XXII INQUA India 2027

QUATERNARY SCIENCE AS SOCIETAL SERVICES



XXII INQUA INDIA 2027

FIELD GUIDE

INPOST - 12

PALEOSEISMIC INVESTIGATION ALONG THE FOOTHILL ZONE OF ASSAM HIMALAYA (NAMERI TIGER RESERVE), NE INDIA.

Priyanka Singh Rao and
R. Jayangondaperumal







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

विज्ञान एवं प्रौद्योगिकी मंत्रालय
MINISTRY OF SCIENCE AND TECHNOLOGY

पृथ्वी विज्ञान मंत्रालय
Ministry of Earth Sciences

INQUA International Union for Quaternary Research

ASSOCIATION OF QUATERNARY RESEARCHERS

Published in 2026 by

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

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

© 2026 BSIP, Lucknow

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

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

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

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

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

INQUA INDIA 2027

Field Guide Book

INPOST-12

Paleoseismic Investigation along the foothill zone of Assam Himalaya (Nameri Tiger Reserve), NE India.

Principal Investigator

Dr. Priyanka Singh Rao

Department of Geology, Delhi University

Co-Principal Investigator

Prof. R. Jayangondaperumal

Professor, Wadia Institute of Himalayan Geology, Dehradun

Team Members

Dr. Arjun Pandey, Dr. Shaikh Mohamedharoon A.

Email of Contact Person

raopriyankasingh@gmail.com

Mobile No.

+91 7890061789

Table of Contents

1.	Team Leaders	1
2.	Abstract	2
3.	Preamble	3
4.	Research Problem	4-9
5.	Regional Geology, including Stratigraphy, Structure, Paleontology, and Quaternary Geology	9-11
6.	Flora, Fauna, and Climate, weather conditions during the field excursion	11-12
7.	Literature Review	12-13
8.	Field Transect	14
9.	Field map showing Local Geology, Road and Excursion Stops	15-17
10.	Location(s) Description	18-19
11.	Geoheritage, UNESCO Heritage, Other Archaeological Sites in the vicinity, Cuisines and Culture	19-20
12.	Local Conveniences	20
13.	Conclusion	21
14.	Acknowledgement	21
15.	References	21-25
16.	Associate Members	26
17.	Annexure	27-28

Team Leaders



Dr. Priyanka Singh Rao

University of Delhi, Delhi

raopriyankasingh@gmail.com

Dr. Priyanka Singh Rao is a faculty member of Geology at the University of Delhi whose research focuses on Paleoseismology and Active Tectonic studies in the Himalayan region. She investigated the primary surface ruptures associated with the 1950 and 1697 earthquakes. Her research uses techniques such as active-fault mapping, tectonic geomorphology, geochronology, GPS surveying, and paleoseismological investigation to understand the patterns of strain accumulation and occurrences of great earthquakes in the Himalaya. She worked with the Geological Survey of India for half a decade as a Geoscientist before joining academia and contributed to Geological Mapping and Mineral Exploration work in eastern India.



Prof. R. Jayangondaperumal

Professor, Wadia Institute of Himalayan Geology, Dehradun

Prof. R. Jayangondaperumal (Perumal) is a distinguished Scientist-G, and Honorary Professor at the Wadia Institute of Himalayan Geology in Dehradun, India. With nearly three decades dedicated to exploring the behaviour of megaquakes in the Himalaya, he has pioneered significant advancements in the fields of Paleoseismology, Tectonics, and Himalayan Geology. He has been a consultant and has conducted several projects, including the mega-hydro power project Subansiri in the Northeast Himalaya, as well as the ropeway and tunnel project in Garhwal and Kumaun Himalaya. His exceptional contributions have garnered numerous honours, including the prestigious National Geoscience Award (2018). He authored the book "Active Tectonics of Kumaun and Garhwal Himalaya" (2018, Springer), and currently leads national-level research projects on Paleoseismology in the NE Himalaya.

Abstract

Paleoseismological studies have been conducted over the last two decades in an attempt to determine the timing, rupture extent, and its variability, magnitude, recurrence, and faulting mechanics associated with the past surface-rupturing earthquakes. Among the dozens of events reported across the entire Himalayan arc, trenches or natural exposures yield one or two events per site, except in western Jammu, Uttarakhand, eastern Nepal, and the Bhutan Himalaya, making a robust estimate of the average recurrence interval for the entire Himalaya difficult.

The Assam Himalayan foothills, located between Bhutan and the Arunachal Himalaya, experienced the most significant and devastating earthquakes in 824 CE, 1697 CE, and 1950 CE. Though it lies in the isoseismal zone of the 1950 C.E. great earthquake, the Subansiri Valley does not show clear evidence of surface faulting, instead displaying the traces of the 1697 C.E. historical event at Hemi Basti (Priyanka et al. (2026) Manuscript # AGU 2026JB034893 under review).

The lack of closely spaced, detailed investigations and inadequate information on overlapping events at the mountain front leads to an underestimation of earthquake cyclicity in this segment of the active convergent margin. Furthermore, a complete understanding of the role of transverse discontinuities along the active fault strike limits confidence in eliminating the lateral extension of central Himalayan medieval events across the NE segments.

The present field excursion is an attempt to demonstrate the transect across the sub- and lesser Himalayan structural framework and to conduct a paleoseismological study in the sub-Himalayan front of the western part of the Assam Seismic Gap. The paleoseismic studies at Nameri have been attributed to ruptures of the 1100 C.E. and 1255 C.E. events, extending eastward from Nepal. However, the role of segment boundaries in arresting or transmitting ruptures during great and large earthquakes is ignored, as affirmed for the rupture propagation of the 1714 C.E. Bhutan earthquake.

Thus, on day 1, an active fault along the HFT that has uplifted Quaternary fluvial terrace surfaces along the Jia Bhoroli River, will be demonstrated on ~2 km long, 15-10 m high E-W trending Kalabil fault scarp. Thereafter, a trench investigation will be conducted, illustrating and discussing the deformation in the trench exposures. This is important for constraining paleoearthquake timing in the gap area between Hemi Basti and Bhutan, resolving doubts about overlapping events, and understanding the role of the transverse segment boundary in surface rupture propagation.

On Day-2, a transect from Balipara, Assam to Sessa, Arunachal Pradesh will be taken to see the geometry of the growing Balipara Anticline, deformed Quaternary surfaces, fault zones of Tipi and Main Boundary Thrust (MBT). This demonstration is helpful for constructing geological cross-sections, 3D kinematic modeling, and estimating the Holocene slip rate along the basal decollement.

Preamble

The Himalayan megathrust repeatedly generates large-to-great earthquakes that shape the geomorphology and seismic hazard of the mountain front. Paleoseismological investigations have revealed a catalog of surface-rupturing earthquakes that far exceeds the completeness of the instrumental record and have repeatedly devastated the densely populated Indo-Gangetic-Brahmaputra alluvial plains and Himalayan foothills. Despite considerable advances in understanding fault geometry and slip rates, critical gaps remain in the spatial and temporal distribution of paleoseismic ruptures, recurrence intervals, and along-strike segmentation behavior. These gaps directly limit reliable probabilistic seismic hazard assessments for the region. This field excursion presents an integrated paleoseismic investigation, tectonic geomorphology, and structural analyses to address these gaps in the Assam Seismic Gap. Through a systematic paleoseismic investigation of the frontal thrust fault scarp, combined with structural analysis across the Balipara Anticline, the field aims to reconstruct the history of surface-rupturing earthquakes, constrain Holocene slip rates, and evaluate segmentation and the potential for future earthquakes. The field excursion component provides participants with direct exposure to the geomorphic and geological signatures of active faulting, offering an unparalleled opportunity to ground-truth remote-sensing observations, develop sampling strategies, and engage with the methodological challenges inherent in earthquake studies in the Himalayan context.

Research Problem

Seismic crustal deformation, including surface ruptures preserved in geologic and geomorphic records, provides valuable insights into rupture dynamics. The objective of such a study is to characterize the strain released during earthquakes along the Himalayan front, which is relevant to the interpretation of contemporary slip-deficit strain signals measured across the region with GPS and to the development of a physical model of earthquake recurrence. Modern GPS measurements show that strain accumulation is concentrated below the Higher Himalayas, along the strike of the Main Central Thrust and northward into Tibet. At the same time, the geological observations indicate that the expressions of strain release in the Quaternary sediments during great surface-rupture earthquakes occur along the Himalayan Frontal Thrust (Bilham et al., 1998; Jayangondaperumal et al., 2011 and 2018; Mugnier et al., 2013).

As active faults are the outcomes of earthquakes, global research on active faults gained pace after their role and activity during highly destructive earthquakes came into the picture. For example, devastating earthquakes such as Mw~6.7 1994 North Ridge (Stein et al. 1992), Mw~7.6 1999 Chi-Chi (Yu et al. 2001), Mw~7.6 2005 Kashmir (Kaneda et al. 2008), and destructive events in the Philippines have occurred on active faults. These studies have raised serious concerns about the seismic hazard posed by active faults to human society and infrastructure, thereby underscoring the need to understand the relationship between active faults and earthquakes.

Investigations along the Himalayan front (HFT) in the western, central, and eastern Himalaya enabled preliminary estimates of seismic parameters. Still, the recurrence pattern of significant and devastating earthquakes along the arc and the slip deficit on different segments of the fault is not well understood. The potential to test these correlations depends on conducting more paleoseismological investigations by excavating numerous trenches at close intervals along the HFT. The paleoseismic studies at Nameri, Assam, have been attributed to the ruptures of 1100 C.E. and 1255 C.E. events, extending for ~600-800 km to the east from Central Himalaya (Kumar et al., 2010; Mishra et al., 2016; Fig. 2). However, the role of segment boundaries in arresting or transmitting ruptures during great and large earthquakes is ignored at Nameri, as affirmed for the rupture propagation of the 1714 C.E. Bhutan earthquake (Roux-Mallouf, et al., 2016; Hetényi et al., 2016) or medieval event in Darjeeling-Sikkim Himalaya (Brice et al., 2024). Varying suggestions from different groups, along with uncertainty in dating methods due to inherent age errors, have led to uncertainty in the placement of paleoearthquake constraints between Bhutan and Hime Basti.

The Kameng River exit exposes the transition from the Siwalik foreland fold-and-thrust belt to the Brahmaputra foreland, making it a key locality for studying active deformation, terrace formation, and river adjustment. Thus, a trench across ~2 km long, 15-10 m high E-W trending fault scarp, preserved at Kalabil due to the faulting along the HFT that has uplifted Quaternary fluvial terrace surfaces along the Jia Bhoroli River (Kameng in Arunachal Pradesh), will be demonstrated and discussed to address the research gap (Figs. 3-4; Excursion stop S1). To understand slip partitioning along the growing fault-related fold structure (Burgess et al., 2012), the long-term vertical deformation rates (<100,000 yr) along

the HFT and their role in the slip deficit, a systematic N-S transect across the sub-Himalaya is planned (Fig. 3). A transect from Balipara, Assam, to Sessa (Bhalukpong), Arunachal Pradesh, will be taken to see the geometry of the growing Balipara Anticline, deformed Quaternary surfaces, fault zones of Tipi and Main Boundary Thrust (MBT). This is helpful in the construction of geological cross-sections, 3D kinematic modeling, and estimation of Holocene slip rate along the basal decollement.

Details of N-S transect from Balipara to Sessa

The N-S transect from Balipara, Assam to Sessa, Arunachal Pradesh extends from the Cenozoic Siwalik strata in the south toward older Permian and Proterozoic rocks exposed in the north. The transect encompasses Tipi Thrust and the Upper and Lower Main Boundary Thrusts (MBT-up and MBT-low) (Fig.3, and Field Photos 3–5, and 7).

The Dafla, Subansiri and Kimin Formations (Photos. 1, 2, and 6) are the Cenozoic units exposed south of the Lower Main Boundary Thrust (Burgess et al., 2012). The Dafla Formation is dominated by massive sandstone and minor conglomerate; the Subansiri Formation consists of massive sandstone with a greater proportion of conglomerate; and the Kimin Formation is characterized by interbedded sandstone and conglomerate. Northward, the MBT system brings older Permian and Proterozoic rocks into the structural succession. The Permian succession consists of coal-bearing shale, sandstone, and pebble conglomerate, whereas the Proterozoic Bomdila Group is dominated by phyllite and slate.

Structural measurements across the Himalayan Frontal Thrust (HFT), Tipi Thrust, MBT (low/S), and MBT (up/N) provide field constraints on the geometry and deformation of thrusts and can be used to develop a balanced cross-section (Fig. 3).



Photo 1: The Kimin Formation is exposed in a road-cut section (27°00′ 59.25″N, 92°38′ 50.35″E) and is characterized by interbedded sandstone and conglomerate. The alternation of coarse-grained conglomerate beds and sandstone is characteristic of this Cenozoic succession. (Excursion Stop S2-2).



Photo 2: The field photograph shows massive sandstone beds of the Subansiri Formation dipping northwest (27°01′ 28.67″N, 92°38′ 01.03″E). The Subansiri Formation is composed mostly of massive sandstone, with a higher proportion of conglomerate than the underlying Dafla Formation. (Excursion Stop S2-3).



Photo 3: The photo shows the sandstone beds dipping 61° toward 325° and 28° toward 320°, exposed (27°02′ 12.52″N, 92°36′ 24.00″E) in the vicinity of Tipi Thrust. The Tipi Thrust marks a structural boundary in the Siwalik succession and juxtaposes the older Miocene Dafla Formation over the younger Pliocene Subansiri Formation. (Excursion Stop S2-4).



Photo 4: The sandstone exposure (27°04′ 07.38″N, 92°35′ 26.01″E) displaying a well-developed shear fabric associated with the MBT (low/ Southern strand), and indicating top-to-southeast shear movement. The attitude of the Y-plane: 57°/14°/327°, and the P-plane 57°/70°/327°. The Lower Main Boundary Thrust (MBT-low/ southern strand) forms the southern boundary of the Permian succession and separates the older Permian rocks to the north from the Cenozoic Siwalik succession to the south. (Excursion Stop S2-5).



Photo 5: The sandstone beds with gentle dip towards 355° with minor conglomerate, belonging to the Dafla Formation, exposed at 27°05′ 01.82″N, 92°35′ 14.84″E.



Photo 6: The deformed sandstone (27°06′ 13.24″N, 92°34′ 03.46″E) displays well-developed Y- and P-planes, and is associated with the Upper Main Boundary Thrust (MBT-up/ Northern strand). The P-plane dips 47° toward 310° and the Y-plane dips 19° toward 315°. (Excursion Stop S2-6).



Photo 7: The intercalated coal-bearing shale and sandstone exposed in the MBT zone (27°04′ 45.83″N, 92°35′ 20.42″E).



Photo 8: NW-dipping sandstone beds with gentle to moderate (23° - 40°) dips towards 325°- 335° exposed near Nechiphu Tunnel Portal (27°09′ 27.88″N, 92°33′ 51.20″E). (Excursion Stop S2-7).

Regional Geology, including Stratigraphy, Structure, Paleontology, and Quaternary Geology

The Himalayan orogen evolved through progressive southward migration of deformation following the collision between the Indian and Eurasian plates at ~55–50 Ma. This evolution is expressed by the sequential development of the Main Central Thrust (MCT), Main Boundary Thrust (MBT), and the presently active Himalayan Frontal Thrust (HFT) in India and the Main Frontal Thrust (MFT) in Nepal, reflecting the outward propagation of the Himalayan fold-and-thrust belt. While the MCT and MBT accommodated much of the earlier crustal shortening and uplift, the HFT currently accommodates a significant proportion of India–Eurasia convergence and is the principal source of large surface-rupturing earthquakes along the Himalayan front.

Regional Geology of the Eastern Himalaya

The NE-plunging, large, crustal-scale antiform, named Namche Barwa antiform, is the salient feature of the Eastern Himalayan Syntaxis (Acharyya, 1978, 1987; Nandy, 2001; Fig. 1). The antiform comprises high-grade gneisses of the Higher Himalayan Crystallines (Burg et al., 1998; Ding et al., 2001; Geng et al., 2006; Yin, 2006; Gururajan and Choudary, 2003; 2007; Yin et al., 2010). The antiform's southern extension is exposed in eastern Arunachal Pradesh, known as the Eastern Syntaxial Bend or Siang antiform, a regional-scale NNW-SSE-striking structure (Fig. 1; Singh, 1993; Kumar, 1997; Choudhuri et al., 2009; Nandy, 2017; Srivastava et al., 2009). Both limbs of the Siang antiform are composed of the older Lesser and Higher Himalayan sequences, while its core comprises younger (Permian to Eocene) lithostratigraphic sequences (Singh, 1993).

Six major tectonic units are recognized in the area. These are: a) the Siwalik Group, b) the Gondwana Group, c) the Miri-Buxa Group, d) the Daling-Shumar-Bomdila Group, e) the Darjeeling-Vaikrita-Sela and Paro Groups of the Higher Himalaya Crystallines, and f) the Tethys Himalaya zone. Tiding Group and the Lohit Plutonic Complex are also found in the Lohit district of Arunachal Pradesh.

The Siwalik group is further categorized into Dafla (Lower Siwalik), Subansiri (Middle Siwalik), and Kimin (Upper Siwalik) Formations. The Dafla Formation comprises massive sandstone with minor conglomerate. The Subansiri Formation also contains massive sandstone beds, but with a higher proportion of conglomerate than the Dafla Formation. Kimin Formation encompasses interbedded sandstone and conglomerate. The depositional ages of 12.2-10.5 Ma, 10.5-2.0 Ma, and < 2 Ma are yielded for the Dafla, Subansiri, and Kimin formations (Chirouze et al., 2012).

Siwalik Group has been overlain by Gondwana, Miri-Buxa, and Bomdila Groups and is separated by the Main Boundary Thrust (MBT) (Fig. 1). The Miri-Buxa rocks are exposed in Darjeeling and Arunachal Pradesh and form a para-autochthon window in this zone. The Outer Crystalline Thrust (OCT) separates the Miri-Buxa and Gondwana group from the overlying low-grade metasediments of the Daling-Shumar-Bomdila Group. The Main Central Thrust (MCT), varying from E-W to ENE-WSW strike from Darjeeling to Arunachal Pradesh, is the base of the Paro Group, while the Vaikrita Thrust delimits a tectonic break between the Darjeeling-Vaikrita-Sela Group and the Paro Group. The Paro Group contains an imbricate zone of thrust slices of the crystalline rocks. The MBT overlaps the NW-SE-trending MCT in the Lohit Valley and extends with an E-W to ENE-WSW trend from Darjeeling to Siang district in Arunachal Pradesh, India. The Tethyan Thrust truncates the Vaikrita Group of gneisses over the upper Paleozoic rocks of the Tethyan Himalaya zone at the Darjeeling-Sikkim region. In the eastern Himalayan syntaxis bend, the Bomdila and Paro Groups of metamorphics curve along their strike, which varies from ENE-WSW to NW-SE. The ophiolitic rocks of the Tiding Group and the Lohit Plutonic Complex represent an eastward continuation of the Ophiolitic Melange and the Trans-Himalayan plutons of the Indus Tsangpo Suture Zone (Thakur and Jain, 1975). The overthrusted Tertiaries of the Tipam, Disang, and Dihang formations represent the northern continuation of the Naga-Patkai ranges in the Tirap district of the SE Arunachal Pradesh.

Geology of the field area:

The field area is located between Kalabil and Bhalukpong Village in the foothills of the eastern Himalaya (Figs. 2 & 4). The Kameng River, the largest stream in the study area, exposes all major structures and lithologic units along its bank. The geology of the area comprises Neogene sediments, which are thrust over the Quaternary alluvium by the low-angle MFT or HFT, and its northern limit is delimited by the MBT. The Permian strata (Miri, Bichom, Bhareli, and Yamne Formations), separating the Proterozoic Bomdila Group to the north and the Cenozoic strata to the south, lie in the hanging wall of the MBT. They are composed of coal-bearing shale, sandstone, and pebble conglomerate. The Cenozoic Dafla, Subansiri, and Kimin Formations crop out continuously along the deep-cut Kameng River. The wide, continuous ridge-forming Dafla Formation (Fig. 2) consists mostly of massive sandstone with minor conglomerate. The narrower ridge of the Subansiri Formation is dominated by massive sandstone beds, but with a higher proportion of conglomerate. The Kimin Formation consists of interbedded sandstone and conglomerate. The bed thicknesses and bedding attitude are constant in the vicinity of major thrusts and folds along the River. The upper section of the Kimin Formation across the forelimb of the Balipara anticline displays a change in the bedding dip due to the rapid rotation of bedding about horizontal axes during folding, post 2 Ma (Burgess et al., 2012).

The Balipara anticline is bounded by the Bhalukpong thrust zone in the north and the Nameri thrust in the south. Across the Kameng River, the Bhalukpong thrust splits into northern and southern strands, thrusting the Subansiri Formation over Quaternary alluvium. This southern strand also displays a prominent fault scarp (Fig. 2). Burgess et al. (2012) estimated the slip rates partitioning of ~8.4 mm/yr on the Bhalukpong thrust, ~10 mm/yr across the growing Balipara anticline, and ~5 mm/yr on the Nameri thrust in the south.

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

January and February offer the best, most comfortable weather for visiting the Nameri Tiger Reserve and Bhalukpong region.

The climate is cool and dry, with daytime temperatures ranging from a mild 10° C to 25° C, though nights can drop to a chilly 5° C to 10° C.

Rainfall is very rare, making it ideal for outdoor activities.

Flora

The landscape transitions through the eastern Himalayan foothills, characterized by incredibly dense, lush greenery despite being the dry season. Canopy is dominated by tropical evergreen, semi-evergreen, and moist deciduous forests. Common species include Hollong (Dipterocarpus macrocarpus), Simul (Bombax ceiba), and Nahor (Mesua ferrea). Grasslands include thick stands of bamboo (Calamus tenuis), and cane brakes are highly abundant, along with narrow strips of savanna woodland along the Jia Bhoroli River.

Fauna

The combination of open grasslands, dense forests, and riverine habitats makes wildlife sightings frequent during these months. Nameri and the neighboring Pakke sanctuaries (near Bhalukpong) are havens for Asian Elephants, Royal Bengal Tigers, leopards, wild dogs, gaur, sambar, and barking deer. The region hosts over 300+ species of birds, including the rare White-winged Wood Duck, the Great Hornbill, and various winter migratory birds. The Jia Bhoroli River is well known for its golden mahseer.

Literature Review

Active fault scarps are observed in a sporadic manner all along the HFT at different places (Nakata, 1972; Kumar et al., 2010; Jayangondaperumal et al., 2011 and 2017; Sapkota et al., 2013; Mugnier et al., 2013; Malik et al., 2016; Hetényi et al., 2016; Rajendran et al., 2015; Bollinger et al., 2014; Jayangondaperumal et al., 2018). These markers, such as fault scarps, are attributed to thrust faulting due to earthquake movement along the HFT. During the last decade, active tectonics and paleoseismic studies have gained pace, and these studies are focused on HFT (Fig. 3). In addition to this, shortening and slip rate studies have been taken up at HFT using geomorphic markers (Wesnousky et al., 1999; Lave and Avouac, 2000; Burgess et al., 2012).

The Assam-Arunachal Himalayan foothills experienced the most significant and devastating earthquakes during 824 CE, 1697 CE and 1950 CE (Fig. 3). Though it lies in the isoseismal zone of the 1950 C.E. great earthquake, the Subansiri valley and Niglok sites do not show clear evidence of 1950 surface faulting; instead, they display the traces of the 1697 C.E. historical event at Hemi Basti (Fig. 3; Kumar et al., 2010; Jayangondaperumal et al., 2011; Priyanka et al., 2017; Priyanka, 2018; Pandey et al., 2021). A paleoseismic study at Nameri (adjacent to the proposed Kalabil site) by Kumar et al. (2010) attributed the rupture to 1100 C.E., which Mishra et al. (2016) later interpreted as 1255 C.E. These authors extended the 1100 C.E. and 1255 C.E. events of Nepal to the east in the Indian Himalayas, making a rupture of ~800km, and overlooked the role of segment boundaries to arrest or transmit ruptures during great and large earthquakes.

The paleoseismic studies in the Bhutan Himalaya revealed surface ruptures from the most recent 1714 CE earthquake, with a rupture length of >170 km (Le Roux-Mallouf et al., 2016, 2020; Zhao et al., 2021). Le Roux-Mallouf et al. (2016) correlated the penultimate event in central Bhutan with the 1100/1255 CE earthquake and suggested a rupture length of 500 to 800 km, but later rejected this in their subsequent studies. The studies in western Bhutan revealed five events in 2600 years with an average recurrence interval of 550±211 years (Le Roux-Mallouf et al., 2020). The work to the west of Bhutan does not display evidence of the 1714 CE event. The 1714 CE rupture could not have propagated east of Bhutan due to the presence of the transverse KF (Hetényi et al., 2016; Coudurier-Curveur et al., 2020). A recent study by Brice et al. (2024) negates the eastward propagation of 1100/1255/1934 CE rupture to the DSH. Rather, they suggested a possible surface rupture at the Chenga site during 1313–395 BCE. They opine that the DSH is a 150 km-long independent segment bounded by transverse structures on either side and has a recurrence interval of ~949–1963 years. Also, the DCFZ coincides with the rupture terminations of the 1934 and 1714 CE earthquakes and is interpreted as an impenetrable gate to the seismic rupture on the Nepal and Bhutan segment (Drukpa et al., 2012; Grujic et al., 2018; Fig. 10). The studies in the DSH and Bhutan Himalaya postulated that the medieval events reported in Nepal, DSH, and Bhutan are not a result of a single earthquake event but rather segment-specific contemporaneous events (Le Roux-Mallouf et al., 2016, 2020; Zhao et al., 2021; Brice et al., 2024).

The recent work in the DSH and Bhutan suggest that the great ~1100/1255 CE and the 1714 CE earthquakes would not have propagated east of MSR and DCFZ, respectively, to the Assam Himalayan segments- the proposed study area (Fig. 3). The proposed along-strike mapping of Kalabil fault scarp and a trench demonstration will open a platform for a discussion about the deformation in the gap area between Hemi Basti and Bhutan (Fig. 4). The discussion will focus on resolving the doubts about overlapping events and understanding the role of the transverse segment boundary on the surface rupture propagation.

Furthermore, fault slip rate studies in the eastern Himalaya show abnormally high geological slip rates. Burgess et al. (2012) estimated a minimum geological slip rate of 23±6.2 mm/yr along the decollement of ~10 km wide MFT (Main Frontal Thrust) zone in the eastern Himalaya near Nameri by deploying the geometry and chronology of the uplifted river terraces (Figs. 2 & 4). This estimated slip rate is potentially high and contrasts with the GPS slip rate of 16±0.5 mm/yr in Arunachal (Jade et al., 2007; Barman et al., 2017) and 18 mm/yr in the Sikkim Himalaya (Mukul et al., 2018). The discrepancies between the geodetic and geological shortening rates can be addressed by studying fault slip and uplift rates at several sites along the strike of the eastern Himalayan arc. Thus, the N-S traverse from Balipara, Assam, to Sessa, Arunachal Pradesh, will demonstrate the deformed Quaternary surfaces and change in the geometry of the growing Balipara Anticline, useful in the Holocene slip rate studies.

Field Transect

Field traverse (Please see Fig. 3 for various stops of the field excursion):

Day 1

Delhi > Guwahati > Balipara (Halt at Jironi Resort)

Day 2

Deformed Quaternary landform survey and Kalabil scarp Trench study

S1-1: Trench study-cum-investigation across Kalabil Scarp (26°55'50.51"N, 92°49'42.20"E);

S2-1: Growing Fan Scarp near Ouhola Gaon (26°55'32.66"N, 92°47'24.42"E);

S3-1: HFT – North of Kathaljuli (K26°56'27.32"N, 92°41'31.63"E)

Day 3

Spots along NS Transect:

S1-2: Siwalik exposures north of Balipara/Kalabil (26°57'5.25"N, 92°48'53.28"E)

S2-2: Kimin Formation - near Bhalukpong Picnic Spot (27°00′ 59.25″N, 92°38′ 50.35″E)

S3-2: Subansiri Formation - North of Bhalukpong Town (27°01′ 28.67″N, 92°38′ 01.03″E)

S4-2: Deformed sandstone in the vicinity of Tipi Thrust – North of Tipi Village (27°02′ 12.52″N, 92°36′ 24.00″E)

S5-2: Deformed sandstone associated with the southern strand of the MBT – Near Navika Waterfall (27°04′ 07.38″N, 92°35′ 26.01″E)

S6-2: Deformed sandstone in the vicinity of the northern strand of the MBT – East of Sessa (27°06′ 13.24″N, 92°34′ 03.46″E)

S7-2: Sandstone exposed North of MBT - Nechiphu Tunnel Notyh Portal (27°09′ 27.88″N, 92°33′ 51.20″E)

Balipara/Kalabil > Bhalukpung > Tippi village > Lumum waterfall > Navika waterfall > Sessa > Nechiphu tunnel.

Day 4

Balipara > Guwahati > Delhi

Field map showing Local Geology, Road and Excursion Stops

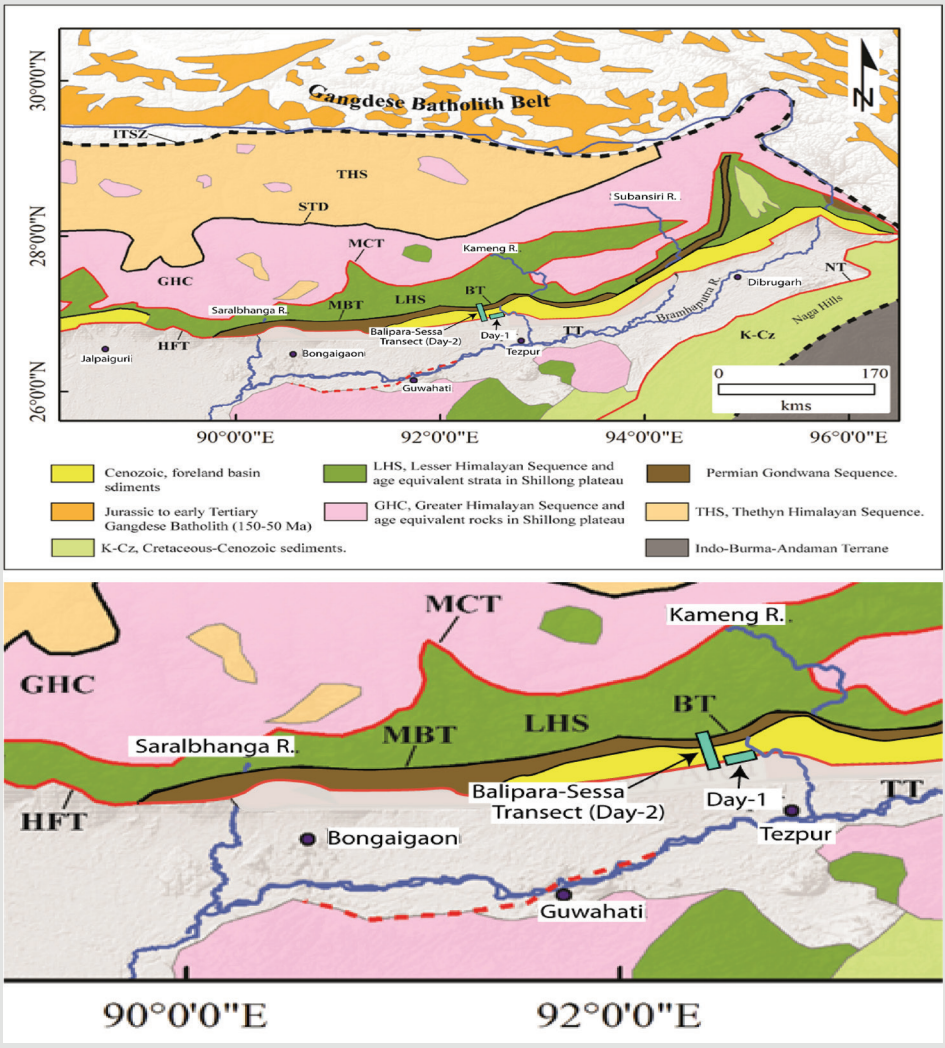


Fig. 1: (top) Regional geologic map of the eastern Himalayan modified after Yin and Harrison (2000) and Yin (2006). The cyan rectangle box shows the field locations for the Day-1 and Day-2 fieldwork. Abbreviations for major faults: HFT—Himalayan Frontal thrust; MBT—Main Boundary thrust; MCT—Main Central thrust; STD—South Tibet detachment; BT—Bomdila thrust; TT—Tipi thrust. NT- Naga Thrust, ITSZ- Indus Tsangpo Suture Zone. The solid polygon in light red represents the study area proposed for the doctoral thesis. Red continuous line-HFT/MBT, Black broken line-ITSZ, Black continuous line-STD. (bottom) Enlarged regional geologic map showing excursion transects (Fig. 3 in detail).

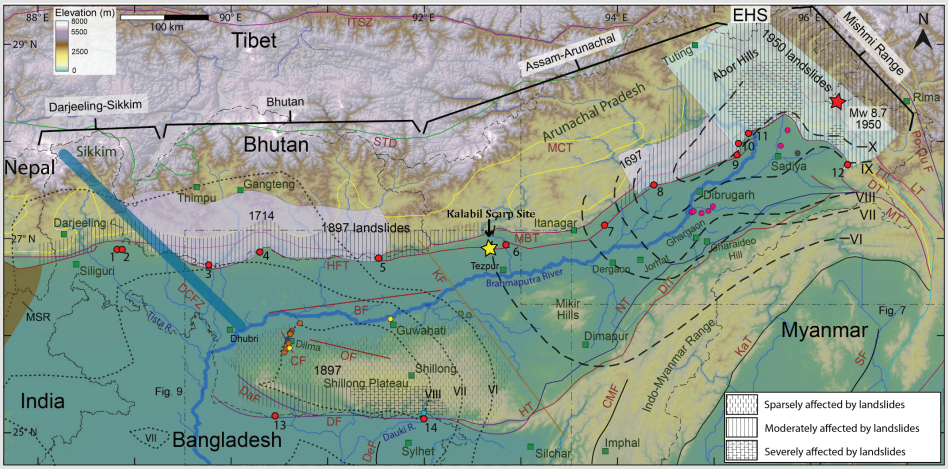


Fig. 2: Regional map of Eastern Himalaya with major faults of the Himalaya and Shillong Plateau. The segments of the NE Himalaya are bracketed by transverse structures: the Dhubri-Chungthang Fault Zone (DCFZ) and the Kopili Fault. The red star marks the epicenter of the 1950 CE Tibet-Assam earthquake, and the thick dashed lines with Roman numerals indicate the isoseismal zones. Red circles numbered 1 to 11 mark the palaeoseismic trench locations carried across the HFT, viz., Panijhora, Chalsa, Piping, Sarpang, Dungsam Chu, Nameri, Harmutty, Himebasti, Niglok, Marbang, Pasighat, and Kamlang. The yellow star is a proposed trench site (After Brice et al., 2021).

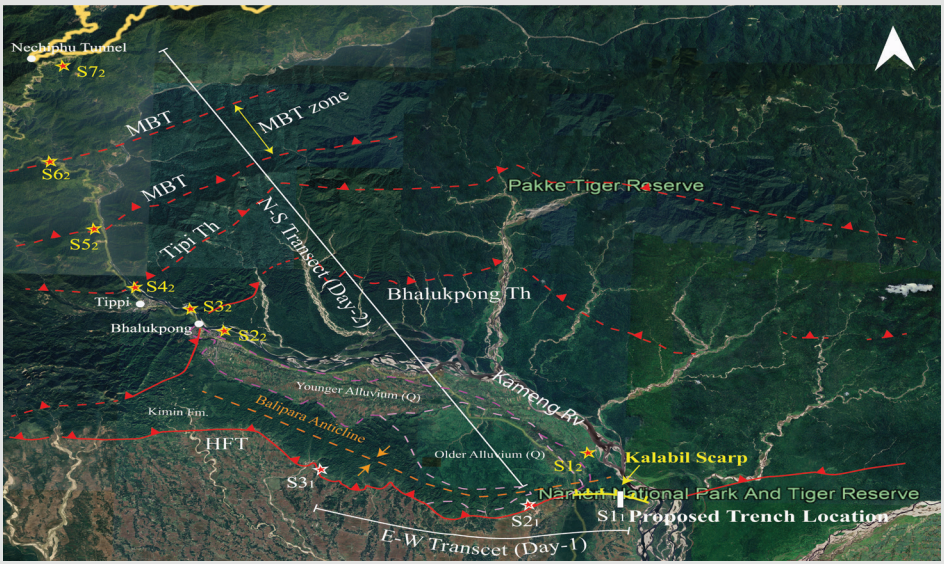


Fig. 3: Google image showing the proposed trench site (white rectangle) of the Kalabil scarp, E-W Transect along the HFT (for Day-1) and N-S transects from Balipara in Assam to Sessa/ Nechiphu Tunnel in Arunachal Pradesh (for Day-2). The white-red stars (S11 to S31) and yellow-red stars (S12 to S72) represent the excursion stops for Day-1 and Day-2, respectively. (Source imagery: Google Earth).

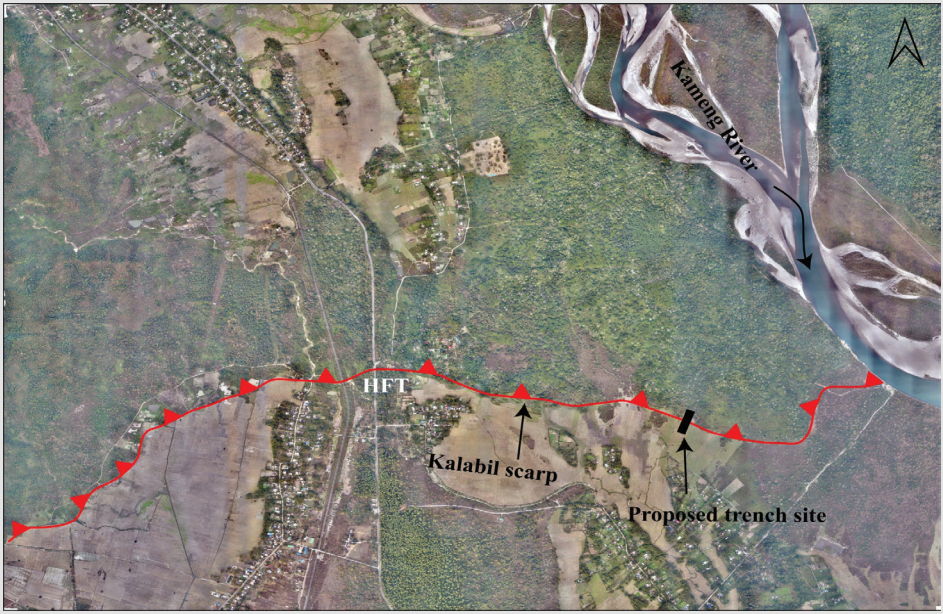


Fig. 4: High-resolution orthophoto mosaic of the Kalabil scarp generated by UAV quadcopter showing the fault scarp (red line with teeth) along the HFT that has uplifted Quaternary fluvial terrace surfaces along the Jia Bhoroli River, and the proposed trench site (black rectangle).



Fig. 5: Field photo showing trace of E-W trending scarp along the HFT at Kalabil village.

Location(s) Description

The Quaternary stratigraphy along the mountain front records several episodes of tectonic deformation and background sedimentation. Along the Kameng River exit, the mountain front is segmented by thrust, ramp-flat structures, and local anticline development, including the Balipara anticline zone linked to Holocene shortening across the Main Frontal Thrust zone. The area is an actively deforming tectonic front where sedimentation, incision, and folding are tightly coupled.

Geomorphology:

The Kameng River cuts across the frontal Himalaya and the Siwalik belt, preserving a stepped alluvial-terrace landscape that is the main geomorphic record used to infer active tectonics and late Quaternary river adjustment. The main geomorphic feature is a staircase of terraces between Bhalukpong and Potasali, with five mapped levels in the structural study and four major terrace levels in earlier morpho-sedimentary work (Srivastava et al., 2008; Goswami et al., 2017). These terraces record repeated phases of aggradation and incision, showing that the Kameng River repeatedly built floodplains and then cut down through them as deformation and base-level conditions changed (Chirouze et al., 2013). The oldest terrace levels are locally tilted, indicating tectonic deformation (Goswami et al., 2017). The river course itself has shifted through time, with uplift of older deposits and thrust-related relief forcing local diversion and leaving unpaired terraces along older channels (Goswami et al., 2017). The HFT trace is expressed at the mountain front as a continuous to discontinuous topographic scarp with varying elevations ranging from 5 to 40 m, reflecting cumulative fault displacement. The NE pressure ridges preserved along the Bhalukpong transect correspond to the surface expression of fault-propagation folds above asymmetric ramp anticlines in the HFT hanging wall.

Sedimentology:

The terrace deposits above the bedrock straths are alluvial, and Chirouze et al. (2013) recognize four main lithofacies along the Kameng terrace. These lithofacies include matrix-supported pebble gravels, clast-supported pebble gravels, and laminated medium sand, which together indicate a shift in depositional energy from coarse, proximal fluvial transport to finer channel reworking (Chirouze et al., 2013). Detrital geochemical and clay-mineral data from the Kameng River section show that the sediment package also preserves long-term changes in the weathering regime and source-area contributions since at least the mid-Miocene (Vögeli et al., 2017). The HFT in the study area has exposed folded and faulted conglomerates and sandstones of the Upper Siwalik Group, which locally overprint Holocene fan gravels on low-angle thrust surfaces, giving clear evidence of recent rupture at the surface.

Geochronology:

Chirouze et al. (2013) used luminescence dating to date the main incision phases in the Kameng terrace sequence and placed the incision phases at about 14 ka for T4 to T3, ~10 ka for T3 to T2, and ~7 ka BP for T2 to T1. The ages indicated by the mountain-front terrace record are predominantly Late Pleistocene to Holocene, although the deeper

sediment-source history and the drainage-evolution history go much further back. The detrital thermochronology and geochemical data from the Kameng River area suggest tectonic exhumation and drainage evolution in the eastern Himalaya since ~13 Ma on longer timescales. Burgess et al. (2012) used the abandonment ages of a terrace sequence across the Main Frontal Thrust zone to infer Holocene shortening, showing progressive river incision and tectonic uplift across the Balipara anticline sector.

Geoheritage, UNESCO Heritage, Other Archaeological sites in the vicinity, Cuisines and Culture

Archaeological Sites:

1. Bhalukpong Fort (10th–12th Century AD): Located roughly 56 km from Tezpur, this historical site on the foothills of Arunachal Pradesh is the legendary capital of King Bhaluka. It marks a fascinating transition zone between the plains and the rugged Himalayan terrain

2. Da Parbatia: Located just west of Tezpur, it features some of the finest and oldest rock carvings in Assam. The ornately carved doorway dates back to the 5th and 6th centuries (Gupta period).

3. Bamuni Hills: Situated just 5 km from Tezpur, these 9th to 12th-century ruins contain a massive cluster of stone sculptures, broken columns, and temple fragments depicting mythological scenes.

Geoheritage & Nature

The Kameng River, flowing through Bhalukpong, this pristine, rapid river (also known as Jia Bhorali) that offers a striking geological divide as the Brahmaputra plains rise into the mighty Eastern Himalayas.

1. Nameri Tiger Reserve is a pristine geoheritage and ecological hotspot located at the foothills of the Eastern Himalayas, roughly 40 km from Tezpur and 25 km from Bhalukpong.

2. Pakke Tiger Reserve (National park, Seijosa, Arunachal Pradesh): Located near Bhalukpong, it is famous for rare birdwatching and rich ecological biodiversity.

3. Tippi Orchidarium (Orchid farm, Tippi Village, Arunachal Pradesh): Located near Bhalukpong, it houses hundreds of rare orchid species native to the region.

UNESCO Heritage

1. World Heritage Sites: While Tezpur and Bhalukpong hold deep cultural heritage, the world-renowned Kaziranga National Park and Manas National Park are just a few hours' drive south.

2. Tentative Sites: Nearby Arunachal Pradesh boasts tentative UNESCO World Heritage sites such as the Thembang Fortified Village and the Apatani Cultural Landscape (in Ziro), showcasing unique traditional ways of life.

3. Local Tribes: The foothills are rich in indigenous culture. You will experience the vibrant traditions of the Monpa, Sherdukpen, Aka, and Miji tribes, who have deep ancestral roots in this region.

Local Conveniences

Hospitals: Tezpur Medical College & Hospital (TMCH); A multispecialty Dorika Hospital; Baptist Christian Hospital (BCH) near Mission Chariali; Nemcare Hospital Tezpur Pvt Ltd.; Primary Health Center (PHC) in Bhalukpong.

Help with a Stolen Passport

• The nearest Police Stations are Bhalukpong Police Station in Arunachal Pradesh and Chariduar Police Station in Assam.

• Most foreign embassies are located in Guwahati, the nearest major metropolitan hub, or New Delhi.

• RPO in Guwahati at 1800-258-1800

Local Bazaars

Balipara Market: Located slightly south of Nameri, this is a larger hub for fresh produce and general groceries.

Tezpur Main Market: This is the main commercial hub, about an hour's drive away, offering everything from pharmacies and clothing shops to ATMs.

Bhalukpong Bazaar: A small but bustling market on the Assam-Arunachal border. It's the last major spot to pick up dry rations, basic electronic needs, and local handicrafts.

Conclusion

The field excursion across the sub- and lesser Himalayan structural framework of the western Assam Seismic Gap is an attempt to bridge the spatial gap between the 1697 CE and 1714 CE ruptures. Investigations of the Kalabil fault scarp along the HFT, which has uplifted Quaternary fluvial terrace surfaces along the Jia Bhoroli River, are expected to yield improved constraints on the timing, resolving the debates on overlapping events, clarifying the role of transverse segment boundaries in arresting or propagating co-seismic ruptures, and refining earthquake cyclicity in this region.

The transect from Balipara to Sessa further offers an integrated structural perspective, linking the geometry of the growing Balipara Anticline and the major thrust zones to the broader kinematic framework of the active convergent margin. Together, these observations will contribute toward more reliable geological cross-sections, 3D kinematic reconstructions, and Holocene slip rate estimates along the basal décollement, ultimately enhancing seismic hazard assessments for the densely populated Assam Himalayan foothills, a region historically struck by catastrophic earthquakes and remaining acutely vulnerable to future great events.

Acknowledgement

We acknowledge the ANRF-DST, Govt. of India (Project No. EEQ/2022/000084), Research Council, Delhi University, and the Director, Wadia Institute of Himalayan Geology (WIHG) for the financial, administrative, and logistic support for this excursion guidebook. We thank the organizing and executive committee for providing the opportunity to organize this field excursion.

References

Acharyya, S. K., 1978. Stratigraphy and tectonic features of the eastern Himalaya. Tectonic Geology of the Himalaya. New Delhi: Today's and Tomorrow's Publications.

Acharyya, S. K., 1987. Cenozoic plate motion creating the Eastern Himalayas and Indo-Burmese Range around the Northeast corner of India. Ophiolites and Indian plate margins (pp. 143–160). Patna University, Patna: In: M.C. Ghosh and S. Varadarajan (Eds.).

Bilham, R., Larson, K., Freymueller, J., 1997. GPS measurements of present-day convergence across the Nepal Himalaya. Nature, 386 (6620), 61-64. https://doi.org/10.1038/386061a0.

Brice, A., Jayangondaperumal, R., Priyanka, R.S., Pandey, A., Mishra, R.L., Singh, I., Sati, M., Kumar, P., Dash, S.P., 2024. Paleoseismological evidence for segmentation of the Main Himalayan Thrust in the Darjeeling-Sikkim Himalaya. Sci Rep. 14, 14537. https://doi.org/10.1038/s41598-024-63539-1.

Burg, J. P., Nievergelt, P., Oberli, F., Seward, D., Davy, P., Maurin, J. C., Diao, Z., & Meier, M., 1998. The Namche Barwa syntaxis: Evidence for exhumation related to compressional crustal folding. Journal of Asian Earth Sciences, 16(2–3), 239–252.

Burgess, W. P., Yin, A., Dubey, C. S., Shen, Z. K., Kelty, T. K., 2012. Holocene shortening across the Main Frontal Thrust zone in the eastern Himalaya. Earth and Planetary Science Letters. 357, 152-167. https://doi.org/10.1016/j.epsl.2012.09.040.

Choudhuri, B. K., Gururajan, N. S., & Sarma, R., 2009. Geology and structural evolution of the eastern Himalayan Syntaxis. Journal of Asian Earth Sciences, 34(3), 258–269.

Chirouze, F., Dupont-Nivet, G., Huyghe, P., van der Beek, P., Chakraborti, T., Bernet, M., & Erens, V., 2012. Magnetostratigraphy of the Neogene Siwalik Group in the far eastern Himalaya: Kameng section, Arunachal Pradesh, India. Journal of Asian Earth Sciences, 44, 117-135.

Coudurier-Curveur, A., Tapponnier, P., Okal, E., Vander Woerd, J., Kali, E., Choudhury, S., Baruah, S., Etchebes, M., Karakas, Ç., 2020. A composite rupture model for the great 1950 Assam earthquake across the cusp of the East Himalaya syntaxis. Earth and Planet. Sci. Lett. 531. https://doi.org/10.1016/j.epsl.2019.115928.

Ding, L., Zhong, D., Yin, A., Ji, J., Zhang, J., & Zhou, Y., 2001. Cenozoic structural and metamorphic evolution of the eastern Himalayan syntaxis (Namche Barwa). Earth and Planetary Science Letters, 192(3), 423–438.

Geng, Q., Pan, G., Zheng, L., Chen, Z., Fisher, R. D., Sun, Z., Ou, C., Dong, H., Wang, X., Li, S., Lou, X., & Fu, H., 2006. The Eastern Himalayan syntaxis: major tectonic domains, ophiolitic mélanges and geologic evolution. Journal of Asian Earth Sciences, 27(3), 265–285.

Goswami, T., Bezbaruah, D., Mukherjee, S., Sarmah, R.K., & Jabeed, S., 2018. Structures and morphotectonic evolution of the frontal fold-thrust belt, Kameng river section, Arunachal Himalaya, India. Journal of Earth System Science. 127. 10.1007/s12040-018-0984-6.

Gururajan, N. S., & Choudhuri, B. K., 2003. Geology and tectonic history of the Lohit Valley, Eastern Arunachal Pradesh, India. Journal of Asian Earth Sciences, 21(7), 731–741.

Gururajan, N. S., & Choudhuri, B. K., 2007. Geochemistry and Tectonic Implications of the Trans Himalayan Lohit Plutonic Complex, Eastern Arunachal Pradesh. Journal of the Geological Society of India, 70(1), 17–31.

Hetényi, G., Le Roux-Mallouf, R., Berthet, T., Cattin, R., Cauzzi, C., Phuntsho, K., & Grolimund, R., 2016. Joint approach combining damage and paleoseismology observations constrains the 1714 AD Bhutan earthquake at magnitude 8±0.5. Geophysical Research Letters, 43(20), 10-695.

Jade, S., Mukul, M., Bhattacharyya, A. K., Vijayan, M., Jaganathan, S., Kumar, A., Tiwari, R.P., Kumar, A., Kalita, S., Sahu, S.S., Krishna, A.P., Gupta, S.S., Murthy, M.V.R.L., Gaur, V.K, 2007. Estimates of interseismic deformation in Northeast India from GPS measurements. Earth and Planetary Science Letters. 263(3-4), 221- 234. https://doi.org/10.1016/j.epsl.2007.08.031.

Jayangondaperumal R., Wesnousky S.G., Chaudhari B.K., 2011. Near-surface expression of Early to Late Holocene displacement along the Northeastern Himalayan Frontal Thrust at Marbang Korong Creek, Arunachal Pradesh, India, Bulletin of the Seismological Society of America. 101, 3060-3064. doi:10.1785/0120110051.

Jayangondaperumal, R., Thakur, V. C., Joevivek, V., Rao, P. S., Gupta, A. K., 2018. Active Tectonics of Kumaun and Garhwal Himalaya. Singapore: Springer.

Kaneda, H., Nakata, T., Tsutsumi, H., Kondo, H., Sugito, N., Awata, Y., Akhtar, S.S., Majid, A., Khattak, W., Awan, A.A., Yeats, R.S., Hussain, A., Ashraf, M., Wesnousky, S.G., Kausar, A.B., 2008. Surface Rupture of the 2005 Kashmir, Pakistan, Earthquake and Its Active Tectonic Implications. Bull. Seismol. Soc. Am. 98, 521–557. https://doi.org/10.1785/0120070073.

Kumar, G., 1997. Geology of Arunachal Pradesh. Geological Society of India, Text Book Series, Bangalore, 217 p.

Kumar, S., Wesnousky , S. G., Rockwell, K. T., Briggs, R. W., Thakur, V. C., & Jayangondaperumal,, R., 2006. Paleoseismic evidence of great surface rupture earthquakes along the Indian Himalaya. Journal of Geophysical Research: Solid Earth, 111(B3).

Lavé, J., & Avouac, J. P., 2000. Active folding of fluvial terraces across the Siwaliks Hills, Himalayas of central Nepal. Journal of Geophysical Research: Solid Earth, 105(B3), 5735–5770.

Le Roux-Mallouf, R., Ferry, M., Ritz, J. F., Berthet, T., Cattin, R., & Drukpa, D., 2016. First paleoseismic evidence for great surface-rupturing earthquakes in the Bhutan Himalayas. Journal of Geophysical Research: Solid Earth, 121(10), 7271-7283.

Le Roux-Mallouf, R., Ferry, M., Cattin, R., Ritz, J. F., Drukpa, D., Pelgay, P., 2020. A 2600-yr-long paleoseismic record for the Himalayan Main Frontal Thrust (Western Bhutan). Solid Earth Discussions, 2020, 1-36. https://doi.org/10.5194/se-11-2359-2020.

Malik, J. N., Sahoo, A. K., Shah, A. A., Shinde, D. P., Juyal, N., & Singhvi, A. K., 2016. Paleoseismic evidence of exemplary surface ruptures along the northwestern Himalayan Frontal Thrust (HFT), India. Journal of Structural Geology, 84, 113–132.

Mukul, M., Jade, S., Ansari, K., Matin, A., Joshi, V., 2018. Structural insights from geodetic global positioning system measurements in the Darjiling-Sikkim Himalaya: Journal of Structural Geology, 114, 346–356. doi:10.1016/j.jsg. 2018.03.007.

Mishra, R. L., Singh, I., PAndey, A., Rao, P. S., Sahoo, H. K., and Jayangondaperumal, R., 2016. Paleoseismic evidence of a giant medieval earthquake in the eastern Himalaya, Geophysical Research Letter, 43, 5707-5715, doi: 10.1002/2016GL068739.

Mugnier, J.L., Gajurel, A., Huyghe, P., Jayangondaperumal, R., Jouanne, F., Upreti, B., 2013. Structural interpretation of the great earthquakes of the last millennium in the central Himalaya. Earth-Science Reviews. 127, 30-47. https://doi.org/10.1016/j.earscirev.2013.09.003.

Nandy, D. R., 2001. Geodynamics of northeastern India and the adjoining region. Calcutta: acb Publication.

Nakata, T., 1972. Geomorphic development and crustal movements of the Himalaya. Science Reports of the Tohoku University, 7th Series (Geography), 22(1), 39–177.

Nandy, D. R., 2017. Geology and Tectonics of Northeast India and Adjoining Region. Concept Publishing Company, New Delhi.

Pandey, A., Jayangondaperumal, R., Hetènyi, G., Priyanka, R., Singh, I., Srivastava, P., Srivastava, H., 2021. Establishing primary surface rupture evidence and magnitude of the 1697 CE Sadiya earthquake at the Eastern Himalayan Frontal thrust, India. Nat. Sci. Rep. 11, 879. https://doi.org/10.1038/s41598-020-79571-w.

Priyanka, R.S., Jayangondaperumal, R., Pandey, A., Mishra, R.L., Singh, I., Bhushan, R., Srivastava, P., Ramachandran, S., Shah, C., Kedia, S., Sharma, A.K., 2017. Primary surface rupture of the 1950 Tibet-Assam great earthquake along the eastern Himalayan front, India. Sci. Rep. 7. doi:10.1038/s41598-017-05644-y.

Priyanka, S.R., 2018, Surface rupture investigations of the 1950- Meisoseismal zone of Assam earthquake along Himalayan Foothill zone, Arunachal Pradesh-Assam Himalaya (PhD thesis).

Rajendran, C. P., John, B., & Rajendran, K., 2015. Medieval pulse of great earthquakes in the central Himalaya: Viewing past activities from the Kaladungi fault scarp. Journal of Geophysical Research: Solid Earth, 120(3), 1623–1641.

Sapkota, S. N., Bollinger, L., Klinger, Y., Tapponnier, P., Gaudemer, Y., Tiwari, D., & Shrestha, S., 2013. Primary surface ruptures of the great 1934 Bihar–Nepal earthquake at the Himalayan frontal thrust. Nature Geoscience, 6(1), 71–76.

Singh, S., 1993. Geology and tectonics of the eastern syntaxial bend, Arunachal Himalaya. Journal of Himalayan Geology, 4(2), 149-163.

Srivastava, P., & Misra, D.K., 2008. Morpho-sedimentary records of active tectonics at the Kameng river exit, NE Himalaya. Geomorphology, 96 (1–2), 187-198, https://doi.org/10.1016/j.geomorph.2007.07.019.

Srivastava, P., Patel, R. C., & Singh, P., 2009. Deformation and structural analysis of the Higher Himalayan Crystallines along Goriganga valley, Kumaon NW-Himalaya, India. Journal of the Geological Society of India, 74(4), 481–495.

Stein R.S., King G.C., Lin J., 1994. Stress triggering of the 1994 m = 6.7 northridge, california, earthquake by its predecessors. Science. 265(5177):1432-5. doi: 10.1126/science.265.5177.1432.

Thakur, V. C., & Jain, A. K., 1975. Some observations on deformation, metamorphism and tectonic significance of the rocks of some parts of the Mishmi Hills, Lohit District (NEFA) Arunachal Pradesh. Himalayan Geol, 5, 339-64.

Wesnousky, S. G., Kumar, S., Mohindra, R., & Thakur, V. C., 1999. Uplift and slip rate of the Blini Thrust, NW Himalaya, India. Journal of Structural Geology, 21(11), 1543–1552.

Yin, A., & Harrison, T. M., 2000. Geologic Evolution of the Himalayan-Tibetan Orogen. Annual Review of Earth and Planetary Sciences, 28(1), 211–280.

Yin, A., 2006. Cenozoic tectonic evolution of the Himalayan orogen as constrained by along-strike variation of structural geometry, structural style, and exhumation history. Earth-Science Reviews, 76(1-2), 1–131.

Yin, A., Dubey, C. S., Webb, A. A. G., Kelty, T. K., Grove, M., Gehrels, G. E., & Burgess, W. P., 2010. Geologic correlation of the Himalayan orogen and Indian craton: Part 1. Structural geology, U-Pb zircon geochronology, and tectonic evolution of the Central Himalaya. Geological Society of America Bulletin, 122(3-4), 336–359.

Yu S.B., Suppe, J., & Hung, JH, 2001. Preseismic deformation and coseismic displacements associated with the 1999 Chi-Chi, Taiwan earthquake, Bull. seism. Soc. Am.,91, 995–1012.

Zhao, Y., Grujic, D., Baruah, S., Drukpa, D., Elkadi, J., Het´enyi, G., King, G.E., Mildon, Z. K., Nepal, N., Welte, C., 2021. Paleoseismological findings at a new trench indicate the 1714 M8.1 earthquake ruptured the main frontal thrust over all the Bhutan Himalaya. Front. Earth Sci. 9, 689457. https://doi.org/10.3389/feart.2021.689457.

Associate Members



Dr. Arjun Pandey

Wadia Institute of Himalayan Geology, Dehradun

Dr. Arjun Pandey is a Geoscientist specialized in Active Tectonics, Paleoseismology, Structural Geology, Geomorphology, Quaternary geology & Remote sensing. Currently, he is a Project Scientist at the Wadia Institute of Himalayan Geology, Dehradun. His research interests are earthquake geology, active tectonics, seismic hazard and strain-release patterns along the Himalaya Frontal Thrust. He has extensive field experience in paleoseismological investigations and expertise in drone-based mapping using LiDAR and photogrammetry and RTK-GPS. He has published 15 peer-reviewed papers and contributed to research appearing in journals including Scientific Reports, Geophysical Research Letters, Tectonophysics, and International Geology Reviews.



Dr. Shaikh Mohamedharoon A.

Wadia Institute of Himalayan Geology, Dehradun

Dr. Shaikh Mohamedharoon A. is a Structural Geologist and currently a Research Associate at the Wadia Institute of Himalayan Geology, Dehradun, India. His research encompasses diverse tectonic settings, such as active rift basins and fold-and-thrust belts. He has worked extensively on fault kinematics, paleostress analysis, seismic interpretation, structural restoration and mapping seismogenic and aseismic faults. His current research focuses on the Himalayan and Indo-Burma regions, particularly the Quaternary tectonic evolution of the Naga Fold-Thrust Belt and estimation of deformation rates.

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.	

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.

8. Do not photograph restricted installations, sensitive locations, or local residents without prior permission.

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

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

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

Disclaimer

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













Scan for
Field Guide Book

Contact Details:

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

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

Phone: +916386696896 | +916392507990