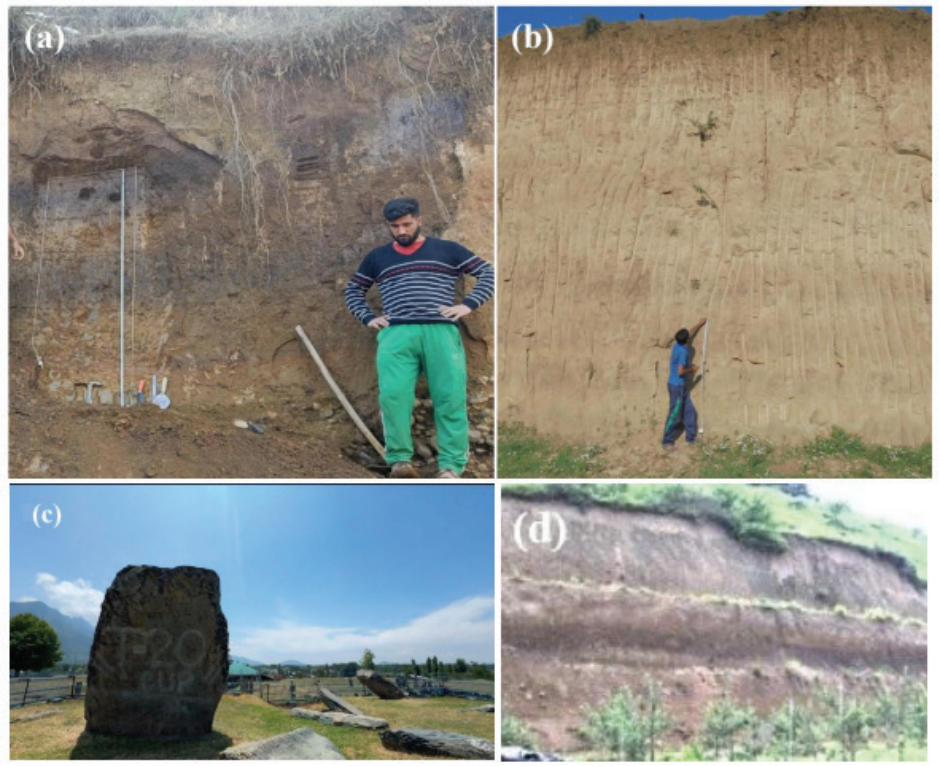


Fig. 8 : Field photographs of the; (a) Shankerpora Section, (b) Makaibagh Section, (c) Burzahama and (d) Manasbal Sections.

Geoheritage, UNESCO Heritage, Archaeological Sites, Cuisine and Culture

Geoheritage and Archaeological Sites

The Kashmir Valley represents one of the most significant geoheritage regions in the western Himalaya, preserving exceptional geological, paleontological, and archaeological

records that document the evolution of the Himalayan landscape and early human occupation. The extensive Karewa deposits, comprising fluvio-lacustrine, glacial, aeolian, and loess–paleosol sequences, form one of South Asia's most important Quaternary archives, providing valuable insights into climate change, tectonic activity, basin evolution, and landscape development over the last several million years. Prominent loess–paleosol sections at Shankerpora, Makaibagh, and Pattan preserve multiple paleoclimatic cycles and serve as important natural laboratories for Quaternary research.

A globally significant geoheritage site is the Permian–Triassic (P–T) Boundary exposed at Guryul Ravine near Khunamoh, Srinagar, one of the world's best-preserved reference sections outside China. The succession records the transition across the largest mass extinction in Earth's history (~252 Ma) and contains fossil-rich marine strata of the Zewan and Khunamoh formations, yielding brachiopods, ammonoids, bivalves, and conodonts that are widely used for international stratigraphic correlation. This exposure is of outstanding scientific value for understanding extinction dynamics, paleoenvironmental change, and global geological history.

The valley also possesses important paleontological resources, particularly within the Karewa fossiliferous horizons of Pampore and Pattan, which preserve fossil plants, molluscs, vertebrate remains, and pollen assemblages that provide evidence of past vegetation and climatic conditions. These localities offer considerable potential for future geoheritage conservation and geotourism initiatives.

Complementing its geological significance, the Kashmir Valley hosts several important archaeological sites. The Burzahom Neolithic site, one of the earliest human settlements in the region, preserves pit dwellings, stone tools, pottery, and evidence of early agriculture, providing critical insights into human adaptation to changing Quaternary environments. Other notable sites, including Harwan Archaeological Site and the historic Mughal Gardens, illustrate the long-standing interaction between human settlements and the valley's geomorphology and hydrology. Together, these geological and archaeological assets make the Kashmir Valley an exceptional destination for geoheritage conservation, multidisciplinary research, education, and sustainable geotourism.

Cuisine and Culture

The Kashmir Valley is renowned for its rich culinary and cultural heritage, shaped by its geography, climate, and centuries of historical influences. Traditional Kashmiri cuisine is epitomized by the famous Wazwan, a multi-course feast featuring delicacies such as Rogan Josh, Yakhni, Rista, and Gushtaba, alongside vegetarian dishes prepared from locally grown vegetables including haak and nadru (lotus stem). Traditional beverages such as Kahwa (saffron-flavoured green tea) and Noon Chai (salted pink tea) are integral to the region's food culture.

The valley's cultural heritage is reflected in its renowned handicrafts, including Pashmina shawls, hand-knotted carpets, walnut wood carving, and papier-mâché, as well as traditional folk music and dances such as Rouf. The widespread use of Kashmiri (Koshur), Urdu, and English, together with the warm hospitality of local communities, offers visitors a unique cultural experience that complements the region's exceptional geological and historical heritage.

Relevance to the field excursion

The geoheritage, archaeological significance, and cultural richness of the Kashmir Valley enhance the scientific and educational value of the field excursion. Exposure to archaeological sites such as Burzahama provides an opportunity to understand early human settlements in relation to Quaternary landscapes. Similarly, visits to glacial valleys, loess–paleosol sequences, and Karewa plateaus enable participants to observe geological features that form part of the region's geoheritage legacy.

Understanding local cuisine and cultural traditions further enriches the field experience by fostering cultural exchange and appreciation of regional diversity. The integration of geological, archaeological, and cultural elements ensures that the field excursion offers a holistic learning experience, highlighting the Kashmir Valley not only as a geological archive but also as a region of profound cultural and historical importance.

Local Conveniences

Bazars: Hospitals & Medical Assistance:

Srinagar: SKIMS Hospital, SMHS Hospital, JVC Hospital, Bone & Joint Hospital Emergency Numbers: Ambulance-108, Police-100/112, Tourist Helpline-1363

Lost/Stolen Passport:

Report at nearest police station and get an FIR
Contact your embassy/consulate (e.g., New Delhi)
Tourist Police & Regional Passport Office, Srinagar

Bazaars & Local Shopping:

Srinagar: Lal Chowk, Polo View, Residency Road, & Zaina Kadal
Dal Lake: Floating Market
Purchases: Pashmina shawls, saffron, dry fruits, papier-mâché, carpets, willow crafts

Advisory:

Warm clothing and trekking shoes recommended
Carry water, notebooks, sunscreen, and personal medication
Mobile coverage generally available in towns; limited in remote areas

Conclusion

This field excursion offers a unique opportunity to explore the Karewa deposits of the Kashmir Valley as one of the most significant Quaternary climate archives of the western Himalaya. By integrating field-based observations with modern analytical and chronological approaches, the excursion aims to advance understanding of regional paleoclimate evolution, tectonic activity, and environmental change over the last ~4.4 million years. The selected geological and archaeological sites will provide valuable insights into fluvio-lacustrine sedimentation, loess-paleosol development, glacial dynamics, and human-environment interactions in the Himalayan region. Through interdisciplinary discussions and international scientific collaboration, the excursion is expected to strengthen future research initiatives, improve regional-to-global paleoclimate correlations, and contribute to a broader understanding of Quaternary environmental change in high mountain systems.

Acknowledgement

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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.

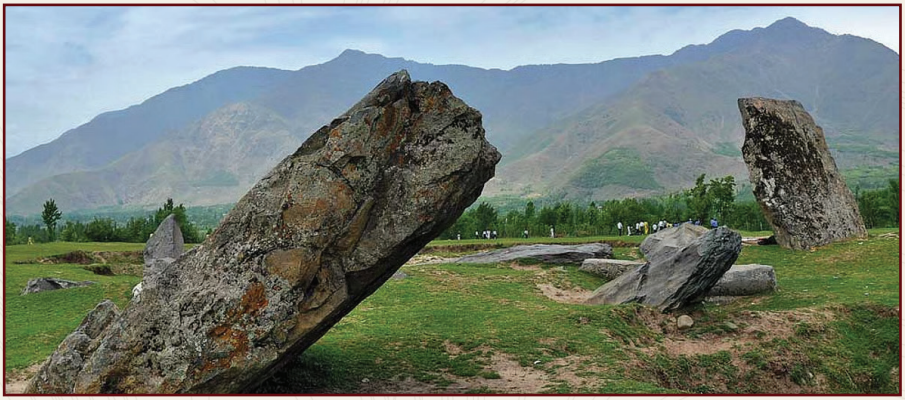
Disclaimer

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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