Quarterly Newsletter
Wadia Institute of Himalayan Geology, Dehradun
(www.wihg.res.in)

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RESEARCH ACTIVITIES

Active tectonics of Dikrong valley, northeast Himalaya, India: insight into the differential uplift and fold propagation from river profile analysis:

The detachment-limited stream power model is a powerful proxy in active tectonics study for identifying the areas of variable rock uplift vis-à-vis bedrock incision. Use of the channel steepness index (k_{sn}) was taken as proxy for the detachment-limited model to estimate the differential uplift across the fold-thrust belt in the Dikrong river valley, northeast Himalaya by considering river profile as a proxy for the local uplift. Though the model has earlier been applied in the northwest Himalaya, its validation in high monsoonal region like the northeast Himalaya was suggested. Based on field observations and analysis of drainage data from 30 m Digital Elavation Model, 147 channel traversing the major structural elememts, viz., the Bomdila Thrust, Main Boundary Thrust, Tipi Thrust, Himalayan Frontal Thrust and the Simna Parvat Anticline have been considered for study. The k_{sn} value for 147 channels varies from 22 to 199, with negligible lithological influence. k_{sn} values between 22 and 53 for streams across the Bomdila and the Main Boundary Thrust, and between 46 and 186 for streams across the Tipi and the Himalayan Frontal Thrusts suggest that the Bomdila and Main Boundary Thrusts are undergoing lesser degree of tectonic uplift than the Tipi and the Himalayan Frontal Thrust. Higher K_{sn} values (84-214) across the nose of the Simna Parvat Anticline suggest that this anticline is propagating towards ENE direction, resulting in the gradual shifting of the Dikrong river towards east and abandonment of paleochannels. (*Himalayan Geology 37 (2), 85-94*)

Boreal spring precipitation variability in the cold arid western Himalaya during the last millennium, regional linkages, and socio-economic implications:

Precipitation in the monsoon shadow zone of the western Himalayan region, largely under the influence of mid-latitude westerlies, is the dominant regional socioeconomic driver. Current knowledge of long-term regional precipitation variability

Announcement

2nd National Geo-Research Scholars Meet May 2 – 5, 2017
www.wihg.res.in, www.ngrsm2017.weebly.com
Wadia Institute of Himalayan Geology, Dehradun, warmly invites you for the 2nd National Geo-Research Scholars Meet

The broad themes of this event are:

- **Societal impact of Earth Science**
- **Geodynamics and Earth processes**
- **Economic Geosciences**
- **Geophysical techniques and their applications**
- **History of Indian Geosciences since the Vedic time**

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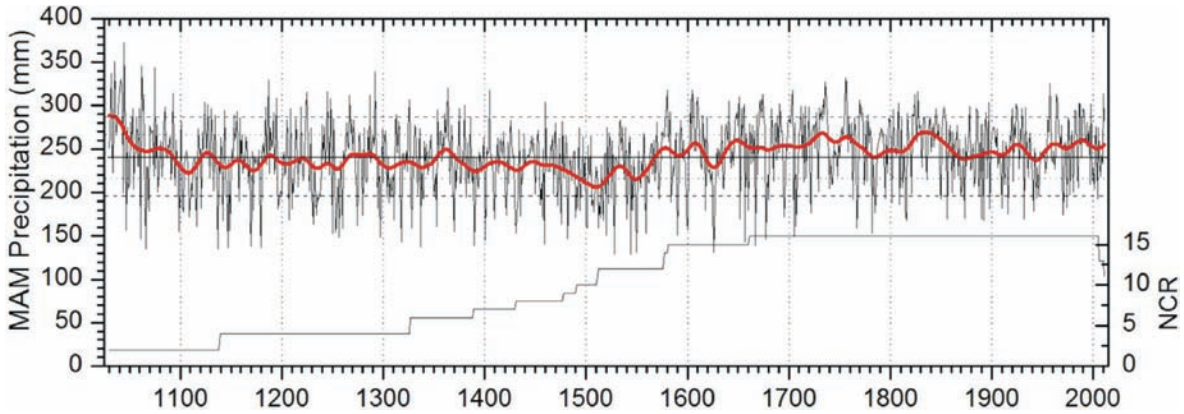


March-May precipitation reconstruction (1030-2011 C.E.) based on a network of sixteen site ring-width chronologies from western Himalaya. Thick line is a 40 years low pass filter. The dotted and dashed upper and lower lines are the 10% and 20% above and below the long-term mean precipitation. The number of chronologies used in the nested reconstruction is shown at the bottom of the panel (NCR).

is scarce due to spatially and temporally limited weather and high-resolution proxy climate records. We developed the first boreal spring precipitation reconstruction for the western Himalaya covering the last millennium (1030-2011 C.E.). The annually resolved reconstruction is based on a large tree-ring data set of Himalayan cedar (*Cedrus deodara*) and neoza pine (*Pinus gerardiana*) from 16 ecologically homogeneous moisture stressed settings in Kinnaur, western Indian Himalaya. The precipitation reconstruction revealed persistent long-term spring droughts from the 12th to early 16th century C.E. and pluvial from the late 16th century C.E. to recent decades. The late 15th and early 16th centuries (1490-1514 C.E.) displayed the driest episode, with precipitation being ~15% lower than the long-term mean. The early 19th century (1820-1844 C.E.) was the wettest period of the past millennium, with mean precipitation ~13% above the long-term mean. The reconstructed boreal spring precipitation from the western Himalaya revealed large-scale consistency with hydrological records from westerly dominated regions in Central Asia, indicating synoptic-scale changes in atmospheric circulation during the major part of the Medieval and Little Ice Age periods. Protracted droughts in Central Asia could have caused severe contraction of the regional economy, as indicated by striking coherence of reconstructed drought periods and historic social upheavals and invasions of India from Central and Western Asian invaders. Vulnerability to climatic extremes underpins the need to develop a better understanding of the temporal and spatial variability in regional hydroclimate in order to devise viable water resource management plans. (*Quaternary Science Reviews 144, 28-43*)

Evaluation of optimal wavelet filters for seismic wave analysis:

Wavelet signal processing is broadly used for analysis of non-stationary data particularly, real-time seismic signals. In the geophysical analysis, numerous wavelet filters are developed to realise the signal characteristics by multilevel spectral synthesis. However, the selection of optimal wavelets family and wavelet filter for seismic wave analysis is a major issue and no rationale exists for choosing the appropriate wavelet filter. The present work aims to solve this problem through evaluating various wavelet filters by two computational analyses, the first one is a descriptive statistical measure of spectral synthesis of seismic samples, which include normal tremors (i.e., ground motion signal ambient vibrations), local-mining blasts, and earthquake signals. These signals were subjected to single level decomposition by adopting Haar, Daubechies, Symlet, coiflet and Biorthogonal wavelets families. Descriptive statistical measures (mean, standard deviation, skewness and kurtosis) are used to evaluate approximation (signal passed through low pass filter) and detail (signal passed through high pass filter) coefficients. Statistical results reveal applications of the descriptive statistics for characterising the seismic signals and understanding the ground response. The analysis of perfect reconstruction error of wavelets suggesting the strength of the wavelet filter is related to reducing the data redundancy. Based on these analysis, it was observed that Daubechies (db3 and db4), Symlet (sym3), Coiflet (Coifl), and Biorthogonal (BIOR3.5 and BIOR5.5) are the best wavelet filters to perform the seismic signal analysis. (*Himalayan Geology 37 (2), 176-189*)

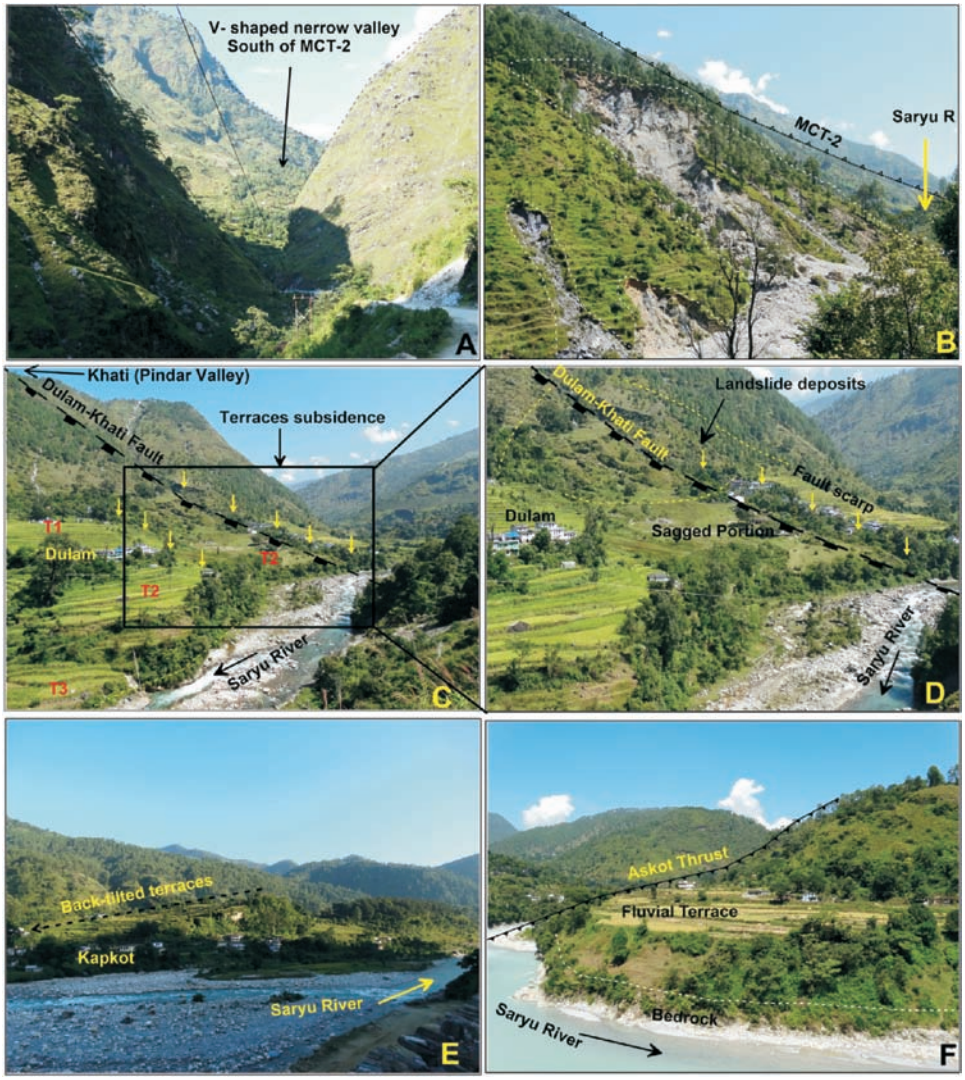
Late Quaternary paleoclimatic oscillation in the Ganga Plain, India during ~59-26 ka decoded from river cliff sediment archive:

Multi-proxy paleoclimatic data-set were generated from ~8m high Ganga river cliff section, exposed at Ramnagar, Varanasi, India to reconstruct past climatic variation during the late Quaternary. The study reports fluctuating climate conditions in the Ganga Plain during ~59 ka to ~26 ka. The sedimentary grain size, magnetic minerology, and geochemical signatures from the

river cliff section indicate two relatively wet and warm climatic phases during ~59 -46 ka and ~39 -26 ka, intervened with a drier interval during ~46 ka, i.e.~2 m of cliff height and also to intensified monsoon across ~39 ka or ~ 4.7 m of the section. These findings are supported by some earlier paleoclimatic and paleovegetation records from the Ganga Plain indicating major hydrological shifts across ~46 ka and 39 ka. This multi-proxy paleoclimatic data set are comparable to global paleoclimatic records as well. The wet phase during the reporting period in the Ganga Plain are concomitant with higher insolation, while the drier interval coincides with lower insolation. The insolation appears to be instrumental toward the late quaternary paleoclimatic oscillation during the studied period in the Ganga Plain region. (*Himalayan Geology 37 (2), 105-112*)

Late Quaternary tectonic landforms and fluvial aggradation in the Saryu River valley: Central Kumaun Himalaya:

The present study has been carried out with special emphasis on the aggradational landforms to explain the spatial and temporal variability in phases of aggradation/incision in response to tectonic activity during the late Quaternary in the Saryu River valley in central Kumaun Himalaya. The valley has preserved cut-and-fill terraces with thick alluvial cover, debris flow terraces, and bedrock strath terraces that provide signatures of tectonic activity and climate. Morphostratigraphy of the terraces reveals that the oldest landforms preserved south of the Main Central Thrust, the fluvial modified debris flow terraces, were developed between 30 and 45 ka. The major phase of valley fill is dated between 14 and 22 ka. The youngest phase of

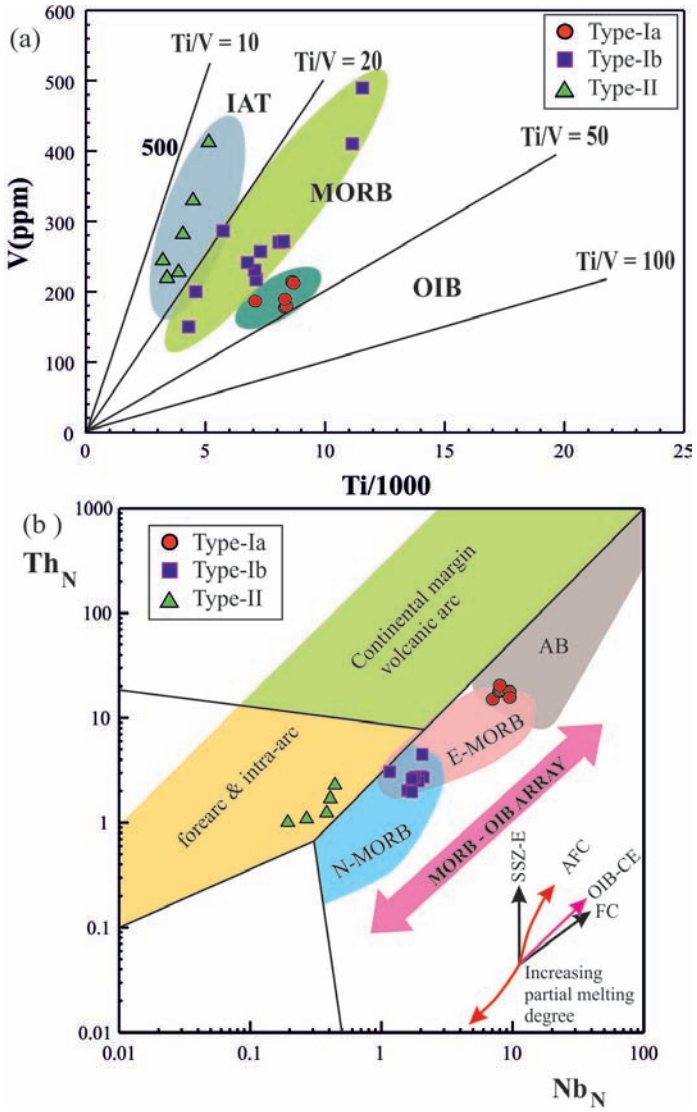


Upper catchment of Saryu valley showing (A) development of V shaped narrow valley south of MCT-1; (B) frequent occurrence of landslides close to MCT-2; (C and D) three levels of fill terraces observed around Dulam. The top terrace is covered by landslide deposits. Subsidence is observed in the central portion of these terraces and a N-S oriented fault scarp has developed (indicated by thick yellow arrows); (E) back-tilted terraces are observed near Kapkot; (F) well-developed fluvial strath terraces observed in and around Bageshwar area.

aggradation is dated at early and mid-Holocene (9–3 ka). Following this, several phases of accelerated incision/erosion owing to an increase in uplift rate occurred, as evident fromthe strath terraces. Seven major phases of bedrock incision/uplift have been estimated during 44 ka (3.34mm/year), 35 ka (1.84 mm/year), 15 ka (0.91 mm/year), 14 ka (0.83 mm/year), 9 ka (1.75 mm/year), 7 ka (5.38 mm/year), and around 3 ka (4.4 mm/year) from the strath terraces near major thrusts. We postulate that between 9 and 3 ka the terrain witnessed relatively enhanced surface uplift (2–5 mm/year). (*Geomorphology 268, 159-176*)

Evidence of Mid-ocean ridge and shallow subduction forearc magmatism in the Nagaland-Manipur ophiolites, northeast India: constraints from mineralogy and geochemistry of gabbros and associated mafic dykes:

The mineralogical and geochemical characteristics of mafic intrusive rocks from the Nagaland-Manipur Ophiolites (NMO) of Indo-Myanmar Orogenic Belt, northeast India to define their mantle source and tectonic environment were discussed in the present work. Mafic intrusive sequence in the NMO is characterized by hornblende-free (type-I) and hornblende-bearing (type-II) rocks. The type-I is further categorized as mafic dykes (type-Ia) of tholeiitic N-MORB composition, having TiO_2 (0.72–1.93 wt.%) and flat REE patterns (La_N/Yb_N= 0.76–1.51) and as massive gabbros (type-Ib) that show alkaline E-MORB affinity, having moderate to high Ti content (TiO_2= 1.18 to 1.45 wt.%) with strong LREE-HREE fractionations (La_N/Yb_N=

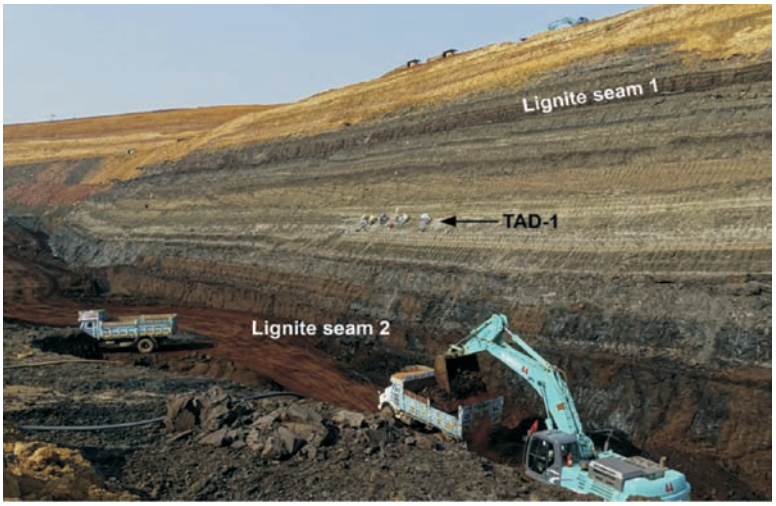


(a) Ti vs. V discrimination diagram, (b) Tectonic interpretation of ophiolitic basaltic types based on Th_N vs. Nb_N systematic. MORB = mid-ocean ridge-basalt, OIB = ocean island basalt. N-MORB = normal-type MORB, E-MORB= enriched-type MORB, AB = alkaline ocean-island basalt.

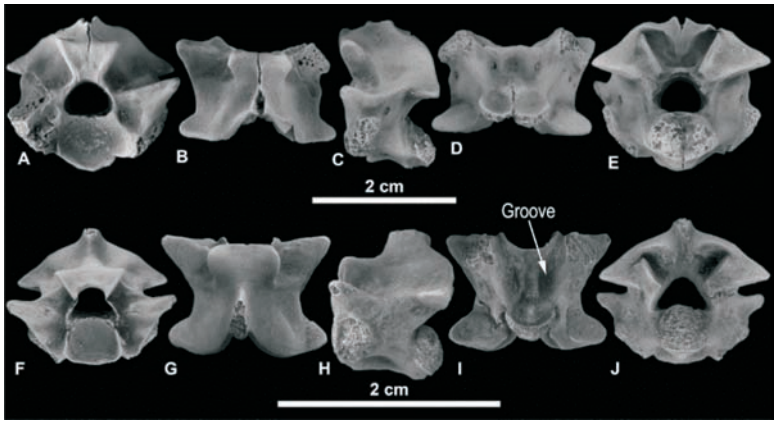
4.54–7.47). Such geochemical enrichment from N-MORB to E-MORB composition indicates mixing of melts derived from a depleted mantle and a fertile mantle/plume source at the spreading centre. On the other hand, type-II mafic intrusives are hornblende bearing gabbros of SSZ-type tholeiitic composition with low Ti content (TiO_2= 0.54 wt.%–0.86 wt.%) and depleted LREE pattern with respect to HREE (La_N/Yb_N= 0.37–0.49). They also have high Ba/Zr (1.13–2.82), Ba/Nb (45.56–151.66) and Ba/Th (84.58–744.19) and U/Th ratios (0.37–0.67) relative to the primitive mantle, which strongly represents the melt composition generated by partial melting of depleted lithospheric mantle wedge contaminated by hydrous fluids derived from subducting oceanic lithosphere in a forearc setting. Their subduction related origin is also supported by presence of calcium-rich plagioclase ($An_{16.6–32.3}$). Geothermometry calculation shows that the hornblende bearing (type-II) mafic rocks crystallized at temperature in range of 565°–625°C ± 50 (at 10 kbar). Based on these available mineralogical and geochemical evidences, it was concluded that mid ocean ridge (MOR) type mafic intrusive rocks from the NMO represent the section of older oceanic crust generated during the divergent process of the Indian plate from the Australian plate during Cretaceous period. Conversely, the hornblende-bearing gabbros (type-II) represent the younger oceanic crust formed at the forearc region by partial melting of the depleted mantle wedge slightly modified by the hydrous fluids released from the subducting oceanic slab during the initial stage of subduction of Indian plate beneath the Myanmar plate.

New early Eocene vertebrates reveal mixed fauna of European and Gondwana affinities:

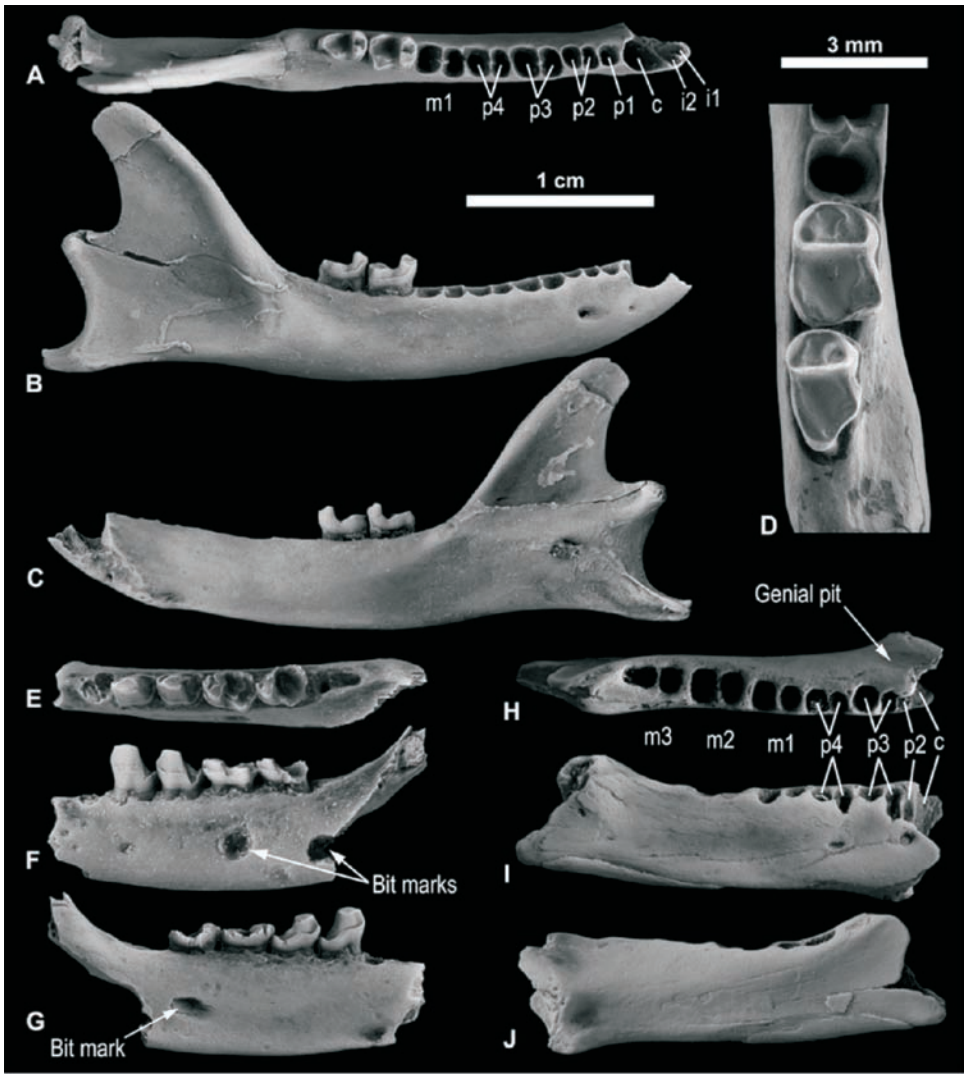
A new vertebrate assemblage from two layers of Ypresian Cambay Shale Formation in Tadkeshwar lignite mine, Gujarat comprises a mammal fauna approximately contemporary and similar to that from Vastan with the co-occurrence of the perissodactyl-like cambaytheriid *Cambaytherium thewissi*, the adapoid primates *Marcgodinotius indicus* and cf. *Asiadapis cambayensis*, and the hyaenodontid *Indohyaenodon raoi*. The presence of these taxa in both Vastan and Tadkeshwar mines and at different levels suggests that the deposits between the two major lignite seams represent a single land mammal age. Apart from the aforementioned species there is a new, smaller species of *Cambaytherium*, and a new esthonychid tillodont. This



Outcrop of the Cambay Formation in Tadkeshwar Mine showing the position of the vertebrate-producing layer TAD-1 relative to major lignite seams 1 and 2.



Madtsoiidae indet. A-E, mid-trunk vertebra. F-J, posterior trunk vertebra.

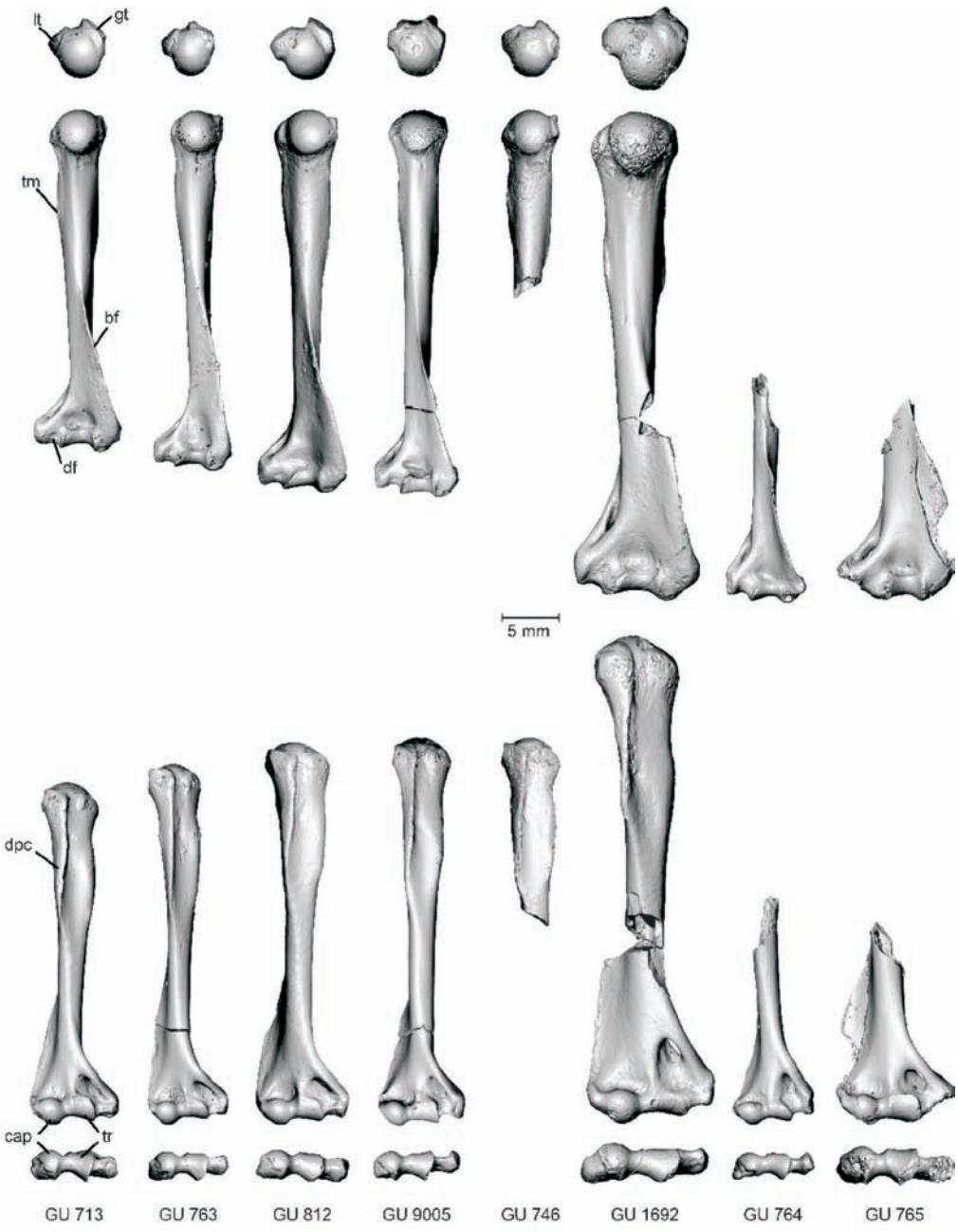


Primates. *Marcgodinotius indicus*. A-D, right dentary with m2-3. E-G, left dentary with p3-m2. H-J, edentulous right dentary.

fauna also contains the first large early Eocene vertebrates from India, including an unidentified *Coryphodon*-like pantodont, a dyrosaurid crocodyliform and a new giant madtsoiid snake. Whereas most of the Vastan mammal fauna shows European affinities, among the Tadkeshwar vertebrates several taxa are of Gondwana affinities, such as Pelomedusoides turtles, dyrosaurids, and large madtsoiids, attesting that the early Eocene was a crucial period in India during which Laurasian taxa of European affinities co-existed with relict taxa from Gondwana before the India-Asia collision. (*Geoscience Frontiers 16 (7), 969-1001*)

New Euprimate limb bones from Early Eocene of western India:

New, exquisitely preserved limb bones of Indian primates have been documented from the early Eocene Cambay Shale Formation of Vastan lignite mine, Gujarat, India. They belong to two distinct clades, Adapoidea (basal members of Strepsirrhini, which includes extant lemurs, lorises, and bushbabies) and Omomyidae (basal Haplorhini, which comprises living tarsiers, monkeys, and apes, as determined from their earlier reported dentitions. The limb bones reveal more primitive postcranial characteristics than have been previously documented for either clade, and differences between them are so minor that in many cases we cannot be certain to which group they belong. Nevertheless, the small distinctions observed in some elements foreshadow postcranial traits that distinguish the groups by the middle Eocene, suggesting that the Vastan primates, though slightly younger than the oldest known euprimates, may represent the most primitive known remnants of the divergence between the two great primate clades. (*Journal of Human Evolution 99, 25-51*)



Euprimate humeri from Vastan Mine. Right humeri in proximal (top), posterior (second from top), anterior (second from bottom), and distal views (bottom). Abbreviations: bf=brachialis flange, cap=capitulum, df=dorsoepitrochlear fossa, dpc=deltopectoral crest, gt =greater tubercle, lt=lesser tubercle, tm=teres major tubercle, tr=trochlea.

Paleoseismic evidence of a giant medieval earthquake in the eastern Himalaya:

The results of a paleoseismic investigation carried across a ~10m high fault scarp at Panijhora village, West Bengal in northeastern India were presented. Accelerator Mass Spectrometer analyzed ^{14}C radiocarbon age constraints from six detrital charcoal samples ranging between 1688 B.C. and A.D. 1152 are consistent with the great medieval earthquake of A.D. 1255 that is interpreted to have produced a minimum observed fault slip of ~5m in the trench exposure. Recalibration of radiocarbon ages from previous studies at Harmutty, Nameri, and Marha in the eastern Himalaya using Bayesian statistical analyses further substantiates the possibility that the A.D. 1255 earthquake might have ruptured the Himalayan front over a length of ~800 km from ~85.87° to 93.76°E longitudes. (*Geophysical Research Letter 43, 5707–5715*)

Proterozoic Sedimentary Successions in the Himalayan Orogen: Stratigraphy, sedimentology and palaeobasinal conditions:

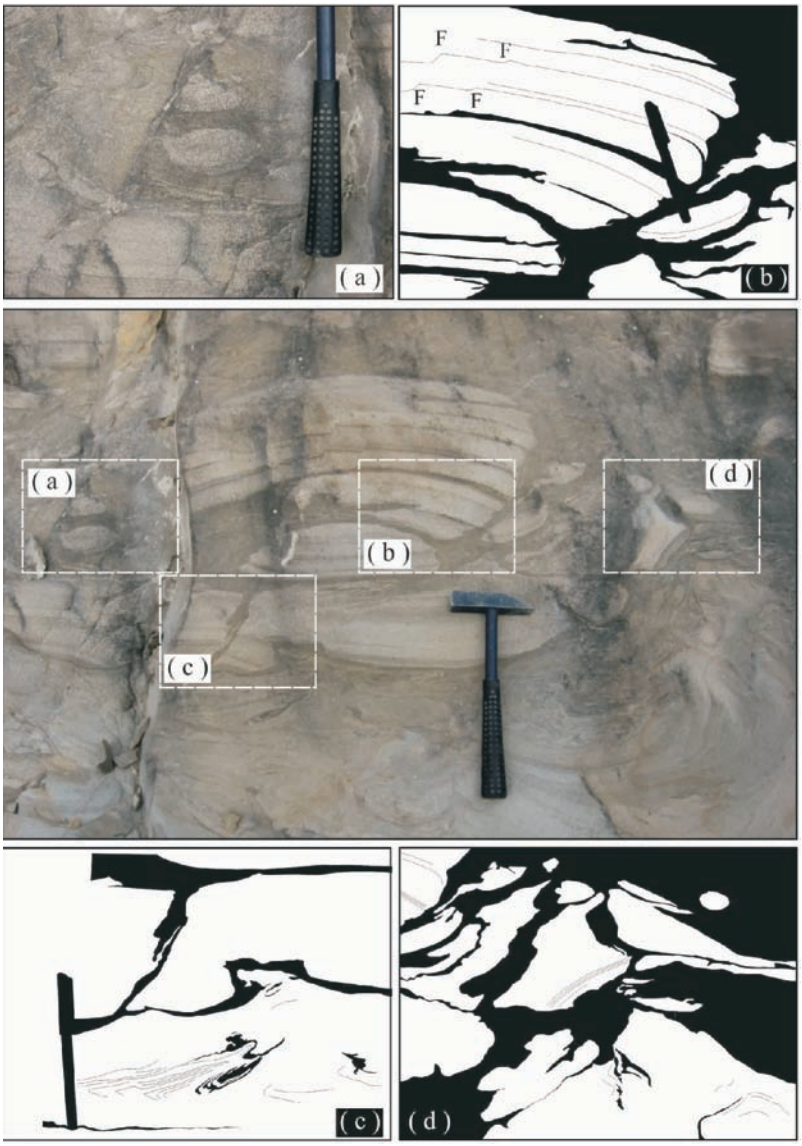
The Himalayan orogen forms a 2500 km long and ~250 km wide arc along the leading margin of the Indian plate. The Higher, Lesser, and Sub-Himalaya are thus slices of the old Indian shield that have stacked over one another by transfer along a series of southward verging thrusts. Four prominent lithoevents are recorded in the Late Palaeoproterozoic to early Palaeozoic sedimentary succession of the Lesser and Tethys Himalayan part: i) Palaeoproterozoic Argillite Siliciclastic, ii) Mesoproterozoic calcareous (limestone)> Argillite, iii) Neoproterozoic Argillite=Siliciclastic, and iv) Late Neoproterozoic-Early Palaeozoic mixed siliciclastic-Argillite-Calcareous (limestone). Based on geologic, sedimentologic and petrographic attributes, the central Lesser Himalayan (Garhwal and Kumaun) Proterozoic succession have been segregated into outer (southern) and inner (northern) domains. Of these the pre-Blaini sedimentary succession of the Outer Lesser Himalaya (OLH) is younger (Neoproterozoic) than Inner Lesser Himalaya (ILH). The gradual coarsening up succession, sub-aerially erupted volcanics, and occurrence of several gravity beds suggest an unstable and shallowing basin. A consistent northwest-southeast trending palaeo-shoreline from Neo and Palaeoproterozoic successions of OLH and ILH has been visualized. The compositional consistency of OLH and ILH siliciclastics hints towards similar source area lithology (the Aravalli-Delhi Supergroup and less commonly the Banded Gneissic Complex and Bundelkhand Granite gneiss). The presence of alluvial fan facies along the Tons thrust possibly hint towards the existence of a palaeo-high (horst) region of the rifted basin between OLH and ILH. The thinning and sagging of the basin floor of the basement and development of shallow marine set up is also consistent as some of the mafic bodies present within the studied sediments bear a "within plate basaltic" signature. It is also consistent with the palaeogeographic settings during the Proterozoic time, when no deep oceans existed around the Indian subcontinent. Precambrian stratigraphy of Himalaya has close proximity and resemblance with the Vindhyan basin which rests unconformably on the Bundelkhand and Aravalli cratons. Though the Vindhyan basin is traditionally considered intercratonic but it is in fact, an epicratonic basin located along the hinges of the Archean nuclei of the Indian shield and has a lots of similarities in sedimentary pattern with the Lesser Himalayan basin. Therefore, it will be appropriate to consider the Precambrian succession of Himalaya as a part in the Aravalli-Bundelkhand craton. (*Himalayan Geology 37* (*2*), *121-140*)

Strain energy budget analysis in the Garhwal-Kumaun region of Central Seismic Gap in Himalaya:

A seismic gap for great earthquake exists in the central part of the Himalaya in India. This region lies between 1905 Kangra earthquake and 1934 Bihar-Nepal earthquake where an intense micro-seismicity has also been observed in a narrow zone south of the Main Central Thrust. In the present work quantitative energy budget analysis has been carried out for this seismic gap. The parameters considered are (i.) energy accumulated:~ 6m of strain (1997), (ii) rate of energy accumulation: 1.8 cm/year (2014), and (iii) average energy release of 0.78 cm/month at eight Epicentral locations as has been worked out in the present work. The evaluation of numerical values of energy release at isolated locations is an important result which needs to be worked out with a larger set of data for this region where a potential of a great earthquake is near future exists. (*Himalayan Geology 37*(*2*), *113-120*)

Soft-sediment deformation structures in the Middle Siwalik rocks near south of Main Boundary Thrust SE, Kumaun Sub-Himalaya, Nainital:

Soft-sediment deformation structures of various morphologies and sizes are observed along the Gaula river valley section of the SE Kumaun Sub-Himalaya. These structures are recognized in multistoried cross-stratified salt and pepper textured sandstones and fine grained rippled sandstones of the Middle Siwalik formations at different stratigraphic horizons. The structures are confined between two undeformed layers and are represented by dykes and sills, pseudonodules, convolute lamination and beddings, folds, faults, water-escape structures (dish and pillar), flame structures, deformed cross-stratification and isolated liquefaction pockets. The structures are exposed at two sites with the deformed horizons ranging in thickness from 0.3mto ~2m.At Site No. 2 three deformed horizons are observed with their maximum thickness measuring up to 1.5 m. On the basis of their sizes and morphologies, and the paleotectonic setting of the region, it is suggested that these structures owe their origin to the ongoing tectonic stress during the time of deposition of the Middle Siwalik sediments (~Late-Middle Miocene), and their formation is interpreted to be due to seismic events. The structures are observed in different layers separated by undeformed layers indicating that each deformed layer represents a separate seismic event. (*Himalayan Geology 37*(*2*), *153-164*)

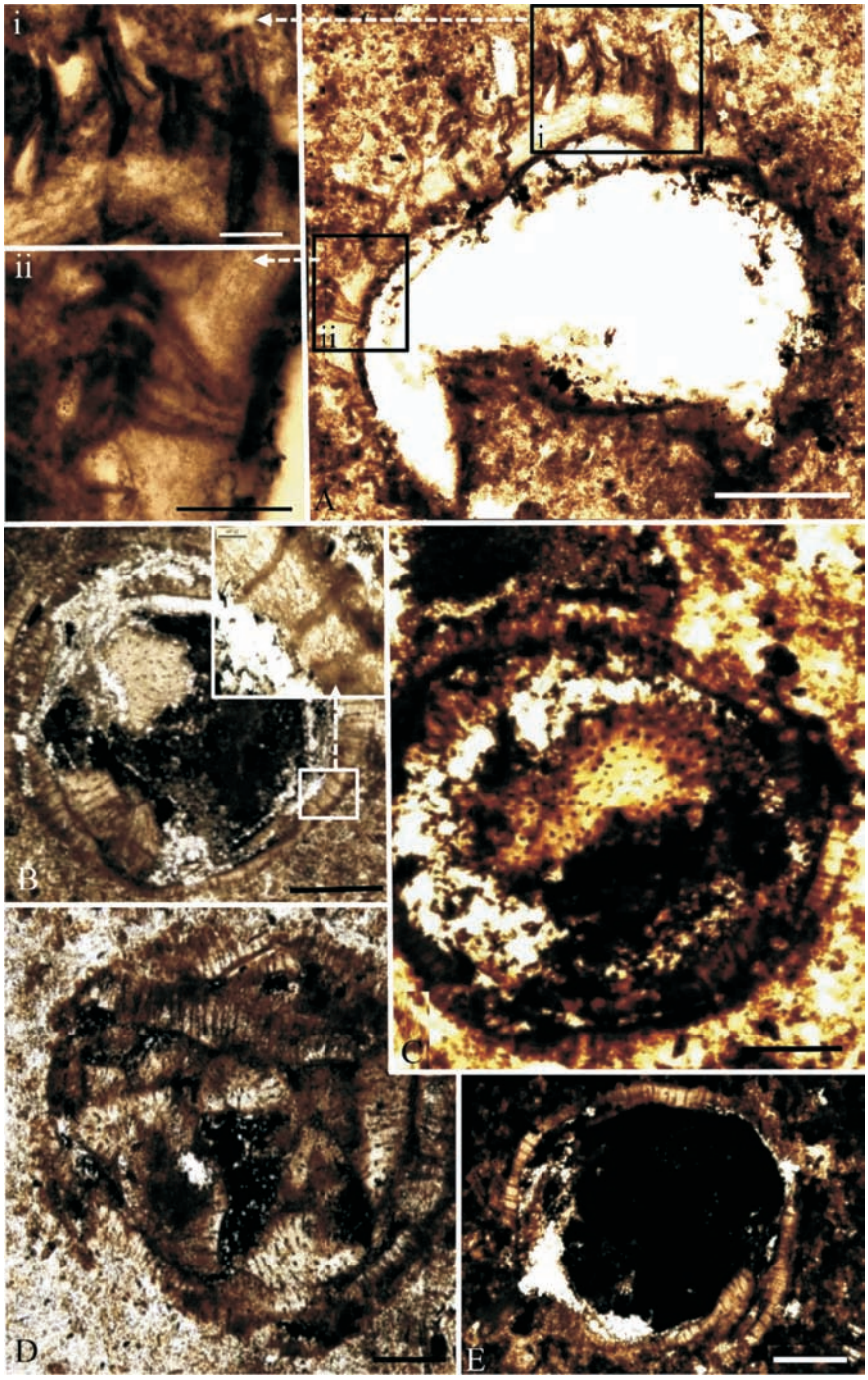


Complete breakdown of the laminated sandstone with the development of sills, dykes and complex flame-like structures; inset (a, b, c & d) showing sills, dykes and isolated sand bodies of various sizes floating in fluidized sediments. F-F indicates normal faults.

Tianzhushania spinosa and other large acanthomorphic acritarchs of Ediacaran Period from the Infrakrol Formation, Lesser Himalaya, India:

Covering a time span from Ediacaran (base of Blaini pink carbonates) to Early Cambrian (base of Tal Group), the Krol belt in the Lesser Himalaya (India), occurs as a series of synclines from Solan, Himachal Pradesh in the north-west to Nainital, Uttarakhand in the south-east. Various lithostratigraphic divisions of this belt reveal many palaeobiological entities, namely cyanobacteria, algae, acritarchs, small shelly fossils and trace fossils. Globally, large acanthomorphic acritarchs of the Ediacaran Period are used as significant biostratigraphic tools for global correlation. In the Krol belt, reports of acanthomorphic acritarchs from the Infrakrol and Krol 'A' formations of the Krol Group have further supported this notion. Well-preserved microfossils including acanthomorphic acritarchs, sphaeromorphic acritarchs, coccoids namely *Tianzhushania spinosa*, *T. polysiphonia*, *Papillomembrana compta*, *Schizofusa* sp., *Gloeodiniopsis lamellosa*, *Sphaerophycus medium*, and the unnamed forms A, B and C are discovered from the chert nodules of the Infrakrol Formation exposed in the Nainital Syncline of the Kumaun Lesser Himalaya. A biostratigraphic correlation based on acanthomorphic acritarchs suggests that the Infrakrol Formation is coeval to the lower Tianzhushania assemblage zone of the Doushantuo Formation of south China. *Tianzhushania* and *Papillomembrana* are significant additions to the

previous record of the Ediacaran acanthomorphic acritarchs from the Lesser Himalaya of India and provide an independent evidence for construction of both biozonation scheme and paleogeography. (*Precambrian Research 286*, *325-336*)



Tianzhushania Yin and Li (1978) emend. Yin et al. (2008). (A) *Tianzhushania polysiphonia* Yin C. in Yin and Liu (1988); (i and ii): magnified view of clustered processes connecting the inner and outer membrane, (B–E) *Tianzhushania spinosa* Yin and Li (1978) emend. Yin C. in Yin and Liu (1988); inset in (B): magnified view of the cylindrical processes connecting the inner and outer membrane. (Scale bar for A, B, C, D, E = 200 μm; for all insets = 20 μm).

RESEARCH PUBLICATIONS

In SCI Journals

Bhakuni, S.S. and Luirei, K. 2016. Soft-sediment deformation structures in the Middle Siwalik rocks near south of Main Boundary Thrust, SE Kumaun Sub-Himalaya, Nainital. Himalayan Geology 37(2), 153-164.

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Technical Reports

Gupta, V., Bhakuni, S.S. and Venkateshwarlu, B. (August 2016) GPR Study and the Engineering Geological Mapping of the Jakhri Landslide, Satluj Valley, Himachal Pradesh, Submitted to Central Scientific and Instruments Organization (CSIO), Chandigarh, 14 pp.

Gupta, Vikram along with other members drawn from various organizations submitted a comprehensive technical report on the feasibility of allowing construction in the Green Areas of Shimla to the National Green Tribunal (NGT), New Delhi.

PARTICIPATION IN CONFERENCES/SEMINARS/WORKSHOPS/MEETINGS

Conferences

- Dr Vikas, Sh. Aravind and Sh Shailendra Pundir participated in the "Rock Deformation and Structures (RDS-IV) conference" at Haldwani, during November 18 to 20, 2016 and presented following posters entitled:
  - Geochronological and Structural Constraints on the deformation along Karakoram Fault Zone, India: A Review. (Authors: Pundir, S., Adlakha, V. and Kumar, S.)
- Sh M. Prakasam participated in the TWAS-ROCASA young scientist conference "Frontiers in Earth & Climate Science" during December 05 to 07, 2016 at DCCC (IISc) Bangalore and presented a paper entitled:
  - Paleoclimatic multiproxy record from Tso Moriri Lake, NW Himalaya, India: during the past 600-years. (Author: Prakasam, M.)

Seminars

- Dr R.K. Bikramaditya attended National Seminar on "Developments in Geosciences in the past decade- Emerging trends for the future & impact on society" at IIT, Kharagpur during October 21-23, 2016 and presented a paper entitled:
  - Geotectonic evolution of the Bomdila mylonitic zone in the Arunachal Lesser Himalaya, Northeast India: constrains from structures and anisotropy of magnetic susceptibility data (Bikramaditya, R.K., Singh, A.K., Sen, K. and Sangode, S.J.)

Workshops

- Sh. Arun Prathap Participated in the 31st Himalaya-Karakorum-Tibet (HKT) Workshop held in Aussios, France during May 9-12, 2016 and presented a paper entitled:
  - Repeating earthquake sequence identified in Garhwal Himalaya region of Northwest Himalaya, India: Implication of the influence of flexure bend in the Indian lithosphere.
- Dr R.K. Bikramaditya attended "Workshop-1 (Morh circle simplified) and Workshop-2 (Mordern Methods of Fabric analysis in deformed rocks)" at IIT, Kharagpur during October 21-22, 2016.

Meetings

- Dr Vikram Gupta attended
  - A Task Force meeting for the formulation of National Landslide Risk Management Strategy at National Disaster Management Authority (NDMA), New Delhi on August 05, 2016;
  - National Green Tribunal (NGT) meeting at Himachal Pradesh Secretariat, Shimla to look into the future construction activities in the Shimla township on August 09, 2016.
  - Task Force meeting for the slope stabilisation study at Sidcul Bhawan, IT Park, Dehradun on September 06, 2016.
  - Expert Group meeting for Disaster Risk Assessment Study for the state of Uttarakhand to review the Inception Report prepared for the understanding the Risk Assessment at Dehradun on September 14, 2016.
  - Landslide Expert Committee meeting in ASCI Hyderabad and presented the work being carried out in the DST sponsored project titled "Geotechnical characterisation of the soil/rocks with special reference to active landslides in Mandakini valley, Garhwal Himalaya" on October 18, 2016.
  - Technical Task Force (TTF) meeting for presenting different designs solutions under slope stabilisation study in GoUA, PIU office, Sahastradhara Road (IT Park), Dehradun on December 05, 2016.
- Dr Jayangondaperumal attended the PAMC meeting held at ISR for the project of "Neo Tectonics…" of MoES during December 15-16, 2016.

EVENTS HELD IN THE INSTITUTE

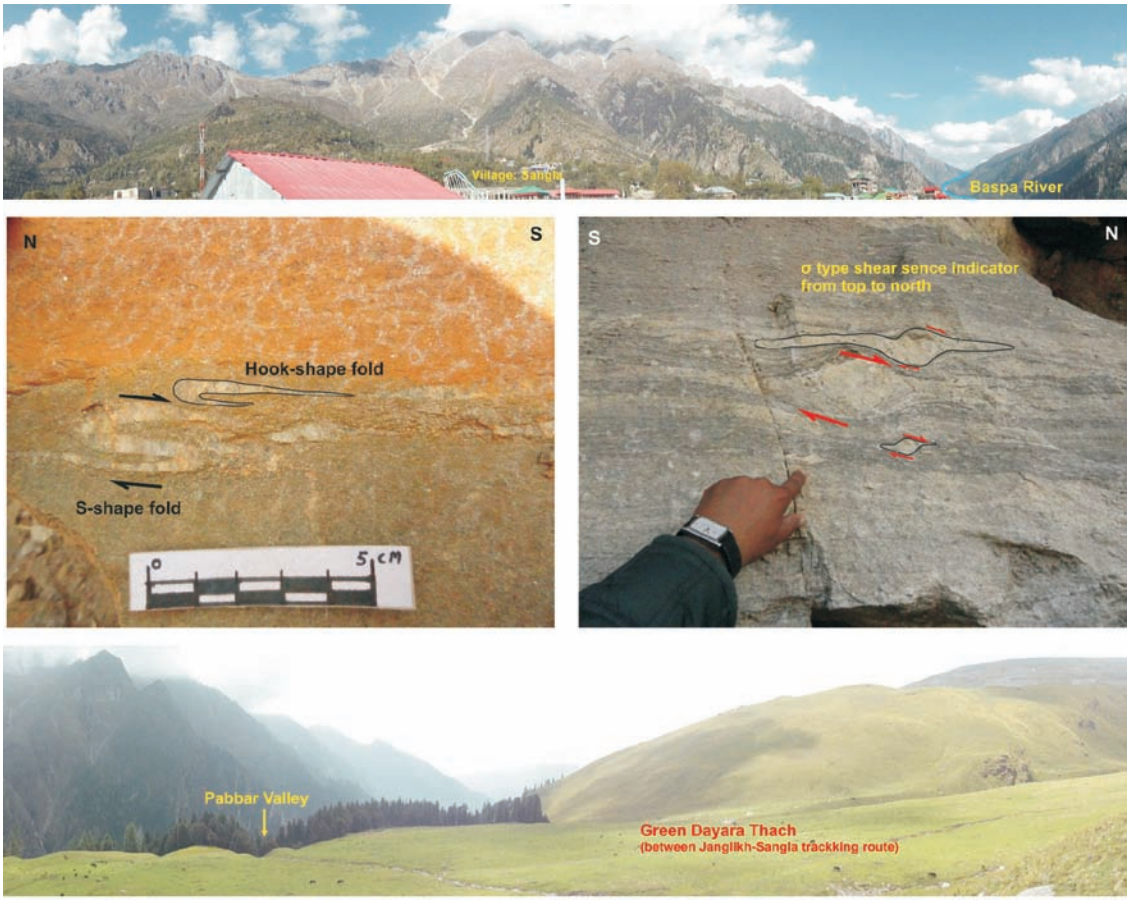
Curtain Raiser Event to the 2nd India International Science Festival 2016:

A Curtain Raiser event to the 2nd India International Science Festival was organized by the Wadia Institute of Himalayan Geology, Dehradun during 28-29 November, 2016 in its premises. The two days event, as decided by the organizing committee had following components and structure: (i) two days science exhibition, (ii) Inaugural lecture on "Science for Masses", (iii) Student-Scientists discussion meet on "Geosciences for Society", (iv) Igniting young minds, (v) Lectures on Traditional Knowledge of Science, (vi) Intellects meet involving Principals, teachers and scientists with focus on "Innovation in Science Teaching", (vii) Screening of Science Movies, (viii) student participation in science poetries and street plays, and (ix) Visit to Geology Museum.

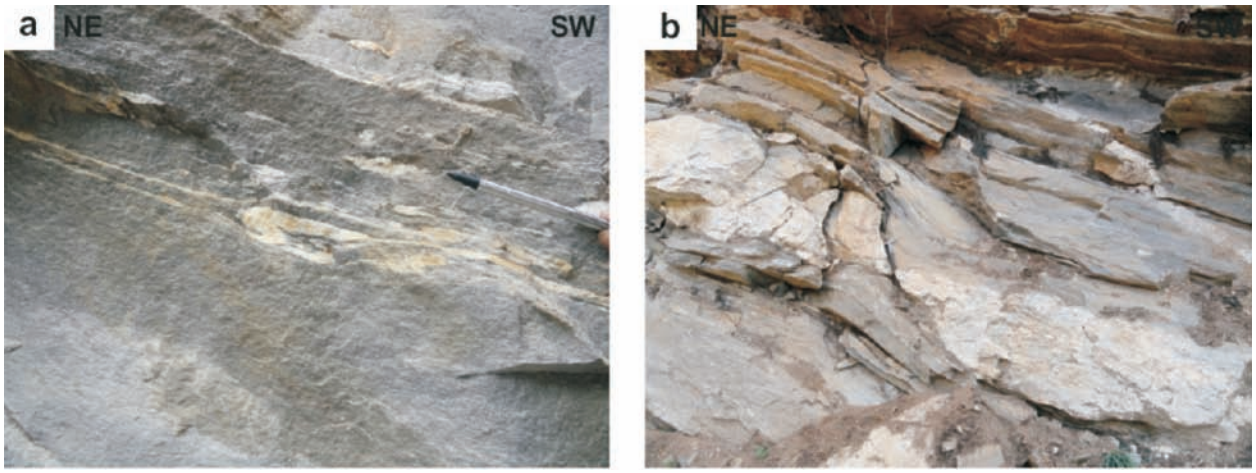
The event was formally inaugurated by Prof. D.C. Srivastava who is Professor of Geology and Head of the Department of Earth Sciences, IIT, Roorkee. The function was presided over of Prof. A.K. Gupta, Director, Wadia Institute of Himalayan Geology. For successful organisation and wider outreach of the event 129 Schools/Government Institutes/Colleges were contacted personally and invited for participation in model exhibition-Short skits-Poetry recitation on subject based on the theme " Science for Masses" and Student discussion on "Geosciences for masses". Besides this, invitations to approximately 40 Colleges/Universities were also sent. Out of these a total of 48 organisations participated where 23 were schools, 11 were various Government research organisations in Doon Valley and 4 were from Colleges/Universities. A total of 235 students and 60 teachers and scientists were registered as participants.

FIELD VISITS

- Dr Paramjeet Singh carried out the geological field work in the Higher and Lesser Himalayan region along the Tiuni-Rohru- Chrigaon- Janglikh- Sangla section of the Himachal Himalaya from September 19 to 30, 2016. The field investigation was aimed to constrain the post-emplacement kinematics and exhumation of the major Jutogh and Vaikrita thrust sheets using the U-Pb, Fission Track Geo-thermochronology technique.



- Dr Akshay Verma and Sh Anupam Anand Gokhale carried out field work in Dunagiri and Bangni Glacier, Chamoli District for setting FRP (Fiber- Reinforced Plastic) hut in Dunagiri (Dronagiri) base camp from September 13 to October 09, 2016. Routine hydro meteorological observations were also carried out during the visit.
- Dr Rajeev Saran Ahluwalia and Sh Purushottam Kumar Garg carried out a field work in Chandra and Bhaga Basin in Himachal Pradesh from September 21 to October 07, 2016. Four glaciers were selected for long term monitoring of Glaciers in Himachal Pradesh.
- Sh Rajeeb Lochan Mishra and Sh Arjun Pandey carried out field work in the Nameri-Bhalukpong areas of the Arunachal Pradesh along the Himalayan Frontal Thrust (HFT) in the northeast Himalaya, during October 27 to November 11, 2016. The purpose of the field trip was to study the recent tectonic activity of the Himalayan Frontal Thrust (HFT) on the fluvial terraces preserved along the Kameng River. Luminescence dating of sediment samples obtained from the strath terraces would help in inferring the geological estimate of convergence rate in this part of the eastern Himalaya.
- Dr Vikas Adlakha and Mr Govind Chaurasia carried out field work in Miyar valley section of Himachal Pradesh during Oct. 01-16, 2016. The aim of the field work was to collect structural data and mapping of certain critical areas for fault/shear zone analysis, collection of samples for Geochronological and themochronological studies to constrain the timing of activity of Chenab Normal Fault (CNF) and the exhumation history of rock units across the CNF. A broad zone of deformation that separates the amphibolite facies metamorphic rocks and leucogranites of the Higher Himalayan Crystallines (HHC) from the low-grade and unmetamorphosed Haimantas (Tethyan Sedimentary Sequence) of the Chamba syncline. Shortening as well extensional shear fabric have been identified in Killar region with its lateral extension in the Miyar valley near Khanjar region of Himachal Pradesh which suggest CNF as an extensional shear zone similar to the

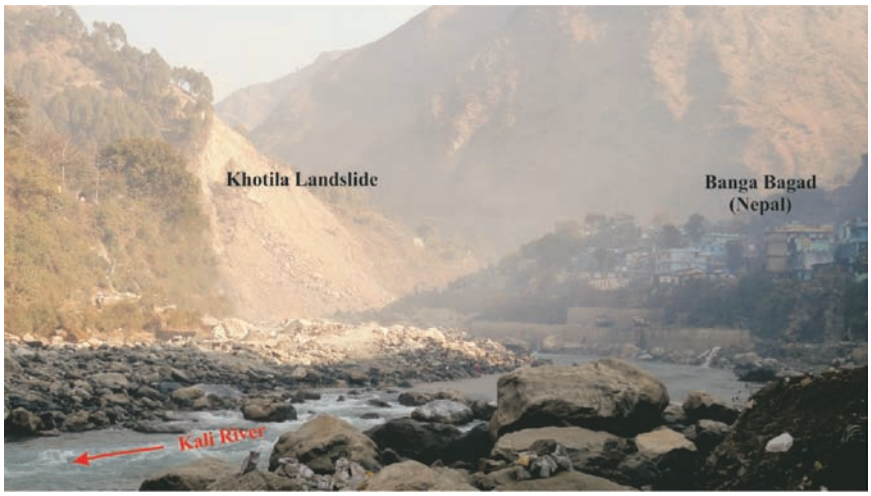


(a) Intrafolial fold showing shortening shear dense due NE.

(b) Extensional shear along CNF in leucogranite near Dharwas region.

Zanskar Shear zone in the north. Samples showing the extensional shear sense as well as undeformed leucogranite samples have been collected for Zircon U-Pb Geochronology. Samples were also collected for Fission Track Dating studies to constrain exhumation rates across the CNF.

- Sh Aranya Sen carried out field work in the Bhagirathi Valley of Garhwal Himalaya from October 17 to 23, 2016. The aim of field work was to collect samples for petrography, geochemistry and geochronology to understand the geodynamic evolution of the Garhwal High Himalaya.
- Sh Atul Kumar and Aravind A carried out field work in Ramnagar- Tanakpur, Himalayan Foothills, Uttarakhand from November 08 to 21, 2016. The aim of field work was to study the exposed river cliff sections, micro-topographic survey using differential Global Positioning system and selection of sites for the trenching.
- Drs R.R. Yadav (C.S.I.R. Emeritus Scientist) and Jayendra Singh carried out field trip in Gangotri and adjoining area, Uttarakhand and collected tree cores of *Cedrus deodara, Pinus wallichiana and Betula utilis* for dendroclimatological studies. Among these, one tree of *Cedrus deodara* is expected to be around 1300 years old. Such old trees from climate stressed sites would provide valuable tool in extending climate record back in time covering Little Ice age and Medieval Warm Period.
- Dr Vikram Gupta, Dr SS Bhakuni and Sh Ambar Solakni carried out field work in the upper Kali valley, during Dec 20-28, 2016 to study the structural control of landslides in the area.



View of the Khotila Landslide located on the right bank of the Kali river upstream of Dharchula village, affecting the Banga Bagad village, located in Nepal on the left bank of the river. In future, it may also endanger the National Highway passing though the crown portion of the landslide.

FOREIGN VISIT

- Dr Vikram Gupta represented WIHG in the regional meeting under Asian Program for Regional Capacity Enhancement for Landslide Impact Mitigation (RECLAIM) in Bangkok, Thailand during November 22-24, 2016. The theme for the meet was "Application of Drone technology for landslide risk management".

INVITED/INTERACTIVE LECTURE

- Dr Jayangondaperumal delivered invited talk in NCESS, Trivendram. The talk entitled "Active fault studies in the Himalaya".

Ph.D. DEGREE SUBMITTED/AWARDED

- Sh Rajeeb Lochan Mishra submitted his Ph.D. thesis entitled "Paleoseismic investigation along the Himalayan Frontal Thrust (HFT), between the meizoseismal zones of the 1934 Bihar-Nepal and 1950 Tibet-Assam earthquakes, North Eastern Himalaya" at Utkal University, Bhubaneswar, Odisha, on 28/12/2016. He completed the research work under the supervision of Dr R. Jayangondaperumal (WIHG) and Prof H.K. Sahoo (Utkal University).

AWARDS/HONOURS

- Dr Perumal Conferred Prof. S.S. Merh Award for the year 2015 by the Geological Society of India held at IIT Khargapur in the Annual General Body meeting of GSI on 23-25 October, 2016.
- Dr Vikram Gupta has been nominated as Member of the Sub Group "Development of Landslide Monitoring and Early Warning System (EWS)" constituted by NDMA under the aegis of National Landslide Risk Management Strategy.

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