ANNUAL REPORT

2013-14

Chorabari Lake (Photo: July 2010)

Outbursted Chorabari Lake during June 2013 'Kedarnath disaster (Photo: September 2013)

WADIA INSTITUTE OF HIMALAYAN GEOLOGY DEHRADUN

(An Autonomous Institute of Dept. of Science & Technology, Govt. of India)

ANNUAL REPORT
2013-14

WADIA INSTITUTE OF HIMALAYAN GEOLOGY

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WIHG ORGANISATIONAL SET-UP

GOVERNING BODY

- Dr. T. Ramasami
- Ms. Sheila Sangwan
- Prof. (Mrs.) Archana Bhattacharyya
- Dr. V.P. Dimri
- Prof. U.C. Mohanty
- Prof. M.P. Singh
- Prof. Shyam Lal
- Prof. R.P. Tiwari
- Prof. Anil K. Gupta
- Shri Dinesh Chandra

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- Ms. Sheila Sangwan
- Shri Harsh Mani Vyas
- Representative of Survey of India
- Dr. Rajesh Sharma
- Shri Dinesh Chandra
- Shri C.B. Sharma

DIRECTOR

RESEARCH ACTIVITIES

RESEARCH GROUPS

- Structure & Tectonics
- Igneous Petrology & Geochemistry
- Sedimentology
- Biostratigraphy
- Geophysics
- Geomorphology& Environmental Geology

THRUST AREA THEMES

- Geodynamic Evolution of the Himalaya and Adjoining Mountains
- Indian Monsoon-Tectonic Interaction and Exhumation of the Himalaya
- Earthquake Precursors Studies and Geo Hazard Evaluation
- Biodiversity - Environment Linkage
- Himalayan Glaciers: their role in Indian Monsoon variability and Hydrological changes in the Ganga Basin

UNITS ANCILLARY TO RESEARCH

- Research Planning & Co-ordination Cell
- Publication & Documentation
- Library
- Museum
- Drawing Section
- Photography Section
- Instrument Maintenance
- Sample Preparation Section

ADMINISTRATION

- Registrar's Office
- Finance & Accounts
- Establishment
- Stores & Purchase
- Works, Building & Maintenance
- Transport
- Guest House

INSTITUTE HIGHLIGHTS

The Wadia Institute of Himalayan Geology (WIHG) has a mandate to study scientific issues related to the Himalaya including its evolution, geodynamics and climate. The Institute plays a lead role in geological and geophysical investigations of the Himalayan region to understand earthquake activity, the glacier-monsoon linkage, the climate-tectonic interactions and in-depth study of the crust-mantle boundary across the India-Eurasia plate. Research activities of the Institute for the 12th Five Year Plan have been grouped into 5 Thrust Area Themes (TAT). A quick look of the prominent achievements in respective themes for the year 2013-14 is as follows:

TAT-1: Geodynamic Evolution of the Himalaya and Adjoining Mountains

? The stress tensor inversion result from the population of Fault Plane Solution in Kangra-Chamba region shows normal stress regime at lower crustal depth and thrust regime for the upper crustal depth.

? The integration of different studies with seismicity in Kinnaur region concentrated to north of South Tibetan Detachment Fault suggests that the region can be divided into several seismogenic crustal blocks, underlain by a fluid-filled fracture zone.

? The Intra-Crustal Low Velocity Zone (IC-LVZ) identified beneath the Ladakh Magmatic arc is inferred to be caused by fluids/partial melts generated due to dewatering and eclogitization of the Tethyan oceanic slab and the Indian continental crust during their subduction beneath the Eurasian plate.

? Geochronological studies show that the deformation and magmatism in Karakoram fault zone lasted till ~13 Ma. The age of syn-tectonic pluton suggests the initiation of Karakoram shear system to be at least ~23 Ma ago, and that the post-solidus deformation continued even after cessation of leucogranite magmatism.

? The proximity of leucosome and mesosome (protolith) compositions of the Miocene leucogranite magmatism in Higher Himalayan Crystallines and their trace element modeling suggest that, the melts were produced by high degree of partial melting (>70%) at temperatures of about ~700°C. And that the fluid influx required for such high degree of partial melting seems to be derived externally by the dehydration of the subducting sediments of the Indian plate.

? The geochemistry of the mafic xenoliths within the Kinnaur Kailash Granite emphasizes that they are tholeiitic rocks developed prominently in zones of crustal extension or occur at intra-plate hot spots. The *P-T* conditions of formation of coronae in the mafic xenoliths indicate at least two distinct tectono-metamorphic events: the isobaric cooling event followed by decompression & cooling event.

? The geochemical and mineralogical studies of mantle peridotites from the Manipur Ophiolite Complex suggest that they represent the residues remaining after low degrees of partial melting (2-12 %) in the spinel stability field of a mid-oceanic ridge environment.

? The study of hydrated phosphate mineral Lazulite from the Main Central Thrust (MCT) in northeast Kumaun Himalaya suggests that P was derived from Berinag quartzite and Mg-Fe from the Higher Himalayan Crystallines, while the MCT acted as conduit for fluid migration originating from a deep reservoir.

TAT-2: Indian Monsoon-Tectonic Interaction and Exhumation of the Himalaya

? The paleoclimatic studies of sand ramps from Spituk, Leh, Choglamsar, Saboo and Shey in

INSTITUTE HIGHLIGHTS

Ladakh indicate that, the Ladakh region experienced major arid phases at 25-16 ka and 12-8 ka, and a wet phase at 30-25 ka and ~8 ka.

? The early Miocene ecosystem as per fossil record in the Himalaya plausibly owes its origin to Middle Miocene Climatic Optimum and thrusting, coupled together as a viable mechanism.

? In Beas Valley, between Pandoh (H.P.) in the north and Talwara (Punjab) in the south four levels of terraces (T1 to T4) have been documented. The deposition condition of T-4 was entirely different from that of other terraces. Clast composition, internal organisation, angular clast with dominancy of slate suggests rapid deposition in the form of debris from the nearby source with intervening stream flow. In contrast to this other terraces were deposited by persistent stream flow.

? A 5 m long core from the Tso Morari Lake, Ladakh was recovered for paleoclimatic reconstruction of the region. The depth-wise results indicate a wet and warm climate phase with higher abundance of C4 plants between 3.0 to 1.6 m depth.

? Ganga River cliff samples were collected at contiguous 5 cm interval from 9 m steep cliff at Oriya Ghat, Ramnagar, Varanasi. The magnetic susceptibility parameters and the sand volume percent suggest a shift from wet and warm phase to a gradually drier climatic condition.

? Speloethems from Sahastradhara and Prakateswar in Garhwal were studied for the petrographic details and sedimentological micro facies analysis. The microlaminae have shown the warm and humid and wet and dry paleoclimatic conditions, indicating a distinct seasonal change in the microclimatic conditions.

TAT-3: Earthquake Precursors Studies and Geo Hazard Evaluation

? Earthquake data are also collected from seismic stations of Kangra, Garhwal, Himachal, Sikkim and Ladakh network. During April 2013 to March 2014, a total of 9971 events have been detected, which include 1252 local events, 4863 regional events, and 3856 teleseismic events. Some earthquake swarm activity has also been observed.

? For GPS studies, an effort is made to develop a computer code using a gcc compiler in Linux to estimate the strain rate of a particular triangular region. The code gives areal strain of the region and the angle of principal axis with respect to the North. The code is validated with published data of the Garhwal Himalaya.

? Considering the requirement of GPS study in HFT, the Institute has established a permanent GPS station in Hardwar (Uttarakhand) just south of the HFT.

? The ground motion estimation at different sites in Doon Valley, Uttarakhand, India was carried out using Horizontal to Vertical Spectral Ratio (HVSR) technique of Microtremor (Ground Ambient Noise). It was observed that the use of microtremor, constitutes an effective and inexpensive approach to site response and soft soil thickness estimation for preliminary microzonation results.

? Preliminary investigations in the trench excavation (15x5x5 m) survey across Logar Gad fault at Logar village showed explicit expression of normal faulting along trench wall. This normal fault in the vicinity of the MBT in northwestern Himalaya is considered to be the result of multiple reactivations after giant earthquakes on the mega thrust.

? The history of great earthquakes of the last millennium are investigated by combining data provided by the historical archives of Kathmandu, trenching through surface ruptures, isoseismal damage mapping, seismites, and the instrumental record. From the geometric and rheologic controls of different types of ruptures it is suggested that, great earthquakes initiate in a wide transition zone between exclusively brittle and exclusively creeping regimes, the extent of which depends on the dip of the Main Himalayan Thrust.

TAT-4: Biodiversity - Environment Linkage

- ? The Ediacaran Krol carbonates and the pre-Ediacarn glacial Blaini diamctites and microbial pink carbonates were studied mainly in the Mussoorie and Garhwal Synclines of the Lesser Himalaya. The studies suggest that the Krol Dolomites were deposited in marginal marine and evaporitic environments. The pre-Ediacaran Blainian global glaciation based on glacial tillites, cap carbonates and negative carbon isotope variation recorded in the cap carbonates indicate major paleoclimatic change that is comparable with the Australian and Chinese Marinoan/Sinian glaciation.

- ? The presence of *Psammichnites* sp. Cf. *P. gigas* usually interpreted as a trail made by a burrowing gastropod or a shell-devoid mollusk is a significant addition to the known fossil record of the Tal Group. Its presence further confirms that the stratigraphic succession of Tal Group is of an early Cambrian age, and shows shallow environment of deposition.

- ? The Chandratal section of the Spiti Basin contains well preserved ichnofauna which reflects diversified behavioural activity in response to the changing environmental conditions ranging from abyssal to intertidal.

- ? The Ordovician-Silurian successions in the Pin Valley of the Tethys Himalaya show microfaunal assemblages of brachiopods, bryozoans and calcified green algae. The collective presence of these microfaunal association indicates shallow marine to near shore environmental conditions followed by different stages of regression and transgression.

- ? The studies of the Assam-Arakan sedimentary depositional basin of the NE India suggest that it was tectonically active during the sedimentation of the upper Barail sandstone, and that the sediment supply may be from the Indo-Myanmar Orogenic Belt (IMOB).

- ? The dental remains of ziphodont Crocodilia were reported from the Paleocene-basal Eocene Kakara Formation in the NW sub-Himalaya, Himachal Pradesh. The new fossils are important additions to inadequately studied Paleocene-basal Eocene biota from the Himalayan region and shed additional light on palaeoecology and palaeobiogeography of that time. They have a close affinity with pristichamsines (Eusuchia), which are primarily terrestrial Laurasiatic forms with their oldest previous record from the late Paleocene of China and therefore provide evidence of faunal exchange between India and Asia during the late Paleocene-basal Eocene.

- ? A rich assemblage of macro-mammals was recovered from the red mudstone succession of the Middle Siwalik Subgroup, exposed in the vicinity of Nurpur, District Kangra, Himachal Pradesh. It is noticed that the faunal assemblage from Nurpur is isochronous to the Turoilian (Late Miocene) Fauna of Europe and Africa. Also, a revision of the mammalian biostratigraphy of the Lower Siwalik sediments of Ramnagar recorded 46 mammalian species, of which 12 species have been reported for the first time.

TAT-5: Himalayan Glaciers: their role in Indian Monsoon variability and Hydrological changes in the Ganga Basin

- ? The debris covered mapping/distribution has been carried out for Dokriani glacier. The debris-cover influences the terminus dynamics and modifies a glaciers response to climate change. An attempt is made to quantitatively evaluate the influence of a debris-cover on the summer ablation, terminus recession and its potential effect on mass balance process. It is observed that due to thick debris covers, the glacier ice melt is reduced, and the results slow down retreat rate of snout. The studies of debris−cover mapping and glacier melting showed high correlation between mean annual ablation of clean ice and altitude and very low correlation between debris-covered ice melting and altitude.

- ? A detail mapping and damage study on Kedarnath devastation has also been carried out in the months of September and October, 2013. The study shows that heavy rains together with

INSTITUTE HIGHLIGHTS

breach of moraine-dammed Chorabari Lake triggered flooding of Saraswati and Mandakini Rivers in the Kedarnath Valley of Rudraprayag District of Uttarakhand and badly affected the whole Mandakini Valley.

? Snow cover and snow/ice avalanche inventory maps of Gangotri Glacier have been prepared using high resolution remote sensing data (Resource Sat-2-LISS IV, Resolution 5.8 m, September 20, 2013). The inventory includes geographical location, aspect, length, area of influence and slope. A total of 24 avalanche sites have been identified and mapped. Lichenometric study has also been carried out on the granite and gneissic terminal morainic boulders for dating the Gangotri Glacier's moraine deposits.

? An initiative is underway to prepare Glacial Lake inventory for the states of Uttarakhand, Himachal Pradesh and Jammu and Kashmir.

Academic Pursuits

The Institute made its presence felt in Academics and under the on-going research programs pursued during the year, the Institute has published 75 papers, out of which 57 are in SCI journals, with around 49 papers being in press or communicated. Four research scholars were awarded Ph.D. degrees, while three theses were submitted for the award. Eleven scientists have also visited abroad to participate in various seminar/ symposia/ workshop/training courses.

To disseminate and share knowledge emerging from more recent research findings, the Institute organized a number of seminars and workshops, which include, (i) *The 4th Third Pole Environment (TPE) Workshop, (ii) Workshop on* Modern Perspective in Himalayan Geosciences, (iii) Workshop-cum-Brain Stroming Meeting on *Mountain Meteorology and Landslides: a way forward, (iv)* XXIV Indian Colloquium on Micropaleontology & Stratigraphy, and (v) National Conference on Implication of Climate Change on Himalayan Environment jointly with Central University of Himachal Pradesh at Dharamsala. The Institute also organised a 15 days winter school on '*Geomathematics', and a b*rainstorming meeting on *'June 2013 Kedarnath Tragedy : Focus on damage assessment and mapping'*.

One of the scientists has been awarded with 'Marie Curie Postdoc Fellowship' for one year within the European Programme for carrying out research at International Centre of Theoretical Physics, Trieste, Italy. Some scientists have also received the best paper presentation award in the workshops like Seismic Microzonation & 3rd Annual Convention on Advances in Earthquake Science, organized by Indian Seismological Research (ISR), Gandhinagar.

The Institute further continued to provide laboratory facilities to sister organizations, academic institutions, particularly the students. During this year the Institute continued the publication of '*Himalayan Geology'*, and brought out the volumes 34(2) and 35(1), along with newsletter 'Bhugarbh Vani' volume 3 (in four parts).

Other Highlights

Hindi pakhwara was celebrated in the Institute during September 14-28, 2013. During this period Hindi essay competition and debate for school children and Institute employees was organized. General orders, circulars and notices were issued in Hindi as well as in English. The Annual Report of the Institute for the year 2012-13 was published in bilingual form (Hindi and English). Various incentive schemes for encouraging progressive use of Hindi were also implemented. The Hindi Magazine *'Ashmika'* volume 19 was also published.

Bereavement

The Institute places on record the untimely death of Dr. Barun Kanti Choudhuri, Scientist 'F'. Dr. Choudhuri was not only a good Structural Geologist but also a very good human being, and served this Institute for more than 33 years.

Anil K. Gupta
Director

TAT - 1: GEODYNAMIC EVOLUTION OF THE HIMALAYA AND ADJOINING MOUNTAINS

TAT - 1.1

Himalayan Deep Image Profiling (HIMDIP) along defined transects

(S.S. Bhakuni, Gautam Rawat, Naresh Kumar, Dilip Yadav and Devajit Hazarika)

Nahan Salient

The structural field data were generated across the Main Boundary Thrust (MBT), Main Boundary Fault (MBF), Intra-Siwalik Thrust (I-ST) and Himalayan Frontal Thrust (HFT). Two new faults, namely the Ghagghar River Normal Fault (GRNF) and Transverse Normal Fault have been delineated between the HFT and MBT. The HFT has thrust the Upper Siwalik conglomerate-sandstone sequence over Quaternaries. A NW-SE trending vertical fault scarp is formed at base of hanging wall of the HFT, which is fresh-looking 4 to >15 m high and 2 km long. A new transverse fault between the HFT and MBF was also delineated (Fig. 1). This normal fault is formed towards south of the apex of Nahan salient and dips 45 to 51° towards west. A 1.2 m thick shear zone has been developed along fault, which has an offset marker bed (~0.75 to 7 m) of the Middle Siwalik sandstone and mudstone sequence. The trend of fault is nearly perpendicular to surface trace of salient. It implies that, the general orientation of NE-SW trending maximum stress of the Himalaya has become vertical with NW-SE oriented extension in the middle part of Siwalik Hills.

The Main Boundary Fault (MBF) forms the crescent-shaped curvature of salient. It has thrusted over the Paleogene rocks over the Neogene Siwaliks. North of MBF, a normal fault oriented parallel to the surface trace of MBF developed along left bank of Ghagghar River, and is referred to as GRNF. Its northern block (hanging wall) has gone down along which the present Ghagghar River flows. The GRNF surface dips 28 to 78° towards NE to E direction, with the development of down-dip striations on fault plane. The southern up thrown block (foot wall) forms the uplifted 1169 to 1206 m high Morni ridge lying between the GRF and MBF. This ridge forms the physiographic front or southern leading edge of MBF or Nahan salient. It implies that the formation of MBF and GRF is broadly synchronous. Towards north in Solan area, the MBT delimite the Lower Tertiaries (Subathu calcareous maroon slaty shales) from the Pre-Tertiary Lesser Himalayan Sequence (Ediacaran Krol dolomitic limestone). The shear fabric is not commonly developed along the very narrow MBT zone.

Towards eastern limb of the salient, the Intra-Siwalik Thrust (I-ST) or the Nahan Thrust near north of Kala Amb, has thrust the Lower Siwalik sandstone over

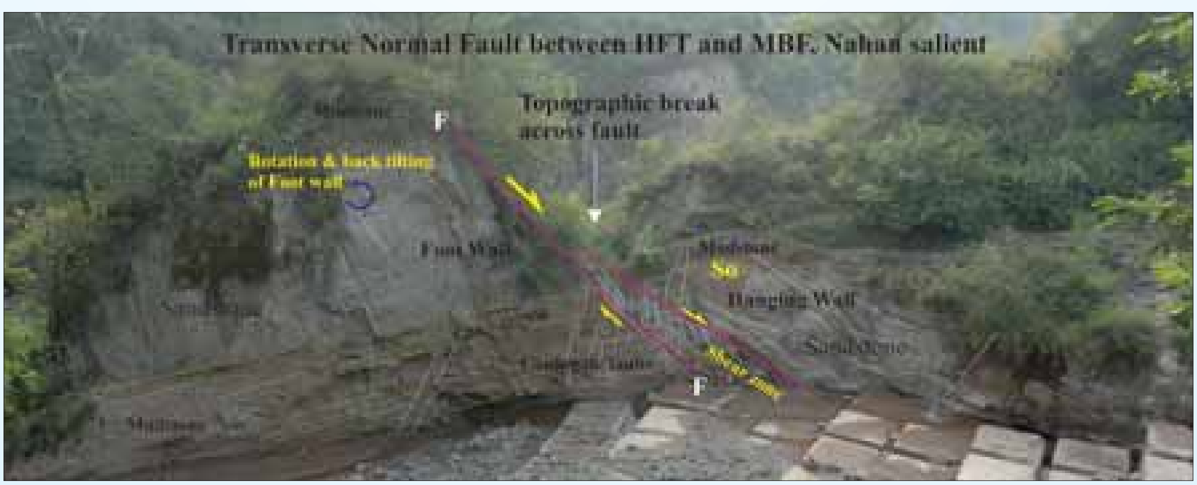

Fig. 1 : N-S trending transverse normal fault observed in the middle part of Siwalik Hills between MBF and HFT towards south of Morni ridge.

the Upper Siwalik conglomerates. Outcrop scale fault propagation folds have developed at the base of hanging wall of I-ST. A conjugate set of 77 to 80° (even vertical) SE dipping normal fault has developed in the basal part of hanging wall. Immediately north of uplifted ridge at Nahan, the Lower Tertiary rocks have thrust over the Lower Siwalik massive sandstone along the MBF. Towards east of Kala Amb, the Middle Siwalik sandstone has thrusted over the alluvium across the HFT. Large pair of fault propagation folds has developed at the basal part of hanging wall of the HFT. Due to folding the hanging wall the rocks of the HFT dips 15 to 27° towards ENE to SE direction, and away from the HFT towards north, beds dip 36 to 48° towards south direction. An outcrop scale back thrust dipping towards SE direction and thrust fault dipping towards NE direction are recognized at the basal part of hanging wall of the HFT. Back thrust has attenuated the limb of fold. Thus the structures described above are associated with the physiographic front located above young deforming detachment surface that lies 6 km deep beneath the sub-Himalaya.

Magnetotelluric (MT) studies in NW Himalaya

Magnetotelluric (MT) data generated along Nahan-Leopargil profile for period band of 1 KHz to 1000 sec, has been collected in different frequency band of different time length at several stations. The five component time-series is robustly processed for MT transfer function. Difference observed in transfer function of different sites, indicates variation in geo-electrical structure along the profile, whereas sounding curves in the period band of 1 to 10 sec indicates conducting layer at mid-crustal depth level. Comparison of sounding curves of this profile with tectonically equivalent sounding curves of Bijnaur-Mallari and Pilibhit-Malpa profile indicates the longitudinal inequalities in subsurface geo-electric structure. The Long Period Magnetotelluric/ Geomagnetic Depth Sounding (LMT/GDS) observations for a period of one month at a site were taken along the Saharanpur-Yamunotri profile at seven places. From the continuous monitoring of MT time series at Ghuttu, it has been observed that, in the month of March 2009 the apparent resistivity curves are slightly shifted upward as compared to the resistivity curves of February 2009. The curve is shifted back to February level after March 2009. The upward shifting of sounding curve is an effect of static shift. This suggests temporal existence of conducting body having dimension less than the investigating period.

Seismic studies in Himachal Himalaya

High seismic activity in Kinnaur region concentrated to north of South Tibetan Detachment Fault (STDF) is a unique feature compared to other similar region of the Himalaya. This data set is utilized to establish a local crustal velocity model, seismo-tectonic model and to assess the attenuation property of the lithosphere. The integration of different studies with seismicity suggests that the region can be divided into several seismogenic crustal blocks, underlain by a fluid-filled fracture zone. The seismicity in Kinnaur is bounded to the west by the Kaurik-Chango Fault Zone (KCFZ) which dips steeply towards west, aligned NS and perpendicular to major thrusts of the Himalaya. This alignment coincides with the strike of the focal mechanism of the 1975 Kinnaur earthquake. Towards south in Garhwal region close to the MCT, the seismicity is aligned to the strike direction of major thrusts of the Himalaya. Attenuation obtained at different frequencies suggests that Qp increases from 58 at 1.5 Hz to 706 at 12 Hz, and Qs increases from 105 at 1.5 Hz to 1,207 at 12 Hz. The developed relations are frequency dependent where $Qp = (47\pm2)f^{(1.04\pm0.04)}$ and $Qs = (86\pm4)f^{(0.96\pm0.03)}$ obtained by fitting power law dependency model. The Q0 and n values show that the region is seismically very active. Qp values lie within the range of values observed for some tectonically active regions of the world, whereas Qs values were the lowest among all. All these factors indicate that the crust is highly heterogeneous. The high Qs/Qp values also indicate that the region is partially saturated with fluids.

Investigations of seismicity in Kangra-Chamba were performed to evaluate the relationship between earthquake source, seismicity, stress drop, tectonics and structure. We applied two approaches of spectral analysis for earthquake data and the box-counting fractal dimension for structural elements in order to understand the seismogenesis of the region in the epicentre zone of devastating 1905 Kangra earthquake. The study reveals that low value for the capacity fractal dimension (D0 of 0.678) and seismically intense clustering has low stress drops generally below 10 bar but up to 26 bar. It has led to the identification of nature of brittleness of the crust and proneness to high strain accumulation indicating the presence of an asperity/barrier in the fault zones. The variation of b value and 3D seismic velocities supports the presence of asperity zone. The significant low DC value represents the possible rupture nucleation point or highly stressed region and shows clustering of the seismic events. The evaluated stress drop is not constant for different sizes of earthquakes (1.5-4.8 Mw) suggesting a self-similar behaviour of earthquake sources. Most of the seismic events in different depth sections are localized either in the High Velocity Zone (HVZ) or on the boundary of a Low Velocity Zone (LVZ) indicating that the brittle part is being ruptured. The high b value and low fractal dimension zones are detected in the localized central part of CN without the presence of any significant surface exposed tectonic element. The results hint the availability of smaller size local hidden tectonic structures or the possibility of many barriers in the setup of major tectonic faults.

The data of earthquakes recorded by the seismic stations of WIHG network in Kangra-Chamba region are collected, processed and analyzed for the determination of Fault Plane Solution (FPS) also. The earthquake events with magnitude ≥3.0 are used for this purpose so that it can have maximum numbers of P-wave first motion arrivals. The USGS determined moment tensor solutions are also incorporated in the studies. From the strike, dip and rake of FPS, Pressure (P) and Tension (T) axes of respective earthquake events with their plunges are determined. In Kangra-Chamba region, out of 41 FPS, 24 FPS are of thrust/strike- slip types with shallow crustal depth of ≤10 km and remaining events are of normal faulting types with depth of ≥ 10 km. The presence of normal faulting in overall compressional environment indicates the effect of local transverse faults/lineaments on the stress regime of Kangra-Chamba region of NW Himalaya. The P-T axes are critically examined and projected along NE-SW section. The depth projected view of P-T axes across the Himalaya in this region shows their orientations along the trend of existing faults/lineaments at depth. The stress tensor inversion result from the population of FPS in this region shows normal stress regime at lower crustal depth and thrust regime for the upper crustal depth.

In the northern part of Kangra-Chamba region, a 4.5 magnitude earthquake occurred in Lahaul-Spiti at focal depth of 10 km on 2nd October 2012. Seismic stations of Kangra-network recorded this event along with 50 aftershocks. These aftershocks are recorded within 15 days of occurrence of the main shock. The aftershock events are collected, processed and analysed for further study. The felt earthquake events of magnitude 5.8, which occurred in the NE of Bhadarwah in Kistwar Window region is extracted from the digital data of seismic stations of WIHG network and compiled for better location. The association of this earthquake event with the tectonic element of the region and its relation with them is further analysed. The fault parameters, like strike, dip, rake, as well as the P- and T-axes are projected in depth profile to relate their orientations with the existing fault/lineaments. Besides this, the Tehri-Garhwal Seismic Network data is also collected, processed and analysed.

Shear wave velocity structure beneath broadband seismological stations of Satluj valley and Ladakh-Karakoram region

In continuation of our previous works, the shear wave velocity models have been estimated beneath 10 broadband seismic stations of Satluj valley by inverting receiver function data till 2013 (Fig. 2). The study reveals increase in crustal thickness from ~50 km at Banjar (BNJR) station located over the Lesser Himalaya (LH) to about 65 km beneath Hurling (HURL) station located to the north of the South Tibetan Detachment (STD) (Fig. 3). Prominent Intra-Crustal low velocity zone (IC-LVZ) is identified in the upper crust at a depth range of 10-25 km. The IC-LVZ diminishes at the stations in the LH (BNJR station).

The IC-LVZ identified beneath the 10 stations of Ladakh seismological network (reported earlier) have been critically examined based on percentage of velocity reduction in the shear wave velocity models and estimations of Poisson's ratio at different depths. Previously, average Poisson's ratio of the whole crust was reported. Based on the values of Poisson's ratios at different depths and geological evidences, the study proposes the presence of serpentinized mantle wedge beneath the fore-arc region, which can cause low shear wave velocity with extremely high Poisson's ratio. The contact between this serpentinized mantle wedge and the eclogitized Indian continental crust is identified at ~47-50 km depth. The IC-LVZ beneath the Ladakh

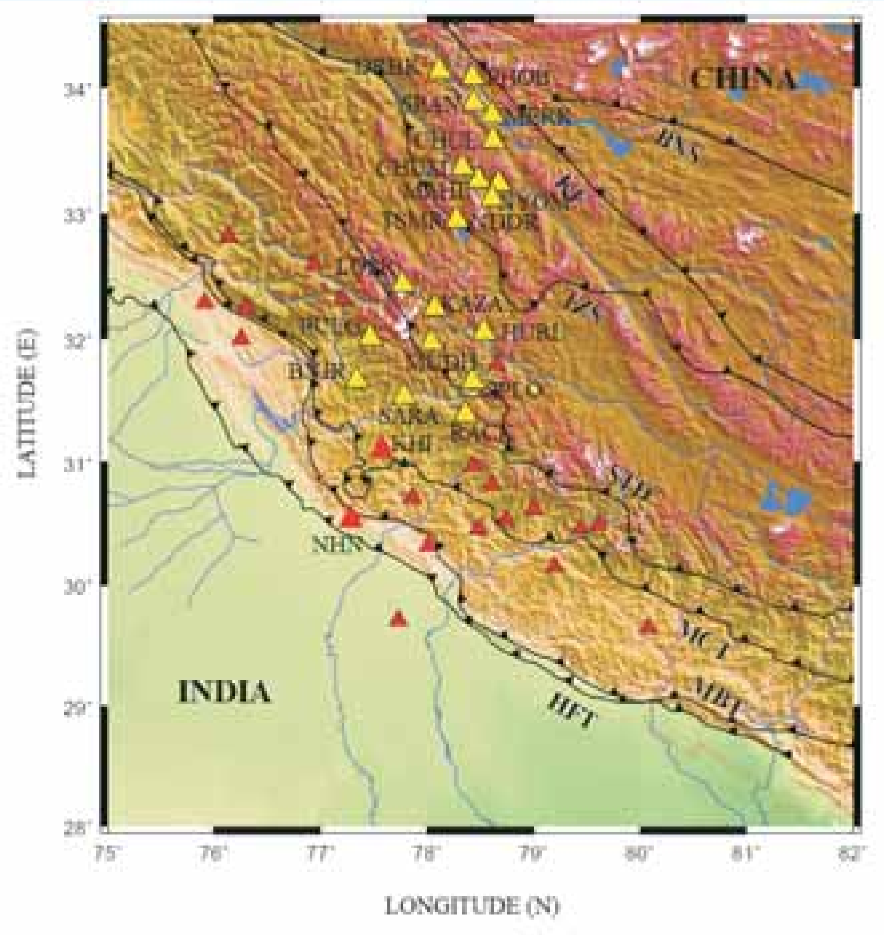

Fig. 2: Topographic map of NW Himalaya with major tectonic features, e.g. Himalayan Frontal Thrust (HFT), Main Boundary Thrust (MBT), Main Central Thrust (MCT), South Tibet Detachment (STD), Indus Suture Zone (ISZ), Karakoram Fault (KF) with locations of seismological stations (Triangles). The yellow triangles show seismic stations used for the study during the reporting period.

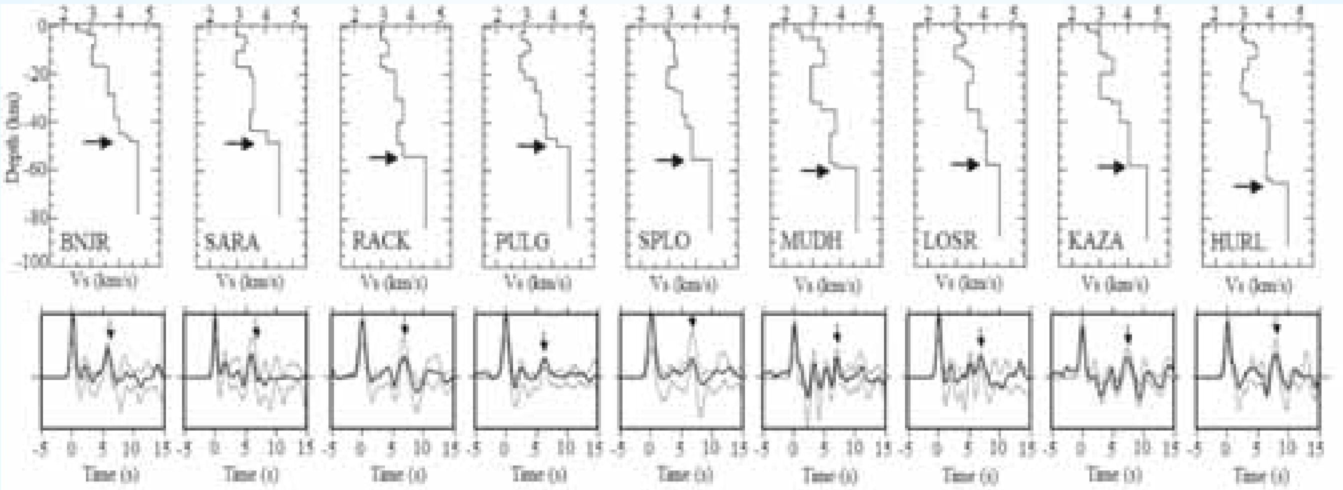

Fig. 3: The upper panel shows simplified shear wave velocity models obtained by Least-squares inversion and grid-search at broadband seismic stations of Sutlej valley using data recorded during 2008-2013. The Moho is marked by arrow at each velocity model. The lower panel shows stacked receiver functions (dark black waveforms) at each station along with ± 1 standard deviation bounds shown by grey dotted lines. The Ps converted phase at Moho is marked by vertical arrow.

Magmatic arc is inferred to be caused by fluids/partial melts generated due to dewatering and eclogitization of the Tethyan oceanic slab and the Indian continental crust during their subduction beneath the Eurasian plate. Breaking off of Indian lithospheric slab, followed by asthenospheric upwelling, granulite metamorphism, and remobilization of metasediments and granitoids possibly created an IC-LVZ beneath the Karakoram fault zone.

TAT - 1.2

Present day Uplift or Subsidence and Gravitational Potential energy change in NW-Himalaya and the NE Himalayan Syntaxis: Crust-mantle density in-homogeneity using Satellite Geodesy/Gravimetry and Seismology

(S. Rajesh, Sushil Kumar and V. Sriram)

The continuously operating Global Positioning System (GPS) data available in the northwestern Himalaya along with campaign observations has been analysed in order to understand the present day activity of the Himalayan Frontal Thrust (HFT) in the Dehradun and Kangra Re-entrants. It has been observed that among the major thrust systems that strike along the Himalayan Arc from west to east, the Himalayan Frontal Thrust and its paleo-tectonic activity is a topic of much scientific debate and investigations. The seismic potential of HFT has been fiercely projected as there would be great earthquakes based on empirical calculation of slip rates from the observed bed-offsets in the strath-terrace deposits. In continuation with our earlier observations on abysmal movement of frontal thrust systems, we analysed available seismic data from various catalogues, which in general show earthquakes of magnitude between 4 and 5, common in this region and having a seismogenic crustal thickness of around 15 km. The cumulative energy release of these events happen close to the MCT, and probably might transfer substantial stress to the south bounding thrust systems like the MBT and HFT. We presumed that rheology at this region is mainly visco-elastic and hence the response of HFT is decremented with time; or otherwise consequential to the available seismic energy to displace. Secondly, we analysed the role of N-S transverse structures and lineaments which are either abutting to HFT or visually terminating at HFT. We analysed the existing gravity and the global topography data from SRTM and the improved Multi-resolution global terrain data. It is observed that, there exists a case of transverse structure-Frontal Thrust collision as far as the kinematics of Himalayan Frontal Thrust is concerned. New processing software of GAMIT has been loaded. Additional new shell scripts were written to pre-process the data and to check the quality factor. A few campaign points are made and all permanent stations are maintained and functional.

Integrated Seismic and Gravity studies on ambient noise spectrum and liquefaction process

The dynamics of fluids in the alluvium pore space and their fundamental decaying frequencies in long and short periods are studied by integrating site amplification observations through the monitoring of passive seismic ambient noise with the temporal gravity data. It has been observed that for the case of thick alluvium large amplitude responses are expected even by one to two Hz fundamental frequency. However, for the case of those regions having thin weathered layer the response spectra requires 15-16 Hz frequency range to produce even a unit magnitude amplitude vibration. Similarly, the temporal gravity data shows, in the case of a seismic event the long period subsurface fluid action like liquefaction lasts of the order of days for the case of thick fluid saturated alluvium.

TAT - 1.3

Tectonics of the Shillong Plateau, northeastern India

(Swapnamita C. Vaideswaran)

The geomorphic field studies in the central as well as southern parts of the Shillong Plateau have identified uplifted terraces and abandoned extensive river channels. Samples from these terraces for OSL dating have been collected, and the chronological age determination analyses are in progress. The central block in the plateau also shows staircase terrace structures and thereby appears to be the most active region in the plateau. Satellite data has been used to identify an active south fault which runs along the Dauki Fault in the east but appears as a separate fault south of the Dapsi Fault. The fault has been mapped using high resolution DEM and Geoeye satellite data. Different tectonic domains can manifest through geomorphic parameters, hence, a quantitative geomorphological estimation on a complete GIS platform using satellite DEM has been carried out for four major river systems in the south of the plateau. Hypsometric analysis, longitudinal profiles, valley profiles, basin asymmetry factor and mountain front sinuosity results indicate a young topography for the region, and that the central part of the plateau is more active than the eastern or western segments. Tilting of the plateau towards east is also present possibly due to submergence of the eastern arc under the Burmese plate. A recent fault has been identified in the field in the southern periphery of the plateau. Preliminary OSL dating estimates for the fault gives an age less than 403±128 years. Plans to revisit the fault site for detailed study of the geomorphology and structures in coming time should shed more light to this significant structure. In the north, the Kulsi Fault has been mapped along with paleochannels over DEM. Samples have been collected from submerged tree trunks for carbon dating. The samples have been sent to BSIP, Lucknow for dating. The results are expected to throw more light on the role of the fault in the 1897 earthquake.

TAT - 1.4a

Tectonic evolution of Shyok Suture and Karakoram Fault Zone Rocks and their bearing on Tibet Uplift

(Koushik Sen and Barun K. Mukherjee)

In Karakoram Fault Zone, study shows considerable field evidences that suggest partial melting was triggered by non-coaxial deformation in the PTZ. The mylonitization of diorites and intrusion of leucosomes indicates a strong correlation between deformation-metamorphism and partial melting. The subsequent accumulation and migration of melts through boudin necks (Leloup, Weinberg, Mukherjee and other 2013, EPSL), and fold hinges indicates synchronous deformation. The utilization of these structures as 'melt pathways' further vindicates the argument of deformation assisted pervasive melt migration in the area.

The microstructural signatures of solid state deformation (Sen et al. 2009 Curr Sci; Mukherjee et al. 2012, Lithosphere) and mesoscopic features show that non-coaxial deformation continued in the KFZ. The concordia plot appears to suggest zircon growth at ~50 Ma, ~30 Ma and ~15-13 Ma. However, it is not possible to say whether these are really times of new zircon growth, or are part of a continuum along a broad discordia from the Palaeocene to ~13 Ma. On the other hand, the leucogranites that crystallized at ~15 Ma were later deformed and mylonitised by deformation in both Pangong and Tangtse strands, which continued till at least ~9 Ma (Mukherjee et al 2012, Lithosphere). U-Pb geochronology of zircons from the Darbuk Pluton gives a crystallization age of 22.7±0.5 Ma with a younger population at 20.2±0.4 Ma. The studies clearly demonstrates that initiation of shearing in the KFZ, deformation/re-mobilization of ~60 Ma diorites and felsic magmatism are synchronous that started at or before ~20 Ma. The findings of this present study are in agreement with those by Lacassin et al. (2004) and Valli et al. (2007) from the southern part of the KFZ that lies in Tibet, where non-coaxial deformation occurred from 25 to 22 Ma. U-Pb geochronology of zircons from the diorotic gneiss gives a crystallization age of 63.8 ± 1.5 Ma and also shows younger zircon growth at ~50 Ma, ~30 Ma and down to ~13 Ma (Sen, Mukherjee, Collins, 2014, JSG). One two-mica leucogranite sample from the Darbuk Pluton gives a common Pb chord lower intercept of 22.7±0.5 Ma (MSWD ~1.8) with the five youngest concordant analyses yielding a $^{206}Pb/^{238}U$ age of 20.2±0.4 Ma (MSWD ~1.14) that is interpreted as the age of crystallization of the pluton. These findings imply that, contrary to previously believed ~15 Ma age of initiation for the KFZ, non-coaxial deformation in the KFZ continued throughout the Cenozoic (early Paleocene to mid-Miocene) until ~13 Ma, and further at ~10 Ma periods, a prominent phase of low temperature metamorphism & deformation is observed.

Salient Points:

? Syn-deformation melt migration and pluton emplacement documented from the Karakoram fault zone.

? Deformation caused remobilization and metamorphic resetting of a pre-existing magmatic arc.

? Geochronology shows deformation and magmatism in Karakoram fault zone till ~13 Ma.

? Age of syn-tectonic pluton suggests initiation of Karakoram shear system at least ~23 Ma ago.

? Post-solidus deformation continued even after cessation of leucogranite magmatism.

TAT 1.4b
Fluid evolution and formation condition of Migmatites of Karakorum region as well as of Ophiolitic rocks of western Ladakh

(H. K. Sachan and Santosh Kumar Rai)

Field work has been carried out in the Tangtse and Darbuk area of Karakorum region as well as in Shergol area of Shergol ophiolitic mélange, and systematic samples of migmatite and metamorphosed mafic rocks have been collected for lab studies. The preliminary petrographic observation of the migmatites present in Karakorum Shear Zone reveals that, the melanosome are characterized by the presence of K-feldspar, plagioclase, quartz and hornblende. The biotite and muscovite are also noticed, whereas leucosome is comprised of plagioclase, quartz, K-feldspar, biotite, muscovite and garnet.

The preliminary fluid inclusion studies of melanosome and leucosome of migmatite reveals the presence of mostly gaseous rich inclusions. They are of three types, viz. the monophase, the biphase and the three phase inclusions. The monophase inclusion contains gas only, whereas biphase inclusion contains gaseous phase along with liquid one. The three phase inclusions are comprised of gas in gaseous phase along with liquid phase of gas and liquid. Some of the three phase inclusions contain halite crystal along with gas bubble and liquid. Re-equilibrated inclusions were also observed. The inclusions become stretched, showing necking phenomena. Some of the inclusions also exhibit implosion texture.

The preliminary petrographic study has been carried out on the metamorphosed rocks of Shergol area to characterize the mineral assemblage as well as the textures. The metamorphosed mafic rocks are categorized into olivine and hornblende bearing metagabbros, blueschists and serpentinites. The olivine bearing metagabbros are comprised of euhedral plagioclase (sericitized), intergrown with subhedral clinopyroxene and hornblende. The hornblende bearing metagabbros are consisted of euhedral plagioclase along with clinopyroxene and hornblende. Clinopyroxene is strongly fractured. Large grains of greenish amphiboles are present, which are rimmed by chlorite. The blueschist rocks are comprised of blue-green amphiboles, plagioclase and chlorite. The subhedral plagioclases are replaced by bluish-green amphiboles. The late stage veins of carbonate and albite veins are also observed. The coarser grains of green amphiboles still preserve the core of bluish amphibole. The early formed olivine grains are replaced by serpentine minerals with mesh microstructure. The domain of olivine grains are cross cut by interpenetrating microstructures of greenish-yellow serpentine. The olivine bearing metagabbros are seen to still preserve the granoblastic texture of dunite protolith. Brown spinel is rimmed by magnetite.

The preliminary stable isotope study has been carried out on the carbonate veins present in mafic rocks. The carbon isotopic ratio ranged from $\delta^{13}C$ -7 to 1.3‰ VPDB while oxygen isotope ratio ranged from $\delta^{18}O$ 12.5 to 8.7‰ VSMOW. These isotopic ratios indicate their derivation from magmatic source.

TAT - 1.5
Crustal evolution processes in the Proterozoic Lesser Himalayan domain of NW Himalaya

(Sumit K. Ghosh and R. Islam)

The Lesser Himalayan is unique from the other Proterozoic basins of Indian sub-continent as being suffered by the Tertiary Himalayan orogeny. The stratigraphic arrangement within the Lesser Himalaya is convoluted, and therefore the correlation or the relationship aspect is more complicated. Keeping this in view, the project-work was focused on the correlation aspect of the pre-Cryogenian sedimentary packages of the Garhwal and Kumaun Lesser Himalaya. Towards resolving the issues, the current study has made following inferences:

? There are significant lithologic variations between the northern and southern parts of the Lesser Himalaya, and traditionally divided into two zones, the Inner Lesser Himalaya (ILH) and the Outer Lesser Himalaya (OLH).

? The stratigraphic scheme of the Lesser Himalaya in ascending order is compised of: the Jaunsar (Chandpur-Nagthat Fms), Mussoorie (Blaini-Krol-Tal Fms) groups for OLH; and Damtha (Chakrata-Berinag-Rautgara Fms), Tejam (Deoban-Mandhali) groups for ILH.

- ? A new demarcating plane (Tons Thrust, identified as a Proterozoic tectonic element) has been visualized between these two zones. The OLH represents younger (Neoproterozoic) and ILH older (Palaeoproterozoic-Mesoproterozoic) sedimentary successions of the Lesser Himalaya.
- ? The Jaunsar Group of the OLH is assigned an early Neoproterozoic age based on its stratigraphic position below the 692 Ma diamictite and cap-carbonate of the Blaini Formation by a regional unconformity.
- ? The siliciclastic succession of ILH is associated with syn-sedimentary basic magmatism, seismites, acid tuff, intrusive granites and uranium mineralization assigned 1.8 Ga.
- ? The distal end of the Berinag-Rautgara cycle of Damtha Group, towards north (Tethys domain) is more argillaceous and seen as Chail-Ramgarh metamorphics.
- ? The syn-sedimentary basic volcanic rocks of Garhwal and Kumaun Himalaya range in composition from sub-alkaline basalt through andesite to andesitic basalt. Further, minor and trace elements also suggest that these volcanics are Fe-tholeiites of continental character and generated in a rift related environment.
- ? The REE data of these basic rocks of both the region exhibit remarkable similarities and characterized by enriched LREE and relatively flat HREE pattern. Primitive mantle normalized multi element spider diagram exhibit an enriched incompatible trace element pattern especially in LILE and distinct negative anomalies for Sr and HFSE from both the suites. The trace and rare earth element characters are also similar to that in rocks of Aravalli and Bundelkhand regions of the Indian shield, and it may infer that the Aravalli, Bundelkhand and Lesser Himalayan region may be forming a large igneous province in the northern part of Indian shield. A major thermal event capable of mobilization of sub-continental lithosphere is indicated by the rift related basic volcanic rocks in Lesser Himalayan region.
- ? The presence and survival of labile components like plagioclase feldspar, phyllites and schists in both the siliciclastics indicate less weathering, short distance of transport. Nearly similar source area lithology persisted from Late Paleoproterozoic till Neoproterozoic.

TAT - 1.6
Metamorphism, Migmatization and Magmatism in Higher Himalayan Crystalline: Geochemical and Geochronological constrain on Leucogranite Granite melt generation and emplacement

(P.K. Mukherjee)

Based on petrographic and geochemistry of the various components of the ortho- and para-migmatites, the present study brings out some important aspects of petrogenesis of the Miocene leucogranite magmatism in Higher Himalaya Crystallines (HHC). On the basis of results of the study the following tentative conclusions can be drawn:

- ? Both, the ortho- and the para-gneiss are equally potential protoliths of the Miocene Himalayan Leucogranites in HHC.
- ? As also envisaged and established by others, the leucogranites in HHC are genetically linked to the partially melted pelitic-psammatic gneisses that are represented by the migmatites that occur at the core of the high grade metasedimentary crystalline rocks.
- ? The proximity of leucosome and mesosome (protolith) compositions and trace element modeling suggest that the melts were produced by high degree of partial melting (>70%) at temperatures of about ~700°C (range 628-735°C as estimated by zircon saturation thermometry and Ti in biotite thermometer).
- ? The melt compositions thus derived by high degree of partial melting do correspond to the various average compositions of the leucogranite bodies in HHC. However, it is possible to derive the leucogranites from the leucosome melt compositions through fractional crystallization, mostly of plagioclases.

? At this temperature, a very high flux of fluid would be required to affect such high percentage of melting. The fluid influx required for such high degree of partial melting seems to be derived externally by the dehydration of the subducting sediments of the Indian plate.

TAT - 1.7
Tectono-metamorphic evolution of Higher Himalayan Crystallines: Perspective of channel flow models

(Keser Singh and T. N. Jowhar)

The Higher Himalayan Crystallines, exposed between the Main Central Thrust (MCT) to the south and the STD to the north, has been studied along the Bhagirathi, Alaknanda and Dhauli-Ganga sections. The metamorphic rocks along the studied transects are divided into two lithotectonic units: the Munsiari Formation (MF) and the Vaikrita Formation (VF). The Munsiari Formation comprising of garnet bearing schists, calc-silicates lenses and quartzite is placed over the Mandhali Formation (Berinag Formation) of the Lesser Himalayan rocks, along the Munsiari Thrust (MT). The Vaikrita Formation, in turn, placed the kyanite bearing gneisses over the Munsiari Formation along the MCT. Overlying the Vaikrita is the Martoli Formation - the basal portion of the sedimentary units of the Tethys Himalaya along the Malari Fault.

Analysis of various shear sense indicators observed along the Alaknanda and Dhauli-Ganga sections show that extensional structures dominate the footwall of Malari fault, while compressional structures dominate the hanging wall of the MCT, however, there is a zone in between which is largely lacking of any shear sense indicators. The extent of shearing and bounding of the high grade metamorphic rocks by two tectonic zones with opposite sense of shear i.e., underneath the thrust faults (MCT) and above the extensional faults (STD) confirm that the metamorphic rocks not only pushed out to the surface but has also developed shear sense indicators in the adjoining lithologies representing the present day geometry.

The uppermost part of the Higher Himalayan Crystallines (HHC) is dominated by widespread *in-situ* partial melting of sillimanite+K-feldspar gneiss that resulted in the formation of migmatite and consequently generation of the leucogranite in five distinct phases. Melt generation and accumulation was initiated since the formation of very first deformation fabric within the HHC. The oldest migmatite phase (Me 1) parallels the main foliation as stromatite layers and concordant as leucogranite bands. The Me 2, Me 3 and Me 5 phases are recorded along small-scale ductile thrust, extensional fabric and structureless patches respectively. Large scale melt migration along the cross-cutting irregular veins define the Me 4 phase. These were possibly conduits for the migration and accumulation of melt into larger leucogranite bodies like Malari Granite (19.0± 0.5 Ma)

P-T estimates have been carried out on samples from the Higher Himalayan Crystallines (HHC) in the Garhwal Himalaya along Sainj-Bhatwari and Lohari Nag-Gangotri sections of the Bhagirathi valley in order to place quantitative constraints on the P-T conditions during the regional metamorphism. Present studies reveal an increase in pressure and temperature from the base to the top of the Munsiari formation i.e., towards the Vaikrita/Main Central Thrust (MCT). Temperature increases from 500 to 700°C and pressure from 6 to 8 kbar from south to north within the Munsiari Formation, thus representing the inverted metamorphic sequence. Work is in progress to understand the P-T variation within the Vaikrita Formation. Pseudosections were generated using some chemical data taken from the published literature from the Himalaya and Alps, and also new data generated from the Garhwal Himalaya to understand the evolution of the metamorphic rocks from the Higher Himalayan Crystallines in this region.

Discussion on propagation of uncertainties in P-T estimates and mathematical procedure on its estimation is done. Computations of errors in P-T estimates by the Monte Carlo Method, Numerical error propagation technique and high precision relative thermobarometry (ΔPT) approach were carried out to solve these uncertainties. Since we are interested in calculating pressure and temperature variations, or differences in P-T (ΔPT), therefore, the contribution of systematic uncertainties e.g. those associated with a-x models and thermodynamic data can be minimized by the high precision relative thermobarometry (ΔPT) approach. Computations on estimation of uncertainties on P-T estimates from Higher Himalayan Crystalline zone of Garhwal Himalaya is done using Monte Carlo method and numerical error analysis.

TAT - 1.8

Geochemical and crustal evolution of the Himalayan orogenic belt in Himachal NW Himalaya, and in the Eastern Syntaxial Belt, NE India

(S.S. Thakur, A.K. Singh, D.R. Rao and Rajesh Sharma)

NW Himalaya

In Sutlej Valley, NW Himalaya, the mafic xenoliths were observed embedded (Fig. 4) in the Palaeozoic Kinnaur Kailash Granite (KKG). Our study shows that these pre-Himalayan granulite-facies metamorphic mafic xenoliths have undergone extensive retrogression after reaching peak metamorphic conditions of 840ºC and 8.5 kbar (Thakur and Patel, 2012, JAES). Several evidences of retrogression including various corona textures such as, garnet corona around clinopyroxene and/or plagioclase, titanite corona around ilmenite, and hornblende corona around clinopyroxene are observed in the rocks. Intensive retrogressions converted most of the mafic xenoliths into hornblende-rich amphibolites. However, a few of the rocks contain relict clinopyroxene and orthopyroxene. Since, the most common retrograde mineral is hornblende, the retrogression in the xenoliths must have taken place when the terrain was undergoing cooling by passing through amphibolite-facies conditions. To understand the *P-T* conditions of retrogression, *P-T* output from Thermocalc3.21, *T* from hbl-grt geothermometry and *P* from hbl-grt-pl geobarometry have been plotted in *T vs P* diagram for garnet bearing xenoliths. It has been observed that most of the retrogression occurred in the temperature range of 550-650ºC and pressure range of 4.5-6.7 kbar. The *P-T* values obtained for cpx-grt (corona)-pl-qtz assemblage sample is 643ºC and 7.3 kbar, which is at the higher end of the *P-T* range. Based on these *P-T* data a cooling path has been proposed for the evolution of the mafic xenoliths.

The *P-T* conditions of formation of coronae in the mafic xenoliths indicate at least two distinct tectono-metamorphic events. The first one is related to the formation of retrograde garnet corona around clinopyroxene. Thakur and Patel (2012) interpreted that the garnet corona have been formed by the reaction cpx+pl = grt+qtz during an isobaric cooling (IBC) event. *P-T* data suggest that this event resulted in cooling of the rocks to a temperature of 640ºC or more at pressure of >7.5 kbar. Such high *P-T* conditions suggest that the IBC event took place either prior to the entrapment of granulite-facies rocks in KKG or in the early stage of emplacement of the KKG under deep-seated condition. In comparison to the retrograde garnet corona, retrograde hornblende in the mafic xenoliths formed at lower *P-T* conditions (T = 550-630 ºC and P <6.5 kbar), which suggest a second retrograde tectono-metamorphic event. Titanite coronae around ilmenite also formed during this event. The *P-T* conditions of formation of retrograde hbl suggest that the isobaric cooling event was followed by decompression and cooling (Fig. 5). The detail work on the retrogression of mafic xenoliths has been published in 2014 volume 88 of 'Journal of Asian Earth Sciences' pp. 41-49.

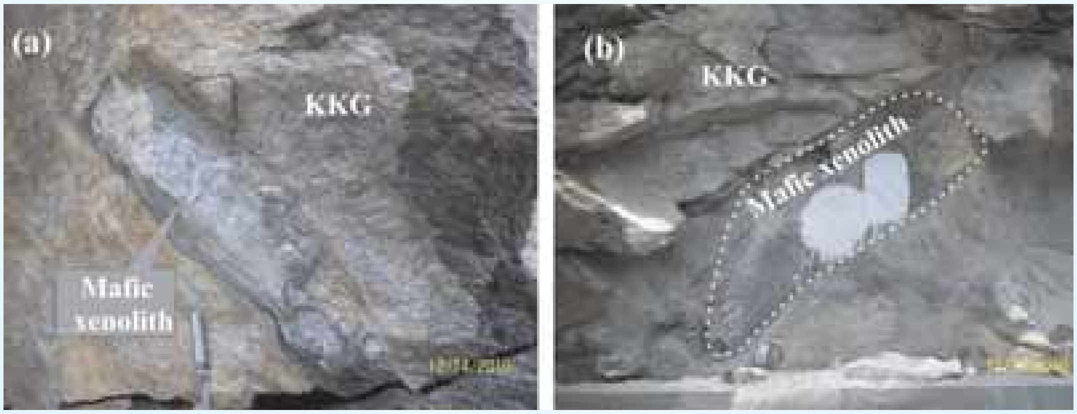

Fig. 4: Field photographs showing mafic xenoliths embedded in the Kinnaur Kailash Granite (KKG) Sutlej valley, NW Himalaya, India.

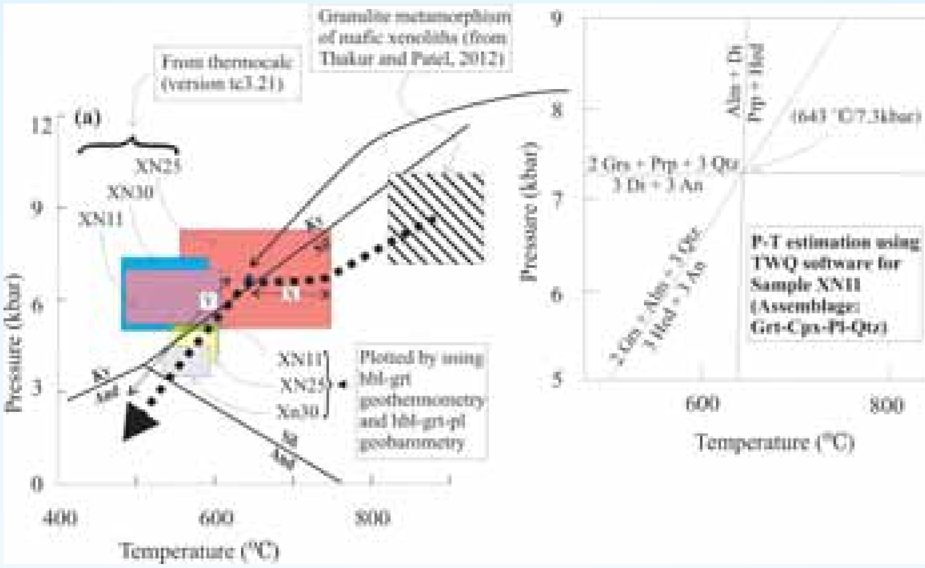

Fig. 5: P-T evolution of mafic xenolith of Sutlej Valley, NW Himalaya.

Further, the geochemistry of these mafic xenoliths and pelitic enclaves within the Kinnaur Kailash Granite has also been studied. The SiO_2 vs total alkalies diagram show that their composition ranges from basalt to basalt andesite. The mg# ranges from 48 to 38 indicating no crystal fractionation. The mafic xenoliths are characterized by high FeO^T (~14%) and TiO_2 (~1.6%) suggesting a normal basaltic composition. On the other hand, the pelitic enclaves have TiO_2 <1.1% and show high Al_2O_3 ranging from 18 to 25%. The mafic xenoliths along with pelitic enclaves have subalkaline affinities, and dominantly plot within the high-Fe tholeiites field on the cation percent of (Fe^T+Ti)Al-Mg ternary diagram, after Jensen (1976). The low Nb/Y ratios (mean value of ~0.42) of mafic xenoliths can also be concluded to reveal their clear tholeiitic affinity. The pelitic enclaves while distinctly plot in the fields of calcalkaline basalt-andesite series, and show calcalkaline nature on the AFM diagram. On various binary discrimination diagrams like, Ti vs V; Zr vs Zr/Y; Zr vs Ti; and ternary tectonic discrimination diagrams such as, MnO-TiO_2-P_2O_5; Zr-Ti-Y and Zr-Ti-Sr the mafic xenolith show MORB characteristics. Also, on the ternary tectonic discriminations such Zr-Nb-Y and Th-Zr-Nb the mafic xenoliths show their enriched MORB character. More so, the plotting of geochemical data of host granites and pelitic enclaves on various diagrams show genetic linkage with one another, suggesting that the pelitic xenolith are the parent source of Kinnaur Kailash Granite. On the contrary, the geochemistry of the mafic xenoliths emphasize that they are tholeiitic rocks prominently developed in zones of crustal extension or occur at intra-plate hot spots in both oceanic and continental regions.

NE Himalaya (Eastern Syntaxial Belt)

Volcanic rocks outcropping at the core of the Siang Window, Eastern Himalaya are characterized by massive, agglomeratic basalt and minor acidic flows. Numerous basaltic flows with pillows and pyroclastics are also encountered in the area. The pillows are predominantly associated with the basal parts of lava flows where the individual pillows vary from ~ 8 to 80 cm in diameter. The pyroclastics present a range varying from coarse agglomerates to volcanic bombs, lapillies (~5 to 12 mm in diameter) and ash. Early eruptions with explosive activities in the sub-areal environment are supported by the relatively higher proportions of pyroclastics, while the presence of pillow structures supports sub-aqueous eruptions. Interflow sediments between the flows are indicative of periods of quiescence during volcanism. Thus, the Abor volcanics comprise multiple phases of volcanic activities spreading over a period of time probably as a result of mantle agitation in response to break-up of Gondwana.

Field, petrography, geochemical and mineral chemical studies of the Higher Himalayan Leucogranites (HHLG) intruding the high grade rocks of the Higher Himalayan Crystallines (HHC) in Arunachal Himalaya of the Eastern Himalaya have also been carried out. The HHLG are characterized by the presence of two micas; normative corundum; high contents of SiO_2 (67-78 wt. %), Al_2O_3 (13-18 wt. %), A/CNK (0.98-1.44) and Rb (154-412 ppm); low contents of CaO (0.33-1.91 wt. %) and Sr (19-171 ppm), and a high ratio of FeO(t)/MgO in biotite (2.54-4.82). These distinctive features, along with their strong depletion in high field strength elements (HFSE), suggest their affinity to peraluminous S-type granite generated by the partial melting of crustal material. Geothermobarometric estimations and mineral assemblages of the HHC metapelites confirm that the HHLG were probably generated in the middle crust (~20 km depth) and the melts produced intruded the HHC in the form of sills/dykes. Microstructurally, the HHLG shows high temperature deformation features including chessboard extinction in quartz and cuspate/lobate grain boundaries between quartz and feldspars (plagioclase and K-feldspar). The deformation microstructures suggest that the HHLG was deformed under early high temperature ductile deformation conditions. These fabrics were subsequently superimposed by later brittle deformation features associated with decreasing temperatures during the exhumation of the HHLG towards shallow structural levels at the time of Himalayan orogeny.

TAT - 1.9

Mineralization and Metallogeny in, northwest Himalaya: Emphasis on the role of complex fluids in magmatic and mineralization processes

(Rajesh Sharma)

The hydrogen isotope data has been generated on hydrated phosphate mineral lazulite from the Main Central Thrust (MCT) in northeast Kumaun Himalaya, which provides evidence of the source of water participated in mineral formation along the MCT. The moderately enriched δD‰ values obtained for lazulite points to the deep crustal/magmatic origin of the aqueous fluids. A local meteoric water or low temperature shallow sedimentary source can not be invoked. The study suggests that MCT acted as conduit for fluid migration originating from a deep reservoir. Together with earlier mineral chemical and fluid inclusion study, it attributes that lazulite from the MCT was formed probably during the initial stages of thrusting from the P and Mg-Fe supplied from the Beringag quartzite and the Higher Himalayan Crystallines respectively, and the aqueous fluid from a deep fluid reservoir.

The fluid inclusion studies are carried out on the Higher Himalayan gneisses and the aplite veins as a part to understand the nature and evolution of fluids at various evolutionary stages. Fluid inclusions in gneiss are studied in (i) early quartz present as mineral inclusions within garnet grains, (ii) relict quartz grains, (iii) garnet grains and (iv) late quartz. Monophase carbonic and biphase liquid-vapour inclusions represent the early fluid preserved in the gneisses, with peak CO_2 density 0.98 g/cm^3. C-O-H fluid in primary inclusions in garnet petrographically represents growth of garnet during metamorphism. The carbonic fluid is nearly pure CO_2 as also confirmed through Raman band positions at 1388 and 1282 cm^{-1}. The CO_2 density is slight low: 0.95 g/cm^3. Fluid in the early quartz is expected to represents pre-garnet prograde fluid, but re-equilibration of their isochors during garnet growth can not be ruled out. The relict quartz grains are observed in the granitic and augen gneisses, which consist of high saline aqueous fluid co-occurring with the low dense carbonic fluid (CO_2 density 0.60 g/cm^3). It is interpreted that such fluid was linked to magmatic fluid system. The combination of the isochors and the halite melting temperatures recorded provide pressure of about 7.5 kbar. The fluid inclusions in aplite veins are aqueous biphase with first melting temperatures corroborating H_2O-NaCl+KCl$\pm MgCl_2$ composition. In some of these fluid inclusions glassy material is seen, which give Raman band position at 449 cm^{-1} matching with quartz. Such solid material is probably a result of rapidly cooled silica locally generated in partial melt. The isochors for successive fluids are at lower PT level indicating exhumation, which is further corroborated by the inclusion morphologies.

The sulphide mineralization in the crystalline host rocks show complex textural relations wherein characteristic replacement, exsolution and intergrowth help in understanding their depositional sequence. The features like remobilization of ore along the S2 planes, fracturing across the mineralized veins and deformation of crystal lattice have been useful in understanding the ore deposition and paragenesis. The volatile enriched ore forming fluid have been active in the crystalline rocks. Liquid-vapour partitioning and exsolution of CO_2 with significant CH_4, confirmed through the Raman spectroscopy, acted for the ore deposition. Theδ$\delta^{34}S$ ‰ in range of about 0 to 10 indicate magmatic sulphur. In one case, the combination of ore textures and isochors suggest pressures of about 4 kb for ore formation.

TAT - 2: INDIAN MONSOON-TECTONIC INTERACTION AND EXHUMATION OF THE HIMALAYA

TAT - 2.1
Sediment production and sedimentation in Drier Himalaya: Patterns, time scales and palaeoclimatic inferences

(Pradeep Srivastava, Anil K. Gupta and Koushik Sen)

Sand ramps in Ladakh were studied to infer paleoclimatic information from arid landscape of Himalaya (Fig. 6). 21 sand ramps were identified in the vicinity of Spituk, Leh, Choglamsar, Saboo, Shey, Thiksey and Stakana. The area, slope and aspect of all sand ramps were measured using remote sensing data and GIS software. The study suggested that most sand ramps (14 Nos) occupy the area that is less than 0.25 km^2 with aspect in SE quadrant. These ramps have variable slopes from head to the distal end, where 30-60% area lies in 11-20° of slope. A ramp near Leh is exceptionally steep where 58% of the area lies under the slopes, that is >25°. Those in the vicinity of Choglamsar, Saboo and Shey are rather low angled ramps with majority of the area has 2-10° slope. These are located along the small tributary of Indus River called Saboo River. Extraordinarily large ramps with an area of 1.42 and 2.06 km^2 are located around Leh, on the northern bank of Indus River where the channel width is maximum. Three of these sand ramps located at Shey, Saboo and Spituk were studied in detail for sedimentology, mineral susceptibility, clay mineralogy and OSL dating. The results indicated that Ladakh experienced major arid phases at 25-16 ka and 12-8 ka and a wet phase at 30-25 ka and ~8 ka.

Fig. 6: Sand ramp located on Leh-Saboo road in Ladakh.

Besides this, the terraces mapped and sampled in Zanskar river valley were dated.

TAT - 2.2
Tectonics vs. climate change as causal mechanism for beginning of non-marine sedimentation in trans-Himalayan Cenozoic basins

(B. N. Tiwari)

Resolution on the aspect that tectonics or climate change initiated non-marine sedimentation in the Suture Zone is important for knowing the causal mechanism in the context of contemporary views in this regard; this project aims to make significant progress in this regard. Incisive and comprehensive studies of non-marine Cenozoic sedimentary packages succeeding marine beds in the Suture Zone, the Outer Himalaya, in the Shield region of Kutch hold the potential of substantiating competing hypotheses and thus paving way of furthering our understanding of early Miocene interval corresponding with Middle Miocene Climatic Optimum (MMCO) in the Indian Subcontinent.

MMCO in the Himalayan Evolution from Kangra Valley of Western Himalaya

During early phase of the Himalayan evolution thrusting regime precedes compressive metamorphism adding significantly greenhouses gases in the atmosphere. Successive thrusting episodes add terrestrial archives as foreland basins prograding towards shield on southern Himalayan flank to become regional feature of the orogen. Climatic coeval MMCO supplied macronutrients from upheaved marine rocks, and water plus moisture in the region regulated by the numerous evolving streams. Fertile alluvial covers the basin. While in coastal region faunal records coeval to MMCO are archived in accommodation due to rise in sea level, for example in Kutch, the early Miocene ecosystem as per fossil record in the Himalaya plausibly owes its origin to MMCO and thrusting coupled together as a viable mechanism.

Work is in progress on Kutch Hominid from MMCO level.

New sivapithecine from the early Miocene of western India

The divergence of Hominidae (humans, great apes, & their ancestors) is thought to have taken place around 15 Ma, when the lineages of the Homininae (humans and African apes) and Ponginae (orangutans) split. This divergence is thought to have occurred in Africa, after which these hominoids dispersed into Eurasia. Here, we report the recovery of a 16 million year old hominoid from India. The presence of indicate that the original radiation of hominids took place earlier than previously thought, and that Asia was colonized by pongids around 16 Ma.

Rodent fossils from Dharmsala Group in H.P.

While constraining Cenozoic evolution of the Himalaya through enlightening fossils we find that Dharmsala Group (intervening Subathu Group and Siwalik Group) in Kangra valley and adjoining coevals yield sporadic fossils. Hence, this first record of fossil rodents from Dharmsala Group is an important addition to an earlier report of dinothere from these horizons. Available crown details in conjunction with distinctive dimensions of the premolar lead to its assignment to Hodsahibia, a baluchimyine taxon; this taxon of Eocene lineage of south Asian-African distribution is already on record from Early Oligocene horizons in Bugti area, Pakistan

TAT - 2.3
River response to allogenic forcing and late Quaternary landscape evolution: Punjab re-entrant

(N. Suresh and Rohtash Kumar)

Four levels of terraces (T1 to T4) were documented from the Beas valley, between Pandoh (H.P.) in the north and Talwara (Punjab) in the south. The litho sections were constructed, and OSL samples were analysed from representative litho units to establish the chronostratigraphy. In the hanging wall of MBT, the topmost terrace (T4) is wide and extensively developed near Pandoh and is traced in the downstream for about 20 km till Mandi. The sedimentary sequence forming the terrace is lithified (Fig. 7a) and comprise of gravels (quartzite, limestone, slate and granite), pebbly and gritty sands, and are 20 to 29 m thick, and is resting over Lesser Himalayan bed rock, but at places resting over T3. Clasts are poorly sorted, disorganized, matrix supported, however, interbedded gritty sand is dark grey and shows trough cross stratification. The gravels are angular at Pandoh, however, in the downstream, roundness increase with dominancy of quartzite clasts. The T3 is 23 to 42 m thick sequence of gravel, sand and mud (Fig. 7b), and comprises dominantly quartzite, limestone and slate. Compare to T4, this terrace is not lithified and the clast size and roundness drastically increase with presence of granite clast, however, at Niyual village downstream from Pandoh this terrace comprises dominantly granite and phyllite followed by rounded quartzite and limestone clasts. The T2 is 24 m thick and consists of gravel, sand and mud (Fig. 7c). The T2 is similar in composition as T3, but gradually the percentage of granite clast increases. The sand is grey, trough cross stratified, and at places gritty. The gravels are clast to matrix supported, poorly sorted, fining upward and imbricated (Fig. 7c), and consist of quartzite, granite, limestone and slate clasts. The paleocurrent data varies between 150-240^{o}. T1 is about 4 m thick and consists of gravel. The OSL ages suggest that the sedimentary sequence forming T3 is the oldest with the basal part to be >80 ka, whereas the basal part of T4 is >29 ka. The top of T2 terrace is 1.8 ka, but the basal part is much older. Based on OSL ages, the top most terraces is a depositional terrace, whereas T-3 and T-2 are erosional, and T-1 is a filled terrace. This suggests that the top most terrace depositional phase occurred in a pre-existing valley as a fill and subsequent terraces were formed as a cut or cut and fill terraces. The deposition condition of T-4 was entirely different from that of other terraces. Clast composition, internal organisation, angular clast with dominancy of slate suggests rapid deposition in the form of debris from the nearby source with intervening stream flow. Where as the other terraces were deposited by persistent stream flow.

In the footwall of MBT, four levels of terraces were also documented from Surjanpur Tira and Nadun-Dera Gopipur areas. They are either resting over Siwaliks or seen as a fill terrace. The topmost is a fan terrace (Fig. 7d) and is identified on the left bank of Beas River, between Nadun and Talwara areas. The alluvial fan sequences are seen as a fill of more than 50 m thick and dominantly comprise gravel (red matrix) and sand (red) litho units (Fig. 7d). The clast composition is dominated by quartzite (90%) followed by granite and volcanics. The OSL ages suggest that the depositional phase of these fan were terminated around 50 ka. The T4

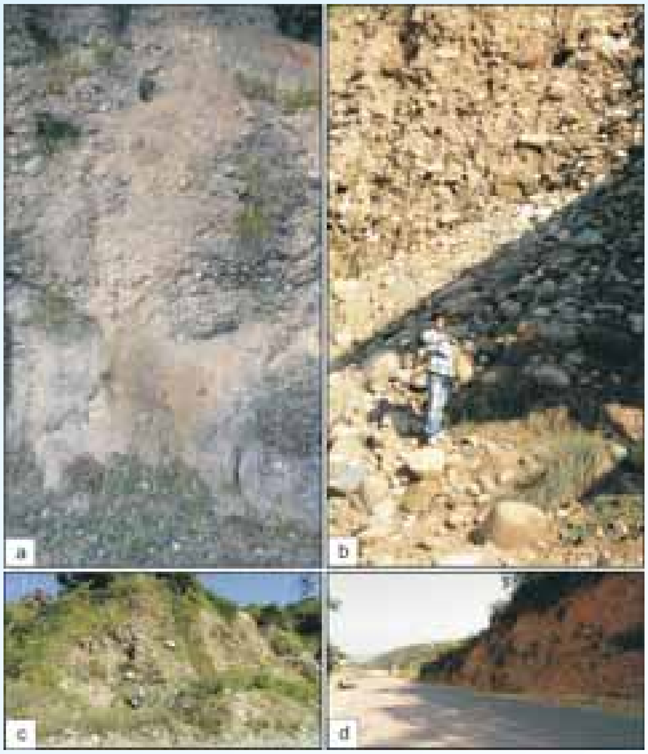

Fig. 7: Various stage of terraces along Beas River: a) T4 terrace sequence at Mandi, north of MBT, comprises lithified gravel (sub-angular to angular clasts of quartzite, limestone and slate), pebbly bed and parallel and trough cross stratified granular to coarse sand; b) the T3 terrace near Mandi consists of pebble to boulder size clasts of quartzite, limestone and slate with minor amount of granite clasts. They are crudely stratified, imbricated, poorly sorted and shows fining upward, c) the T2 terrace, similar to T3, comprises gravels (dominated by quartzite, volcanics and granite). It exhibits cyclicity of gravel and sand beds and d) The T4 terrace at Nadun, south of MBT, represented by the alluvial fan sequences as a fill, more than 50 m thick, dominantly comprises gravel (red matrix) and sand (red) litho units. The clast composition is dominated by quartzite (90%) followed by granite and volcanics.

on the right bank of Beas River is a strath terrace 4.2 m thick sediments resting over 90 m thick Siwalik rocks and is comprised of gravels (paleoflow: 200-260°), dominated by quartzite (90%; white: 75%, pink: 15%), volcanics (2-3%), granite (5%) and undifferentiated Lesser Himalayan rocks that are embedded in red matrix (2%). The T3 terrace comprises 5-10 m thick sediments resting over Siwalik bed rocks, and which is 60 to 74 m above the river bed. The T2 terrace (at Maanpaul, Kaloor, Dera Gopipur), is 5.4 m thick (paleoflow: 120°), and comprises quartzite (90%; white: 75%, pink: 15%), granite (1%) and volcanic (15%). The T1 terrace is very extensive (at Silh, Chamba Pathan, Dera Gopipur), 2 to 4.4 m thick and rests over Siwalik rocks. The paleoflow varies between 260 and 310°. The stratigraphy of these terrace deposits together with chronology is under process, and will through light on the evolution history with respect to Quaternary tectonic deformations and climatic variations.

TAT - 2.4

Late-Quaternary paleomonsoon study in Ladakh, North western Himalaya and Indo-Gangetic plain, India

(Narendra Kumar Meena, Sudipta Sarkar, Anil K. Gupta and M. Prakasam)

Late-Quaternary paleomonsoon study in Ladakh, India

The Ladakh Himalayan region has scarcity in paleoclimatic data, and hence a 5 m long core from the Tso Morari Lake, Ladakh was recovered toward paleoclimatic reconstruction of the region. The lake cores were sliced contiguously in two different resolutions of 2 cm and 0.5 cm. The samples were analyzed for multi-proxy paleoclimatic studies.

The Indian summer monsoon shows decreasing trend more toward north across the Himalaya. Therefore, the Himalayan foothill region receives maximum rainfall, whereas the northern-most part gets very low rainfall. However, there are reports from the Tsokar Lake and other Tibetan lakes, which show higher rainfall in the early Holocene time period. The project is mainly focused to provide high resolution paleoclimatic data from the Ladakh Himalaya. The lake core samples from the Tso Morari Lake, Ladakh were measured for environmental magnetism and stable carbon isotope ($\delta^{13}C$). The carbon isotope values (reported against VPDB) show contrasting variation in the values that range from -13‰ to -26‰. The age-dating of the lake core is under process. The depth-wise result indicates a wet and warm climate phase with higher abundance of C4 plants in the Tso Morari area in the depth range of 3.0 to 1.6 m. The values of carbon isotope range between -22‰ to -26‰ in this depth range. The$\delta\delta^{13}C$ values abruptly increased (-14‰ to -13‰) in the depth range of 1.6 to 0.5 m. The climate, as represented in this depth zone, became arid and the abundance of the C4 plants increased. The $\delta^{13}C$ values decreased to -23‰ between

0.5 m to the near surface, that again shows wet and warm climate phase in the area. The recent past shows increase in the $\delta^{13}C$ values that exhibits dominance of arid climate in this area. The magnetic susceptibility data also supports the stable carbon isotopic interpretation.

Late-Quaternary paleomonsoon study in the north-western Himalaya, India

The 5 m long core from Renuka Lake, bisected at 2.5 mm and 1 cm resolutions, were analyzed for magnetic susceptibility. Higher values of the magnetic susceptibility in this core were interpreted as wet and warm climate phase. Renuka Lake has a catchment with steep gradient (hill slope) and hence, the catchment wash increases with the increased rainfall. On the other hand, the lake based productivity and the organic content are responsible for the lower values of the magnetic susceptibility. The age-dating of the lake core is under process. The other proxies, such as detail geochemistry and grain size etc. are under progress.

The top 2 m of core samples from the Rewalsar Lake have been measured for the magnetic susceptibility, Saturation Isothermal Magnetization (SIRM) and Anhysteretic Remnant Magnetization (ARM). The age-dating of the top 2 m lake core is under process.

Late-Quaternary paleomonsoon study in the Indo-Gangetic plain, India

Ganga River cliff samples were collected at contiguous 5 cm interval from 9 m steep cliff at Oriya Ghat, Ramnagar, Varanasi, U.P., India. Around 80 samples were processed and analyzed for grain-size using Laser Particle Size Analyzer to study the down-depth grain-size variation in the river cliff section (Fig. 8). Magnetic susceptibility parameters were analyzed for around 80 river cliff samples. Around 20 samples were analyzed for XRD. Based on the magnetic susceptibility and grain-size data, the whole profile can be broadly subdivided into three zones: Zone-I (0 to 290 cm) shows highest values of magnetic susceptibility (χlf) at an average value of 2.26 x 10^{-8} m^3/Kg. Sand volume percent is also showing the highest values in this zone, and ranges between 20 to 35%. Zone-II (290 to 560 cm) represents relatively lower values both for the magnetic susceptibility (average value of 1.46 x 10^{-8} m^3/Kg) and sand (10 to 15%). Zone-III (560 to 830 cm) exhibits lowest values of magnetic susceptibility (average value of 0.89 x 10^{-8} m^3/Kg) and sand (5 to 15%). Thus, all the magnetic parameters and the sand volume percent decreases from Zone-I to Zone-III which seems to be indicative of a shift from wet and warm phase to a gradually drier climatic condition.

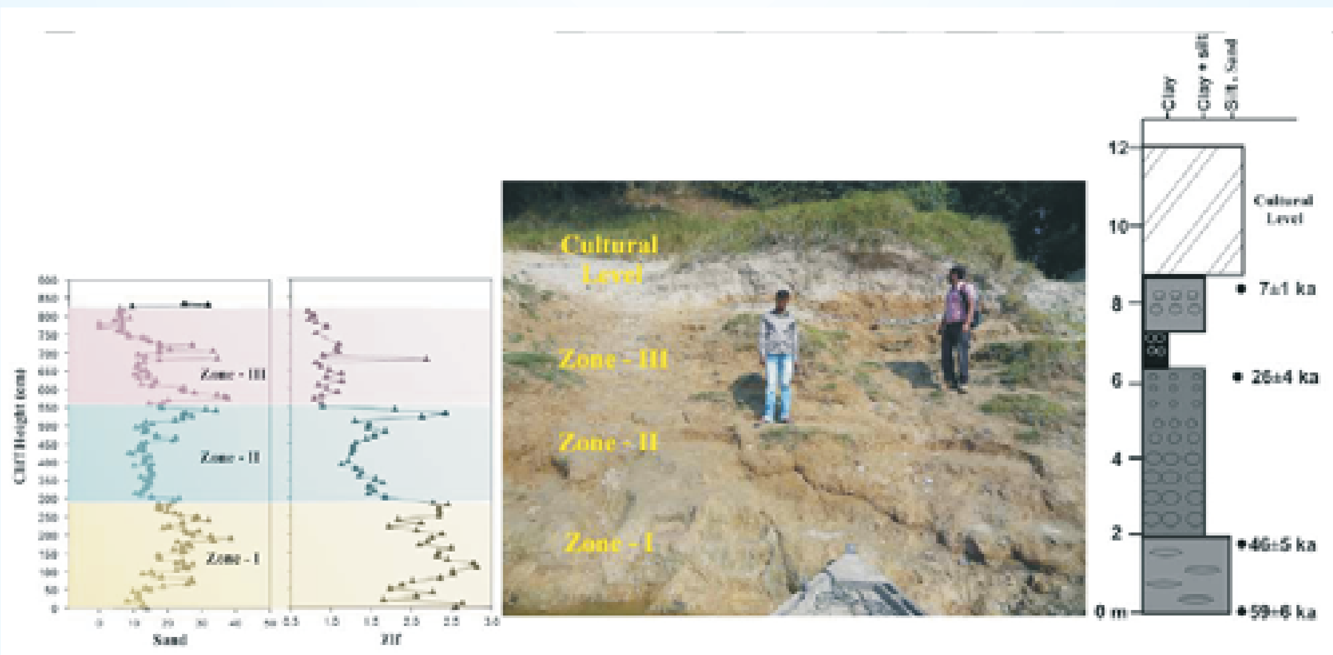

Fig. 8: Grain-size (sand) and magnetic susceptibility (χlf) plots against schematic litholog Oriya Ghat River Cliff Section, Ramnagar, Varanasi, U.P., India. (Ages after Shukla et al., 2012; Geomorphology).

TAT - 2.5
Climate Variability and Treeline Dynamics in Western Himalaya

(P.S. Negi and Jayendra Singh)

Treeline dynamics has been studied to understand the climate change implications in high Himalayan region. In total 26 treeline data points have been collected so-far from the field. After the investigation of the field data sets and their subsequent analysis, treeline dynamics has been reported 10.2 m/year in Chorabari Glacier valley and 1.7 m/year in the Dokriani Glacier Valley during last 51 years i.e., during 1962 to 2013. The altitudinal difference of 40 m and aerial distance of 1.7 km between the treeline and glacier snout in Dokriani Glacier valley, and 466 m altitudinal difference and 3.7 km aerial distance in Chorabari Glacier valley was investigated to be the main geomorphic factor attributed to the variable treeline dynamics. The study also extended to the Gangotri Valley that harbour a largest glacier of the India i.e., Gangotri Glacier (Fig. 9). The area representing climate change implications in the form of spatial changes in treeline includes the snowline and glacier regime.

The shift in treeline at spatial and temporal context is a signature of climate change. At the same time forest expansion to the erstwhile snow-ice domain due to treeline rise is bound to alter radiative energy balance and carbon sequestration potential in alpine ecosystem. The samples of dominant species from treeline composition collected earlier were prepared and identified duly from standard herbarium at FRI Dehra Dun. The dominant species are *Quercus semicarpifolia, Taxus baccata, Abies spectabilis*, *Rhododendron companulatum, Betula utilis*, *Juuniperus squamata*, *Juuniperus Indica* and *Sorbus acuparia*. Aerosols monitoring instrument are being procured for further installation in the study area.

Fig. 9: Rising treeline in foreground and Bhagirathi Peaks in background in the Gangotri Valley.

To understand long term climate history, ring-width chronology of Chir pine (*Pinus roxburghii*) was developed from Balcha in Tons valley, western Himalaya. The existence of significant positive relationship between ring width indices and that of June-August mean temperature was further used to develop first statistically significant temperature reconstruction, using Chir Pine ring-width chronology from India (Fig. 10). *Cedrus deodara* ring-width chronologies were also prepared from the Tons valley, western Himalaya. The chronologies were tested for the climate change studies and further used to develop February-June temperature reconstruction back to AD 1455 (Fig. 11). Out of the 83 tree core samples collected last year from Bhagirathi and Mandakini (Chorabari Glacier valley) River valley, 22 samples have been polished. The dating of growth rings exactly to the level of calendar of their formation of each tree core is in process.

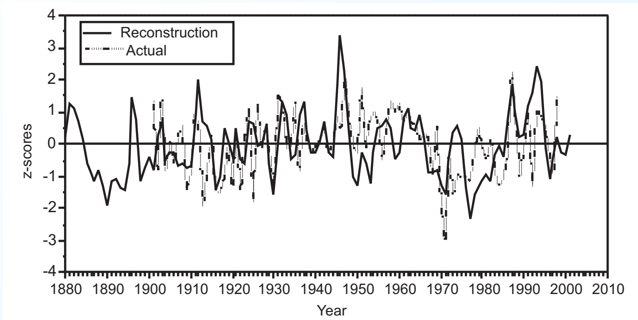

Fig. 10: Reconstructed June-August temperature (solid line) and actual temperature (dotted line).

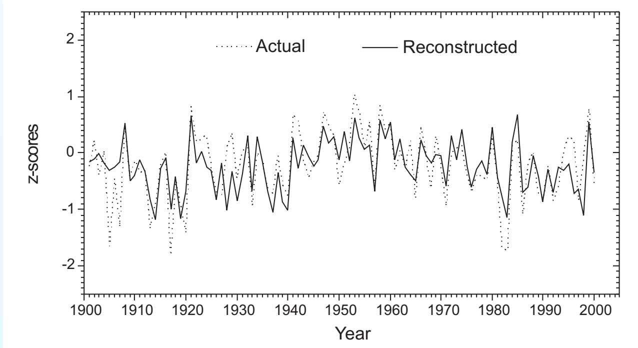

Fig. 11: Comparison between actual (dotted line) and reconstructed (solid line) February-June temperature.

TAT - 2.6

Geochemical & isotopic studies as tracers of weathering and erosion processes in the NW Himalaya

(Santosh K. Rai and S.K. Bartarya, Anil K. Gupta and A.K.L. Asthana)

Geochemistry of the samples collected from the Indus, Shyok and Nubra rivers were used to infer about the nature of weathering (silicate vs. carbonate) in this drainage. Towards this, $\delta^{13}C_{VPDB}$ (measured in dissolved inorganic carbon (DIC) range from 0.4 to -5.7‰) and SiO_2 (ranging from 73 to 280 μE) are correlated in Indus River waters. This shows that the alkalinity in these rivers is linked with silicate weathering which seems to be a plausible mechanism to produce the alkalinity in these rivers. This observation is consistent with the fact that the silicates (granites, gneisses, schists etc) in Indus valley comprise mainly of minerals including quartz, plagioclase, alkali feldspar biotite and muscovite, and dissolution of which can produce the silica and alkalinity together. Further, as Indus River flows through the Indo-Psongpo Suture Zone with a high tectonic activity producing highly fractured/ sheared rocks, these are prone to silicate weathering. In addition, the $\delta^{13}C_{VPDB}$ in organic phase has also been determined to understand the sources of organic matter in the Indus River system and further work is underway.

During the year work has also been carried out on analytical studies of landform development of the Ramganga basin of Garhwal Himalaya. The studies have shown a variety of landforms, the bulk being represented by the massive fluvial terrace, piedmont fans, flood plains and intra-basinal depressions filled with Quaternary deposits. Interplay of Quaternary tectonic is clearly visible in the area. The Ramganga lies between 29°45 to 30°30 N latitude and 79°12 to 79°35 E longitude covering an area of 3000 km^2 approximately. The upper catchment of this river is subjected to neotectonic forces of Himalaya that decreases significantly in its foreland counterpart. The whole catchment however receives water from a single climatic system i.e. SW summer monsoon. These significant differences in hydrological and tectonic conditions in the two zones of this river i.e. the Himalaya and the foreland make it an ideal laboratory to understand, the time resolved, process based source-sink relationship within these zones.

As a part of the ongoing research programme efforts were also made for laboratory and procedural development. Towards this, a vacuum line (Fig. 12) of stainless steel coupled with a computer controlled CO_2 laser system was fabricated to extract oxygen from rock forming mineral in the BrF_5 environment (Clayton and Mayeda, 1963). The line is equipped with suitable valves and traps for the efficient recovery of oxygen from the silicate minerals and reliable handling of hazardous oxidant BrF_5 that is used for the breaking of Si=O bonds. This set up is installed recently for the first time in India at the Wadia Institute of Himalayan Geology, Dehradun. This extraction system is interfaced with a newly set up continuous flow Stable Isotope Ratio Mass Spectrometer (IRMS; ; Delta V Plus). The system is being used for the oxygen isotopic ($\delta^{18}O$) measurements in silicate and oxide minerals. Here we report the ($\delta^{18}O$) results on a set of silicate rocks and standards reference materials including Norway olivine, Gee Whiz quartz standard from University of New Mexico, olivine from Norway Fan, silicate rocks from North West Himalaya (India) and NBS-28 quartz (a standard reference material of IAEA). The average$\delta\delta^{18}O$ values (relative to V_{SMOW}) and 2SD are 6.4±0.5‰ (N=17) for Norway olivine, 12.7±0.2‰

Fig. 12: BrF5 Laser Fluorination System for measurement of $\delta^{18}O$ in silicate minerals, established at WIHG.

(N=10) for Gee Whiz garnet, and 9.5±0.3 ‰ (N=12) for NBS-28 quartz. In addition to these samples, some of the quartz vein and quartzites from the Garhwal Himalaya were measured to establish the end-member composition for oxygen isotopes ($\delta^{18}O$) near the Main Central Thrust (MCT) zone. Such information is helpful to infer about the origin of quartzite and their relationship with possible protoliths in the region. This system is being successfully used for the ($\delta^{18}O$) measurement in silicate minerals by Institute users including PhD Students and other outside users. Further, efforts are on to make improvements on these measurements.

TAT - 2.7
High resolution Paleoclimate records from the Himalaya and adjoining regions

(Vinod C. Tewari, Anil K. Gupta, Pradeep Srivastava, Narendra K. Meena, Jayendra Singh , M. Prakasam, Raj Kumar Singh (on lien) and Santosh K. Rai)

A multi proxy attempt has been made to study the paleoclimatic change in the NW and NE Himalaya. Himalayan speleothems, high altitude lakes, climate tectonics of the Himalayan river basins and tree ring records of paleoclimate will provide strong evidences to understand the climatic and monsoon variations in the Himalaya. Speloethems from the Sahstradhara and Prakateswar in Garhwal have been studied for the petrographic details and sedimentological micro facies analysis. The microlaminae have shown the warm and humid and wet and dry paleoclimatic conditions. There is a distinct seasonal change in the microclimatic conditions as revealed by the light and dark carbonate lamina of the different speleothems. The presence of microbial cells/laminae in the speleothems indicates the formation of some of the speleothems is microbially induced and the bacteria present are being studied in detail for its biomolecular details, SEM, EDAX etc.

The caves at Sahastradhara, Dehradun were studied for the paleoclimatic and sedimentological studies. All the seven caves of the system are exposed to light, and from the roof of the caves water continuously drips. There is a permanent water line inside the caves. The cave flora at the entrance in the outer photosynthetic region consists of autotrophic organisms like algae (Cyano bacteria), lichen, mosses and ferns (Fig. 13). The cave has a total length of 11 m, height 1.5 m and width varying between 1-3 m at different places. The main cave entrance is 2.5 m in height and 1.25 m in width. These caves host a number of spectacular stalactites and stalagmites ranging from 1 cm to 1.5 m in length (Fig. 14). Stalagmites are much smaller in size. The speleothems and cave deposits near the entrances have a greenish grey appearance on the outermost zone, and are creamy white in the inner zones (Fig. 15). The carbonate petrography, geochemistry, isotopic, XRD and SEM study of the stalactites and stalagmites have been done on selected samples. Trace elements (Ba, Ca, Cd, Cr, Fe, K, Mg, Mn, Si and Sr) were detected. The detection limit for most of these elements is <1 µ/1.

The carbonates in the samples were analyzed for $\delta^{18}O$ and $\delta^{13}C$ isotopes. The results were reported against the Vienna Peedee Belmenite (VPDB) for both $\delta^{13}C$ and $\delta^{18}O$. Geomicrobiological investigation was done on the speleothem samples and the cellular structure associated with the microstromatolites (microbial laminae) has been recorded, and cathodoluminescence microphotograph clearly shows the nucleus and the filamentous chain (cyanobacterial) community (Fig. 16). Geochemical analysis of the drip waters indicates concentrations of, Ca: 85 mg/1, Fe: 1.02 mg/1, K: 2.74 mg/l, Mg: 55 mg/l, Mn: 6 µg/1, SiO_2: 70 mg/l, Sr: 540

Fig. 13: The cave flora at the entrance in the outer photosynthetic region consists of autotrophic organisms like algae (Cyanobacteria), lichen, mosses and ferns.

(a)

(b)

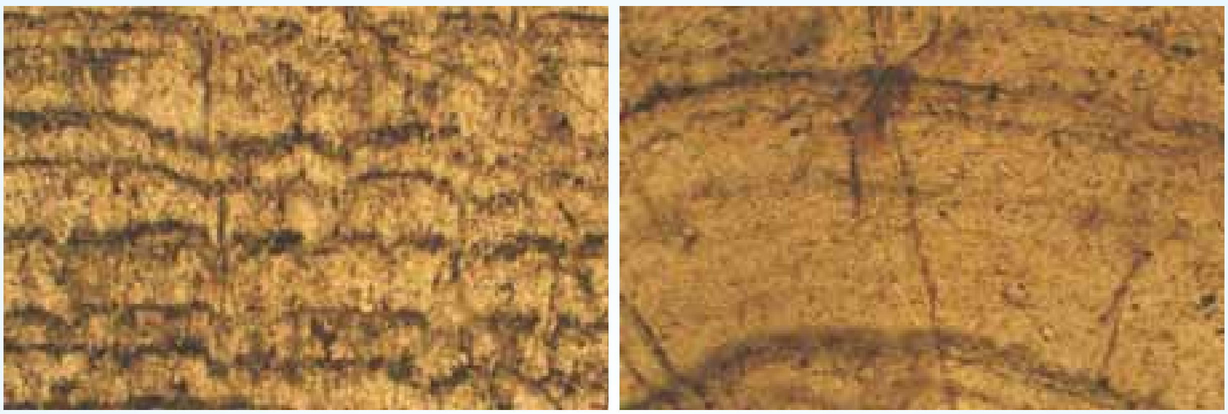

Fig. 14 : (a) Stalagmite column in the Sahastradhara caves. (b) Microstructures of the speleothem showing microbial influence.

Fig. 15 : The speleothems and cave deposits near the entrance have a greenish grey appearance on the outermost zone, and are creamy white in the inner zones.

μg/l, and minor concentrations of Ba: 22 μg/l, Cr: 3μg/1 and Cu: 7 μg/l. The in-situ pH ranged from 7.4-7.6. The water temperature was 17°C, whereas the air temperature inside the cave was 17-20°C. The humidity in the cave was ca. 60 %.

SEM pictures showed large numbers of spiral filaments, long spiral and tubular filaments, calcite minerals in close association with filamentous structures, bacterial cells, empty filamentous organic structures and fibrous calcites. The minerals were closely associated with microbial filaments. Some minerals shows circular cavities lined with organic matter. The size of the cavities conformed to the size of the filaments. SEM-EDAX analysis performed on a dense mesh of these calcite filaments indicates presence of Ca and Fe. The dating of some of the speleothems is in progress. Dendrochronological studies include the ring-width chronologies of *Cedrus deodara* developed in Kinnaur, Himachal Pradesh. Tree growth-climate analysis is in process to develop millennia long robust climate records for the region. Tree ring samples collected from Shillong area are being processed, and 15 samples has been measured with an accuracy of 0.001 mm. Dating of growth rings to the level of calendar year of their formation is also being done for further climate change studies. New unexplored caves form the Lesser Himalaya will be studied for the sedimentological, paleoclimatic/monsoon, geochemical and high resolution oxygen isotope ratios in the speleothems. Geomicrobiological studies will also be taken up for the determination of the role of microbes in speleothem development. Additional tree core samples would be collected from climate stressed sites to enhance the sample replication back in time. Ring-width chronologies developed would be utilized to reconstruct high-resolution long-term robust climate records for the Himalayan region.

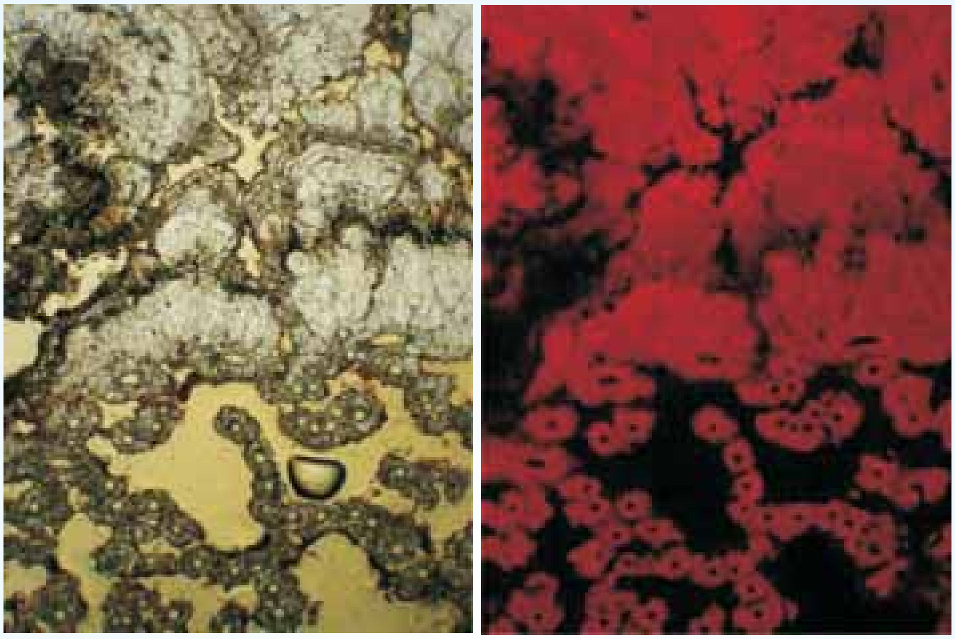

Fig. 16: (Left) Microstromatolites and filamentous cyanobacteria found in the Sahastradhara cave. (Right) Cathodoluminescence microphotograph clearly shows the nucleus and the filamentous chain (cyanobacterial) community.

TAT - 3: EARTHQUAKE PRECURSORS STUDIES AND GEO HAZARD EVALUATION

TAT - 3.1

Seismological, seismotectonic and subsurface related studies seismic hazard evaluation from the Ladakh, Kinnaur, Kangra and Garhwal-Kumaun regions of the NW Himalaya

(Sushil Kumar, Ajay Paul, Dilip Kumar Yadav and Devajit Hazarika)

Earthquake data are collected from seismic stations of Kangra, Garhwal, Himachal, Sikkim and Ladakh network. Local and regional earthquakes recorded are under process for the period 2013-2014. This database is being used for different seismological studies such as source mechanism study, stress & strain analysis in Himalaya. Around 41 Broad Band Seismographs in the NW Himalaya, and a network consisting of 8 Broad Band Seismographs in Sikkim Himalaya, along with other Geophysical equipments were operated. The data is being acquired and analyzed continuously by the networks. During July 2007 and March 2014, a total of 27,997 events have been detected which includes 509 local events, 10504 regional events, and 12,402 teleseismic events (Fig. 17). During April 2013 and March 2014, a total of 9971 events have been

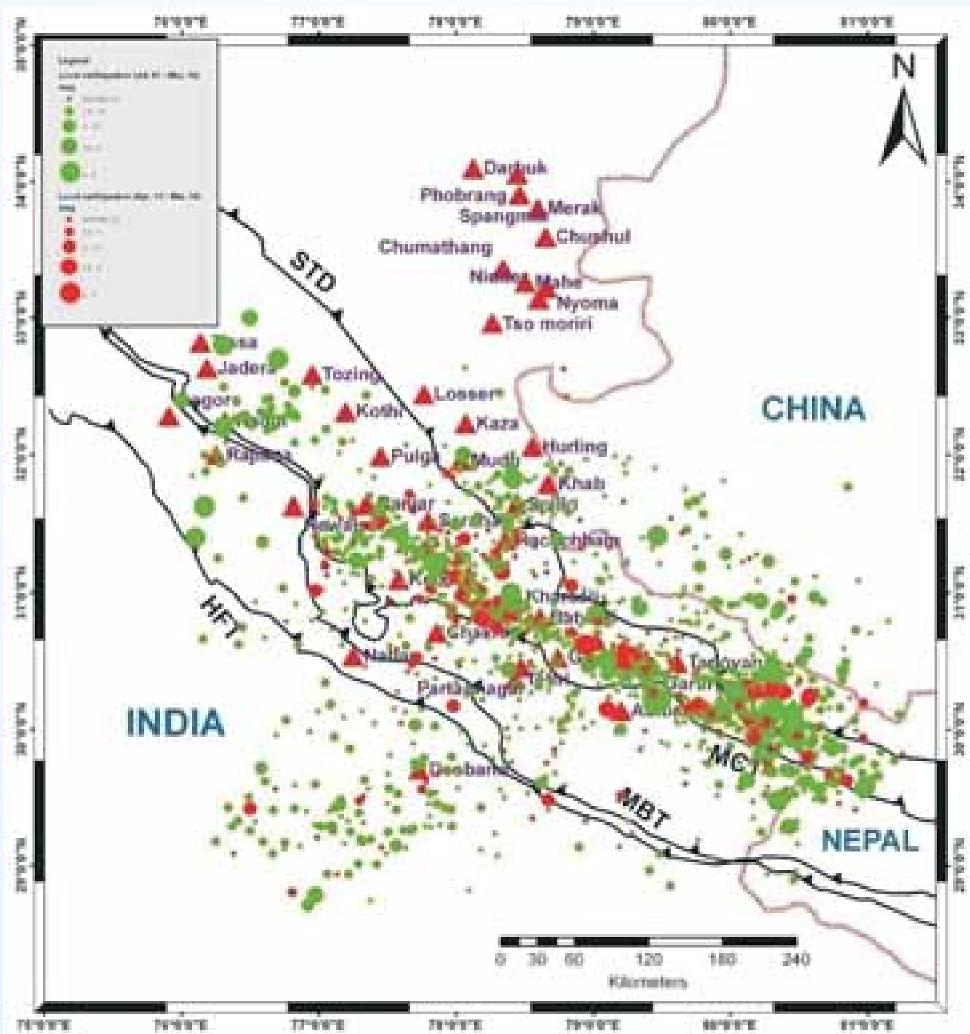

Fig. 17: Seismicity recorded during July 2007 and March 2014.

detected which includes 1252 local events, 4863 regional events, and 3856 teleseismic events. The space time pattern are regularly being examined to demarcate the zones of enhanced/quiescence that invariably precede the large earthquakes in this region. Some of the earthquake swarm activity has been observed.

Detection threshold of magnitude 1.8 events have been achieved. Variations of Vp/Vs ratio have been studied for the period July to March 2014 (Fig. 18). No anomalous pattern or any other precursor phenomenon is identified during the one year period between April 2013 and March 2014. It is significant to note from the seismicity pattern of Main Himalayan seismic belt, the region south of MCT is trending along the main Himalayan thrusts. The region continues to record shallow focus events with low stress drop values.

The migratory behavior of the regional seismicity of western Himalaya has also been analyzed during 1985-2013. The three and five years' time window has been examined covering 28-34°N latitude and 74-82°E longitude of Western Himalaya. The epicenters show two major clusters centered over the Kangra and the Garhwal Himalaya with a well-defined seismic quiescence zone over Shimla sector. In recent years few small clusters are also seen in the southern region. In this work we have discussed the migration of seismicity in either increase or shift along the features which are transverse to regional tectonics (Fig. 19).

WIHG is also providing On-line contribution of Broadband seismic data (10 stations, 3 components) to National Seismological Data Centre at IMD, New Delhi; and Indian National Centre for Ocean Information Services (INCOIS), Hyderabad for Tsunami Early Warning System.

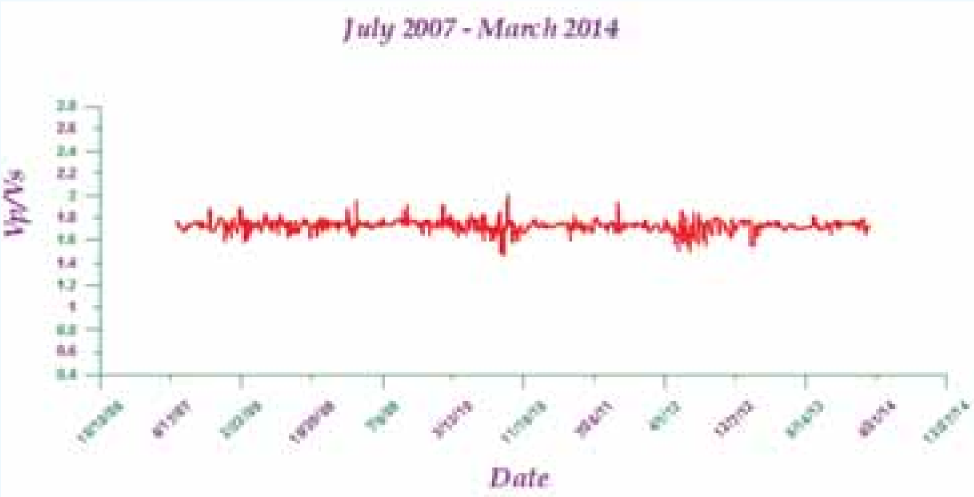

Fig. 18 : Vp/Vs plot for the events recorded from July 2007 till March 2014.

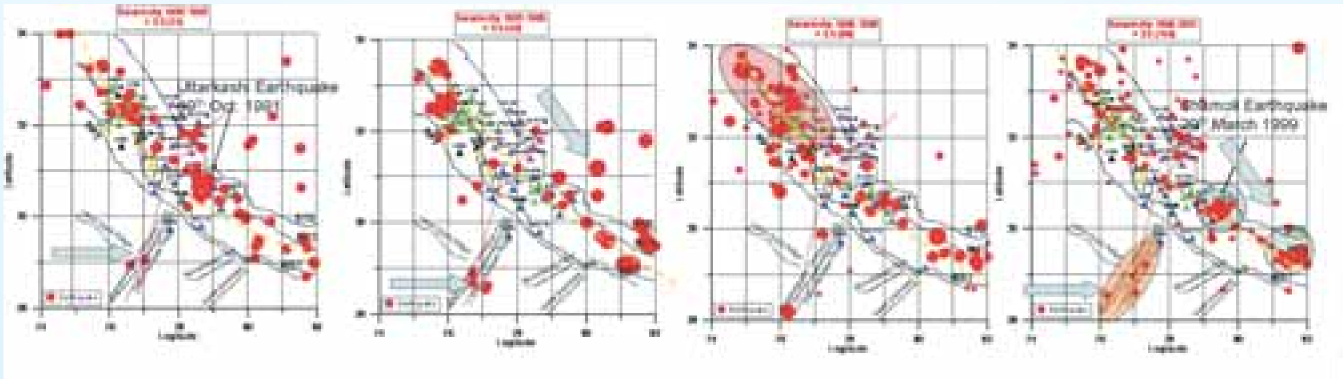

Fig. 19: Seismicity with 3 year Time space M>3.5.

TAT - 3.2:
Earthquake Precursory studies in the Himalaya through Multiple Geophysical Approach

(Naresh Kumar, Gautam Rawat, P.K.R.Gautam and V. M. Choubey)

Anomalous behaviour in MPGO data during the occurrence of Kedarnath flash flood

The Kedarnath region of Garhwal Himalaya was shattered with the occurrence of a devastating flash flood in the month of June 2013. The Multi Parameter Geophysical Observatory (MPGO) records indicate that there was continuous precipitation of rain for 52 hours during June 15-17, 2013. Over six years, the continuous data set of different geophysical and hydrological parameters of this observatory indicates that, the intensive rainfall of June 15-17, 2013 is an extreme event that resulted in the abrupt changes in the ground water table observed in boreholes. The variation reported in the radon concentration within soil at 10 m depth is high, and within water at 50 m depth is extra-ordinary. This flash flood was described as the "Himalayan Tsunami" by press and print media because causing a wide spread loss with over 4,000 casualties. The parameters at Ghuttu sensitive to the changes in atmosphere and to the earth's surface are required to be processed and analysed. These parameters are rainfall records, water table variations and radon measurements; all are continuously collected at 15 minute interval using same equipment. The other parameters also effected, however, the changes are small and not so much apparent.

Rainfall measurements: The Ghuttu station is merely 40 km away from the worst effected part Kedarnath and perhaps this is the only site of the region for making continuous rainfall records at a high sampling rate of 15 minute interval. Hourly, daily and 52 hour duration accumulated rainfall is calculated for the entire event period, and also for the same duration of previous years during 2008 to 2013, when there was intensive rainfall. The observations show that the rainfall precipitation was almost continuous for 52 hours during June 15-17, 2013, the longest event of continuous rainfall during for whole data set (Fig. 20). The comparison of these data sets indicates that in 2013 the rainfall precipitation occurred every hour for ~52

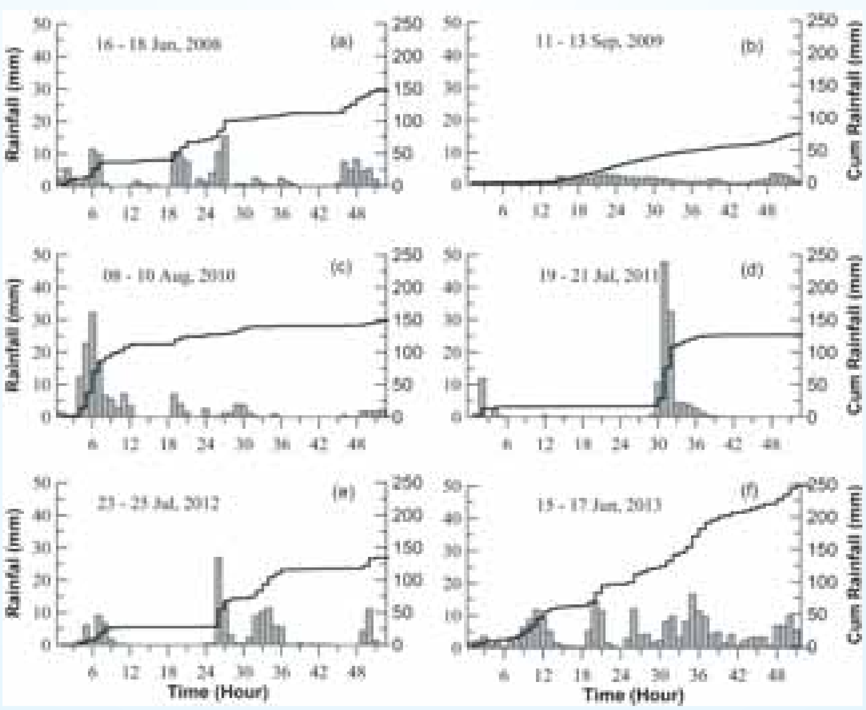

Fig. 20: Plots of rainfall in the form of bar chart for hourly data and step chart for cumulative values of 52 hours data sets for each year during 2008-2013. Intensive rainfall of each year is shown for (a) 2008 (b) 2009 (c) 2010 (d) 2011 (e) 2012 and (f) 2013.

hours resulting in flash flood. However, in other data sets although some times the rainfall is more in one hour duration, it was not continuous for such a long time of more than two days. The total cumulative rainfall occurred during this event in 2013 is 247 mm which is ~100 mm in excess than compared to intensive rainfall for the same duration occurred in any period of previous years. The average rainfall per hour is 4.75 mm in this period of 2013 which is a high value. This intensive rainfall event is not only unique for the present data set, however, it is an extreme event detected for a much longer period of decades or more in this region.

Water level variations: The changes in the water level within borehole were also enormous within small span of time which is observed first time at this site. A total rise of ~13.3 m in water level is recorded as a result of the heavy rainfall that occurred continuously for ~52 hours. After intensive continuous rainfall the level of the water table increased very fast and reached to just 13.7 m from earths surface which was 26.9 m before the event. It directly indicates the unusual precipitation of rainfall had resulted in the occurrence of flash flood disaster. The continuous and intensive rainfall for long duration was a unique event and was the main reason for extraordinary rise in the level of water table prior to the onset of rainy season. It has also been reported that the sudden change in water level is taking place during the occurrence of strong earthquake and that it is treated as earthquake precursor based on earthquake occurrence mechanism. However, the results of the present data set are pointing about removal of the rainfall effect from sudden increase of ground water level, although the anticipated effect may not be as high as observed during this event. Therefore the present analysis is not only useful for this flash flood, but also equally important to the objective of this observatory.

Radon measurements: It is also observed that other parameters other than rainfall and water level are also responded to this event, mainly radon emanation has extraordinary variation. Based on earthquake generation mechanism, it has been reported all over the world that anomalous changes in radon emanation are occurring during strong earthquake. At Ghuttu, the continuous recording of radon at 15 minute interval is being performed within soil and underground water in a 68 m deep borehole for this purpose. Both records have shown a very high anomalous change which is equally important to the present work as well as earthquake precursory research. For evaluation statistical approach is adopted, the mean and standard deviation is obtained for data of 200 days for the period January to August, 2013. At 50 m depth probe, the anomaly was high, the value exceeding to twice the standard deviation from mean, and that it is recorded at the time of highest water level within borehole. Before the occurrence of this event there was not such high fluctuation of radon within water. In case of soil radon emanation (10 m depth probe), the trend is reverse, the radon concentration starts decreasing with the increase of water level. Its concentration was lowest at the peak of water table and then again starts increasing to reach to initial level. It is found that the amount and trend of increase in the radon concentration within water is reverse to that of soil. The enhancement of radon emanation within water is equivalent to decrease in soil. Simply, it can be interpreted that there is an increase of volume of water within the borehole accounting for increase of radon contents, and there is decrease in the volume of soil air within borehole above the ground water, that accounts for the decrease of the radon content in the soil. It suggests that, the radon fluctuation is highly affected with the hydrological changes that have to be removed from recorded data, to create new time series for earthquake precursory research. In the post event period also, the water level fluctuations were highly related to rainfall precipitation, and in this period immediately the radon concentration again started increasing, which as even crossed the previous highest level. The radon concentration was more than twice the standard deviation for a quite long time, although the trend was totally opposite in post event period. During this the increase in water level inserted a decrease in radon content and vice-versa. It can be stated that, in this time series of more than six years data, the water-radon fluctuation during Kedarnath disaster is unique and scanning whole data set, the event can be recognized easily. The present data set is pointing to the concern of the removal of hydrological and other related effects from the radon time series to utilize it for earthquake precursory research.

Changes in gravity data related to other geophysical parameters

Continuous gravity measurements are being carried out at MPGO, Ghuttu through the Superconducting Gravimeter (SG) for observe its variation due to ongoing regional tectonic processes. It is the only SG station in the Himalayan region to observe the gravity changes to sub-microgal level. The highly accurate gravity observations to μGal level is influenced by many factors such as tidal forces (ocean and solid), atmospheric pressure, changes in water table, moisture etc. These are the external effects in the gravity, a careful scrutiny and high level processing is required to remove these effects. The gravity data collected at Ghuttu station for a period more than four years indicates a heavy influence of hydrological effects in addition to systematic variation related to tidal forces and atmospheric pressure. The main emphasis is on to adopt an approach which allows detecting the minor variation of hydrological effects and successfully removing these to make time series for earthquake precursory research. Continuous measurement is also being performed of GPS time series, rainfall and changes in the water level in a borehole at Guttu station. Here an attempt is made to analyse these data sets along with gravity data, and it is observed that annual variation in all the data set are matching. Also, the grace data and soil-moisture contents are extracted from the freely available data of that region. The data sets of all these parameters are compared for the period 2007 to 2010. Based on the water level changes in the 68 m deep borehole, it has been already reported that hydrological cycle influences the gravity field in three forms; such as i) abrupt changes in all cases are associated with intense rainfalls during rainy season ii) medium-term changes on a time scale of few days correlate well with ground water level fluctuations, and iii) slow seasonal gravity changes appears to be the combined effects of degree of soil saturation as well as rate of recharge of aquifer. There is a good correlation of annual change in GPS time series (vertical component) with the grace data and that is also matching with the changes in the gravity residual. However, there is some phase difference in the gravity variation compared to other two time series. The variation in soil-moisture is mainly depending upon the rainfall and the water level changes. It has been reported earlier that there is also a phase difference in the water level variation and the annual change in the gravity residual obtained after removing the tidal effect and atmospheric changes. Therefore, all these results indicate a multi effects on the gravity data.

Seismo-Electromagnetic

Magnetic field variations recorded at Multi Parameter Geophysical Observatory (MPGO) at Ghuttu using digital fluxgate magnetometer are investigated in frequency band of 0.03-1 Hz and for 19-20 h UT for the month of June, 2011. Polarization analysis based on planar wave assumption for far field, is applied in order to discriminate the signatures of seismo-magnetic signatures. The dynamics of earthquake processes considering as self-organized critical system is also studied using fractal dimension of ULF band geomagnetic field variations. Marginal increase in polarization ratio and fractal dimension few days before the earthquake is significant in the background of global geomagnetic activity. At the same time, effect of post-seismic readjustment of seismogenic processes are clearly marked by significant changes in fractal dimension and increased polarization ratio after the earthquake.

Ultra low frequency (ULF) geomagnetic data, obtained at multi-parametric geophysical observatory (30.53°N and 78.74°E) in Garhwal Himalaya region of Uttarakhand, India, is analysed for a period of one year, from January to December, 2010. Polarization ratio variability indicates presence of seismo-magnetic disturbances superposed upon background geomagnetic variations. Considering earthquake process as a SOC system based on flicker noise characteristic, variability in fractal dimension are estimated from two methods namely power spectral (FFT) method and Higuchi method. Estimates from Higuchi method are consistent in comparison to estimates obtained from FFT method. Variability in fractal dimension is studied in the background of local earthquakes ($M \geq 3.5$) within a zone of 150 km radius from observing station MPGO at Ghuttu. Fractal dimension has increased during first half of the year when there is seismic activity within zone of 150 km radius, whereas in the second half of the year when there are no earthquakes, the fractal dimension shows a steady behaviour (Fig. 21).

GPS studies

To achieve the objective of deformation evaluation and earthquake precursory study, we are monitoring a network of permanent GPS stations in the different part of the Himalaya. As one CGPG was established at Multi-parametric Geophysical Observatory (MPGO), Ghuttu in the central Himalaya, we have analyzed the continuous five years data of GHUT station for the period of 2007-2012 using the version 10.40 of GAMIT/GLOBK software. We produced yearly time series and analyzed the pattern of the horizontal

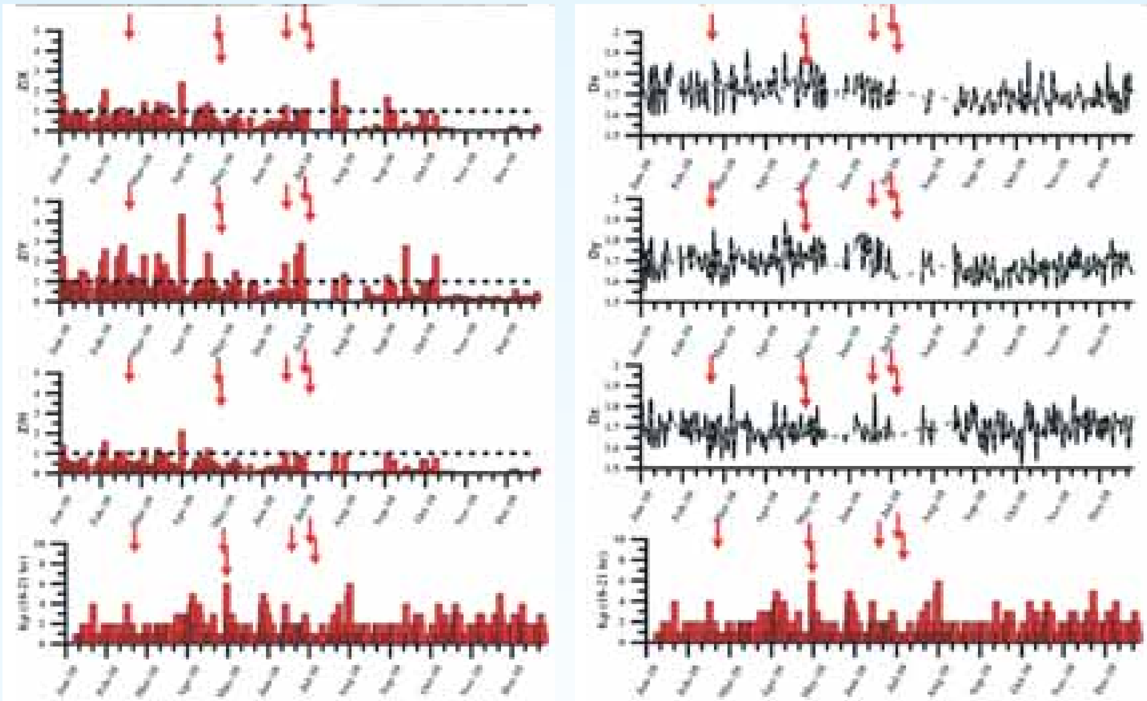

Fig. 21: Temporal evolution of polarization ratio and fractal dimension for year 2010. Red arrows are the earthquake occurred within 150 Km radius of MPGO Ghuttu.

offsets of GHUT station. Horizontal velocity vector are estimated in ITRF05 reference frame. In this analysis, we have tried to find out deformation pattern of GHUT station, and also tried to pick up any significance anomalous changes in the time series due to any earthquake occurrence in nearby region of Ghuttu.

We also made an effort to develop a computer code using a gcc compiler in linux to estimate the strain rate of a particular triangular region. The code gives areal strain of the region and the angle of principal axis with respect to the North. We validated the code with published data of the Garhwal Himalaya.

To consider the requirement of GPS study in HFT, we have established a permanent GPS station in Haridwar (Uttarakhand) just south of HFT.

TAT - 3.3

Shallow sub surface studies and site response estimates in 1905 Kangra Seismic zone and urban sites of Frontal Himalaya

(A. K. Mahajan (on lien) and A.K. Mundepi)

The ground motion estimation at different sites in Doon valley, Uttarakhand, India was carried out using Horizontal to Vertical Spectral Ratio (HVSR) technique of Microtremor (Ground Ambient Noise). The fan deposited alluvium filled synclinal valley of town lies between Main Boundary Thrust (MFT) and Himalayan Frontal Thrust (HFT) in the Himalayan active seismic belt, and has experienced many earthquakes in the past.

The earthquake damage is generally larger over soft sediments than of firm rock out crops. Earthquakes, unlike other natural calamities are unpredictable in regards to origin in terms of time and space, and cause devastations within short period. The effects of the waves generated by any seismic event behave differently as per the dynamic characteristics of the geological units present in the area. If the ground dynamic characteristics of the medium are characterized, and the structures are designed accordingly, the damages of seismic events could be minimized. In this study, geophysical approaches (H/V method) were applied in the Doon valley, as the rapid city growth makes a microzonation study necessary for the city development and also it is convenient and inexpensive. Nakamura (1989) demonstrated that the H/V ratio of the ambient noise records is related to the fundamental frequency of the soil beneath the site and to the amplification characteristics.

The micro tremor measurements were taken using velocity transducer, Guralp CMG-40T-1(1s to 100 Hz) and 24 bit DM24-S3 digitizer at sample rate of ~100 samples/sec. About 45 minutes to one hour of seismic noise was recorded at each station. The location of each site was determined by using GPS receivers. In total about 240 samples were collected in different parts of the valley (Fig. 22). First of all the data was visually and then analyzed to remove singularities, if any. All three components data were collected in Guralp Compress Format (GCF), which is transformed into Simple Alignment Format (SAF). Data was processed applying the horizontal to vertical (H/V) spectral ratio method (after Nakamura, 1989), using the GEOPSY software. The fundamental frequency was calculated for each point (Fig. 22).

The HVRS at different sites of Doon valley ranges between the predominant frequencies of 0.13 to 12.77 Hz. The lower frequency range (0.13 - 4.5 Hz) is related to the Quaternary deposit, and the higher frequency to the Siwalik group (Fig. 23). Variations within short distance may be due to variation in compactness of sediments. The results reflect spatial distribution of the soft sediments in the study area in terms of the resonance frequencies. Further, an average thickness of soft sediment is estimated from the observed fundamental frequency. The use of microtremor, therefore, constitutes an effective and inexpensive approach to site response and soft soil thickness estimation for preliminary microzonation results.

Model HVSR Matlab routines (Herak, 2008) were used to invert the observed HVSR spectra to obtain the most likely geotechnical models of the soil. The algorithm is based on a combination of the simple and the guided Monte Carlo search, in the model space. Assuming that recorded noise is composed of body waves, vertically incident from the half space, the theoretical HVSR was computed for all HVSR measurements based on the initial above constrained. In the large majority of cases, a reasonable fit between the observed and the theoretical HVSR is obtained (Fig. 24). By inversion of the HVSR, we obtained the depth profile (Vs) in the representative sites in the Doon valley.

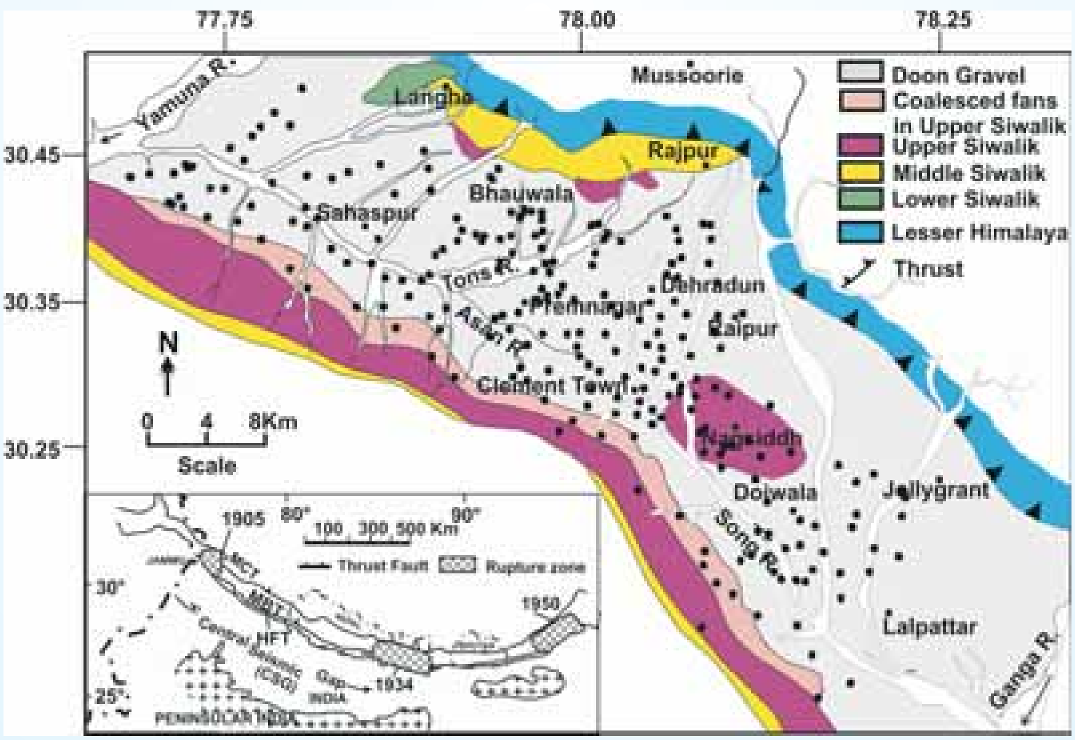

Fig. 22: Geological environment in Doon valley (after Nossin, 1971) and location of observation/survey points (black dots). Inset: Tectonic map of Himalayan region showing central seismic gap and rupture zones (shaded) of great earthquakes (modified from Khattri, 1999).

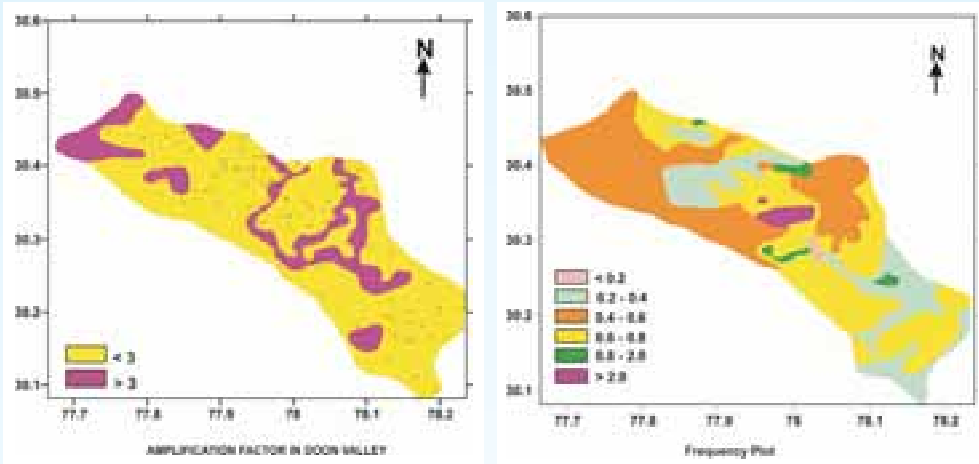

Fig. 23: Predominant frequency and amplification obtained from HVSR in the Doon valley.

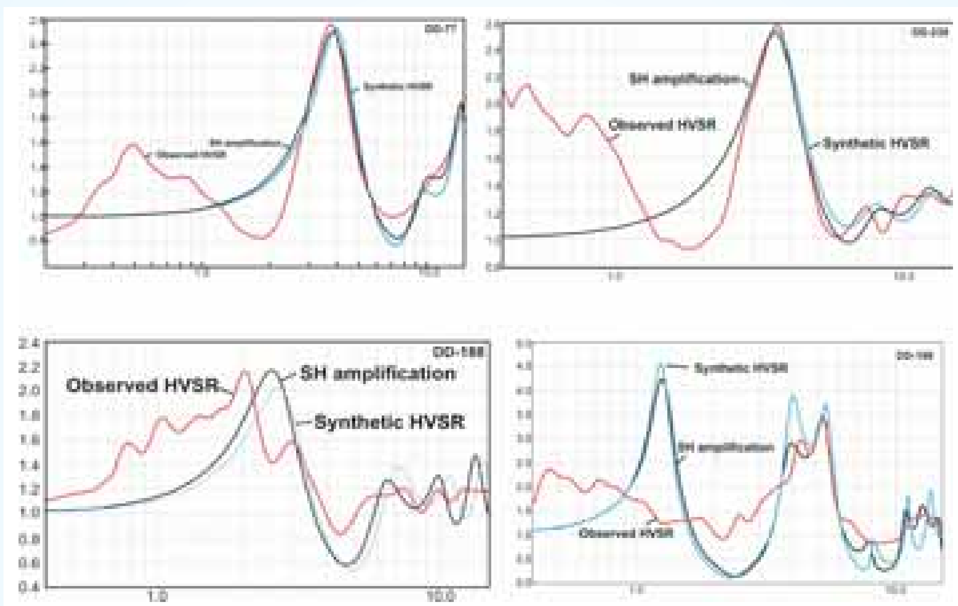

Fig. 24: Samples of the matching theoretical and observed HVSR curves to get the depth profile.

TAT - 3.4

Identification of Active Faults, Paleoearthquake ruptures and quantification of Fault slip history between HFT and MCT: Implications to Seismic Hazard Assessment in Indian Himalaya

(G. Philip, N. Suresh, R.J. Perumal, Pradeep Srivastava, B.K.Choudhuri and Khayingshing Luirei)

TAT - 3.4a

Active tectonics and paleoseismological studies within the zones of Himalayan Frontal Thrust and Main Central Thrust in Uttarakhand and Himachal Himalaya.

(G. Philip and N. Suresh)

During the year, the study has been carried out mainly in the Doon valley in Garhwal Himalaya and the Logar Gad valley in Kumaun Himalaya. The satellite data helped delineating surface expression of Quaternary faults in these valleys. In Doon valley the Bhauwala fault, identified by earlier workers near the Bhauwala township, is being further studied to understand its displacement behaviour in the Quaternary. The GPR survey carried out across the fault has verified the existence and limited subsurface trend of the fault. This active fault, which runs almost parallel to the MBT, has displaced the Quaternary alluvium (Doon gravels). It is therefore essential to investigate in detail the timing and magnitude of the past large magnitude seismic events in the Doon valley. Hence it is planned to carry out trench excavation surveys for paleoseismic investigations across the Bhauwala fault in the forthcoming year. Towards this, potential sites have also been identified.

In Kumaun Himalaya, the Logar Gad fault in Logar Gad valley, reported by Valdiya (1992) has been studied in further detail. The explicit expression of the fault identified and mapped on the satellite image has been established in the field. This NW-SE trending fault observed in the Quaternary alluvial fan coincides with the MBT near Logar village. The Tertiary rocks (~Dharamsala Formation of Oligocene-Lower Miocene overlain by the Siwalik group of rock of post-Miocene) form the footwall. The hanging wall is occupied by the pre−Tertiary rocks belong to Bhimtal-Bhowali formation with a definite tectonic contact with the rocks of Upper Tertiary (Siwalik) group of rocks. In the hanging wall, the Bhimtal-Bhowali formation mainly comprises of alternate sequence of quartzite and meta-volcanics. The Bhimtal volcanics is massive green amygdaloidal and vesicular basalts transformed largely to amphibolites and chlorite schist. At the same time the Amritpur granite, which is a porphyritic granite, is characterized by 5 to 8 cm long phenocrysts of feldspar, and has intruded into the quartzite meta-volcanic sequence of Bhimtal-Bhowali formation. This pre-Tertiary rocks are thrusted over the Tertiary rocks. The Quaternary fan developed at Logar village consists of clasts, both from the pre-Tertiary Bhowali-Bhimtal formation, Amritpur granite and the Tertiary lithological units.

At Logar, the linearly trending Logar Gad fault in the Quaternary fan has deflected the Kakarchar Gadhera, the major tributary of Logar Gad to its west. The alluvial fan is faulted (normal fault) with a measurable fault length as expressed on satellite data is about 4.5 km. The faulted and uplifted fan also shows wind gaps and water gaps besides depressions (sag ponds) developed in the hanging wall. Although, the NW-SE trending fault scarp is modified and cut across at places by seasonal streams, the scarp height varies all along the fault length, and reaches a maximum of 38 m from the present day river bed at Logar. Based on the surface expression of the discontinuous scarp, the fault has been further extended on either side to a total length of ~7 km where drainages and lakes are also aligned parallel to this fault.

Fig. 25: A part of the trench wall across Logar Gad fault (F-F) at Logar village in the vicinity of the MBT in Kumaun Himalaya. Reactivation after giant earthquakes on the mega thrust is considered to generate this normal fault.

To understand the nature of the fault, a trench excavation (15x5x5 m) survey across Logar Gad fault at Logar village has been carried out (Fig. 25). The trench wall shows explicit expression of normal faulting. While the study is in progress, this normal fault in the vicinity of the MBT in northwestern Himalaya is considered to be the result of multiple reactivations after giant earthquakes on the mega thrust.

TAT - 3.4b
Timing, size, and lateral extent of earthquake ruptures along the Himalayan Frontal Thrust *(TSLER-HFT)*

(R.J. Perumal, Pradeep Srivastava and B.K. Choudhuri)

Geometric and kinematic analyses of minor thrusts and folds, which record earthquakes between 1200 AD and 1700 AD, were performed for two trench sites (Rampur-Ghanda and Ramnagar, India) located across the Himalayan Frontal Thrust (HFT) in the western Indian Himalaya (Fig. 26). The present study aims to re-evaluate the slip estimate of these two trench sites by establishing a link between scarp geometry, displacements which is observed very close to the surface, and the slip at deeper levels. It is for the first time we report that in the south-eastern extent of the western Indian Himalaya, Ramnagar scarp consists of minimum two events (i) pre 1400 AD, and (ii) unknown old events of different lateral extents with overlapping ruptures (Fig. 27). If to be more optimistic, two seismic events scenario is followed, the rupture length would be at least 260 km, and would lead to an earthquake greater

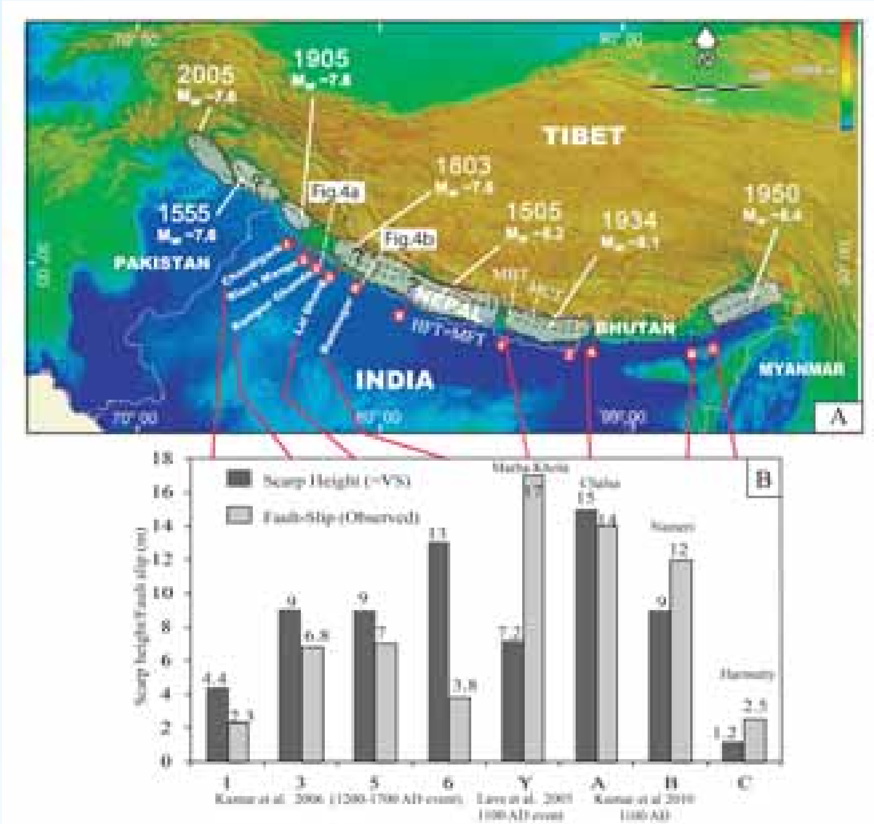

Fig. 26 : (Top) A simplified SRTM (Shuttle Radar Topographic Mission) map showing Historic earthquake ruptures and location of trenches. (Bottom) Histogram showing fault slip determined from trench investigations together with corresponding trenched fault scarp height.

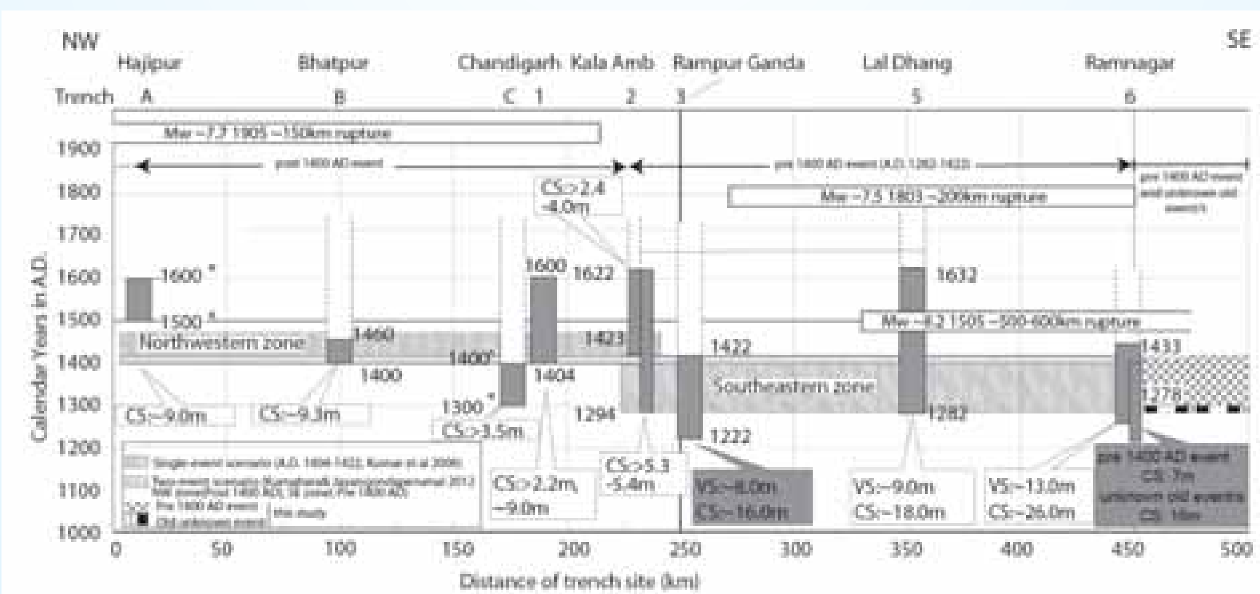

Fig. 27: Space-time diagram showing timing of surface rupturing events studied by previous workers together with the re-evaluated fault slip for studied trenches.

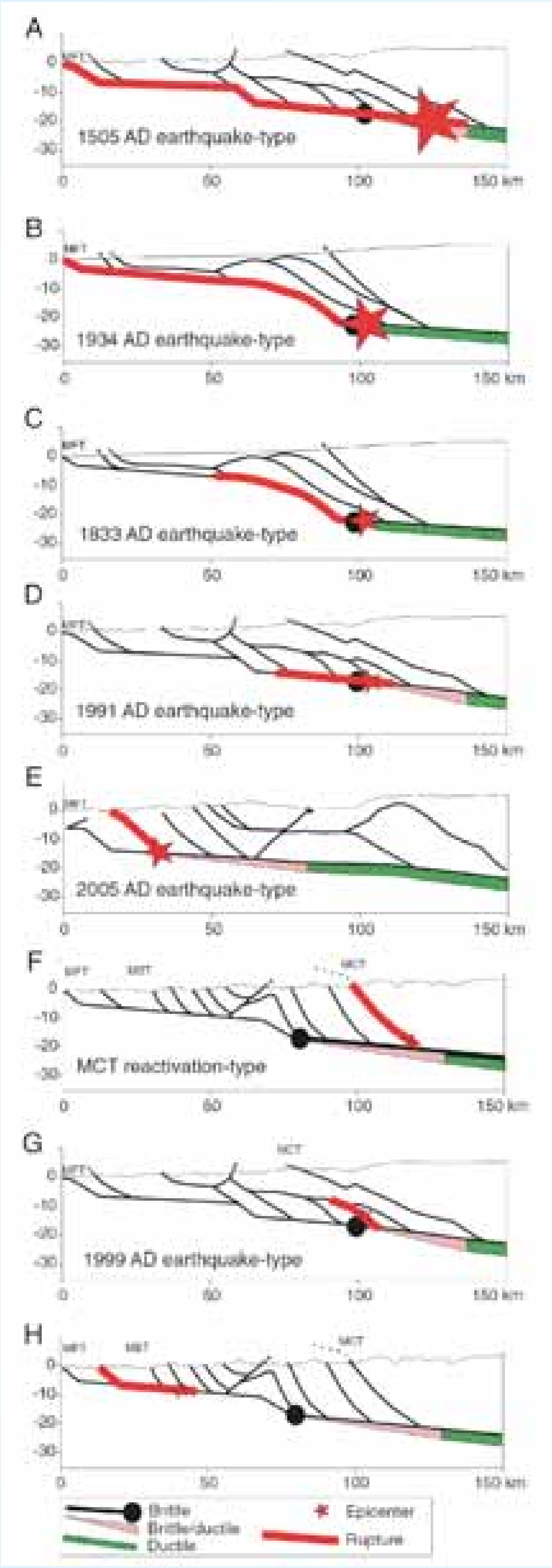

Fig. 28: A sketch showing different types of Himalayan earthquake ruptures.

than Mw 8.5 (Jayangondaperumal et al., 2013).

A major question about the Himalaya remains open: does a great earthquake (like the Mw ~8.1 of the 1934 earthquake) release all the strain stored by the Tibet-India convergence during the preceding interseismic period and only that strain, or can it also release a background store of energy that remained unreleased through one or more earlier earthquakes, and so potentially engender giant events or a relatively random sequence of events? To consider this question, the history of the great earthquakes of the last millennium are investigated here, by combining data provided by the historical archives of Kathmandu, trenches through surface ruptures, isoseismal damage mapping, seismites, and the instrumental record. Geometric and rheologic controls for the different types of ruptures during the medium (Mw ~7), great (Mw ≥8), and giant (Mw >8.4) earthquakes are illustrated in structural cross-sections (Fig. 28). It is found that the epicenters of great Himalayan earthquakes are located on the basal thrust farther north or close to the locked zone, which is defined from geodetic measurements of regional deformation during the interseismic period. Thus, it suggests that, great earthquakes initiate in a wide transition zone between exclusively brittle and exclusively creeping regimes, the extent of which depends on the dip of the Main Himalayan Thrust.

TAT - 3.4c:
Morphotectonic evolution of the Himalayan frontal belt between Kosi and Kali rivers, Kumaun Himalaya

(Khayingshing Luirei)

The Himalaya frontal part around eastern extremity of the Kumaun Himalaya in Tanakpur area is characterized by aggradational landforms. Geomorphologically, the study area is constituted by various levels of coalescing fans and terraces. Fans comprise predominantly of sandstone clasts laid down by the steep gradient streams originating from the Siwalik range. The alluvial fans are characterized by compound and superimposed fans with high reliefs. They are interpreted to be directly related to the tectonic activities associated with the Himalayan Frontal Thrust (HFT). The fan deposits in the foot hills are as old as 50 ka to sub-recent (~ 5 ka); while some other fans are as young as two years. Due to the lack of exposure of the contact between the fan deposits and the bed rocks initiation of the deposition of fans cannot be ascertained. Recent tectonic activity is observed in the form of truncation of fan as a result of uplift along the HFT. The truncated fan is observed as an escarpment running almost E-W for about 5 km and about 100 m height. At Senapani two phases of tectonic activities are imprinted in the Quaternary terrace deposit resting on the hanging wall of the HFT. The first phase is represented by tilting of the terrace sediments by 30° towards NW direction; while the second phase is evident from deformed structures in the terrace deposit comprising mainly of reverse faults, fault propagation folds, convolute laminations, flower structures and back thrusts. The second tectonic uplift produced a fault-slip of ~1.0 m in the terrace sediments. The lower deformed and the upper undeformed inclined fluvial sediments give OSL age of 40 ka and 34 ka, respectively. Inclined and deformed terrace deposit suggests tectonic activity along the HFT that took placed after 34 ka, while fault escarpment and strath terrace indicate uplift along the HFT post 10 ka. Similar tectonic landforms are also recognized across the splay thrust of the HFT in the form of up-warped fan observed towards south of the HFT trace. The mountain front of the Tanakpur is characterized by faulting-parallel landforms pertaining to tectonic activities (Fig. 29).

In the Ramnagar-Kaladhungi area the objective is to correlate the drainages and landforms developed across mountain front defined by the Himalayan Frontal Thrust (HFT) with the geomorphic indices determined. This thrust traced between the Dabka and Baur rivers in the Kumaun Himalaya is morphogenic in nature, where a 100 m high escarpment extending for about 21 km trends almost E-W. Geomorphological evidences suggest westward migration of the Dabka River by ~10.5 km; while Baur River has migrated eastward by ~5.2 km as a result of uplift of hanging wall along the HFT. At Laldhang the HFT is offset by transverse fault which suggests that faulting postdates the reactivation of the thrust between 500 to 100 ka. Different levels of strath terraces along the mountain front suggest episodic uplift. Morphometric indices such as stream-gradient (SL) index, mountain front sinuosity (S_{mf}) index, ratio of valley floor width to valley height (V_f) are computed. Values of the former two, the first being high, strongly correlate with field evidences. The HFT zone is characterized by high value of SL. The Lesser Himalayan rocks have overridden the colluvial deposit along the Main Boundary Thrust (MBT). In the northern dipping limb of the Pawalgarh Anticline the Quaternary sediments, resting over the Upper Siwalik sandstones, are tilted by 24° towards NE; while in the hanging wall of the Pawalgarh Thrust the sediments are tilted by 10° towards NW. This implies active deformation suffered by the Quaternary sediment due to uplift along the Pawalgarh Thrust.

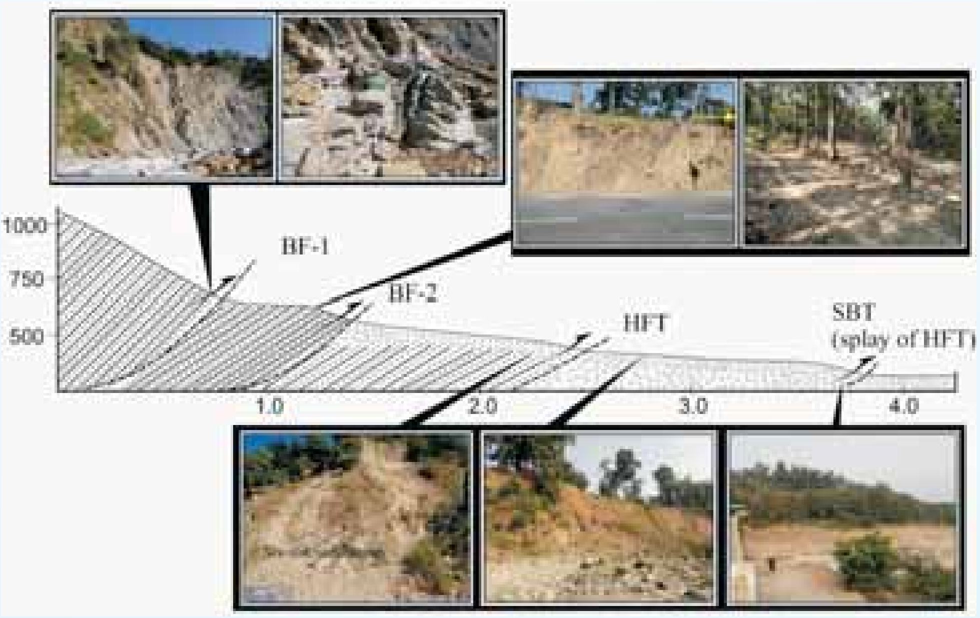

Fig. 29 : Schematic diagram supported by photographs showing tectonic landforms developed around Bastia north of Tanakpur.

TAT - 3.5

Geoengineering studies and the Petrophysical characteristics of rocks in the selected transects of Uttarakhand and Himachal Himalaya

(Vikram Gupta and B.S. Rawat)

Various rock types including highly deformed to undeformed quartzites, granites, granitic gneisses, gneisses, metabasics and dolomites collected from different formations of the Lesser and Higher Himalaya were tested to evaluate correlation between (i) the uniaxial compressive strength (UCS) vs point load test (PLI), and (ii) between Schmidt hammer rebound (SHR) value vs compressional wave velocity (Vp). Various equations have been developed using regression analysis between UCS & PLI, SHR & Vp and compared with the equations developed by other researchers around the world.

It has to be noted that various geotechnical properties are attributed to mineralogical and textural characteristics of rocks. Also, that quartzites, despite being mono-mineralic, exhibit vast variation in properties. Thin section studies revealed that different micro-fabrics in the quartzites are associated with different deformational phases operative during tectonic activity of an area. Therefore, it is opined that deformed and un-deformed rocks should be grouped separately while deriving such equations.

The study has also been carried out on the influence of quartz microstructures on the seismic wave velocities in the Himalayan quartzites of the Garhwal Himalaya. Quartzites consisting dominantly of quartz mineral were chosen for the study so as to nullify the effect of other mineral constituents on the seismic velocity. Samples were collected from different tectonic settings of the Higher and Lesser Himalaya. These are mainly Pandukeshwar quartzite collected from the hanging wall of MCT, Tapovan quartzite collected from the MCT zone and Berinag quartzite collected from the foot wall of the MCT. The samples of Berinag quartzite were collected from near the klippen and the thrust, termed as Alaknanda Thrust. The vast differences in microstructures and associated seismic wave velocities have been noted in different quartzites. It has also been observed that quartzites of the MCT zone and Alaknanda Thrust have higher seismic velocities, whereas quartzites located around Nandprayag Klippen have the lowest seismic wave velocities.

During the year, kinematic rock fall hazard assessment along a transportation corridor between Chamoli and Badrinath in the Upper Alaknanda valley, Uttarakhand Himalaya has also been carried out. All along the transportation corridor, in-situ Lesser and Higher Himalayan rocks are exposed at 23 localities. These rocks are highly jointed and in view of the orientation of the joints with respect to the slope direction, blocks of rock of varying sizes are susceptible to fall, endangering the vehicular traffic and the numerous village settlements along the route. It has been observed that the orientation of the discontinuities in rocks of the Higher Himalaya with respect to the slope/transportation route is such that, greater part of the area in the Higher Himalaya lies in the low to moderate hazard, contrary to the area in the Lesser Himalaya.

Further, soil samples of the Bhagirathi valley have also been collected, and the process of analyzing for the extraction of various geotechnical properties is underway.

TAT - 4: BIODIVERSITY - ENVIRONMENT LINKAGE

TAT - 4.1

Geobiological study of the Neoproterozoic-early Cambrian sequence of carbonate belt, Lesser Himalaya including study of microbiota and microbiotic processes and their interpretation in terms of palaeo-environment and correlation of evolutionary trend with global bioevents

(Meera Tiwari and Santosh K Rai)

Ichnofossils are employed as a significant tool to understand the behavioral, sedimentological and ecological events during the Ediacaran-early Cambrian explosion of life as they carry the records of life and events that existed *in situ*, during or soon after the deposition of sediments. Mussoorie Syncline in the Lesser Himalaya, India, represents one of the best sites for the occurrence of the early Cambrian trace fossils. The arenaceous member of the Deo-Ka-Tibba Formation contains a number of ichnofossils (Banerjee et al. 1976; Singh and Rai 1983; Tripathi et al. 1984; Tiwari and Parcha 2006). A very well preserved ichnospecies *Psammichnites* sp. Cf. P. *gigas* has been identified from this member (Fig. 30). Samples containing *Psammichnites* were collected from purplegrey siltstone bed of arenaceous member of the Deo-Ka-Tibba Formation, exposed along the Mussoorie-Dhanaulti road section.

The specimens are well preserved, non-branching slightly curvilinear, bilobate burrows, broadly curved and cross cutting with a uniform diameter. These burrows are overcrossing and look like rope passing over one another.Considering the kind of backfill, the transverse sculpture on the ventral, and a sinusoidal line on the dorsal side, *Psammichnites gigas* has been interpreted as the work of a slug-like animal that bulldozed inside the sediment and collected food from the surface with a pendulating siphon. It is usually interpreted as a trail made by burrowing gastropod or shell-devoid molluscs. It is known from lowermost Cambrian shallow-marine deposits of Sweden, Australia, Greenland, Spain, France, Canada, United Sates, Sardinia and South Australia (Torell 1870; Hofmann and Patel, 1989; Walter et al., 1989; Pickerill & Peel, 1990; Zhu 1997; Alvero & Vizcaino 1999; Jenson et al. 2002; Dzik 2005; Jago and Gatehouse 2007). The presence of *Psammichnites* sp. Cf. *P. gigas* is a significant addition to the known fossil record of the Tal Group. Its presence further confirms that the stratigraphic succession of Tal Group is of an early Cambrian age and shows shallow environment of deposition.

Fig. 30: Psammichnites sp. cf. P.gigas, inset showing the flattened figure of eight, and the arrow marks at the median furrow.

TAT - 4.2

Bio-event stratigraphy of the Lower Paleozoic successions of Himalaya in context with global event stratigraphy

(S.K. Parcha)

Stratigraphic and sedimentological analyses of well-preserved Lower Paleozoic deposits of Himalaya are critically significant for understanding the depositional environments as well as the chronology and evolution of contemporary tectonic episodes. The sedimentary history of the Tethyan Himalayan region as a whole and that of the Lower Paleozoic times in particular are under a considerable debate throughout. Evaluation of bio-events in the Lower Paleozoic successions of Zanskar-Spiti, Kumaun-Garhwal, Kashmir and their relation to these events in the Himalayan region will help to bring the precession in global correlation and the relationship of organisms to the paleoenvironmental condition.

Trace fossil evidence from late Permian succession in Guryul ravine, Kashmir

The present study is focused on the Late Permian (Changhsingian) succession, present in the Guryul ravine, Kashmir Basin. The basin has a complete Cambro-Triassic sequence and thus contains a unique position in the geology of Himalaya. The Guryul Ravine Permian mainly comprises of mixed siliciclasticcarbonate sediments deposited in a shallow-shelf or ramp setting. The present assemblage of Ichnofossils is the first significant report of trace fossils in the Guryul ravine since early reports in the 1970s. The Ichnofossils reported from this section include: *Diplichnites, Dimorphichnus, Monomorphichnus, Planolites, Skolithos* along with burrow, scratch marks and annelid worm traces? The ichnofossils are mainly preserved in medium grain sandstone-mudstone facies. The Ichnofossils are widely distributed throughout the section and are mostly belonging to arthropods and annelid origin, showing behavioral activity, mainly dwelling and feeding, and evidence the dominant presence of deposit feeders. The vertical to slightly inclined biogenic structures are commonly recognized from semi-consolidated substrate which are characteristic features of the near shore/foreshore marine environment, with moderate to high energy conditions. The topmost layer of silty shale contains trace fossils like *Skolithos* and poorly preserved burrows. The burrow material filled is same as that of host rock. The studied Zewan C and D sequence represents the early to late part of the Changhsingian stage, from 40 to 5 m below the top of Zewan D member with bioturbation still evident in some limestone layers till 2 metres above. No trace fossils could be recognized in the topmost 3 m beds of Zewan D due to their gliding related amalgamated structure. The widespread distribution of traces and their in situ nature will be useful for interpretation of the paleoecological and paleoenvironmental conditions during the late Permian in the Guryul ravine of Kashmir.

Ichnofossils from the Early Cambrian successions of Chandratal section of the Spiti Basin

The early Cambrian succession is well preserved in the Chandratal section of the Spiti Basin. The Chandratal area contains well preserved ichnofauna. Ichnofossils identified in this section are: *Chondrites, Dimorphichnus, Isopodichnus, Lockeia, Monomorphichnus, Nereites, Palaeophycus, Planolites, Scolicia* and *Skolithos* along with some scratch marks. These Ichnofossils reflects diversified behavioural activity in response to the changing environmental conditions. The distribution of Ichnofossils in the Chandratal section indicates that with the increase of energy level the complexity of Ichnofossils also increases. The diversity of the Ichnofossils is represented by the development of Nereites to Skolithos ichnofacies. The complexity of Ichnofossils represents a depositional environment ranging from abyssal to intertidal. These studies show that the early Cambrian succession of the Chandratal region was deposited under fluctuating wave and current energy.

Species Opsidiscus from the Middle Cambrian succession of the Spiti Basin

The Middle Cambrian Genus *Opsidiscus*, along with other trilobite forms dominates the lower Middle Cambrian succession. In the present study two new species of *Opsidiscus, Opsidiscus wadiai* and *Opsidiscus srikantiai* are reported from the lower Middle Cambrian succession of Debsakhad section. The species were differentiated on their morphological features and their multivariate analysis. The multivariate analysis applied here is used as a supplement method to qualitative analysis in order to differentiate between the cranidial characters of *Opsidiscus*. The qualitative study of each species studied individually shows more or less close affiliation as is observed by different quantitative methods. The presence of *Opsidiscus* has a great stratigraphic significance in this region, as they first appear from informal Stage 5 of Series 3 and goes up to the Drumian Stage of Series 3 of the Cambrian System in the Debsakhad section, which helps to correlate this section with other well-known sections of the idle Cambrian. In total nineteen cranidia of *Opsidiscus* were studied by qualitative and quantitative methods. On the basis of their morphological features, primarily two species were identified. The quantitative analysis applied here is used as supplement to qualitative analysis in order to differentiate the two groups of *Opsidiscus* on the basis of cranidial features. In the present study various quantitative analysis, were applied on the specimens of Opsidiscus (Cranidium) to verify the interpretation based on morphological study. It has been observed that the bivariate plots are useful to interpret the relationship between two variables and also to define their linear relationship. The present study shows a positive linear relationship ($r^2 = 0.92$ for a1 vs a2 and $r^2 = 0.83$ for g1 vs g2), which is further supported by cluster analysis. The quantitative data supports the qualitatively.

Geochemical studies of Neoproterozoic metasedimentary rocks of the Batal Formation, Haimanta Group, Spiti Basin

The geochemical studies carried out on Neoproterozoic metasedimentary rocks of the Batal Formation, Haimanta Group in the Spiti Basin suggests that deposition of sediments took place in an active continental to passive margin environment. The sediments were considered to be derived from recycled quartzose sediments. The recycled sources represent quartzose sediments of mature continental provenance, and the derivation of the sediments could be from highly weathered granite, gneiss terrain and/or from a pre-existing sedimentary terrain. Further, the sandstones reflect the highly weathered source area with presence of clay minerals that were derived during the cold period. From the studies it is also envisaged that the sediments were deposited under low to moderate oxygenated environmental conditions.

Micro faunal assemblages of the Ordovician-Silurian successions, Pin Valley, Tethys Himalaya

In the present studies the carbonate beds in Ordovician and Silurian successions yielded a number of micro fossils, among which are the calcareous algae (Dasycladacea), bryozoans, crinoids stems, broken fragments of cephalopods, lamelli branches, hyolithids together with the brachiopods; fragmentary remains of arthropods and trace fossil. The various genera of bryozoan identified are as *Calloporella*, *Cyphotrypa*, *Dekayai*, *Eridotrypa*, *Insignia*, *Trematopora*, etc. with these a variety of calcareous algae were found in association in the same thin sections. Among them, the prominent genera are *Dasyporella*, *Moniliporella*, and *Vermiporella.* The diversity of bryozoans as well as calcareous algae also increases as we go higher in the succession. The body fossils reported from these formational units are *Dalmanella*, *Orthis*, *Plectorthis*, *Rafinesquina* and *Pentamerus.* In the light of these studies, an attempt been made to correlate it on the generic level with the analogous successions of the Kinnaur and with the other well-known sections of the world. The genus *Vermiporella* is widely known genus reported from the Ordovician successions of the Tarim basin China, eastern North America, Baltic region, Poland, and Scotland. The genus is also reported from the Silurian successions of Netherlands, Sweden and in India from the Kinnaur basin. The genus *Dasyporella* is reported from the Middle to Late Ordovician successions of the Tarim basin in China, eastern Kazakhstan, Utah, Nevada, Norway and India. In the northern California *Dasyporella* is reported from the Silurian successions. The genus *Moniliporella* ranges in age from Middle Ordovician to Early Silurian successions of the Tarim basin and from eastern Kazakhstan. Parcha and Pandey (2008) report the genus *Moniliporella* from the Pinsection in India. In the present studies, it has been observed that *Dasyporella* and *Vermiporella* are most abundant in the Middle- and Late-Ordovician. The combination of the presence of brachiopods, bryozoans and calcified green algae in this succession indicates shallow marine to near shore environmental conditions followed by different stages of regression and transgression.

TAT - 4.3
Paleogene and Neogene foraminiferal biostratigraphy, sedimentation and paleoclimate change of the Assam-Arakan Basin, northeast India

(Kapesa Lokho and V.C. Tewari)

Ichnofossils from the Middle Bhuban Formation, Northeast India

A range of depositional environments from shallow marine-deltaic and brackish water-outer neritic-bathyal settings were interpreted by various workers for the Surma Group of rocks in the Northeast India. This wide range of paleoenvironment are due to presence of calcareous benthic and agglutinated foraminifers, occurrence of abraded shallow marine benthic foraminifers and dominance of marginal marine palynofossils associations. A broad environmental setup ranging from deltaic-foreshore-shoreface-offshore for the deposition of the Middle Bhuban Formation was suggested by Tiwari et al. (2011) based on the *Skolithos* and *Cruziana*ichno facies at Bawngkawn locality Aizwal, Mizoram. In present work, while mapping and collecting pilot sampling from the Middle Bhuban Formation in and around Aizawl town (Mizoram), traces of ichnogenus *Psilonichnus* were collected along with *Skolithos, Teichichnus and Ophiomorpha.* The significance of particular ichnogenus *Psilonichnus* in reconstruction of paleoenvironmental setting is discussed by several workers. A combined ichnological-sedimentological model for shoreface-estuarine-fluvial settings was proposed by Nesbitt & Campbell (2006).

World wide, the ichno genus *Psilonichnus* has proved to be an extremely useful paleoenvironmental indicator, in studies of sequence stratigraphy, and in identification of past sea-level positions in tropical carbonate settings. Different ichno species of *Psilonichnus* ichno genus have been recorded from the supra-tidal to shallow shoreface, and in estuarine settings, but not in deep water or in fluvial or terrestrial environments (Nesbitt & Campbell, 2006). The ichno genus *Psilonichnus* recorded here is represented by the ichno species *Psilonichnus upsilon.* The occurrence of *Psilonichnus upsilon* with abundant *Skolithos*i sp. indicate the presence of *Skolithos* ichno facies. The *Psilonichnus upsilon* burrows from the Miocene succession of the Middle Bhuban Formation were collected throughout the sections from silty-shale and sandstone beds, and filled by sands and occur in association with abundant *Skolithos*. Therefore, we interpret them as having been produced under a shallow marginal-marine channel complex dominated by tidal channels as evident from the soft sediment structures (Fig. 31), cross- and flaser-bedding structures (Fig. 32a,b) and presence of *Ophiomorpha* which indicate a high rate of sedimentation. An integrated ichnological-sedimentological framework

Fig. 31: Soft sediment deformations structure preserved at sole of the sandstone beds of the Durtlang section and the Chanmari section.

Fig. 32: a) Cross bedding preserved in sandstone at the Durtlang section, b) Flaser bedding at the Durtlang section.

indicates that the Middle Bhuban Formation in the Mizoram region was deposited under shallow marginal-marine channel complex dominated by tidal channels where the tidal and wave actions are dominated along the boundary of Estuarine and marine setting (Fig. 33). The preserved sub-vertical burrow also indicate that the burrowers affect the substrate, developing traces usually in vertical direction for the space availability to compensate sediment erosion produced by storm waves and wave currents.

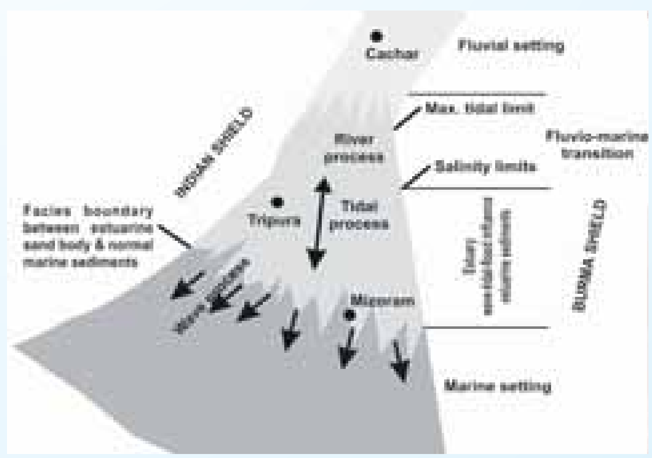

Fig. 33: Paleoenvironmental reconstruction of the Middle Bhuban Formation, Mizoram, Northeast India.

Sedimentogical and Paleoclimatic studies

During the year, sedimentological and paleoclimatic studies were carried out on the samples collected from Nagaland. Petrographic thin sections of the Disang Group (late Cretaceous to late Eocene) and Barails (late Eocene to Oligocene) in the AssamArakan sedimentary basin of the NE India have been studied in detail. The samples were collected from the Botsa section; Wokha road section, Phiro section, Shankitong section and Yekhum section of the Nagaland area. The sandstones and shales were studied for the petrographic, mineralogical, nature of sediments, source rock characterization, paleoenvironment, paleoclimate and tectono-sedimentary implications. The thick shaly-sandy sequence overlying a thick shale sequence of Disang Group in Nagaland is known as Barail Group. The underlying Disang and the overlying Barail are folded and occur in a number of localities and are the part of the inner Paleogene fold belt of Nagaland. Disangs are the oldest group of rocks of the Tertiary sequence in Nagaland. Disangs are predominantly made up of bluish grey and buff colour shales interbedded with thin beds of hard fine grained siltstone. The shales are highly sheared, shattered, crumpled as seen under petrographic thin sections. The sedimentary structures are not very commonly found. The overlying younger Barails are made up of well bedded sandstone alternating with thin beds of compact shales and silty shales. The coarsening upward sequence is deposited in the shallow marine environment (high energy tidal flat). The thin section of the Barail sandstones (Oligocene) reveals the presence of dominantly sub-angular to sub-rounded quartz grains and rock fragments from the sedimentary as well as metamorphic provenance. The sandstone may be classified as sub-lithi carenite. Subordinate mica flakes and feldspars are found. The presence of well developed sedimentary structures in the Barails like wavy bedding, ripple marks and cross laminations also indicate shallow marine near shore environment of deposition. Quartz is the main constituent of the Barial sandstone and monocrystalline to polycrystalline in nature. Feldspars like microcline, orthoclase and plagioclase are common. Muscovite and biotite micas are present. They show distinct cleavage and are pleochroic in nature. Biotite is brownish in colour and show parallel extinction. Muscovite grains show crumpling and bending along the grain boundaries. The rock fragments of igneous and metamorphic are found in the sandstones. The matrix is composed of the quartz and clay minerals. The cementing material is mostly ferruginous, and occurs as iron and clastic grains. Quartz overgrowth is common and authigenic in nature. Among accessories heavy minerals, black to brownish colour opaque minerals of iron oxide are commonly found. Rounded tourmaline and zircon grains are found as heavy minerals recycled from the earlier sediments. The petrography reveals that the Barail sandstone can be classified as quartz arenite and arkosic sandstone. A humid to sub humid paleoclimate is inferred for the Barail sandstone of the area. It is interpreted that brown to reddish sandstone indicates oxidizing conditions of depositional basin, however the grey colour sandstone must have deposited in less oxygenic conditions. The coarse thick bedded sandstone with well developed sedimentary structures suggests that it has been deposited in marine (shallow continental shelf) environment. The sandstone is mature, with mostly quartz grains, low in feldspar, rock fragments and accessory minerals etc. The angular grains indicate less transport of the sediments in some thin sections of the Barail sandstone. Diagenetic features under thin sections have been observed like stylolites (pressure solution phenomenon), kink banding in micas and quartz grains. The sedimentation history of the area suggests that the Disang shales were deposited in slightly deeper marine part of the basin. The overlying Barail sandstone is deposited in the passive continental margin and the climate was changing from humid in the lower part (coarse grained sandstone) to semi-humid to arid in the upper part (fine grained sandstone) as supported by petrographic studies. The depositional basin was tectonically active during the sedimentation of the upper Barail sandstone and the sediment supply may be from the Indo-Myanmar Orogenic Belt (IMOB).

TAT - 4.4

Biotic, mineralogical and geochemical investigations of Early Tertiary successions from NW Sub-Himalaya and western India with reference to India-Asia collision and faunal dispersals

(K. Kumar and N.S. Siddaiah)

Early Eocene land vertebrate fauna from the NW sub-Himalayan as well as western Indian sections

The study of Early Eocene land vertebrate fauna in reference to India-Asia convergence and faunal dispersals was continued. A total of 32 days field work was carried out in selected Paleogene sections of the NW sub-Himalaya and Western India for collecting and prospecting of vertebrates and associated biotic remains and mineralogical and geochemical studies. New collections were made from the NW sub-Himalayan as well as western Indian sections.

The dental remains of ziphodont (serrated-toothed) Crocodilia were reported for the first time from the Paleocene-basal Eocene Kakara Formation of Bakhalag-Bughar area (Solan District) in the northwestern sub-Himalaya, Himachal Pradesh (Fig. 34). Associated biotic remains comprise isolated teeth of diverse fish including the nurse shark *Ginglymostoma*, which was hitherto unknown from the Himalayan region and some invertebrate fossils including poorly preserved turritellid gastropods and a well preserved naticid gastropod entombed in a pyrite nodule. The new fossils are important additions to inadequately studied Paleocene-basal Eocene biota from the Himalayan region and shed additional light on palaeoecology and palaeo biogeography of that time. The ziphodont conical teeth from the Kakara Formation have a close affinity with the teeth of pristichamsines (Eusuchia) which are primarily terrestrial Laurasiatic crocodilians with their oldest previous record from the Late Paleocene of China and therefore provide evidence of faunal exchange between India and Asia during the

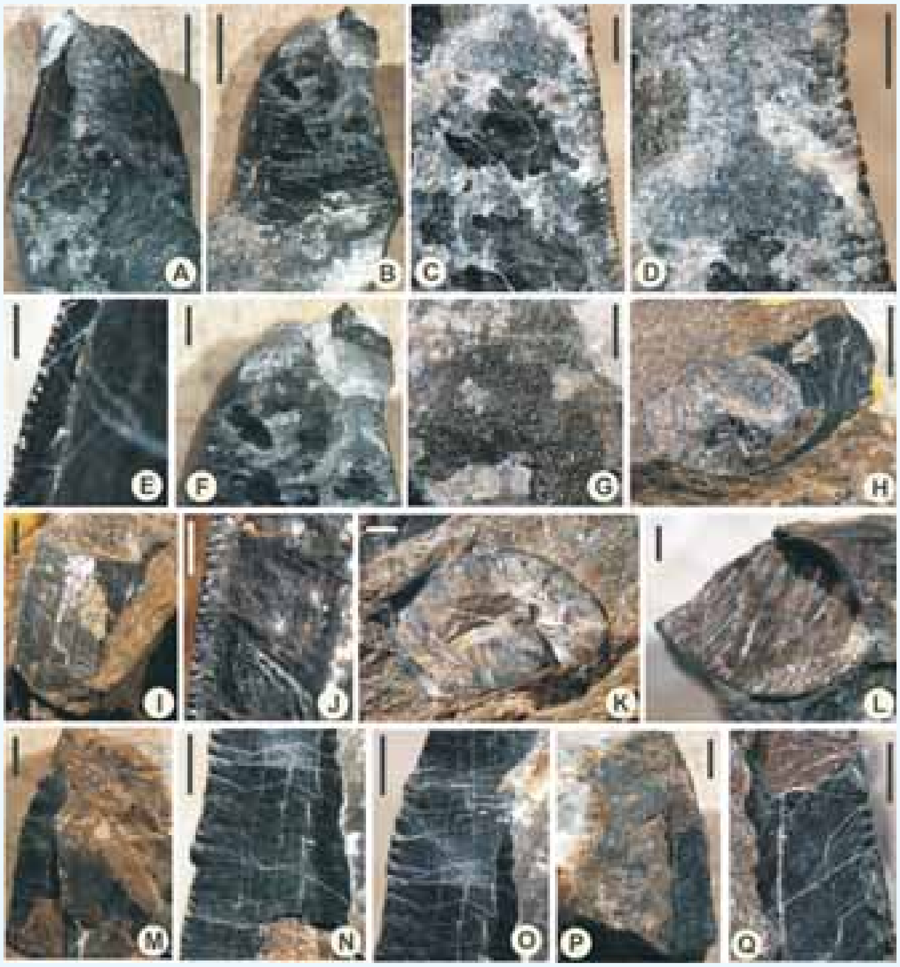

Fig. 34: Pristichampsinae gen. et sp. indet. isolated teeth A-G: labial and lingual views (A-B), close up of serrations along anterior ridge (C-D), close up of serrations along posterior ridge (E), close up of apical part of the tooth showing rugosity/wrinkling of enamel (F-G), Note the quartz vein piercing through the apical part of tooth (F). H-K: broken tooth in apical (H), labial (I-J) and cross-sectional (K) views. L-Q: cross-sectional (L), labial (M-O) and lingual (P-Q) views. Scale =5 mm in A, B and H, 2 mm in F, I, M and P, and 1 mm in C, D, E, G, J-L, N and O.

Late Paleocene-basal Eocene. Their occurrence in the shallow marine horizons is rather intriguing and suggests that possibly pristichampsines could also survive in shallow marine/coastal conditions. It is equally possible that their remains were washed into the marine realm from nearby coastal land. Either way their occurrence in the Kakara Formation raises the possibility of recovery of some vertebrate elements from coastal habitats, which will be valuable for palaeo biogeographic reconstructions.

The Ypresian Cambay Formation at Vastan Mine in Gujarat, western India,

The Ypresian Cambay Formation at Vastan Mine has yielded a rich herpetological fauna including snakes, lizards and amphibians, but strangely, lizards are only represented by Acrodonta. The acrodontan assemblage was described based on numerous, diverse and well-preserved dentaries, premaxillae, and maxillae (Figs. 35 to 38). Among the five taxa described one new genus and species characterised by a short splenial represents the youngest occurrence of the extinct family Priscagamidae. The other four taxa belong to the extant family Agamidae. Two of them previously known, *Vastanagama susanae* and *Tinosaurus indicus*, are here revised. The two other taxa are new. The first one, *Suratagama neeraae* gen. et sp. nov., is characterised by the presence of six small pleurodont teeth with a nearly cylindrical shaft and an obtusely pointed apex. The second, the *Indiagama gujarata* gen. etsp. nov., has rectangular teeth in lateral view, unicuspid crowns forming a nearly horizontal cutting edge, and wear

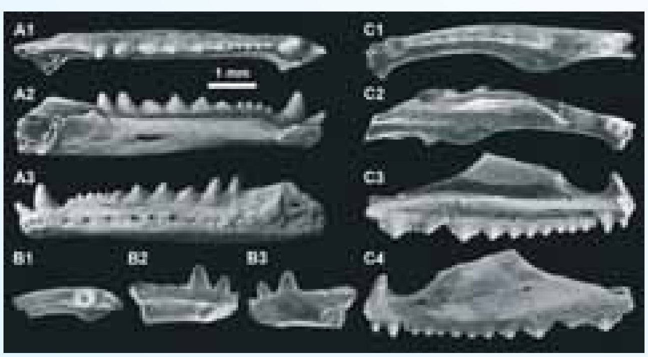

Fig. 35: *Heterodontagama borsukae* gen. et sp. nov., A. nearly complete left dentary, in occlusal (A1), lingual (A2) and labial (A3) views; B. anterior most part of a left dentary in occlusal (B1),lingual (B2) and labial (B3) views; C. nearly complete left maxilla in occlusal (C1), dorsal (C2), lingual (C3) and labial (C4) views.

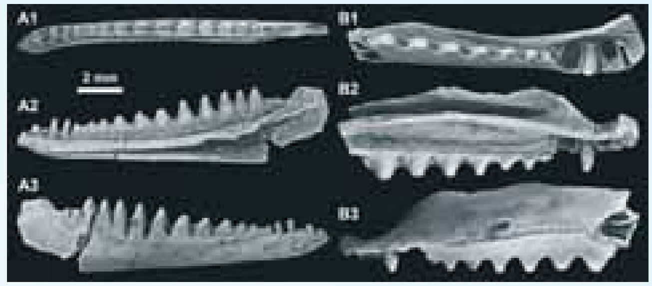

Fig. 36: *Suratagama neeraae* gen. et sp. nov. A. nearly complete right dentary, in occlusal (A1), lingual (A2) and labial (A3) views; B. nearly complete left maxilla in ventral (B1), lingual (B2) and labial (B3) views.

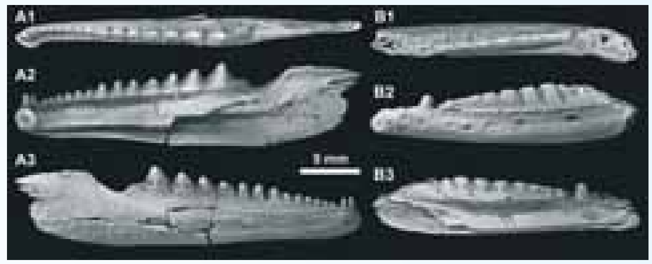

Fig. 37: A. *Vastanagama susanae*, nearly complete right dentary, in occlusal (A1), lingual (A2) and labial (A3) views. B. *Indiagama gujarata* gen. and sp. nov., nearly complete left dentary, in occlusal (B1), labial (B2) and lingual (B3) views.

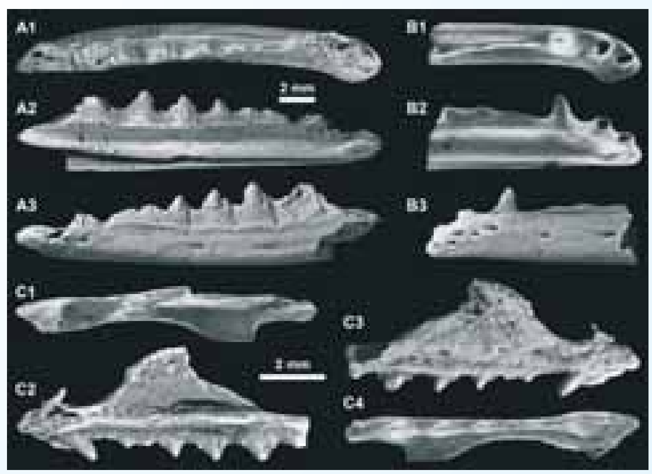

Fig. 38: *Tinosaurus indicus*, A. nearly complete left dentary, in occlusal (A1),lingual (A2) and labial (A3) views; B. anterior most part of a left dentary in occlusal (B1), lingual (B2) and labial (B3) views; C. nearly complete right maxilla in dorsal (C1), lingual (C2), labial (C3) and occlusal (C4) views.

facets on both the lingual and labial sides of the dentary. Our results confirm that Acrodonta is the only lizard group present in Vastan, whereas many other groups are already present from the beginning of the Early Eocene on the other continents. The diversity of the agamids in Vastan and the absence of non-acrodontan lizard in India tentatively support the Out-of-India hypothesis for agamids.

Apart from these studies, fresh attempts to collect continental vertebrate remains from the crucial Late Paleocene-Early Eocene horizons resulted in the find of some rodent remains from the older red beds of the Subathu Formation. The preliminary results were presented in the 24th ICMS. The detailed study of this material is being taken up on priority.

TAT - 4.5

Vertebrate faunal studies of the Neogene Siwalik Group (NW Himalaya) with reference to migration history and Himalayan uplift

(R.K. Sehgal)

In view of the recent fossil findings, especially micro-mammals (rodents - published in Quaternary International, 2012), a revision of the mammalian biostratigraphy of the Lower Siwalik sediments of Ramnagar was attempted and published. This locality is famous for primate fossils, and has yielded a rich and diversified mammalian assemblage. In all 46 mammalian species were recorded from the area and, among these 12 species have been reported for the first time from this area. Bulk of the fauna depicts a Lower Siwalik age for the sediments, and there are at least eleven taxa in the assemblage which are found to be restricted within the Chinji Formation of the type section in Potwar Plateau, Pakistan. No fauna belonging to the Kamlial Formation (older part of the Lower Siwalik) has yet been reported from India. Therefore, Ramnagar locality can be safely regarded as the oldest fossil yielding locality for Siwalik sediments in India. A distinct characterization of the mammalian assemblage from Ramnagar is reproduced in Table given below. Further the faunal assemblage from Ramnagar was compared to various other Lower Siwalik localities including the Chinji Type Section and Daud Khel (both in Pakistan), Kalagarh (India) and Dang Valley (Nepal). It shows a very close faunal resemblance with the Chinji Type Section, Daud Khel and Dang Valley. However, the Kalagarh assemblage is comparatively younger and represents Lower/ Middle Siwalik transition.

A rich and diversified mammalian assemblage is known from the Miocene sediments of India. Though the major part of the Miocene mammals is reported from the Siwalik sediments; there are also other localities and stratigraphic horizons from where significant mammalian faunas of Miocene age have been reported. In India, the Lower and Middle Siwalik sediments of Jammu (J&K), Kangra & Bilaspur (HP) and Kalagarh (Uttarakhand) have yielded rich and diverse continental

Faunal characterizations of Ramnagar fauna, with reference to the Chinji type section (after Sehgal, 2013)

First Appearance:	*Antemuschinjiensis, Megacricetodon* cf. *sivalensis, Sivacanthion complicates, Kanisamys* cf. *potwarensis, Sivapithecussivalensis, S. indicus, S.simonsi, Eomellivoranecrophila, Vishnuonyxchinjiensis, Percrocutacarnifex, Viverrachinjiensis, Vishnufelis* sp., *Prodeinotherium* sp., *Gomphotherium* sp., *Tetralophodon* sp., *Aceratherium perimense, Gaindatheriumbrowni, Brachypotherium* sp., *Chalicotherium* sp., *Hippopotamodon haydeni, Conohyuschinjiensis, C. sindiense, Propotamochoerus*sp., *Sus* sp., *Anthracotheriumpunjabiense, Hemimeryxpusillus, Dorcabuneanthracotherioides, D. nagrii, Dorcatherium majus, D. minus, D. nagrii, Giraffapriscilla, Giraffokeryxpunjabiensis, Helicoportaxtragelaphoides, H. praecox, Protragocerus gluten, Miotragocerusgradiens, Gazella sp., Kubanotragussokolovi*
Restricted Species: (within Chinji Formation)	*Antemuschinjiensis, Megacricetodon* cf. *sivalensis, Kanisamys cf. potwarensis, Eomellivoranecrophila, Vishnuonyxchinjiensis, Viverrachinjiensis, Hippopotamodon haydeni, Conohyuschinjiensis, Anthracotheriumpunjabiense, Dorcabuneanthracotherioides,Giraffapriscilla*
Survivor species: (from older horizons)	*Sivaladapis palaeindicus, Dissopsaliscarnifex, Amphicyon* sp., *Deinoitherium pentapotamiae, Chilotherium? intermedium, Listriodonpentapotamiae, Progiraffa* sp.

Miocene mammalian fossils. From the Himalaya, other than Siwalik Group, the Miocene mammals are on record from the Kargil Molasse Group of Ladakh Himalaya, and also known from the Murree and Dharamsala Group of the Himalayan foreland basin. From the Indian shield region, while a very significant Miocene mammalian assemblage, both continental and marine, has been reported from Kutch, Gujarat (western India), a beginning has been made very recently from Baripada Beds, Orissa (eastern India). A synthesis of the Miocene mammals from India and future prospects of fossil mammal studies is published. The map showing the important Miocene mammalian localities of India is given as figure 39.

A rich assemblage of macro-mammals was recovered from the red mudstone succession of the Middle Siwalik subgroup, exposed in the vicinity of Nurpur, District Kangra Himachal Pradesh. The systematic description of the fossils recovered was attempted. In all nine species have been described, and among these five species are being reported for the first time from this area, which include *Dissopsaliscarnifex, Aceratherium perimense, Hippopotamodon* (=*Dicoryphochoerus*) *vinayaki, D. minus* and *Hydaspitherium megacephalum*. The fossil material includes the lower and upper dentition, and the taxonomic characters of the dentitions are well preserved. All the above mentioned taxa are known from the Middle Siwalik subgroup. The mammalian fossils representing *Hippopotamodon vinayaki* and *Hydaspitherium megacephalum*, hitherto unknown from Nurpur area, are known to be restricted in the Dhok Pathan Formation of the type area in Potwar Plateau, Pakistan. In view of the new fossil discoveries as a

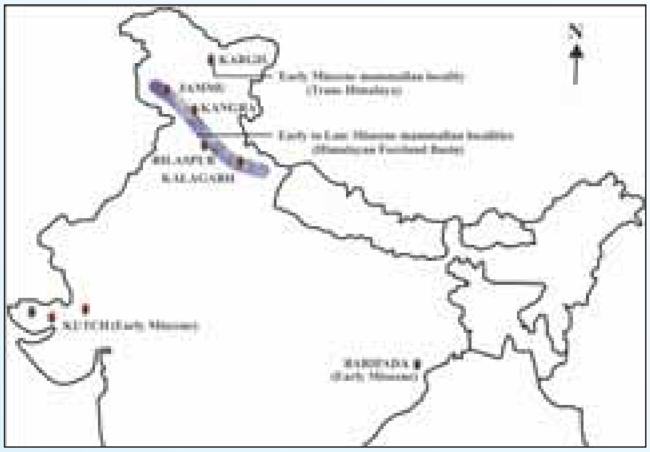

Fig. 39: Miocene mammalian localities of India (after Sehgal and Bhandari, 2014).

refinement to the prevailing stratigraphy, the fossil bearing horizons of Nurpur have been assigned equivalent to the Dhok Pathan Formation. Besides enumerating systematic paleontology, the paleo biogeographic analysis of the immigrant taxa was also attempted. It is noticed that the faunal assemblage from Nurpur is isochronous to the Turoilian Fauna (Late Miocene) of Europe and Africa.

The mammalian faunal dispersal patterns during the Miocene period have been interpreted. Preliminary results show that the Himalaya attained a significant height around 10 Ma. It is also noticed that the bulk of the Siwalik fauna is non-endemic. Further, a large quantity of the samples from the Siwaliks and the Murree Group were macerated for the recovery of microfossils. The samples belonging to the Siwaliks yielded some good identifiable microfossils, but from the Murree Group only fragmentary vertebrate were noticed. From a new locality near Chandigarh (Upper Siwalik) a few microfossils were recovered and these are under study. Also, a stable isotope study of a few fossil samples was carried out in Institute's Lab. The data is under study.

TAT - 4.6

Sedimentology, Basin Analysis, Paleoclimate and Global correlation of the Ediacaran Sedimentary Basins of the Lesser and Tethyan Himalaya

(V.C. Tewari)

The Earth's severe global paleoclimatic cycles, from global icehouse to greenhouse conditions, witnessed in the Neoproterozoic and also recorded from the Lesser Himalaya successions. Sedimentological and chemostratigraphy or the clastic-diamictite and carbonates from the Lesser Himalaya (Blaini-Krol) Formations indicate Neoproterozoic (Ediacaran) global events of glaciation and warming. A detailed study of such sequences well developed in the NW and NE parts of the Himalaya both in the Lesser and the Tethyan seas is required to know the development of the Prototethys, it's evolution, distribution in the Himalaya and global correlation. The Ediacaran Krol carbonates and the pre-Ediacarn glacial Blaini diamctites and microbial pink carbonates were studied mainly in the Mussoorie and Garhwal Synclines of the Lesser Himalaya. Sedimentological investigations include detailed petrography, microfacies analysis, geotechnical properties of the limestones, microbially induced sedimentary structures and the C-isotope chemostratigraphy and its global comparison. The Krol Dolomites deposited in marginal marine and evaporitic environments. This is also true globally for the Neoproterozoic carbonates from South China, Iran, North Africa, Namibia and Russia. The pre-Ediacaran Blainian global glaciation based on glacial tillites, cap carbonates and negative carbon isotope variation recorded in the cap carbonates indicate major paleoclimatic change that is comparable with the Australian and Chinese Marinoan/Sinian glaciation.

Additional microbial sedimentary structures have been studied from the Krol carbonates. The Upper Krol C carbonates are highly fractured and jointed, and based on UCS test they are characterized as moderately strong, and it is highly prone to landslides in the area. The Krol C or the Middle Krol Limestone is found in the middle of the limestone succession of the Krol belt in the Lesser Himalaya. The revised age of this limestone is now considered Ediacaran (Terminal Neoproterozoic) based on the occurrence of the stromatolites, oncloites, Vendotaenids Ediacaran biota and acritarchs from the Infra-Krol and Krol Formations of the Lesser Himalaya. The limestone is highly folded, brecciated, with pockets of recrystallised calcite and intraclasts etc. The bulk lithology is the finely laminated stromatolitic limestone with alternating light (white) and dark (organic/ biogenic) lamine. The black chert bands are also found in the limestone. The stromatolitic laminae are also disturbed due to tectonic activity and show crenulated, microfaulted/displaced columns and interspaces are filled with reworked clasts and grains and these features are clearly seen in the polished samples of the stromatolitic limestone and the thin sections. Polished samples also show micro laminations, domal and columnar forms with highly recrystallized calcite veins and breccia in the interlaminar spaces. The thickness of the lighter coloured bands is more and stylolites (pressure solutions) are also observed. The evidence of sub-aerial exposure and development of microbial mats and fenestral structures are also found. The depositional environment of the Krol C Limestone is shallow marine based on the formation of stromatolites, intraclasts and fenestral structures. The Krol C Limestone is cement grade (CaO varies from 50- 99%). Fenestrae within the granular-micritic sediment of stromatolitic facies are lined by isopachous fibrous carbonate. Fragments of the fibrous carbonate crusts occur within the sediment as intraclasts, broken off through erosion, or possibly desiccation. The petrographic thin section study reveals that many of the grains in the Middle Krol carbonates (Krol C) are composed of micritic carbonate, intraclast, breccia, microbial clots (Fig. 40) and some of this may have been precipitated as micrite, there is also the possibility that microbial micritisation has taken place. The Krol C limestones contain evidence for marine cementation. Fibrous carbonate fringes and crusts up to several mm to cm thick occur upon and within stromatolites (Fig. 41).

The Himalaya is formed due to the collision of Indian and Eurasian plates some 50 million years ago. However the pre collision Proto and Paleo Tethys geological history of the India is very well documented in

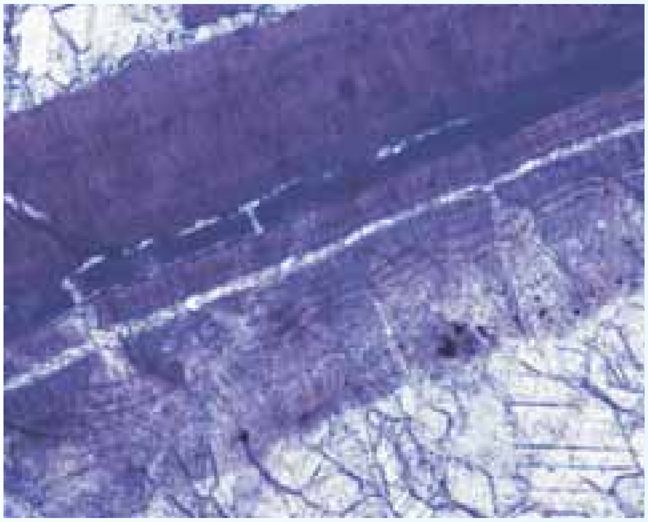

Fig. 40: Microbial micritization in the Upper Krol carbonate, Mussoorie syncline.

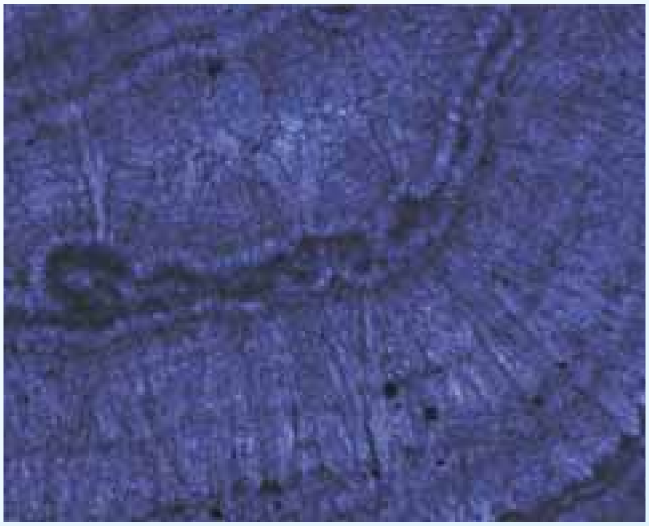

Fig. 41: Fibrous carbonate fringe in microstromatolitic facies of Krol carbonate.

the present day Lesser Himalaya. The basement of the Lesser Himalaya is yet not well established, however, sedimentological evolution of the Lesser Himalaya initiated with late Palaeoproterozoic rifting event (1800 Ma) followed by a shelf cycle of tidal flat sedimentation during Mesoproterozoic. The northwestern Lesser Himalaya is characterized by two major sedimentary belts in sequence stratigraphic order. The older sequence is late Palaeoproterozoic to early Neoproterozoic (750 Ma) in age and major lithofacies of this belt are (i) volcano-siliciclastic (Rampur-Manikaran-Chamoli-Berinag quartzite) (ii) clastic-argillaceous (Sundernagar-Hurla-Rautgara-Rudraprayag-Bhawali quartzite and volcanics) (iii) microbial-stromatolitic carbonate-phosphorite (Shali-Larji-Deoban-Lameri-Pipalkoti-Gangolihat-Dharchula), and (iv) argillo-calcareous (Sataun, Mandhali-Sor-Thalkedar) in stratigraphic order. The glacial boulder beds have not been reported from the inner belt. The Deoban-Jaunsar Group in the Lesser Himalaya represents preglacial, pre-Ediacaran older carbonate-siliciclastic shallow marine sedimentation. The complete absence of Ediacaran biota, non-glacial sedimentation and characteristic Mesoproterozoic stromatolite taxa and microfossils in black cherts confirm a pre-Ediacaran age. The unconformably overlying Blaini Formation (diamictite) is a Neoproterozoic (Marinoan/ Blainian) glacial deposit corresponding to snowball Earth palaeo latitude (Cryogenian Period). The overlying pink cap microbial carbonate of the Blaini Formation represents the base of the Terminal Neoproterozoic. The younger carbonate sedimentary succession of the Krol belt is Terminal Proterozoic (Ediacaran, 650-540 Ma) in age and stretching over a distance of 350 km showing major facies variations at Solan, Nigalidhar, Korgai, Mussoorie, Garhwal and Nainital synclines. The Krol carbonates represent passive continental marginal (carbonate ramp) facies variations as cyclic para sequences like shaly limestone and calcareous shale facies and purple green shales with lenticular bands of limestone and gypsum. Brecciated cherty, oolitic dolomite facies characterized by various types of oolites, bird's eye structure, microbial laminated and stromatolitic build-ups, oncolites indicate that the depositional environment was tidal flat (high energy peritidal). The shaly limestone facies of the Upper Krol grades into the Chert-Phosphorite Facies of the Lower Tal characterized by black chert, shale and phosphorite associated with pyrite, oncolites and stromatolites. The P/C boundary transitional facies shows upwelling and stratification of sea as revealed by carbon isotope excursions of Korl-Tal basin. The other Lower Cambrian facies of the Tal Formation includes bioturbated purple grey siltstone (trace fossil) facies and channel sandstone, orthoquartzite facies of fluvio-deltaic and marine shelf facies at the top of the sequence. The Krol-Tal basin was possibly obliterated during Lower Cambrian period due to Pan-African epeirogenic movements around 550 Ma (by well documented granites of this age, Almora and Mandi granites) in the Lesser Himalayan region. The post-Ediacaran sedimentation of the Lesser Himalaya is represented by chert-phosphorite, siltstone and sandstone facies variation (lagoonal tidal flat environment). The stratigraphic position of the Tal Formation is restricted to only central part (Nigalidhar-Korgai-Mussoorie and Garhwal synclines). The Upper Tal Formation (quartzite) marks the end of sedimentation and regression of the sea from the Lesser Himalaya. The beginning of the Ediacaran period is well defined by the earth's severe paleoclimatic change from snowball Earth to post-glacial carbonates. The emergence of the Ediacaran biota from the Lesser Himalaya is a major paleobiological event and the recent discovery of the fossilized egg from the Krol Formation by GSI is quite significant.

The global correlation of these paleobiological and palaeoclimatic events is mostly based on carbon and sulphur isotope chemostratigraphy. The reconstruction of Rodinia supercontinent and the palaeo position of India (including Lesser Himalaya, Southern China, and Marwar Supergroup of western Rajasthan) based on palaeomagnetic data strongly suggest that a possible connection of the Lesser Himalayan Meso-Neoproterozoic sedimentary basins (Inner Deoban-Gangolihat belt and outer Blaini- Krol belt) must have existed with the Rodinia. Early Earth possibly witnessed its most extreme climatic fluctuations during the mid late Neoproterozoic between 750-550 Ma. Palaeoglaciers even reached the equator around 635 Ma covering the whole earth. Evidences from Australia, South China, India, Oman, Polar regions of Europe (Svalbard and Oslo), Newfoundland, Canada, Death Valley, California, USA, Africa, Antarctica, South America (Brazil), suggest that there might have been three or more palaeoglacial events during this 200 million year interval. Carbon isotopic excursions from all continents have given the identical results and strongly support the existence of a supercontinent Rodinia during 1100-650 Ma.

TAT- 5: HIMALAYAN GLACIERS: THEIR ROLE IN INDIAN MONSOON VARIABILITY AND HYDROLOGICAL CHANGES IN THE GANGA BASIN

TAT - 5.1

Mass balance and snout fluctuation studies of Dokriani and Chorabari glaciers, Garhwal Himalaya

(D.P. Dobhal)

The present work is a continuation of the ongoing long term glaciers monitoring programme on glaciers mass change in context to climate and water budget. The Dokriani (7.0 km^2) and Chorabari (6.6 km^2) glaciers in Bhagirathi and Alaknanda river basin respectively, Garhwal Himalaya are being monitored for the present study. Data on mass balance and snout position (October 2012-October 2013) and meteorological parameters were collected on both glaciers during the study period. The strength and lost/disappeared ablation/accumulation stakes were re-placed at or nearby location of old stakes by the steam drill (insert 8 to 10 m in ice surface) in October, 2012 and re-measured in first week of May, 2013 to estimate the net winter balances. Snow/firn and ice densities were measured at several locations in accumulation zone as well as ablation area. The data obtained from the stakes measurement was used in final calculation of net annual mass balance for the budget year 2012-2013. Besides these, the debris covered mapping/distribution has been carried out for Dokriani glaciers. The debris-cover influences the terminus dynamics and modifies a glacier's response to climate change. An attempt is made to quantitatively evaluate the influence of a debris-cover on the summer ablation, terminus recession and its potential effect on mass balance process.

Annual Mass Balance and Snout Retreat

Annual mass balance of the Dokriani and Chorabari glaciers for the period 2012-13 calculated was negative with specific balance of (-) 0.35 m w.e. and (-) 0.81 m w.e respectively. The total net accumulation measured at the end of summer from the pits was ~ 0.55 m w.e. in both the glaciers; whereas the mean average ablation was 3.5 m w.e. for Dokriani and 2.75 m w.e. for Chorabari glaciers. The net annual mass balance and equilibrium line altitude (ELA) was estimated from the field observation as well as vertical mass balance gradient shows the negative mass balance trend (Fig. 42). The snout position of the glaciers was monitored by total station survey with respect to stable makers made near the snout for the study period. The total recession of the snout at centre part of the glaciers was measured 12 m for Dokriani and 9.0 m for Chorabari glaciers. The sudden decline in retreat rate of Dokriani glacier snout from 18-20 m/y (2007-2012) to 12 m in 2013 may be due to the huge debris deposit over the terminus area of the glacier. The debris sediments appeared to be old moraine deposits which exists both sides of the glacier valley (Fig. 43). The unusual rainfall in the early summer of this year create flash flood type situation erode and deposited huge amount of moranic sediments over the terminus area of the glacier. Due to thick debris covers, the glacier ice melt reduced and results slow down retreat rate of snout.

Debris covered mapping and glacier melting

In order to evaluate the influence of debris cover on melting, an attempt has been made to relate the varying debris cover thickness with glacier surface melting for Dokriani glacier. The 16 stakes were used to calculate ablation on debris-covered and debris free

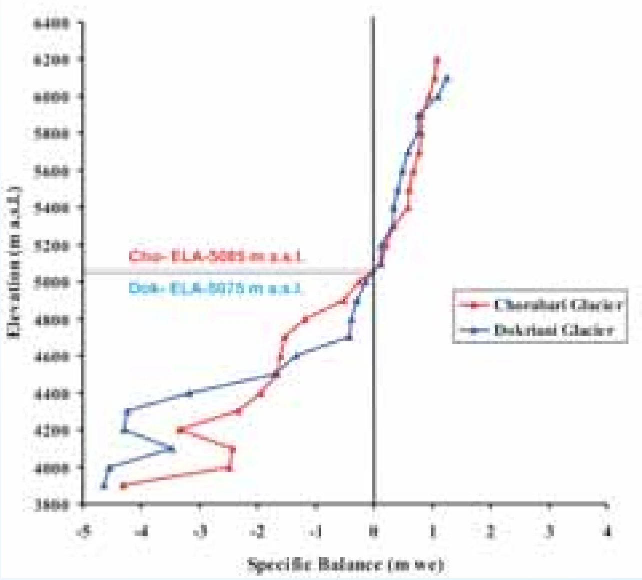

Fig. 42: Relationship between specific mass balance gradient and elevation on Dokriani and Chorabari Glaciers for the year 2012-2013.

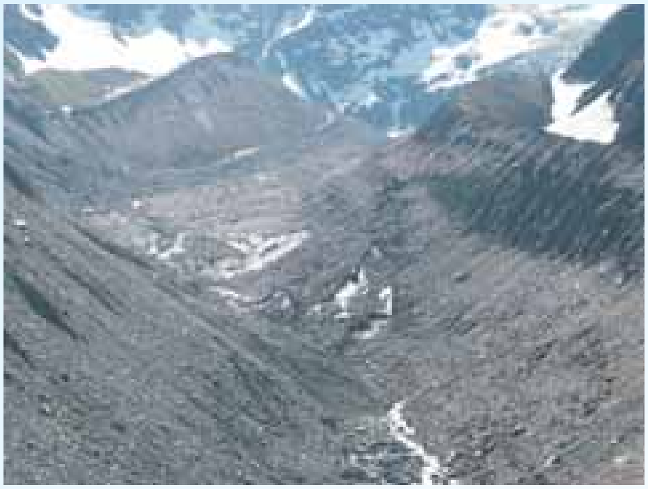

Fig. 43: The debris covered termini of Dokriani Glacier.

surface of Dokriani Glacier (ablation area 3.5 km^2) during the entire ablation period in 2013. The study found high correlation (R^2 = 0.92) between mean annual ablation of clean ice and altitude, whereas very low correlation (R^2 = 0.14) was found between debris-covered ice melting and altitude. Melting was maximum for thin debris (1-6 cm) and abruptly decreased at ~9 cm of debris thickness and reached minimum at 40 cm of debris thickness. The melting obtained for a thick debris-covered surface was 0.5-0.8 cm/day and for debris free surfaces and thin debris cover, it was 3.5 and 4.3 cm/day respectively. Furthermore, the study found that even a small thickness (~5 cm) of debris cover decreases the ice melting as compare to clean ice on annual basis. Annual ablation measurement between 3900 and 4400 m asl from the initial visit in October, 2012 to the end of ablation season in 2013 show that debris cover reduced ablation by 37% as compare to clean ice melting on Dokriani Glacier. A strong downwasting were observed in the ablation area of Dokriani Glacier with average annual ablation recorded -4.50 m w.e. a^{-1}. It is postulated that the presence of supraglacial debris strongly influences glacier ablation under similar weather conditions. Generally ablation take place below the ELA and ablation rates increase with decreasing elevation, but at lower altitudes where the debris-cover thickens (>40 cm), ablation rates decreases (Fig. 44). The months of June, July, August and September have maximum melting. This period is also known as peak summer melting season. During the study period, July has the maximum melting compare to other months. The overall monthly melt

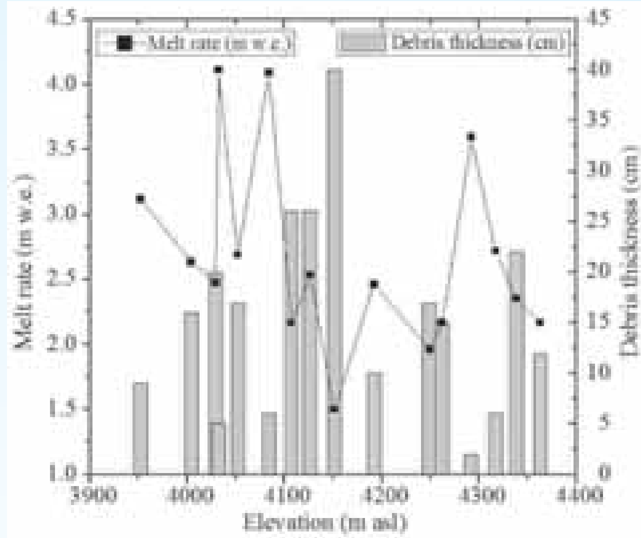

Fig. 44: Relationship between debris thickness and ice melting along the centre line of the Dokriani Glacier during entire ablation period, 2013.

rate of varying debris thickness at different elevation has significant variations in annual balance year. This is probably due to differences in seasonal meteorological condition such as quantity of insulation, snow line depletion, temperature and precipitation.

TAT - 5.2

Assessment of Potential Hazards in the Glaciated Regions: its Causes and Consequences

(Vikram Gupta, D.P. Dobhal and Swapnamita C. Vaideswaran)

Gangotri glacier (latitude 30°43'20" to 31°01'07" N and longitude 78°59'42" to 79°17'10" E) is one of the most important glaciers in Central Himalaya which is the source of the river Bhagirathi. The Gangotri glacier is compound basins accompanying by eight large tributary glaciers and forming a large glacier system. The total area of the Gangotri catchment is 549.25 km^2 out of that 147 km^2 area is covered by Gangotri Glacier. The Glacier extends between elevation 4000 and 6700 m asl and the perpetual (annual) snow line fluctuates between 5000 and 5100 m asl. The Gangotri is highly glaciarised as the winter snowline falls down to about 2200 m asl. Between 2200 and 4000 m, the valley is composed of loose unconsolidated glacier material and is the source of several hazards like rock-fall, debris flow and flood, particularly during the summer period when the snow/ice melting is at its peak coupled with monsoon rains. Similarly above 4000 m asl (present snout of the Glacier), the area is highly snow covered with ~10-15% permanent snow/ice covered and is also the zone of triggering snow/ice avalanches. Snow cover and snow/ice avalanche inventory mapping have been prepared using high resolution remote Sensing data (Resource Sat-2-LISS IV, Resolution 5.8 m, September 20, 2013). The geographical location, aspect, length, area of influence and slope are few of the parameters which have been used for the preparation of the inventory. A total of 24 avalanche sites have been identified and mapped as shown below, however, the studies are still continuing.

Lichenometric study has also been carried out on the granite and gneissic terminal morainic boulders for dating the Gangotri Glacier's moraine deposits, as well as estimation of colonization delay of *Rhizocarpon-geographicum* species of lichen. Four criteria that make the Gangotri Glacier ideal for a study of this type are:

? The Gangotri Glacier has been under a state of continuous recession and the pattern appears to be continuing even at present

? It is the most studied glaciers in the Himalayan terrain and its recession history in terms of the

Spatial distribution of avalanche sites in the Gangotri basin

Point ID	Longitude	Latitude	Height	Aspect
1	78:56:28.38 E	31:00:35.62 N	4386	South
2	78:57:02.08 E	31:00:53.49 N	4917	East
3	78:58:16.26 E	31:01:31.92 N	4966	South
4	78:59:41.90 E	31:01:43.72 N	5083	South
5	79:00:39.22 E	31:01:29.56 N	5039	South
6	79:01:10.92 E	31:00:23.15 N	5183	South
7	79:02:48.04 E	31:00:36.29 N	5206	South
8	79:04:07.60 E	30:59:16.04 N	5270	East
9	79:04:46.80 E	30:58:15.62 N	5726	West
10	79:04:51.85 E	30:57:39.55 N	5233	West
11	79:05:40.05 E	30:57:02.45 N	5509	East
12	79:05:37.69 E	30:56:40.20 N	5269	South
13	79:05:51.18 E	30:56:45.93 N	5225	East
14	79:03:06.93 E	30:55:31.94 N	4984	East
15	79:02:49.08 E	30:55:38.69 N	5085	North
16	79:02:35.24 E	30:56:12.40 N	4737	North
17	79:00:55.10 E	30:56:31.96 N	4912	East
18	79:01:26.46 E	30:57:26.58 N	4518	North
19	79:00:32.52 E	30:57:33.66 N	4816	East
20	78:59:59.81 E	30:58:04.34 N	4821	North
21	78:58:40.24 E	30:58:24.91 N	4848	North
22	78:57:30.37 E	30:58:35.20 N	4632	North
23	78:57:32.12 E	30:58:53.16 N	4275	North
24	78:57:20.23 E	30:58:41.52 N	4448	North

position of the snout is well defined and has been identified and marked on the boulders in the field

? The recession of the glacier is along a linear path from NW to SE. Thus the aspect of the boulders exposed is more or less uniform

? The recession of the glacier is marked by the terminal moraines dominantly comprising the boulders of granite along with boulders of granitic gneisses and gneisses.

It has been concluded that the colonization delay for the said species is different for both the rock-types. It is about 78 years for granite and between 50 and 78 years for the gneisses. The study will help to establish the absolute ages of the various terminal moraines of the Gangotri Glacier, which in turn will help to ascertain the recession history of the glacier. The outcome of this work has major implications. Since *Rhizocarpon geographicum* is widely used for the lichenometric applications and the granite and gneisses are the two rock-types dominantly available in the glacial environment, the establishment of its colonization delay on the granite and gneisses will help to ascertain the absolute ages of the various terminal moraines of the glaciers climatically similar to the Gangotri Glacier. This will, in turn, will help to establish the recession history of the glaciers.

TAT - 5.3
Hydrogeology of Himalayan Springs

(S.K. Bartarya and S.K. Rai)

A hydrogeological study of springs in Tehri region of Garhwal Himalaya has been undertaken. Three hydrogeological units may be recognized in the study area namely; *fractured hard rocks, fluvial and colluvial deposits, and karst aquifer.* The capacity of absorption and retention of water of each unit is very distinct. Three types of the springs viz; fracture joint related springs, colluvial springs and seepages and contact springs are present around the Tehri dam. The springs show wide variability in discharge.

The discharge in these springs varies from 0.8 to 120 l/min. Direct infiltration of rainwater through joints, fractures and weathered zones is the main cause of recharge to the springs. The amount of water discharged by the spring varies with time and depends on both recharge to the aquifer, the storage of groundwater and the transmission properties of the aquifer, all of which govern spring discharges. Fluctuation in spring discharge is because of the variations in the quantum of rain water that is able to infiltrate the ground (springs related to secondary permeability show a marked response to rainfall variation). Flowing rain water starts percolating down through the weathered mantle recharging groundwater and augmenting discharge of springs/seepages. High rate of discharge lowers the water table, reduces its gradients and diminishes the pressure in pore spaces. This alteration of recharge and discharge is the cause of seasonal, local and short term fluctuations of springs. A balance precipitation and attendant recharge produce uninterrupted discharge of water in the month of July/August/September which decreases causing deficit and then rises as snow starts melting. Springs fed by shallow subsurface water emplaced above the water table are subject to the greatest fluctuations and may completely disappear at certain time. Springs fed by ground water have a more or less steady supply, even though discharge varies seasonally. The chemical analysis of the springs shows abundance of the major cations Ca > Mg > Na > K and anions in the order HCO_3 > Cl > SO_4 > NO_3 > Br > PO_4 and weathering of rocks within the catchment area is controlling the major ion composition of the spring water. However pollutants are increasingly added to the groundwater system through various human activities evidenced from presence of total coliform and e.coli bacteria and elevated nitrate and bromide concentrations.

Hydrochemistry of Hot Water Springs

Geothermal springs of Ladakh and Himachal region were studied for their major ion and stable isotopes ($\delta^{13}C_{DIC,}$ $\delta^{18}O_{H2O,}$ $\delta^{13}D_{H2O)}$. They have very high concentration of Dissolved Inorganic Carbon (DIC) with concentrations of HCO_3 (1300 to 13400 µEq/L) indicating these fluids carry large fluxes of CO_2 derived from metamorphic reaction. $\delta^{13}C_{DIC}$ of these springs show a strong variation from (-8.4‰ to +1.7‰ VPDB) pointing towards the varied sources of their origin with enriched $\delta^{13}C_{DIC}$ indicate a deeper origin. Water isotopes $\delta^{18}O_{VSMOW}$) were also measured in thermal springs which range between -16 ‰ to -7.3 ‰ and δD vary from -124 ‰ to -45 ‰. This shows that the thermal waters are mixing with a meteoric dominated reservoir because most of the samples fall on the line defined by Local Mean Water

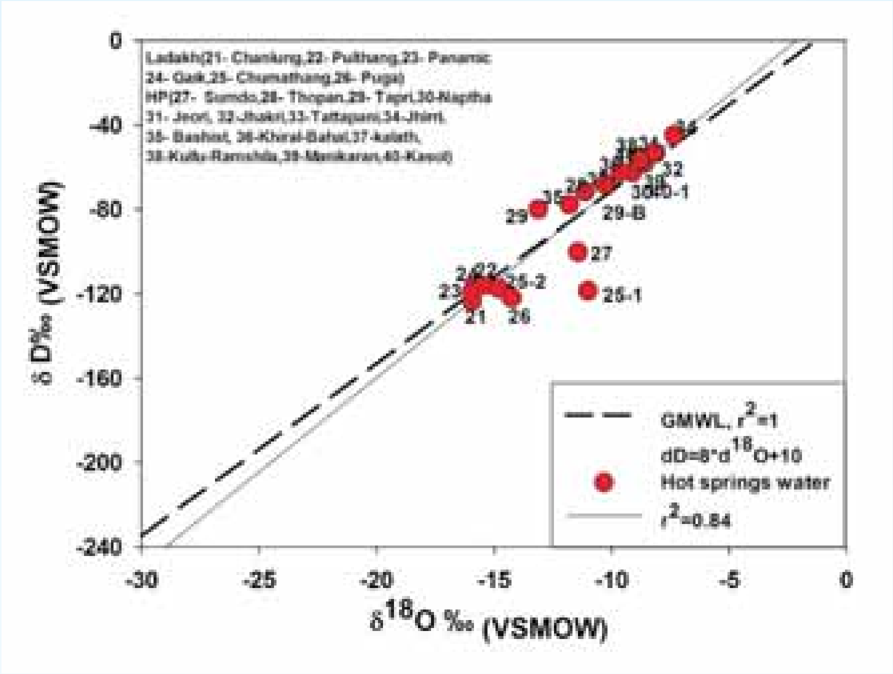

Fig. 45: Samples from (Puga and Chumathang) fall below δ the LMWL indicating a non surface origin.

Line (LMWL) shown in figure 45. Two of the samples from (Puga and Chumathang) fall below on the LMWL indicating a non meteoric origin

TAT - 5.4

Geochemical investigation of Stream and Soil Sediments of Piedmont Regions/Plane South of Kumaun Shiwalik Himalaya

(P.P. Khanna, N.K. Saini and R. Islam)

Fifty six samples of soil and sediments were collected during the last field work in all the river catchments of district Udham Singh Nagar of Uttarakhand (Fig. 46). Udham Singh Nagar is basically an industrial district and many industry related professions are prevalant here. Integrated Pantnagar, Sitarganj and Kashipur regions have a large number of Heavy industrial units, established recently. The fertile land lends itself to different forms of agriculture giving rise to agriculture related activities and industries, making this land a green place which has resulted into prosperity all around. The district has a dense network of the drainage pattern. The rivers of the district belong to the Ganges drainage system. Of these, Sarada, Kosi, Gola and Phikka river and their tributaries are Sawaldeh, Bour, Nandhour, Bhak, Kailash etc. drain the district. There are several big major water reservoirs like Tumaria (Jaspur), Gularboj and Haripura (Gadarpur), Dron, Baghul and Nanak Sagar (Sitargunj) and Sarada Sagar (Khatima) in the study area. Samples were collected from almost all the major and minor rivers and water bodies.

The collected samples were dried and sieved through -80 mesh sieve. Sieved portion was further pulverized to approx. -200 mesh powder using tema mill. Pellets were prepared using this powder. Solutions of samples were prepared using acid mixture and open digestion process. Pellets were analyzed using XRF and a few sample solutions were analyzed using ICPMS, for major, trace and rare earth elements. Summary of analysis is given in following tables 1 and 2 for major oxides and trace elements analysed by standard WDXRF technique. Complete geochemical database of the studied area was prepared and geochemical variation maps of almost 15 important elements were also prepared. Analysis of the data was performed for assigning background concentration and regional trends of geochemical variation, identification of anomalous areas and their causative factors for assessment of pollution and/or contamination in the study area.

Udham Singh Nagar district may be broadly divided into two physiographic units from north to south viz., Bhabar and Tarai respectively. Since the area

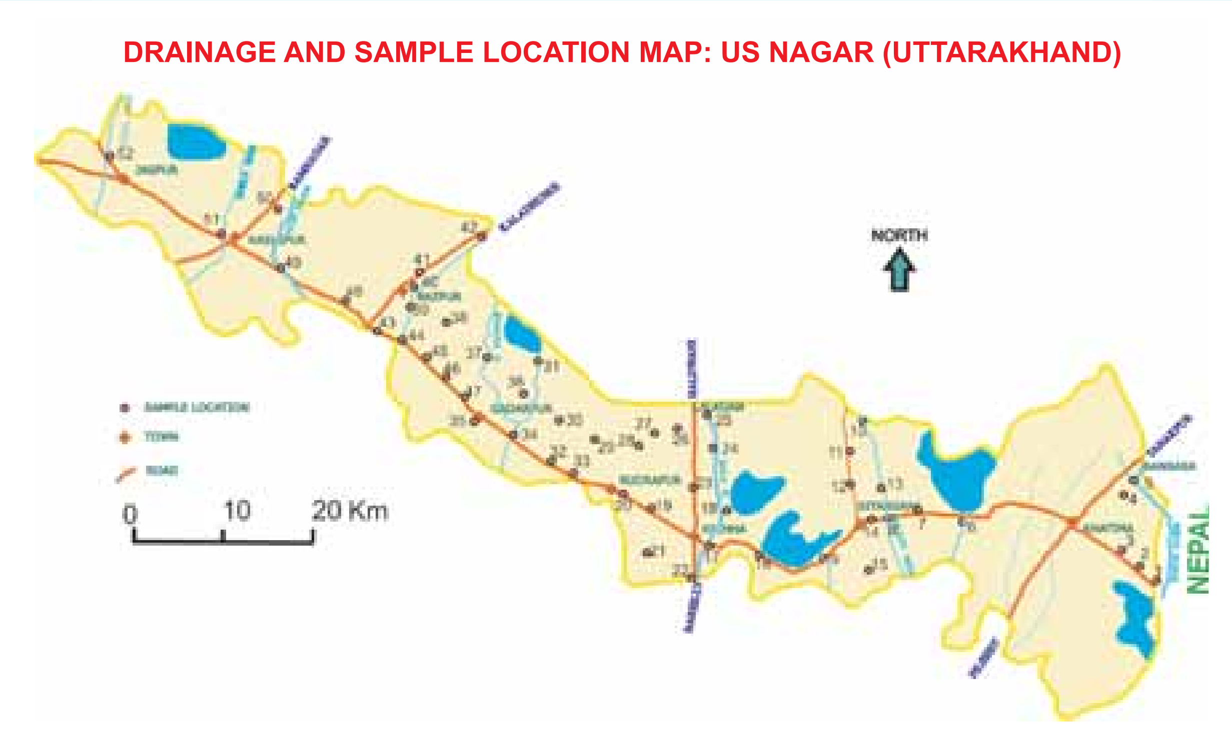

Fig. 46: Sample Location Map in Udham Singh Nagar of Uttarakhand.

Table 1: Concentration (%) of Major oxides in US Nagar soils/sediments.

	SiO_2	Al_2O_3	CaO	MgO	Na_2O	K_2O	Fe_2O_3	TiO_2	MnO	P_2O_5
Minimum	58.45	1.95	0.16	0.25	0.23	0.51	1	0.24	0.026	0.03
Maximum	91.61	15.9	6.68	5.09	1.47	3.48	5.78	1.02	0.186	0.31
Average	73.13	7.9	1.77	2.13	0.82	1.82	3.13	0.5	0.05	0.09
Median	70.85	8.43	1.35	2.39	0.8	1.95	3.02	0.44	0.047	0.08

Table 2: Concentration (ppm) of Trace elements in US Nagar soils/sediments.

	Ba	Cr	Cu	Nb	Ni	Pb	Rb	Sc	Sr	Th	U	V	Y	Zn	Zr
Minimum	175	16	5	6	2	14	18	0	8	7	0.0	20	11	3	114
Maximum	471	400	38	22	72	33	168	12	74	18	4.7	105	29	121	942
Average	297	86	15	11	17	23	73	6	39	12	2.5	57	21	36	267
Median	287	49	14	10	15	23	72	7	39	12	2.3	51	21	32	219

is located in the Himalayan foothills, a very thick column of alluvium is deposited, which further is classified into two distinct divisions: *(i) The piedmont fan deposits known as Bhabar (ii) The Tarai Alluvium .* The soil types are controlled by the topography and rock types.

Based on the National bureau of soil survey and Land Use Planning (ICAR) Nagpur, the soils of the district Udham Singh Nagar can be classified into Udifluventic Ustochrepts, Typic Ustipsamments, Udic Ustochrepts, Udic Haplusstolls, Typic Ustochrepts as determined by their diagnostic properties. The Bhabar soils lay at the northern extremity of Khatima and Bazpur blocks, part of the alluvial fan deposits. Soils are shallow with sandy to loamy texture, poorly sorted, comprising mainly of gravel, sand, silt, clay with pebbles etc. Piedmont alluvial deposits represent the geology of the study area.

Sediments act as both carrier and sink of heavy metals in the ecosystem, where large portions of the metallic substances are ultimately incorporated in their composition. Heavy metals of river sediments in aquatic systems are more sensitive, than dissolved concentrations, indicators of possible sources of contaminants. Spatial distribution of various elements can illustrate areal variation of natural background abundances of respective elements. Sediments near industrial and urban areas are typically polluted by heavy metals, and are usually present in higher amount than their natural background abundances. As no data is available on the distribution of heavy metals in the Udham Singh Nagar area, we report results based on analysis of stream sediments collected from the investigated area to determine heavy metals concentrations and their spatial distribution in stream sediments, to assess sediment quality and its relation to urbanization/industrialization, and is given in Table 3 below and some of the element variations are shown in figure 47.

Major Inferences

- A geochemical database has been prepared with each sample co-ordinate and elemental abundance. Statistical methods were used to derive several indicative parameters like range, average, median etc. for each element to draw useful conclusions regarding background concentration and regional trends in the four major catchments (Sarda, Kosi, Gola and Phikka) in the area. Geochemical variation maps were prepared for majority of elements investigated in the whole Udham Singh Nagar area.

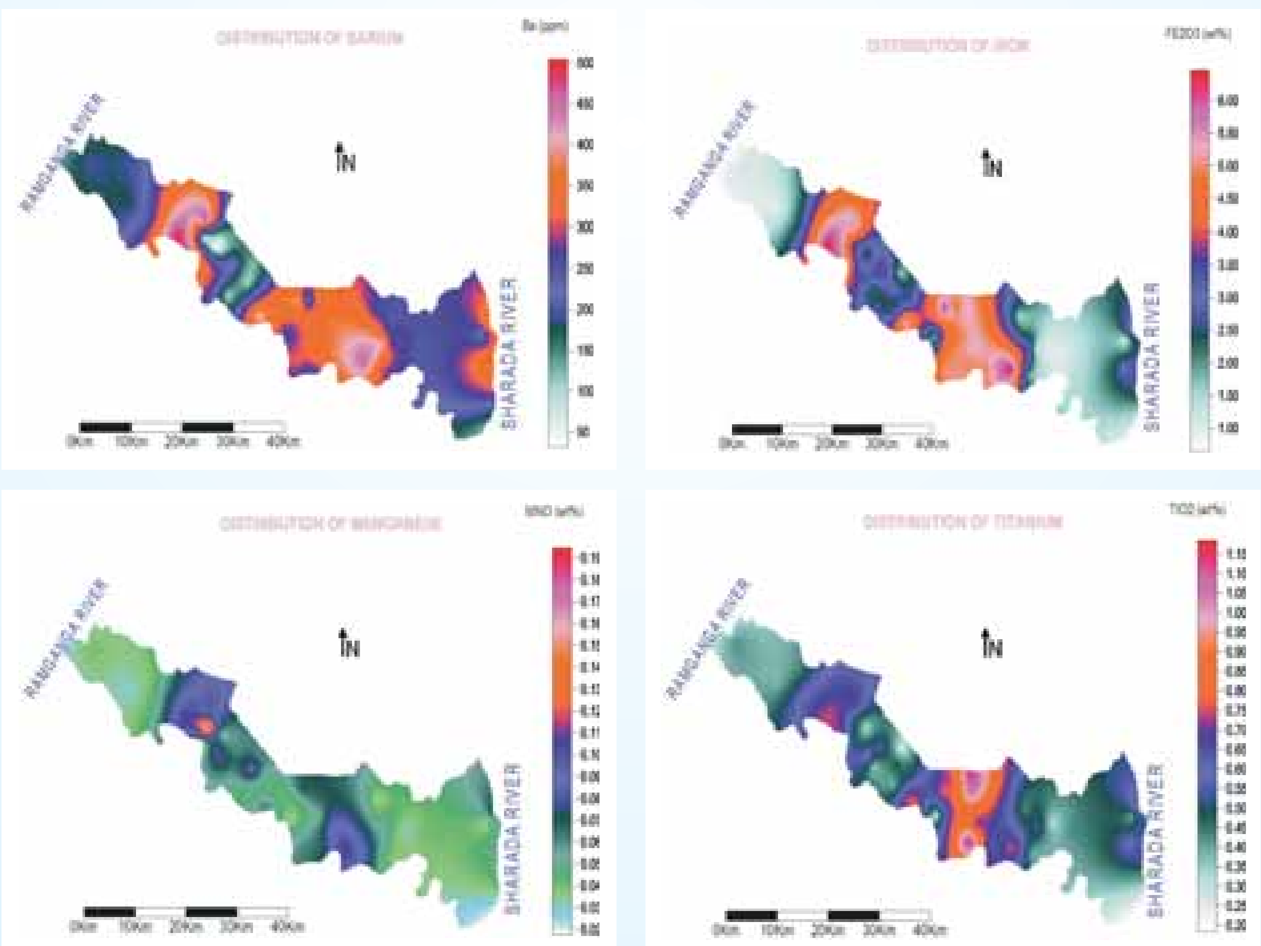

Fig. 47: Geochemical variation maps of some important heavy elements in Udham Singh Nagar of Uttarakhand.

Table 3: Concentration (ppm) of some Heavy metal elements compared with uncontaminated AUCA values.

	Ni	Cu	Zn	Pb	Ti	Mn	Fe
Minimum	2	5	3	14	1439	201	3777
Maximum	72	38	121	33	6115	1440	39868
Average	17	15	36	23	2979	409	20694
Median	15	14	32	23	2638	364	20144
Average upper crustal abundance	20	20	61	18	3060	539	27680

- The concentration of Pb and Cr show relatively appreciable amount of contamination in the sediments of Bhakhra and Gola river catchment around highly populated and industrial town areas of Rudrapur, Kashipur and Sitarganj in comparison to other catchments. Extent of contamination, delineated using geo-accumulation index (I-geo) indicates that the sediments are moderately contaminated with Pb and Cr.
- Correlation coefficient of various elements indicates that enrichment of heavy metals is related to other than sedimentary processes or lithological factors, most probably anthropogenic input.
- The finer fraction of the sediments was found to contain higher concentration of heavy metals because of their incorporation in clay minerals by adsorption.

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Project

Mineralization and petrogenesis of mantle sequence and cumulates of the Manipur Ophiolite Complex, Indo-Myanmar Orogenic Belt, NE India

(A. Krishnakanta Singh)

The Manipur Ophiolite Complex (MOC) located in the Indo-Myanmar Orogenic Belt (IMOB) of Northeast India forms a section of the Tethyan Ophiolite Belt of the Alpine-Himalayan orogenic system. Whole rock compositions and mineral chemistry of the mantle peridotites from the MOC show an affinity to the abyssal peridotites, characterized by high contents of Al_2O_3 (1.28-3.30 anhydrous wt. %); low Cr# of Cr-spinel (0.11-0.27); low Mg# of olivine (~Fo_{90}) and high Al_2O_3 in pyroxenes (3.71-6.35 wt. %) (Fig. 48a). They have very low REE concentrations (ΣREE = 0.48-2.14 ppb). Lherzolites display LREE-depleted patterns (La_N/Sm_N = 0.14-0.45) with a flat to slightly fractionated HREE segments (Sm_N/Yb_N = 0.30-0.65) whereas Cpx-harburgites have flat to upward-inflected LREE patterns (La_N/Sm_N = 0.13-1.23) with more fractionated HREE patterns (Sm_N/Yb_N = 0.13-0.65) than the lherzolite samples.

The distribution patterns of platinum group of elements (PGE) and gold (Au) in peridotites and associated podiform chromitites of the MOC were also discussed to elucidate the nature of the upper mantle of the MOC. Total PGE (ΣPGE) concentrations of chromitites are low, ranging from <100 ppb to 544 ppb. The high-Cr chromitites have higher content of ΣPGE (186-544 ppb) as compared to the high-Al chromitites (ΣPGE = 81-185 ppb). Au concentration is quite variable in both the high-Al chromitite (6-32 ppb) and high-Cr chromitite (10-42 ppb). Their chondrite-normalised PGE patterns display a flat trend between Os and Ru with negative Ir anomaly, a negative slope between Ru and Pt, and a positive trend between Pt and Pd. Enrichment in the IPGE (Os, Ir, Ru) over the PPGE (Rh, Pt, Pd) in these chromitites is typical for ophiolitic-hosted mantle chromitites. Their low PGE content may reflect a lack of sulphur saturation of the parental magma during an early stage of their crystallization. The PGE diversity between the high-Al and high-Cr chromitites in the MOC may be attributed to the differences in chemistry of the magma involving in the chromitite formation and geodynamic setting. It also further indicates that the high-Cr chromitites formed in a supra subduction environment have higher contents of

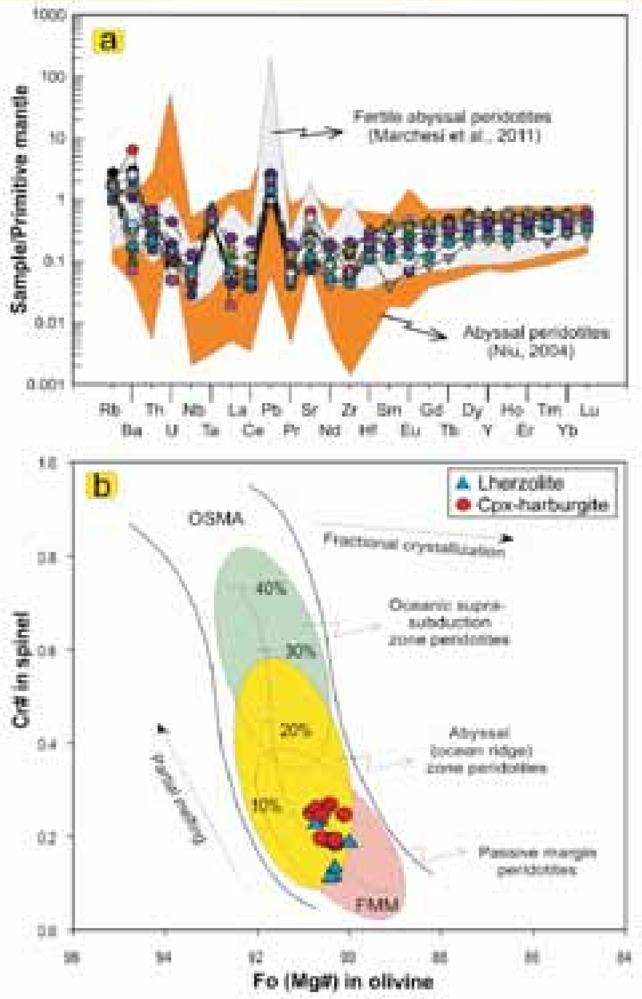

Fig. 48: (a) Primitive mantle-normalized trace element patterns of Cpx-harzburgite and lherzolite of the Manipur Ophiolite Complex (MOC) peridotites. Fields of fertile abyssal peridotites (after Marchesi et al., 2001 and Niu, 2004) are also shown for comparison. Normalizing values are from Sun and McDonough (1989). (b) Plot of spinel Cr# against olivine Mg# for the MOC peridotites. The approximate fields for abyssal (ocean ridge) zone peridotites (Arai, 1994), the oceanic supra-subduction zone peridotites and passive continental margin peridotites (Pearce et al., 2000) are also shown for comparison. The olivine-spinel mantle array (OSMA) and melting trend is from Arai (1994).

PGE as compared with PGE contents in the high-Al chromitites generated in a mid-oceanic ridge setting. The total PGE contents of peridotites vary between 28 and 79 ppb and the concentrations are 0.01 to 0.02 times the chondrite values. Two types of PGE distribution patterns have been observed in the mantle-normalised PGE plot. The type-I display flat patterns from Os to Pt, and positive slope from Pt to Au whereas the type-II samples have Os, Ru, Rh and Pd enrichment relative to Ir and Pt. Their distinct mantle-normalised PGE patterns with the Pd/Ir values (1.7-11.4) and Pt/Pt* values (0.2-1.4) who their affinity to residual mantle material, and suggest their derivation by varying degree of partial melting rather than magmatic fractionation. The mineralogical and petrological evaluation of these peridotites further suggests that they represent the residues remaining after low degree of partial melting (~ 2-12 %) in the spinel stability field of a mid-oceanic ridge environment (Fig. 48b). The well-preserved mid-oceanic ridge characteristics of these peridotites further suggest that the mantle section was subsequently trapped in the fore arc region of the subduction zone without undergoing significant modification in their chemistry by later subduction-related tectonic and petrological processes before its emplacement to the present crustal level.

Project
Geodynamic evolution of the Indian Plate through high resolution Geoid/Gravity from SARAL/ ALTIKA altimeter

(S. Rajesh and T. J. Majumdar, SAC/ISRO)

It is intend to study the geodynamic evolution of the Indian plate using high resolution geoid/gravity data obtained from SARAL/ALTIKA radar altimeter data in this project. The Indian Plate is unique owing to the complexity involved in its geodynamic evolution. The plate boundaries of the Indian plate consist of zones of both ocean-ocean divergences and convergences like the Carlsberg, Central Indian Ridges and the Andaman subduction zone in the northwestern and northeastern Indian Oceans, respectively. In this work, we try to understand the present status of those tectonic elements through the SARAL/ALTIKA altimeter derived marine geoid. Being a static field there is need to get more spatially resolvable altimeter data with long period of observation. However, we tried to analyze the available Interim Geophysical Data Record (IGDR) in the native format at 1 Hz frequency resolution provided from the SAC/ISRO server site. We have collected IGDR data from the second cycle onwards to the available full passes of ninth cycle. Based on the SARAL product Handbook the corrections were applied on the range in both ascending and descending tracks. Track intersection and cross over analysis with equal length interpolation are taken up to generate the Sea Surface Height (SSH) grid. For cross over analysis we are currently testing the available cross over analysis methods developed both by Wessel and Xu. To check the resolution of the SARAL data, we also carried out track wise analysis of SARAL data with the available JASON-2 mission data; although there are no match in the Exact Repeat Mission (ERM) paths of SARAL and JASON-2. However, very near tracks of SARAL with JASON-2 along a few of tracks were selected in both the northwestern and northeastern Indian Ocean regions respectively, for the comparison with the available ship-borne data that cut across the aforementioned tectonic structures. Further work in this regard for getting the marine geoid is in progress, and would be compared with the existing geoid data. Although we have observed many omissions in the passes of GDR data, but found to be more useful once the number of cycles of GDR is available to us.

Project
National Geotechnical Facility (NGF)

(Anil K. Gupta , V.C. Tewari, B. Venkteswarlu, Ruchika Tandon, Mohd. Sazid)

The primary vision of the 'National Geotechnical FacIlity' (NGF) is to facilitate geo-technical assistance to the national as well as international projects. It is being developed at par with the Norwegian Geotechnical Institute. The primary mission of the project is to develop the geotechnical facility and geotechnical and allied research in the field of natural disasters and mitigation. The project is under the administrative control of WIHG since June 2012. Three scientists are currently working on different aspects of the geotechnical investigations in the Himalaya and other areas. The highlights of the achievements of NGF during the year 2013-2014 are summarized below.

Calibration of the various instruments for soil/rock testing has been undertaken. Several tests on the rock and soil samples collected from the Alaknanda river valley, Mussorrie and adjoining areas have been done. The results of which are either published/ communicated/or in progress. A total of 30 samples from various Himalayan litho units were tested for slake durability test and Point Load Index (PLI). Further, the PLI is converted into strength using ISRM suggested method. The interpretation of the results is in progress. Apart from this detailed petrographic study on 35 samples of Beringag Quartzites has been done for correlating their mechanical and seismic behaviour. In this context, data on unconfined compressive strength using compression testing equipment QMat 5.64a/Q5457 as well as determination of Vp using Ultrasonic Concrete Tester have also been done on these samples. Quantitative rock fabric study is still being carried out. The GPR field survey has been carried out in various sites such as (i) at Bhauwala to map Neotectonic activities, (ii) in IIT, Earthquake Department, Roorkee to validate GPR results with MASW, and (iii) in Parade Ground to identify densified metal objects during the visit of Shri Narendra Modi ji,

Project

VSAT Linked Seismic Network for Seismic Hazard studies in Garhwal Himalaya

(Ajay Paul)

A seismic network of 10 Broad Band Seismograph (BBS) (Fig. 49) equipped with Trillium-240 (broadband) seismometer of high dynamic range (> 138 dB) and Taurus data acquisition system (DAS) along with VSAT connectivity to Headquarters at Dehradun were installed in Uttarakhand (7 BBS), Himachal (2 BBS) and Uttar Pradesh (1 BBS). The data is being acquired on-line and analyzed continuously. Till March 2013, a total of 17,955 events have been detected which includes 3,745 local events, 8,519 regional events and 5,691 teleseismic events. The events recorded for the period April 2013 to March 2014 are 622 (local) 2,299 (regional) and 2,435 (teleseismic). The space time pattern are regularly being examined to demarcate the zones of enhanced/quiescence that invariably precede the large earthquakes in this region. The striking feature

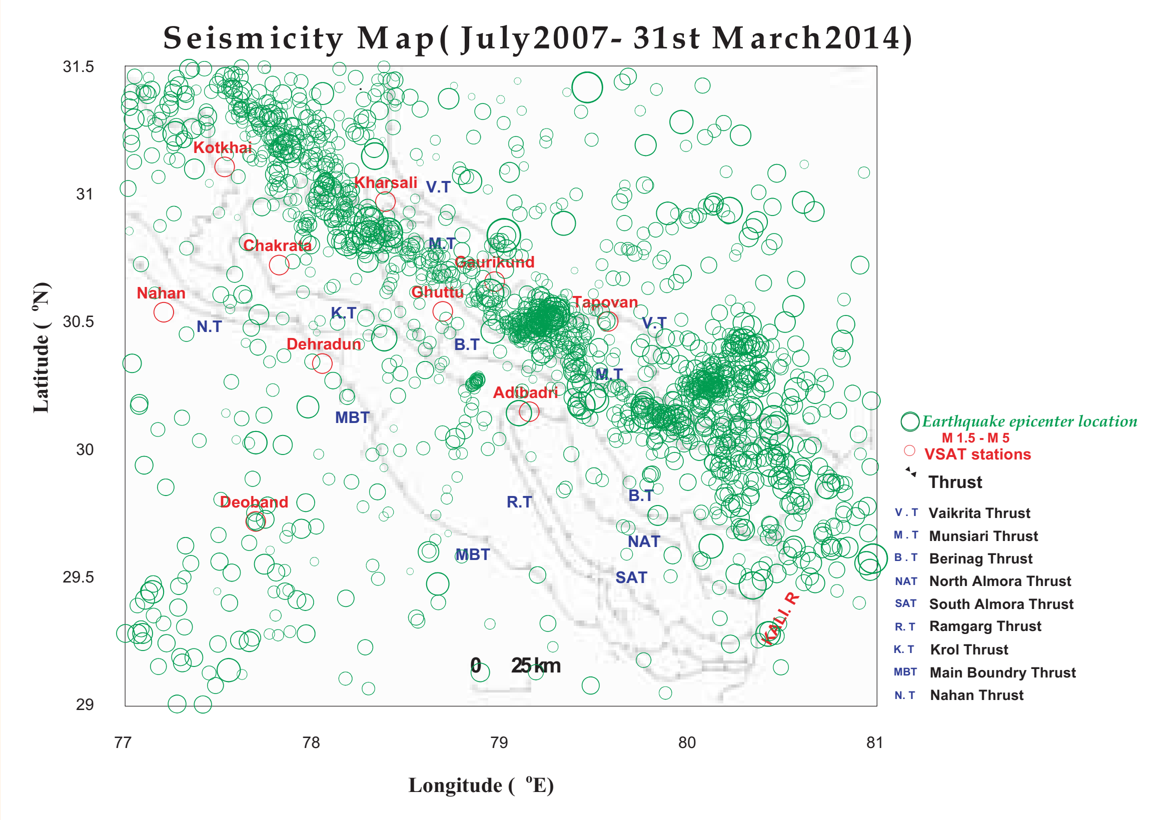

Fig. 49: Tectonic Map of the region (Valdiya, 1980) showing seismic network and epicentral locations of the events from July 2007 to March 2014.

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of seismicity in Kumaun-Garhwal Himalaya is the narrow belt of seismicity that follows the trend of the MCT zone extending throughout the study region from west to east (Fig. 49).

The change in the velocity ratio Vp/Vs is one of the precursor phenomenon. Variations of Vp/Vs ratio have been studied for the period July to March 2014 (Fig. 50). It shows that the value of Vp/Vs is uniform around 1.73, and the phenomenon of drop of Vp/Vs (by about 10-15%) and its recovery has not been observed till date. It is significant to note that the seismicity pattern of Garhwal-Kumaun region as recorded by the present network suggests that the region south of MCT trending along Munsiari thrusts is seismotectonically active (Fig. 49). The region continues to record shallow focus events with low stress drop values. Detection threshold of magnitude 1.8 events have been achieved. On-line data contribution to National Seismological Data Centre at IMD, New Delhi for earthquake monitoring and Indian National Centre for Ocean Information Services (INCOIS), Hyderabad for Tsunami Early Warning System.

The pre- and the post-seismicity around Tehri reservoir is analyzed to visualize and evaluate the impact after the impounding of water in the reservoir. Seismic data around the dam shows that, the seismicity is corresponding to drawdown levels of the reservoir rather than to higher water levels.

The stress field, source characterization and source parameters were examined for the 22nd July Kharsali earthquake. It has been found that, the tectonic structure along which the deformation occurred is of step type with strike slip reverse movement in the deeper section and strike slip thrust movement in shallow part, making overall movement toward northeast.

Velocity model for precise locations of Earthquake hypocenters in the KumaunGarhwal Himalaya had shown that most of the events have their genesis in the upper crust (upto 20 km). The inverted velocity model divides the upper crustal section into four layers. Majority of earthquakes are located in the upper crust, significant numbers of them are also located in the mid-lower crust.

Analyzed 42 well located local earthquake waveforms to study the seismic attenuation characteristics in the Garhwal Himalaya, India. The frequency-dependent attenuation of P (i.e., Q_P) and S (i.e., Q_S) waves are estimated using the extended coda-normalization method for the frequency range of 1.5, 2, 3, 4, 6, 8, 10 and 12 Hz, with earthquakes' hypocenter range from 20 to 200 km. We obtained Q_P=63.62 ± 7.99 $f^{0.732}$ and Q_S=186.08 ± 6.32 $f^{0.813}$ by fitting a power-law frequency dependence model with the estimated values over the whole region. Both Q_P and Q_S values

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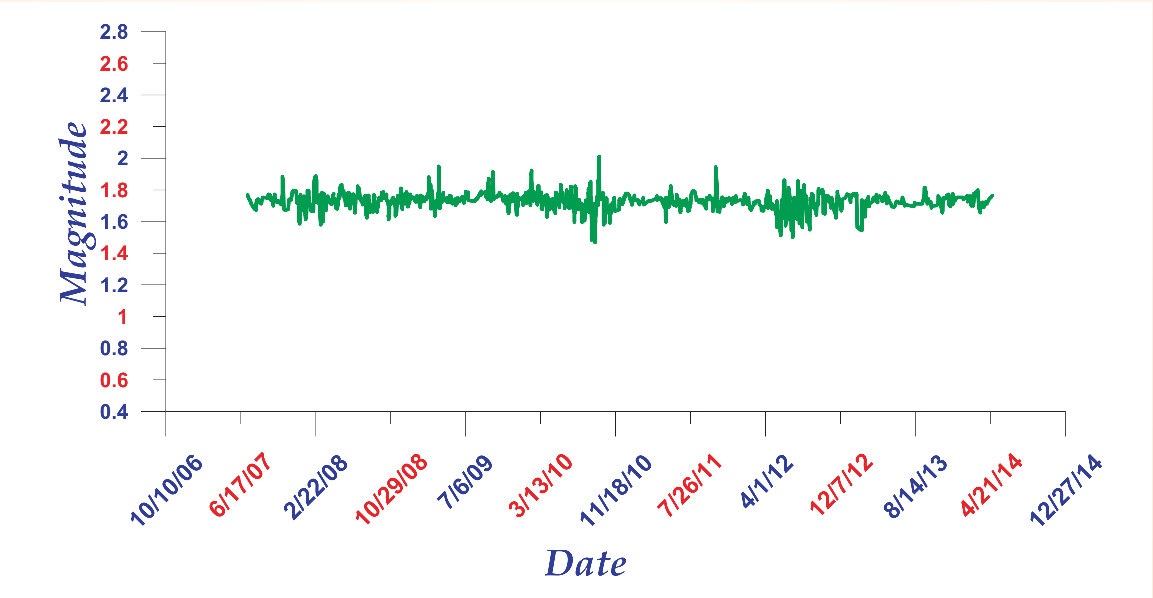

Fig. 50: Vp/Vs Curve for the period July 2007 to March 2014**.**

indicate a strong attenuation in the crust of Garhwal Himalaya. The ratio of $Q_S/Q_P>1$ obtained for the entire analyzed frequency range may suggest that scattering loss is due to random and high degree of heterogeneities in the earth medium, and plays an important role in seismic-wave attenuation in the lithosphere.

Project

Evolution of marine Triassic biota and carbon cycle: from the Alps to the Himalaya

(S.K. Parcha)

Field work had been carried out in Spiti region and Kashmir region to understand the Lower Triassic successions, however, field work in Kalapani region of Kumaun region could not be carried out for various reasons. In the Spiti Region the sections Lalung and Lingti have been visited and investigated. The research of the Lalung section mainly concentrates on biostratigraphy, definition of the Griesbachian-Dienerian boundary and the Late Permian Mass extinction (LPME) event. Investigations at the Lingti section also focus on the LPME.

In Kashmir, three sections, Guryul Ravine, Barus and Mandakpal have been visited and investigated mainly to deal with the LPME. It has been proposed that the event at Guryul Ravine section is marked by tsunami sediments (tsunamites), which however contradicts the hypothesis given by Krystyn et al., 2014. In the Guryul Ravine section the entire Lower Triassic has been investigated by us, while mainly the boundary interval was investigated by previous research groups. Brookfield et al., 2013 in recent times claimed for tsunami-related event beds induced by the Siberian Trapp basalts in this section, which according to us is questionable. Identical storm generated carbonate beds occur not only during a short interval close to the Permian-Triassic (P-T) boundary, but through a major part of the late Permian (Changhsingian) succession as low as 26 m below the so-called tsunami beds. Moreover, during our recent study in Madakpal which is less than 10 km away, no signs of 'tsunamites' have been detected in time-correlative fine grained sediments? Based on sedimentary and trace fossil evidence we interpret the late Permian of Guryul as relatively shallow, neritic and delta-influenced. The so-called 'tsunamites' are shelly-enriched discontinuous carbonate lenses fed down slope through local channels. Judging from the distinct facies change from sandy towards muddy background sedimentation at the base of the 'tsunamites' a sudden deepening may be explained by local and still rift-related tectonics along the North-Indian Gondwana Margin (NIM) which led to episodic seismic induced sediment redeposition in channel influenced places like Guryul. Syn-sedimentary tectonic activity with tilting and eventual Horst and Graben structure building along the large NIM is indicated by margin inversion during the P-T boundary interval, leading to sedimentary breaks and 20 times thinner, condensed limestone deposits far offshore from Guryul in Spiti (Krystyn et al., 2007) and Tibet (Orchard et al., 1996). Thus, local seismic activity seems to be a far more logic explanation of the Guryul 'tsunamites' than the eruption of the Siberian Traps which is more than 6000 km away.

Project

Earthquake Hazard and Risk Reduction on the Indian Subcontinent (RRISC) - Towards an earthquake-safer environment

(Vikram Gupta)

It is a joint collaborative project involving institutions like NORSAR, Norway and NGI Norway, Geological Survey of Bhutan, Bhutan, Indian Institute of Technology, Roorkee, C-MMACS, Bangalore, Wadia Institute of Himalayan Geology, Dehra Dun, Assam Engineering College, Guwahati. The Wadia Institute of Himalayan Geology as part of its research activity had planned to study earthquake risk and loss assessment in the hilly areas, particularly in Mussoorie and Nainital townships (Uttarakhand).

In order to understand the effect of topography and rock mass conditions on the amplification of the ground motion/seismic waves, three Broadband Seismometers along a profile between Dehra Dun and Mussoorie at different elevations varying between 800 m and 1800 m asl had been installed during previous year. The recording of the earthquake data is in continuous mode at sampling of 100 SPS. Till January 2014, a total of 29 earthquake events have been recorded. The recorded data of earthquake events (M>4.0) are from the local, regional and tele-seismic distances. In addition, the earthquake data base of the past events covering a period of past century of the northwestern Himalayan region has been prepared.

Further, in order to understand the slope geometry, topographic cross sections at three sites viz. Gujrala Inter School, Kolu Khet and Ghannanand Inter School have also been prepared. Modeled Rayleigh wave phase velocity dispersion curves along with the modelled H/V dispersion curves have also been prepared for these three different sites. From these curves, shear wave velocity profile for these locations have been interpreted and it has been observed that the shear wave velocity for the upper part of soil cover for few meter (<5 m) is less and increases drastically with depth. Thereby, it has been interpreted that thickness of the overburden on the slopes in the Mussoorie township is very shallow of the order of 5 m only.

Also, during the year a number of field visits to Nainital have been done to understand the geological, geotechnical and geomorphological characterization of the area. GPR profiling at number of sites in Nainital township and its environs has been carried out to understand the thickness of the overburden/loose material on the slopes. It has been observed that dominant part of the area is constituted by the limestone and dolomite belonging to the Krol Formation. A major Nainital Fault trending NW-SE, runs along the length of the Naini Lake. The expression of this fault is very clear in the Balia Nala, where rocks have been noted to be pulverized and highly fragile. A number of landslides have also been reported along the Balia Nala. An offshoot from this fault has also been observed on the Sher ka Danda hills, in the premise of the Birla Vidya Mandir School, where numerous cracks on the ground and building of the school have been noted, suggesting for continuous movement along this fault.

Project

MoU Collaborative Research Work with University of Savoie, France

(R.J.G. Perumal and Pradeep Srivastava)

The investigator have studied the surface expression of the Main Himalayan Thrust in Jammu-Kashmir, NW Himalaya, locally called the Riasi Thrust and regionally called as Medlicott-Wadia Thrust (MWT). The study area is located south of the Pir Panjal range and at the foot of the great Vaishno Devi limestone range. The thrust is in the same structural location as that of the causative fault of the 2005 Mw 7.6 Kashmir earthquake. The work confirms that the Riasi Thrust consumes a regular uplift of 10 mm/yr since 38 ka, and it is one of the main emergences of the Main Himalayan Thrust during a great earthquake

Project

Damage Assessment Mapping of Bhagirathi Valley with special reference to extreme rainfall event of the June 2013, Uttarakhand

(Anil K. Gupta, Pradeep Srivastava (Co-ordinator), Vikram Gupta, R.J.G. Perumal, Manish Mehta and Rakesh Bhambri)

In response to the Uttarakhand disaster of June 2013, DST has formulated this project, with WIHG focusing on the mapping of disaster elements like landslides, infrastructure like roads, government buildings, bridges, natural resources like forest cover etc in the Bhagirathi River. 20 students were trained for the data collection and mapping along these river sections. During the entire duration of data collection from the field, Scientists of the Institute supervised the work of the students.

Bhagirathi river which forms the part of Ganga River system upstream Devprayag, originates from Gaumukh glacier at an elevation of ~4000 m asl (snout) and drains southward for more than 170 km to meet Alaknanda river at Devprayag (458 m asl). The longitudinal river profile of the river shows two major zones. Zone-I that lies above Uttarkahsi has channel gradient ~11.8 degrees, is characterized by the bedload dominant sediment load and steeper tributaries. The lower part of this zone coincides with second physiographic transition with high rainfall and thick vegetation and the headwaters are semi-arid with thin vegetation cover. The size of the bedload in this zone ranges from couple of tens centimetres to more than a meter. The upper reaches, at places form deep and narrow gorges showing rapid vertical erosion. Zone-II is characterized by gentle hill slopes and thick vegetation cover. The cannel has lower channel gradient (~8°) and suspended load dominantly constituting the sediment load. The whole valley till Rishikesh including the Nayar basin was surveyed using software application provided by the Indian Institute of Remote Sensing and National Remote Sensing Centre. Twenty students selected from different colleges/universities of Uttarakhand were trained and are then deployed in this survey. Below we provide a summary of the survey.

Landslides

Several types of mass wastings that include landslides, debris flow and rock fall were mapped under this category. The survey shows that total number of 1034 landslides got reactivated/initiated due to the high rainfall event of June 2013. When plotted on a geological map, the mapped landslides appear to have occurred in two zones. Zone-I falls in the part of catchment having phyllitic rocks. Phyllites are fine grained low grade metamorphic rocks. These rocks are fragile and the hill slopes having thick mantel of weathered phyllitic rocks are vulnerable to failure during high rainfall events. Zone-II largely coincides with physiographic transition between the Lesser and Higher Himalaya. This is a fragile zone which is characterized by a wide belt of crushed zone of the Main Central Thrust (MCT) of the Himalaya and high rainfall. The combination of steep hill slopes, poor rock strength and high rainfall lead to widespread mass wasting in this zone. Also, the weaker rocks along the North Almora Thrust (NAT) and friable Siwalik belt compounded the causative factors. The maximum numbers of slope failure are observed between the floor thrust of MCT (Munsiari Thrust) and roof thrust of MCT (Vaikrita Thrust). These landslides blocked and affected the national and state highways, damaged the arable land and forest cover.

Bridges and Culverts

In the Bhagirathi Valley, bridges and culverts were found damaged at 44 locations where most sites of damage are present in the zone of river that has steeper channel gradients and larger bedload. It is inferred that large amount of outsized bedload brought down by the trunk as well as the tributary channels are responsible for damages in bridges and culverts.

Damage to Buildings

A total number of 717 buildings were found partially or totally damaged. This damage largely follows the two landslide clusters. The first cluster lies in the lower zones where damage is controlled by weaker rock type (phyllite) where most houses have their foundation in the weathered mantle of phyllitic rocks. The failure or creep in the weathered mantle induced by the increased pore pressure during the high rainfall event lead to the damage of several buildings in this zone. Whereas, the second cluster that lies in the upper part of the catchment shows damage to the buildings due to steep gradients, thrust zones, high stream power. While in most houses minor cracks on the walls and roofs were seen whereas some have suffered the complete damage. The houses located on the riverbed or fill terraces located adjacent to the river channel fell/completely damaged due to collapse of the terrace due to undercutting by the river.

Damage to other infrastructure

Damaged forest cover and agricultural land was mapped under this category. A total of 92 locations were documented that showed such damage, where most are clustered in the lower reaches of the catchment that have phyllitic rocks. In most cases the agricultural fields were washed away due to high discharge in the small gadheras or toe cutting of sedimentary fill by major rivers. The forest cover, in most cases, is damaged due to landslides. Damages in the government buildings like Panchayat Bhavans, Post Offices, Government offices, communication network, water supply lines etc. were mapped under this category. A total number of 320 sites were found damaged and the damage seems to be clustered into two zones as landslides. Roads in Bhagirathi-Nayar river valleys mostly follow the course of the rivers and run 20-200 m above the channel. Roads were seen damaged at 494 places and the damage is almost uniformly distributed mainly controlled by the landslides, riverbank erosion and overland flow. The topography of the mountain in general did not seem to be controlling the road damage.

Riverbank erosion

Riverbank erosion along Bhagirathi and Bhilangna occurred mainly above the town of Uttarkahsi at 170 locations. The catchment of River Assi Ganga was most affected. The damage has occurred along the course of the channel with relatively steeper gradients and where the terraces are of fill in nature. The fill terraces collapsed due to toe cutting by the channel. River bank erosion has mainly affected the agricultural terraces and has triggered landslides in the region.

Project

Damage Assessment Mapping of Yamunotri Valley with special reference to extreme rainfall event of the June 2013, Uttarakhand

(*Anil K. Gupta, Vikram Gupta (Co-ordinator), P.S. Negi, Gautam Rawat, Kalyan Kumar and B. Venkateswarlu*)

In response to the Uttarakhand disaster of June 2013, DST has formulated this project, with WIHG focusing on the mapping of disaster elements like landslides, infrastructure like roads, government buildings, bridges, natural resources like forest cover etc in the Yamuna River. 20 students were trained for the data collection and mapping along these river sections. During the entire duration of data collection from the field, Scientists of the Institute supervised the work of the students.

The study area involved the collection of data for the entire catchment of Yamuna valley between the Yamunotri temple and the Vikasnagar, spanning a length of about 150 km along the road. The field work for the data collection was carried out in two phases. First phase involved the collection of data in the upper reaches of the Yamuna valley, between the Yamunotri temple and Barkot during October 11-30, 2013. The first phase was planned and executed immediately after the sanction of the project as the working time in the area was limited because of the onset of the extreme winter condition. Second phase involved the collection of data in the lower reaches of the valley between Barkot and Vikasnagar and was carried out during November 11-28, 2013.

A total of 2,778 spatial distributions of various damage points were digital mapped and data collected were uploaded directly on to the Bhuvan Portal. Bhuvan is a geoportal of ISRO, showcasing Indian imaging capabilities in multi-sensor, multi-platform and multi-temporal domain. The break-up of the collected points is given in the table below:

The POI is uniformly distributed in the entire valley, so are the small and large landslides. However, most of the damages due to landslides are concentrated. These concentrations are mainly related to the presence of a hydropower project/dam near village Kharadi, or the already defined weak/landslide susceptible zones in the area. The river bank erosion has mainly been noted in the middle and lower stretch of the valley.

Some of the salient features observed/inferred during the project investigations as follows:

? Total annual rainfall along with the total rainfall during the monsoon months (June to September) is higher during 2013 as compared to the previous years. The rainfall data collected from Barkot township located in the Yamuna valley depict that after 2009 the average annual rainfall as well as rainfall during the monsoon months have increased.

? During the extreme rainfall event of June 2103, water level in the Yamuna river at the Yamunotri temple site had risen to about by 2 m. It is important to mention here that the water level during June 2013 extreme rainfall event is lower than the level of water that had risen during the preceding years.

? The incessant rainfall in the entire valley during June 2013 has created superficial, small-scale landslides on the slopes, mainly on the cut slopes.

? Almost all along the area, the National Highway-134 (NH-134) follows the Yamuna river at varying height ranging between 20 m to 150 m from the present level of river.

? During June 2013 tragedy, first major blockade of the NH-134 occurred near village Wariya

Sr. No.	Items	Number
1	Point of Interests (ATM/Bank/Guest House/ Post Office/ School/Tourism places/Museum)	1742
2	Landslides	333
3	Buildings	210
4	River bank erosion	172
5	Other infrastructures (Hospital/Electric line/Mobile Tower/School/ Water Tank/Retaining wall)	161
6	Damage to Roads	117
7	Landcover and natural resources	36
8	Bridges / Culvert	07
	TOTAL	**2778**

(30º55´36.00″N & 78º23'35.80″E), located about 35 km west of Tehsil Headquarter Barkot between the Rana Chatii and Hanuman Chatti (ref. toposheet No 53J/5). The Village is located between elevation 2000 m and 2400 m above msl. The village is situated on the old landslide zone that has been reactivated because of the oversaturated conditions. Presently because of the landslide along the NH and toe cutting by river Yamuna, the entire village is in danger and immediate corrective measures are suggested/ required after the scientific study.

? Towards the upper reaches of the Yamuna valley, most of the village are located on higher elevation and river flows through the hard consolidated material/rocks, thus no or little damage has been reported in terms of toe erosion/river bank erosion. Most of the damages were reported in terms of the cracks in the buildings, mainly due to subsidence caused by the saturation of materials on the slopes. At places where road is situated on the Quaternary materials or weak deposits, the damage to roads has been noticed.

? The greater damage in the area, was in Kharadi village, located about 10 km upstream of Tehsil headquarter Barkot. The village is mainly situated on the terrace deposit. The damage is primarily because of the small hydropower project located towards its upstream side, and as told by the villagers that all dam/reservoir gates were opened instantaneously leading to very high discharge in the river that directly hit the base/toe of the Kharadi village leading to toe/bank erosion. Many residential and commercial complexes (about 15 in number) were completely washed away.

? Further downstream in the lower reaches of the Yamuna valley, isolated patches of landslides have been observed, mainly because of the oversaturation of slopes and toe cutting.

? Bank erosion has also been observed in the downstream plain area, and is predominant seen near Dakpathar and Vikasnagar, where the river width is quite large of the order of ~100 m. The erosion at this stretch is mainly because of the concentrated flow from the Yamuna as well as the Tons river.

? In terms of loss and damage, June 2013 disaster witnessed more loss/damage due to secondary hazard (loss of revenue due to tourism, great decline in crop productivity etc.) as compared to primary hazard (direct loss of life, damage to infrastructure).

? No loss of life was reported in the entire Yamuna valley during this extreme climatic event

Project

Geodynamic Evolution of the Mylonitic Zone across the Lesser Himalayan Belt of the Eastern Himalayan Syntaxis in Arunachal Himalaya, Northeast India

(R.K. Bikramaditya Singh)

The eastern limb of the Eastern Himalayan Syntaxis (EHS) is represented by three major tectonic units namely the southwestern Himalayan part and the northeastern Trans-Himalayan part the Lohit Plutonic Complex (LPC), separated by the Indus Psangpo Suture Zone (IPSZ). The Himalayan part consists of two tectonic units namely the lower Lesser Himalayan unit and the upper Higher Himalayan unit. The Lesser Himalayan unit consists of quartzite, gneiss, phyllite and schist. This unit is limited at the base by the Main Boundary Thrust (MBT) or the so called the Mishmi Thrust. The LHC is thrusted over by the Higher Himalayan Crystallines (HHC) along the Main Central Thrust (MCT). The IPSZ rocks tectonically overlie the HHC. The lithounits of the IPSZ represent ophiolitic mélange that consists of a narrow zone of amphibolites overlain by a thick body of ultramafic rocks which are mostly converted to serpentinites. The mélange is thrust over by the LPC along the Lohit Thrust. The HHC is represented by a narrow discontinuous belt of graphitic schists containing garnet, staurolite, kyanite/ sillimanite, associated with thin bands gneisses and amphibolite boudins. The Lesser Himalayan Granitoids (LHG) is exposed over a broad area, bounded by the MBT at the base and the MCT at the top. The whole body of the LHG is penetratively deformed where the intensity of deformation is heterogeneous within the body. At places, development of minor shear zones consisting of ultra-mylonite and phyllonite occur. The prominent features of the LHG are the development of a penetrative foliation representing the mylonitic foliation and asymmetric augen feldspars are common (Fig. 51a).

The Lesser Himalayan Crystallines (LHC) is affected by three phases of deformation. The first phase of deformation (D_1) produced F_1 folds which are small-scale tight isoclinal, reclined to recumbent folds and occur as intrafolial or rootless folds (Fig. 51b). The second phase of deformation (D_2) is the most prominent one throughout the area. The S_2 foliation is penetrative and represents regional type. In the LHG, the S_2 foliation can be recognized by the alignment of micas wrapping around the feldspar porphyroclasts. The S_2 trends NNW-SSE with moderate dip mostly towards NE. The F_2 folds are mostly tight isoclinal upright to overturn. The trend of the axial plane of F_2 folds generally NNE-SSW. The L_2 lineation is the most prominent lineation in the area and has a general NW-SE trend that is mostly plunging towards NW. The third phase of deformation (D_3) produced open folds of regional extent. The S_3 foliation is recognizable under the microscope as a well developed crenulation cleavage. The third phase of folds (F_3) is mostly open type, and at places the F_3 folds are represented by kink and chevron folds on a small scale and a crenulation foliation especially in the area where there is competency contrast between different lithologies. The fold axes of the F_3 folds are NNE-SSW or NE-SW trending with minor variation of their plunge (15-20^o) towards SW or NE. The asymmetrical folds and asymmetrical feldspar porphyroclasts in the gneisses indicate top-to-the-south shear sense (Fig. 51a).

The Lesser Himalayan Granitoids (LHG) is medium- to coarse-grained rock. It exhibits well defined foliation by alignment of muscovite and biotite. It consists of quartz, K-feldspar, plagioclase, biotite and muscovite as essential minerals with minor epidote, apatite and zircon. The strong preferred orientation of muscovite and biotite define the main foliation, which wraps around the porphyroclasts of K-feldspar and plagioclase. Quartz mainly occurs as granoblasts and at

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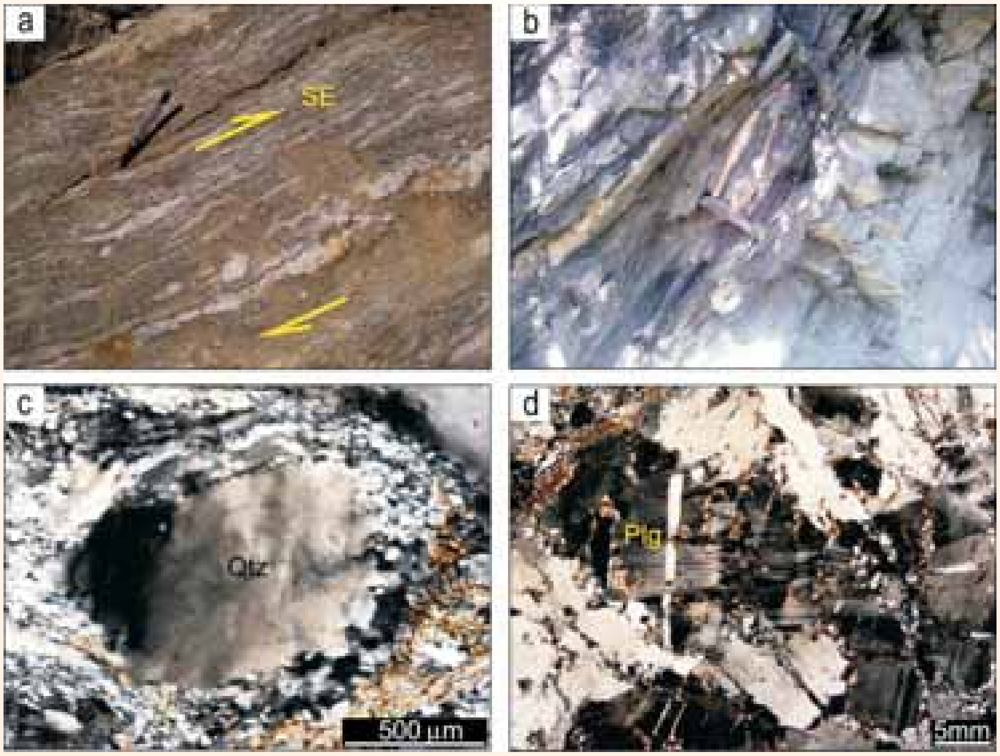

Fig. 51: Field photographs showing (a) asymmetrical augens with development of penetrative foliation in the Lesser Himalayan Granitoids and (b) tight isoclinal fold in the Lesser Himalayan Crystalline of the Eastern Syntaxis; (c) Photomicrograph of quartz porphyroclast showing undulose extinction with subgrains at the rim as a core and mantle structure; (d) Photomicrograph showing bending and fractures filled by quartz and mica in plagioclase.

places it forms augens and shows undulatory extinction, ribbon structure, core-mantle structure (Fig. 51c). K-feldspar occurs as augens wrapped-up by micas. Small grains of K-feldspar also occur in the groundmass associated with quartz. The K-feldspar shows perthitic textures, cross hatched and Carlsbad twinning. Plagioclase occurs as anhedral to subhedral coarse grains in the form of augen structures. It shows undulose extinction, bending and fractures (Fig. 51d). Recrystallized plagioclase is also observed in some samples. Biotite is a dominating ferromagnesian mineral, which occurs as small to medium grained flakes along the foliation with muscovite. It is dark to light brown in colour with pleochroism from yellowish brown to reddish brown and some of the flakes are greenish brown in colour.

Project

Palaeobiology of the Birmania Basin, Rajasthan and its correlation with the Krol-Tal belt of Lesser Himalaya

(Rajita Shukla)

Birmania Basin is an oval-shaped, isolated remnant of the Marwar Basin, roughly trending north-south, located in the central part of the Thar Desert, western Rajasthan. It is underlain by the Malani Igneous rocks (780-680 Ma) and unconformably overlain by the Lathi Formation (Jurassic). It comprises of ~900 m thick sequence of siliciclastic, carbonate and phosphorites facies rocks. The sedimentary rocks of Birmania basin are broadly grouped into two formations, the lower Randha Formation and the upper Birmania Formation. Based on the published isotopic data the Birmania Formation has been correlated with the Bilara Group of Marwar Supergroup, thereby indicating an Ediacaran to Early Cambrian age for the Randha and Birmania Formations. The Birmania Basin thus emerges as a promising area for the study of palaeobiological records of the Ediacaran-Early Cambrian times. The studies pertaining to the palaeobiological entities have been very limited in this basin and are being taken-up through this current project.

The reconnaissance field work was carried out in January, 2014 in the Birmania Basin of Jaisalmer area, Rajasthan. Meanwhile, microfossil and acritarch study continued on the samples which had been collected in the previous fieldworks from the Krol Formation. The area was surveyed in detail, and locations for sampling were identified around Randha, Birmania and Barsingha villages of Jaisalmer district. Thin section studies for palaeobiological entities are being carried out on the collected samples.

Project

Centre for Glaciology

(Anil K. Gupta and D.P. Dobhal)

During the year 2013, Hydro-meteorological data were collected by Automatic Weather Stations (AWSs) on both Mandakini (Chorabari) and Din Gad valleys (Dokriani). The meteorological data analysed for glacier surface melting and establishment of relationship between melt and various meteorological variables for Chorabari Glacier. A glacier lake inventory for Mandakini valley was also carried out using high resolution satellite data. A detail mapping and damage study on Kedarnath devastation has also been carried out in the month of September, 2013. The study shows that heavy rains together with breach of moraine-dammed Chorabari Lake triggered flooding of Saraswati and Mandakini Rivers in the Kedarnath valley of Rudraprayag district of Uttarakhand and badly affected the whole Mandakini valley.

Effect of wind speed and direction on glaciers mass balance

The present study investigates the influence of wind speed and direction on snow/ice melting for the period of 2011-2013. Networks of three meteorological stations (K1, K2 and K3) of Automatic Weather Station (AWS) were established at different altitudes on the Chorabari Glacier (Mandakini valley) catchment. The location of AWS's are (i) Station K1 (4,270 m asl) near the ELA, (ii) Station K2 (3,820 m asl) Base Camp near the snout, and (iii) Station K3 (2,760 m asl) at Rambara town. The aim of this study is to scrutinize the glacier wind in more detail and to develop the relationship between valley wind and glacier ablation. The wind speed and direction pattern is observed to be different for day and night and varies with seasons. During the day time the wind speed is found to be higher around 13:00 to 14:00 hrs in summer due to stronger temperature deficit (temperature difference between near-surface and ambient atmosphere) in the afternoon while in winter season it is around 06:00 to 07:00 hrs. It is observed that station K2 is experiencing more variation of wind speed in day time followed by station K3.

However, the mean hourly variation in wind speed for station K1 is smaller due to minimum temperature difference between near-surface and atmosphere, influenced by glacier regime. The mean wind speed is observed to be 1.4, 2.6 and 2.1 ms^{-1} for K1, K2 and K3 stations respectively (Fig. 52). For the observation period wind speed is observed to be higher during winter season.

The direction of wind is primarily influenced by the topographical condition of valley and also plays a significant role in melting of snow/ice. The maximum frequency of wind direction is observed to be NNW-NNS in K1, N-S in K2 and K3 (Fig. 52). In summer season, the rate of recurrence of valley wind (anabatic wind) resulting from greater heating of the valley sides as compared with the valley floor has higher frequency leading to increment of sensible heat causing more melting on glacier. As a result of exchange of sensible heat flux with glacier surface during winter season denser cold air at higher elevations drains into down valleys. This results (mountain wind, Katabatic wind) causing adiabatic heating of the air that travels down along the glacier valley leading to cooling of glacier surface. During the entire observation period the fraction of mountain wind is estimated as 68% which is more than the valley wind, 32% showing inadequacy in the melting produced by sensible heat.

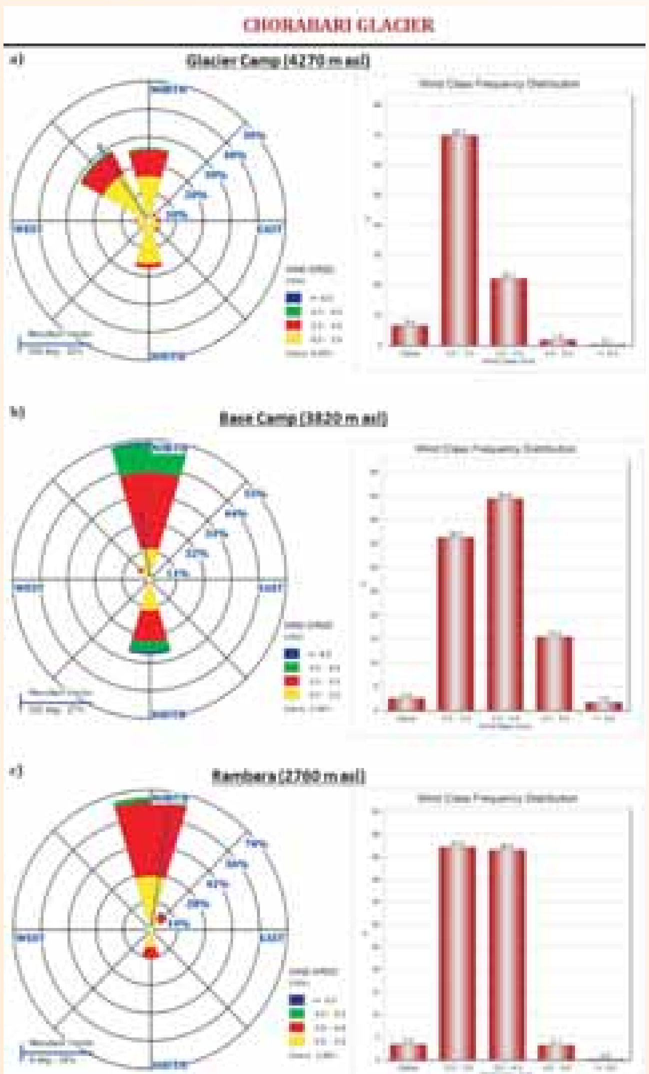

Fig. 52: Average wind speed and direction variations in different stations of Chorabari Glacier (Nov 2012-Oct 2013).

Glacier surface melt modeling for Chorabari glacier, Garhwal Himalaya

An attempt is made to examine the effect of different weather parameters on glacier surface melting, and to establish relationship between melt and various meteorological variables for Chorabari Glacier catchment. Data are recorded near the snout of glacier and empirical melt models incorporating temperature, net incoming solar radiation, relative humidity and wind speed are presented. Models are calibrated using ablation season data of year 2012 (June 10 to October 25) and are validated with the available data of year 2010 (July 10 to October 10) to check their applicability (Fig. 53). Furthermore, performance of the established empirical equations is tested through different statistical indicators like, coefficient of determination, mean percentage error (MPE), mean bias error (MBE), root mean square error (RMSE),

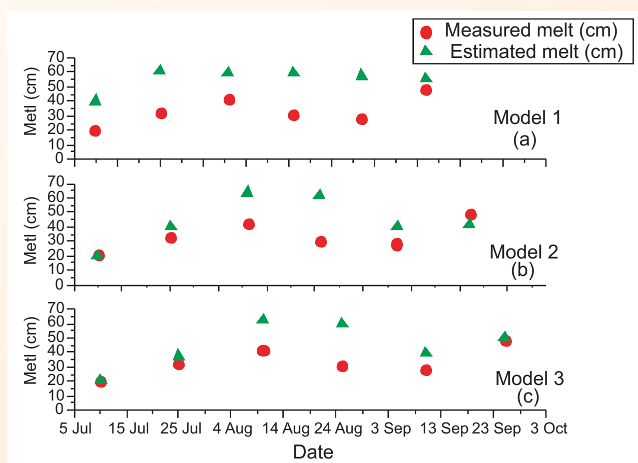

Fig. 53 : Comparative plot of recorded and estimated melt for (a) model 1(b) model 2 (c) model 3 from July 10 to October 10, 2010.

skewness and kurtosis. The statistical results enable to conclude that proposed models offer a good agreement between the measured and simulated melt data. Consequently, the study allows to illustrate that ablation not only depend on temperature but the other weather parameters such as, relative humidity, wind speed and net solar radiation also play a significant role in the melting of glaciers.

Chorabari lake outburst; Kedarnath devastation

The recent flash flood which occurred on June 16-17, 2013 in different parts of Uttarakhand state resulted in heavy loss of infrastructure, agricultural fields, lives, roads and widespread devastation of natural resources. The Kedarnath valley is one of the worst devastated areas in the region. Pre- and post-disaster field investigation, meteorological observations and remote sensing data sets are considered duly for the study. Extreme rain about 325 mm within 24 hours combined with melting snow caused horrific floods in the Mandakini River. Breaching of moraine dammed Chorabari Lake and deposited >5 m, loose unconsolidated moraine debris on the Kedarnath town; were the main causes of the devastation in and around the Kedarnath town as well as downstream of the valley. River aggradations accentuated the flooding in the downstream and completely washed-out Rambara with moderately washed Gaurikund, Sonprayag etc. Moreover, 33 new and 7 old re-activated landslides were identified and mapped between Sonprayag to Kedarnath route. Such a magnitude of disaster was perhaps not witnessed by the region at least over the last 100 years. Thus, this disaster can be considered as an Extreme Climatic Event of the century.

Glacier Lake inventory in Mandakini valley

A moraine-dammed Chorabari lake (Gandhi Sarovar) burst, at the periphery of Chorabari Glacier on June 17, 2013 and released large volume of water that caused flash flood in the Kedarnath town leading to heavy devastation downstream. It has now become imperative to identify glacier lakes in Himalaya not only to understand the impact of climate change on lakes but also to mitigate hazardous situations arising due to glacial lake outburst flood (GLOF). The glacier lake mapping by the conventional field surveys are laborious and can be dangerous in high mountainous regions, whereas multi-spectral and multi-temporal satellite data offer great potential to monitor these glaciers lakes at regular intervals (e.g. yearly or decadal). Therefore, high resolution multi-spectral space imageries from different sensors such as Resourcesat 2/LISS IV, Landsat 8/OLI and Terra/ASTER were evaluated for end of ablation season. The Resourcesat 2 LISS IV satellite images were acquired from National Remote Sensing Centre (NRSC, http://www.nrsc.gov.in/). In addition, Landsat 8/OLI and Terra/ASTER images were obtained from earth explorer and Land Processes Distributed Active Archive Center (LP DAAC; https://lpdaac.usgs.gov) respectively due to partial cloud cover in optical LISS IV satellite images.

Glacial lakes were automatically identified using the Normalised Differenced Water Index (NDWI, [NIR-BLUE]/ [NIR+BLUE]). Since LISS IV data lacks a BLUE channel the GREEN channel were used as a substitute. Misclassified pixels due to shadows were eliminated by a shadow mask using the SRTM DEM. However, this mask partially eliminated shadow from the NDSI images probably due to course resolution of SRTM DEM. Therefore, glacier lakes were manually identified based on visual interpretation. This method has been successfully applied for the detection of water bodies of Swiss Alps (Huggel et al. 2002), Nepal Himalaya (Bolch et al. 2008) and Garhwal Himalaya (Bhambri, 2012).

Total 14 lakes are identified in Mandakini basin covering an area of 343,478 m^2. Out of these, 7 are Cirque lakes whereas 4 belong to pro-glacier type lakes (Fig 4). All the lakes are located at the > 3700 m a.s.l. Vasuki Tal is the largest lake (74,656 m^2) in the basin. Chorabari Tal is the single moraine-dammed lake in the basin. This lake has 1/3 area (25,445 m^2) of Vasuki Tal. However, Chorabari Tal released large volume of water on 17th June, 2013 that caused flash flood in the Kedarnath town. Satellite interpretation of temporal images shows that area of Chorabari Tal fluctuates significantly in different seasons. Extreme rainfall during the 16-17 June, 2013 increased the volume of Chorabari Tal that caused burst of this lake (Fig. 54). This suggests growth of Chorabari Tal is an infrequent short-lived event and thus a great challenge to monitor by ground and satellite data as well.

Fig. 54: Pre- and post-disaster photograph of Chorabari Glacier. The red circle shows the breaching point of lake and red arrows indicate the Chorabari Lake and the snout of the Glacier. (Pre-disaster photo was taken on July 2010 and post-disaster on September 2013.

Project

Multi-Parametric Geophysical Observatory for Earthquake Precursory Research at Ghuttu, Garhwal Himalaya

(Naresh Kumar, Guatam Rawat, Devajit Hazarika, P.R. K. Gautam, Vishal Chauhan)

ULF band magnetic field variations at MPGO Ghuttu for June - 20, 2011 earthquake in Garhwal Himalaya

ULF band magnetic field variations using digital fluxgate magnetometer are investigated in frequency band of 0.03 to 1 Hz and for 19 to 20 h UT for the month of June, 2011. Polarization analysis based on planar wave assumption for far field, and fractal dimension variability, considering the earthquake system as self-organized critical system, is also studied. It was found that there is marginal increase in polarization ratio and fractal dimension few days before the earthquake. This is significant in the background of global geomagnetic activity. At the same time effect of post-seismic readjustment of seismogenic processes are clearly marked by significant changes in fractal dimension and increased polarization ratio after the earthquake.

The Table below gives the list of earthquakes with M > 3.0 that occurred within the radius of less than 1000 km from the MPGO Ghuttu during the month of June, 2011. It can be seen from the Table that, among all earthquakes in the month of June, MPGO Ghuttu is within preparation zone of earthquake occurred on 20.06.2011 as per the Doborvolsky criterion. Further, it may be noted that the epicentre of this earthquake is embedded in a narrow belt of concentrated seismicity, named as Himalayan Seismic Belt (Fig. 55). The area around this also formed seat of 1999 Chamoli earthquake (M6.3) and is currently active as evidenced by the occurrence of seismic swarms. Therefore, it can be expected that some precursory signatures might exist, which can be related to preparation process of this earthquake.

Polarization Analysis

Ratio of spectral densities of vertical (S_Z) and horizontal magnetic field (S_H) components is called the Polarization ratio. The method is based on the assumption that waves (natural EM field) from far distance (several thousand km) are planar and therefore do not have vertical component whereas field of near source origin is non-planar and thus, have vertical component. Therefore, increased S_Z/S_H ratio indicates presence of near source field and temporal variations of polarization ratio, in different frequency band, enable us

Table : List of earthquakes for the month of June 2011 around MPGO Ghuttu (Source: IMD).

Date	Origin Time	Epicentre	Depth	Magnitude	Distance from MPGO (in km)	Strain radius (in km)
03.06.11	00:53:21	27.5°N, 88.0°E	20	4.9	962	127.9
15.06.11	00:59:28	30.6°N, 80. 0°E	10	3.4	130	28.9
20.06.11	06:27:18	30.5°N, 79.4°E	12	4.6	63	95.0
24.06.11	22:13:46	30.0° N, 80.5°E	05	3.2	178	23.77

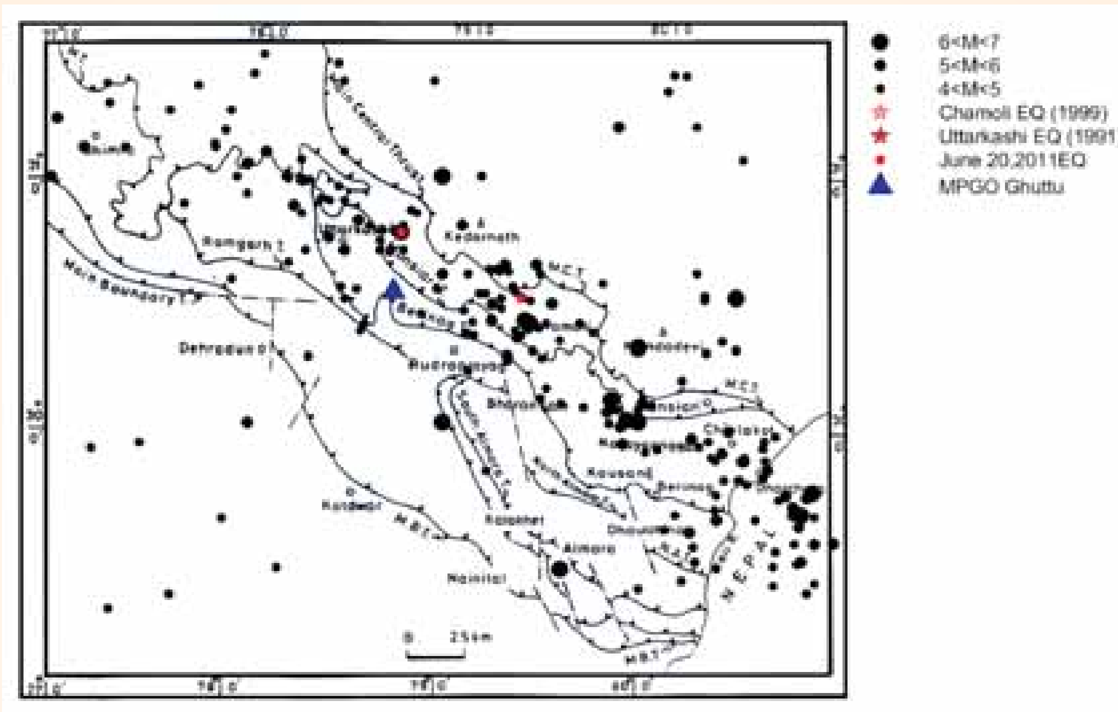

Fig. 55: Earthquakes of June 2011 in the background of seismicity of Himalayan seismic belt.

to distinguish seismo-magnetic signals from the background geomagnetic field fluctuations of space origin. Figure 56 gives the histogram of daily S_Z/S_H, S_Z/S_y, S_Z/S_x, ratio for the selected hour (19 to 20 UT) along with Kp variations showing global magnetic activity for entire month of June, 2011. The 3-hour magnetic index Kp shown in the figure 56 correspond to 18 to 21 UT (source: NGDC, NOAA) to overlap with time period whose magnetic data is processed by us. It can be observed that the global geomagnetic variations and polarization ratio are not strongly correlated and the observed S_z/S_H shows significant variability with mean value of 0.38±0.13. The isolated large polarization ratios observed on June 3rd, 5th and 7th before the earthquake, and again on June 22nd and 25th after the earthquakes may manifest complex phase inter-play between planar and non-planar fields. Marginally high ratios starting from June 15th till the occurrence of earthquake on June 20th, especially when geomagnetic calm prevails, may signify dominance of non-planar source associated with strain build up close to failure leading to earthquake. As the global geomagnetic activity increases, the planar field characterized by nearly vanishing vertical field tends to dominate, and hence reduction in polarization ratios below the average value, particularly during prolonged spells of geomagnetic sequences, e.g. June 21-25 and June 9-14, 2011, is a expected feature.

Fractal Analysis

Earthquake dynamics can be studied based on Self Organized Criticality (SOC) concept where earthquake occurrence is considered a critical stage.

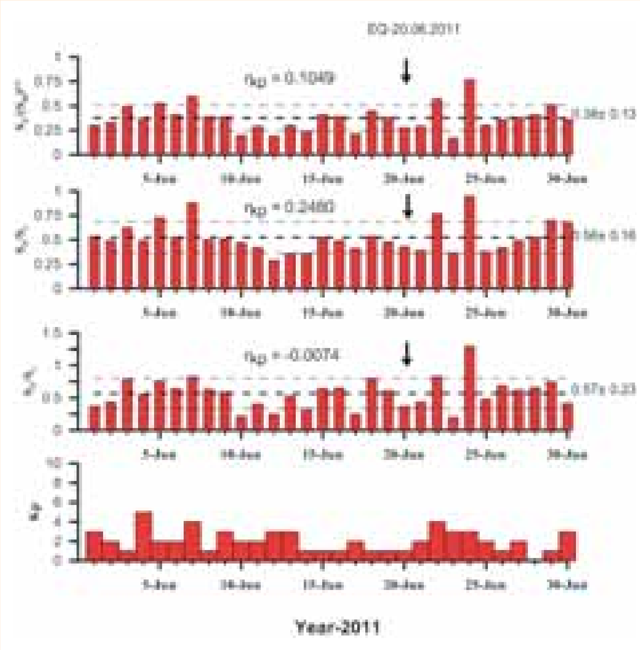

Fig. 56 : Variation of polarization ratio for June 2011.

Earthquake preparation processes leading to this stage can be considered intermediate stage of SOC evolution. Since the dynamics of such system reflects power law distribution, studying behaviour of 1/f characteristics with time can give information about different stages of earthquake preparation process. In order to study the characteristic 1/f behaviour, the slope of power spectrum behaviour $s(f)f^{-}$ is obtained from the best fit line in the log-log plot of selected frequency band. This slope can be linked with fractal dimension using Berry's equation (D= (5-)/2).

Seismic activity in NW Himalaya is limited to upper crustal depths and delimited by the geometry of detachment in this part of the Himalaya. Considering the geo-electrical structure of Garhwal Himalaya frequency band 0.03 to 0.10 Hz corresponds to upper crustal and mid-crustal depths. We therefore limited our data analysis for this frequency band in order to obtain signatures from depths where seismogenic processes dominates in NW Himalaya.

Fractal dimension (D) variability in three components is found different and is having negative correlation with Kp variation of 18 to 21 h UT (Fig. 57). An increase in the fractal dimension before earthquakes is reported by different researchers studying seismic electromagnetic phenomena during earthquake preparation processes. The amplitude of the precursory

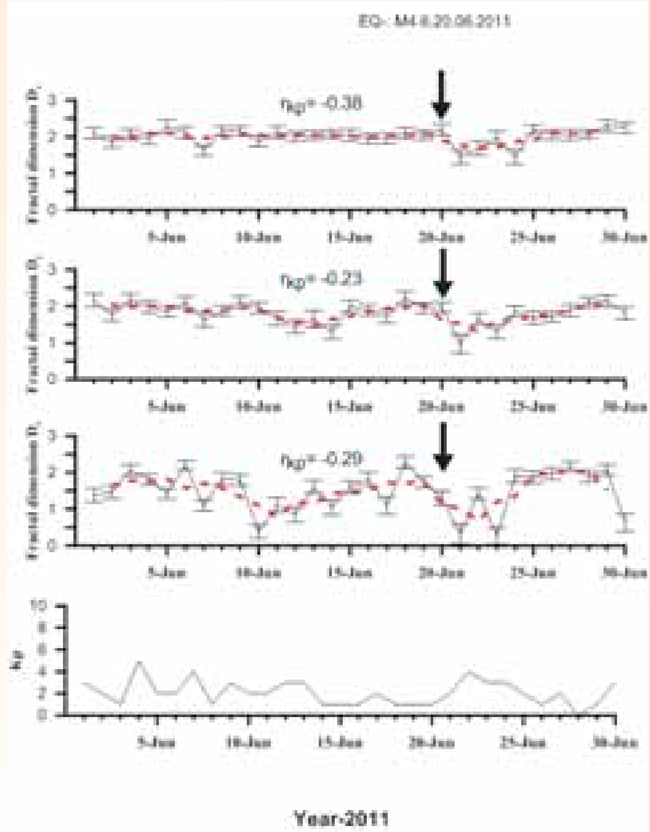

Fig. 57: Fractal dimension variability for the month of June-2011.

signal as well as precursory time, i.e. time from the first appearance of the anomaly till the occurrence of the earthquake, vary with the magnitude and distance of the earthquake. The increase, both in fractal dimension and polarization ratios in 5 to 6 days before moderate magnitude (M4.6) earthquake is conformity with such emerging scenario. The observation that temporal variability of fractal dimension vary considerably among three components is an important feature. We found fractal dimension variability in X (N-S) magnetic component is more compared to Y (E-W) and vertical component. The fractal dimension for vertical component is more or less stable around the mean value of 2, except for four days (June 21-24, 2011) just after the earthquake. The difference in variability in all three components may be linked with the azimuth of primary disturbance. Recent magneto-telluric studies have mapped fluid filled high electrical conductivity ramp structure running parallel to the MCT. The role of high pore-pressure fluids in generating localised seismic activity has been emphasized by seismic tomographic results. Given these evidences of high pore-pressure fluids, electro-kinetic effect may be one possible source mechanisms for seismo-EM fields for the earthquakes in this region.

Project

Fluid Flow in Ladakh Accretionary Prism, Indus Suture Zone: Implications For Modeling Of Fluid Process Of Subduction Regime

(H.K. Sachan)

The field work has been carried out in the Ladakh especially in covering Lato-Upshi, Nimu-Chilling section of Ladakh accretionary prism (LAP) as well as in Shergol ophiolitic mélange in the summer of August 2013-2014. The veins of LAP (transverse section from Indus thrust to Zanskar thrust) have been studied by analysing a suit of isotopes (C, O, Sr and Pb) to determine their source. The $\delta^{13}C$ and $\delta^{18}O$ values of calcite veins are akin to the mantle field, near Indus thrust, which were fractionated toward Zanskar thrust. The $\delta^{13}C$ and $\delta^{18}O$ composition of calcite veins from Indus thrust to Zanskar thrust varies from -13.2‰ to -0.7‰ (VPDB) and 10‰ to 21.2‰ (VSMOW) due to alteration/mixing processes. The $\delta^{18}O$ values of quartz veins display a range of 12.9‰ to 23.5‰ (VSMOW), confirming its magmatic source. The $^{87}Sr/^{86}Sr$ ratio of the calcite veins varies from 0.705 to 0.709 that becomes more radiogenic from Indus thrust to Zanskar thrust. $^{87}Sr/^{86}Sr$ ratio of calcite near Indus thrust is about 0.705-0.707, showing affinity to the mantle field and is similar to the adjacent Ladakh magmatic arc (0.703-0.707). The $^{206}Pb/^{204}Pb$ ratio of these veins ranges from 18.58 to 18.75 whereas $^{207}Pb/^{204}Pb$ ratio varies from 15.64 to 15.72. The $^{208}Pb/^{204}Pb$ shows small variation in range from 38.83 to 39.22. Both Sr and Pb isotope compositions of these vein carbonates display close resemblance to Enrich Mantle 2 (EM2) field.

Project

Siwalik Mammalian faunas of the Himalayan foothills

(A.C. Nanda)

The main objective of the project is to write a monograph on the mammalian faunas of the Siwalik Group. The work has been completed and it has been reviewed by experts. The work has been broadly divided into two parts, Part 1 deals with the Siwalik stratigraphy and relation of faunas, whereas the Part 2 deals with the systematic palaeontology of mammalian fossils. It is illustrated by more than 50 plates, and by several figures and tables. This work on the *'Mammalian faunas of the Siwalik Group'* will be published in form of a monograph by Wadia Institute.

The work includes, a comprehensive faunal list of the Siwalik Group, based on recent works in India and Pakistan, and an attempt has been made to include all the discoveries made since 1832. About 230 genera, represented by 446 species, are listed. The Recent Mammalian Fauna of India contains 178 genera, represented by 397 species, and thus comparatively rich Siwalik faunas prevailed between 18-0.6 million years ago. The work also covers the recent advances particularly carried out in the Lower Siwaliks of Ramnagar (Jammu), Middle Siwaliks of Nurpur and Haritalyangar (Himachal), Middle Siwalik of Piram Island (Gujarat), Lower and Middle Siwaliks of Kalagarh (Uttarakhand), and Upper Siwaliks of Chandigarh and Jammu regions of India, are highlighted. In addition, recent works carried out in various fossil localities of Pakistan, Nepal and Myanmar are discussed, Pakistan Siwalik localities include the type localities of Potwar Plateau, Lower and Middle Siwaliks of Daud Khel, Upper Siwaliks of Mangla-Samwal, Pabbi Hills, and Bhittanni Marawat Ranges. Upper Siwalik faunas of Manchar Formation and Lower and Middle Siwalik faunas of Sulaiman Range and Bugti area are also commented. Lower, Middle and Upper Siwaliks of Nepal are also discussed. The Lower Siwalik fauna of Dang Valley and Upper Siwalik faunas of Surai Khola and Rato Khola are compared with the respective faunas occurring in India and Pakistan. The faunal lists of the above-mentioned fossiliferous areas of India, Pakistan and Nepal are compiled. In addition, Middle and Upper Siwalik faunal elements occurring in the Irrawaddy Group of Myanmar are also commented and faunal lists of Lower and Upper Irrawaddy faunas are prepared. In addition to the well-known Middle and Upper Siwaliks taxa, the Lower Siwalik elements are also present in the Irrawaddy Formation.

The Siwalik faunas either became extinct or migrated from the Himalaya foothills at 0.6 Ma. The relations of the Siwalik faunas with the Middle and Upper Pleistocene faunas of Peninsular India and Indo-Gangetic Plain, and Late Pleistocene-Holocene Kurnool Fauna are also worked out. The necessary faunal lists of different horizons are compiled. The systematic descriptions of mainly of Upper Siwalik mammalian fossils are dealt in detail. The different taxa belong to families Mustelidae and Hyaenidae (Order Carnivora), Elephantidae (Order Proboscidea), Equidae and Rhinocerotidae (Order Perissodactyla), and Hippopotamidae, Suidae, Anthracotheriidae, Camelidae and Giraffidae (Order Artiodactyla).

The Standard Reference Sections of the various formations of the Siwalik Group are recognized. While erecting the reference sections fossiliferous areas having magnetostratigraphic ages are considered. Each reference section has the lower and upper boundaries, except for the Boulder Conglomerate Formation. Kamlial fossils are not known from the Indian Siwalik; so the Standard Reference Section for the Kamlial Formation is not recognized.

Project

Report work under Indo Norwegian Project on Geothermal Energy

(S.K. Bartarya)

Space heating using geothermal energy is one of the well-known applications of geothermal energy utilization from decades. The usage of geothermal energy for space heating provides an economical and a non-polluting way for achieving human comforts. Chumathang located in Ladakh area in NW Himalayan region is having good geothermal potential in the form of hot springs and other exploration wells drilled. The climate in the region is very cold such that minus temperature is recorded during night for almost six months a year. Due to lack of natural resources in the area required for construction of houses, the houses are less insulated and hence adding to room heating requirement for human comfort. The demonstration project in Chumathang for space heating taken by Research Council of Norway in collaboration with WIHG will help in promoting geothermal utilization for space heating on a larger scale in the area. The demonstration project will also help learn about various factors to be considered for large scale applications since the conditions involved for designing are different due to local house construction, climatic and geographical conditions prevailing in the area.

A technical design of the demonstration project was prepared considering heat load requirement for three rooms and a restaurant for -20°C ambient temperature. The heating system is designed for 29 kW heat load as per heat load estimation. The high heat load is reflected by the typical structure of Ladakh houses due to lack of natural resources available for house construction. It is also planned to use solar energy for pumping the hot spring water in the heating system.

Usage of Ground source heat pump for space heating and cooling is a well-known technology in many developed nations. The technology is also gaining its importance in developing countries as a concern to increased energy demand and environmental awareness. Improvements are still going in the field of technology and applications. The project for utilization of Ground source heat pump will be a further forward movement of our Nation in the area of green energy utilization. With the increased electricity prices and demand usage of ground source heat pump will surely lower the cost considering the life time for air conditioning requirement at the place of application. The demonstration will also promote the application of technology on large scale in the country in future. Such technology transfer will also promote indigenous developments of such systems.

The project also involves installation of ground source heat pump system in the premises of Wadia Institute of Himalayan Geology at Dehradun for space heating requirement in winters. The heat pump is being designed for maintaining room temperature of 20°C for 40 rooms assuming 1°C ambient temperature. The mechanism involves running reversed vapour compression cycle with ground water heat as a source obtained by circulating heat through borehole heat exchangers.

Project

On establishment of two new permanent GPS stations in Panamik at J & K and Pithoragarh region in Uttarakhand

(P. K. R. Gautam and S. Rajesh)

As the crustal shortening is concern to the plate boundary phenomenon, it was observed by the earlier workers a convergence zone along the Himalaya. To see the present convergence scenario in Ladakh (J&K) and Pithoragarh in Uttarakahand region, we installed two permanent GPS stations one at Tangtse (J&K) and another one at Pithoragarh in Uttarakhand under MoES sponsored project. The data are acquired at two frequency 1 sec and 30 sec sampling interval simultaneously. The 30 sec sampling data is collected for the crustal deformation study, while the near real time 1 sec sampling interval data is important for earthquake study.

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SEMINAR/SYMPOSIA/WORKSHOP ORGANISED

4th Third Pole Environment Workshop (April 1-3, 2013)

The Wadia Institute of Himalayan Geology (WIHG), in association with the Third Pole Environment (TPE), a flagship programme of the United Nations Educational, Scientific and Cultural Organization organized *The 4th Third Pole Environment (TPE) Workshop* during April1-3, 2013 at its premises in Dehradun. The hosting of this workshop was endorsed by the Hon'ble Prime Minister of India and His Excellency President of Iceland, and will gather International Scientists, NGOs and interested policy makers to exchange notes on local environmental change processes and their influences on, as well as responses to, changes occurring in the global systems. The workshop was organized jointly through the TPE Programme Office in Beijing and the WIHG, Dehradun. Prof. Anil K. Gupta, Director WIHG was the Chairman of Local Organizing Committee and Dr Kishor Kumar was the Coordinator.

The inauguration of the Workshop was held at 2.00 PM on the first day of the workshop in the Anjaneya Auditorium of the Wadia Institute. Dr Ólafur Ragnar Grimsson His Excellency President of Iceland was the Chief Guest and Shri S. Jaipal Reddy, Hon'ble Union Minister of Science & Technology & Earth Sciences, Govt. of India was the Guest of Honour. Other invited dignitaries included Dr T. Ramasami, Secretary of Minsitry of Science & Technology, Govt. of India, Mr G. Eiriksson Ambassador of Iceland in India, Mr. O. Thorsson, Secretary General, Office of the President of Iceland, Mr. H. Olafsson, Minister Counsellor, Embassy of Iceland in New Delhi, Mr. Dagfinnur Sveinbjornsson, Special Advisor to the President of Iceland on Climate Change, Dr Tandong Yao, Dr L.G. Thompson and Dr V. Mosbrugger TPE Co-Chairs. Over 40 delegates from countries like USA, France, Germany, China, Japan, Sweden, Tajikistan, Bangladesh, Myanmar Nepal, Kyrgystan, Netherlands Iceland Canada, Switerzerland and a dozen from India

Dr Ólafur Ragnar Grimsson, President of Iceland, Shri S. Jaipal Reddy, Minister of Science & Technology & Earth Sciences, Govt. of India with other dignitaries during inauguration of the 4th Third Pole Environment Workshop.

attended the workshop. Over thirty oral presentations were made followed by detailed discussions.

The first two scientific sessions were held after the inauguration on the first day in the afternoon and evening. The remaining five scientific sessions were held over the second and third day, with a concluding session wrapping up the workshop on the afternoon of the third and final workshop day, i.e. April 3, 2013. The Group and Plenary Discussion, was organized according to four main topics: High-elevation observations led by G. Greenwood, a Precipitation Working Group (PWG) follow up summary led by D. Yang, a Glacial Mass Balance Working Group report led by K. Fujita, and Climate in the past 2 ka led by L. Thompson.

Workshop on Modern Perspective in Himalayan Geosciences (June 11-12, 2013)

The Wadia Institute of Himalayan Geology (WIHG) organised two day workshop on the "Modern Perspective in Himalayan Geosciences" during June 11-12, 2013, at its premises in Dehradun. The workshop was organised as part of the celebration of the 'Golden Jubilee Year' of Indian Geophysical Union. Prof. Anil K. Gupta, Director, WIHG was the Chairman of Local Organizing Committee and Dr. Rajesh Sharma, Scientist 'G' was Convener of the workshop. The workshop aimed to provide platform to the Himalayan geoscientists, particularly the young research students to deliberate upon the new developments in the Geoscience of the Himalayan orogenic belt. Padam Shri Prof. Harsh Kumar Gupta, Hon'ble member, National Disaster Management Authority, Government of India was the Chief Guest and delivered the Inaugural address. Padam Shri Prof. V.P. Dimri, President Indian Geophysical Union highlighted the IGU activities and its Golden Jubilee Celebration programmes to the participants. Over 100 participants from various Institutions and Universities like, NGRI, IITs, Delhi University, BHU, Kumaun University, Kurukshetra University, Indian Statistical Institute, IIG etc attended the Workshop.

Prof. V.P. Dimri, President Indian Geophysical Union addressing the audience.

The focus of the Workshop was on recent geophysical and geological researches in understanding Himalayan Evolution. The two days workshop included technical presentations and field-work. Total seventy eight technical presentations were made, of which 23 presentations were oral and fifty five presentations were through the poster presentations. The presentation were made on the key issues like (i) understanding the lithospheric structure and tectonic fabric of Himalaya through geophysical parameters, (ii) its lithotectonic evolution, (iii) the landform development, shallow subsurface processes and neotectonic actively, (iv) paleoclimatic variations in Himalaya and the (v) geoscience for the society. Five invited talks were arranged to disseminate knowledge on the Key issues. The key note speakers include, Prof. Mrinal Sen, Prof. Ram S Sharma, Prof. A.K. Jain, Dr. V.C. Thakur and Prof. D.C. Srivastava. The highlight of the Workshop was that 53 research scholars presented their research work on various aspects of the Himalayan Geosciences. In addition, twenty two master level students also participated to learn the recent developments in the Himalayan Geosciences. Adequate time was given to the technical sessions arranged for the poster presentations. As a token of appreciation four posters were adjusted for the Best Poster Awards.

Brainstorming meeting on "June 2013 Kedarnath Tragedy: Focus on damage assessment and mapping" (July 28, 2013)

Uttarakhand faced the worst disaster of recent centuries in which thousands of pilgrims and local people lost their lives and livestock due incessant rains on June 16-17, 2013. The flood of June 2013 of Alaknanda is so far recorded highest, even higher than the flood recorded in 1970 and 1894 (Irrigation department of Uttarakhand at Srinagar). Considering the fact of the damage caused or geomorphic signatures left by extreme event, a one day Brainstorming meeting was organized by Wadia

Dr T. Ramasami, Secretary DST, Govt. of India addressing the participants.

Institute of Himalayan Geology, Dehradun on July 28, 2013. The meeting was chaired by Dr. T. Ramasami, Secretary to Govt of India, Department of Science and Technology, New Delhi and Coordinated by Prof. Anil K Gupta, Director, Wadia Institute of Himalayan Geology. The agenda of the meeting was to discuss the strategies to accurately assess the damage and its mapping that happened as result of June 2013 Kedarnath Tragedy.

The meeting was attended by Sri Shyam Saran (Ex Foreign Secretary to Govt of India), Prof. S K Singh, Vice Chancellor of Garhwal University, Prof. Talat Ahmad, Vice Chancellor of Kashmir University, Sri Amit Prasad, IPS and DIG of ITBP. Also, more than 60 representatives from NGOs, ITBP, Lucknow University, Kumaun University, Garhwal University, Kashmir University, JNU, New Delhi, NIDM, New Delhi and Wadia Institute participated in the meeting.

During deliberations it was felt that there are three major causes of this unprecedented natural event (i) cloud bursts in more than one river valleys (ii) Heavy rainfall and breaching of glacial lakes, and (iii) disintegration of the Kedar Dome, a glacier-like body of rock and ice. It was also felt that the widespread and almost unregulated expansion of giant hydro-electric projects in the region, mushrooming residential constructions, the unscientific construction of roads to serve the rapidly increasing tourist population, have adversely interacted with the fragile ecosystem in the region and caused for the devastation that Uttarakhand.

Dr. T. Ramasami, Secretary, DST suggested to set the roadmap and strategies to be deployed in combating the disaster. A major program *'Mapping the neighbourhood in Uttarakhand (MANU)'* was envisaged in this meeting. The program is designed to map the disaster elements such as landslides, damaged roads, riverbank erosion, damaged infrastructure and damaged natural resources where local student community will be recruited to complete the job. The first phase of this program will focus on Chardham yatra routes along the rivers of Yamuna, Bhagirathi, Alaknanda, Mandakini and Pinder.

Workshop on Mountain Meteorology and Landslides: a way forward (September 1-3, 2013)

A two days Workshop on *'Mountain Meteorology and Landslides: a way forward'* was organized in the Wadia Institute of Himalayan Geology from September 2-3, 2013 which was co-sponsored by the National Disaster Management Authority (NDMA), New Delhi. The Workshop was inaugurated by Hon'ble Chief Minister of Uttarakhand Shri Vijay Bahuguna. Prof. Anil. K. Gupta, Director, Wadia Institute of Himalayan Geology, Dehradun welcomed the Chief Guest and other guests on the occasion. Shri Bahuguna ji in his inaugural speech raised various burning issues of the Uttarakhand in the light of recent Kedarnath disaster. He emphasized that an action plan to be prepared from a scientific view point to ensure that the people in the hills and border areas also benefit from the development. He suggested

Shri V.K Duggal, Member, NDMA, New Delhi with other dignitaries on the dais.

for the development of an early warning system in order to inform the local people about earthquakes, cloud bursts, heavy rainfall or extreme weather condition in advance. He had also inaugurated the Automatic Weather Station (AWS) installed in the campus of the Wadia Institute of Himalayan Geology, Dehradun. The AWS will give the daily online weather data and it is made available on the WIHG web site www.wihg.res.in for all users.

The workshop mainly focused on landslides, national hazard mitigation, bioengineering technologies including uses of Geosynthetic cover for erosion control. Glacial lake outburst flow mapping and need for Doppler weather radar in hilly region for precise early warning. Also, an aspect of river restoration, hydropower, Himalayan environment, damaged road reconstructions, alternative routes and tunnel construction was discussed. Shri V.K Duggal, Member, NDMA, New Delhi had chaired the valedictory session, and recommendation and conclusions from the presentations and discussions were submitted in form of a report to NDMA for further action and implementation of reconstruction and sustainable development in the Uttarakhand.

XXIV Indian Colloquium on Micropaleontology & Stratigraphy (ICMS), (November 18-20, 2013)

The XXIV Indian Colloquium on Micropaleontology & Stratigraphy (XXIV ICMS) was organized by the Wadia Institute of Himalayan Geology (WIHG) during November 18-20, 2013. The XXIV ICMS deliberated on a wide range of topics across disciplines and provided a common platform for scientists and students from both academia and industry to share and propagate the latest findings and developments in the fields of micropaleontology and stratigraphy.

Prof. S.K. Shah Former Head, Department of Geology, Jammu University was the Chief Guest and delivered the Presidential Address. Prof. Anil K. Gupta, Director WIHG welcomed the participants. Prof. S.C.D. Sah former Director, WIHG, Prof. S.B. Bhatia Former Head, Department of Geology, Panjab University, Prof. MP Singh Former Head, Department of Geology, Lucknow University, and Dr A. Govindan were the Guests of Honour. Seven conveners of the past colloquia (Drs. Prabha Kalia, M.P. Singh, Jagdish Pandey, Rajiv Nigam, Devesh K. Sinha, Rahul Garg, and N. Malarkodi) also graced the inaugural function. Other dignitaries like Drs. S.A. Jafar, D.M. Banerjee, D.N. Singh, and S.P. Mohan were also present. More than 200 delegates including 85 research scholars from more than 50 Research organizations, IITs, university/college departments, research institutions and corporate sector across India attended the colloquium and presented their research findings.

The colloquium featured 85 oral presentations including 14 keynote addresses which were grouped under 8 technical sessions. In addition, 96 presentations were made through poster presentations, providing an opportunity to interact informally with the contributors during dedicated poster sessions and extended tea/coffee breaks. The 'Abstract Volume' of the colloquium contains 214 abstracts. The large and successful gathering of scientists testifies to the immense growth of this field in India over the years. Dr Kishor Kumar, Convener of the 24th ICMS proposed the vote of thanks.

Prof. S.K. Shah, President of the 24th ICMS and other dignitaries during inauguration of the 24th Indian Colloquium on Micropalaeontology & Stratigraphy.

Dignitaries and participants of the 24th Indian Colloquium on Micropalaeontology & Stratigraphy.

Participants attending a lecture during Winter School in 'Geomathematics'.

Winter School in Geomathematics (December 16-30, 2013)

The Wadia Institute of Himalayan Geology organised 15 days *'WIHG Winter School in Geomathematics'* during December 16-30, 2013. This winter School was sponsored by Science and Engineering Research Board (SERB), Department of Science & Technology, Government of India. Twenty six young researchers were selected as participants from all over India, that represented total number of 18 Universities/Research organizations like IITR, IITB, IIG, ISM, JNU, University of Pune, Osmania University, Pondicherry University, University of Burdwan, IIRS-Dehradun, WIHG etc. The main objective of this winter School was to expose young researchers pursuing Ph.D. in Earth System Sciences to latest/important mathematical techniques and their applications in Earth System Sciences, so that they can solve/investigate their research problems in a better way using these mathematical techniques. This course also provided exposure to various tools/computer software/programming for solution of the mathematical techniques.

The winter school was inaugurated by Chief-Guest, Prof. Mrinal K. Sen, Director, NGRI, Hyderabad on December 16, 2013. Prof. Anil K. Gupta, Director, WIHG welcomed the guests and highlighted the importance of Geomathematics. Dr. T.N. Jowhar, Scientist 'F', WIHG and Course co-Coordinator introduced about the Winter School, and its importance towards improvement of scientific study related to Earth System Sciences. Dr. M. Mohanty of DST highlighted the importance of training. Sixteen experts from various renowned organisations like NGRI, ISM, IIT Roorkee, DIT University, Jadavpur University, PRL and WIHG provided high standard training and scientific interaction.

Prof. Mrinal K. Sen delivered two inaugural lectures on "Basic Concepts of forward and inverse problems in Geophysics" and "Uncertainty Quantification in Geophysics or Uncertain Uncertainty?" A total of 45 lectures were delivered and around 20 tutorials were arranged as part of the fortnight training course. Participants also visited museum, library and various laboratories of the Institute and also interacted with scientists of the Institute. On 25th December a field excursion to the participants was also arranged to give exposure of Himalayan Geology. Prof. A.K. Awasthi, pro-Vice Chancellor, Graphic Era University, Dehradun was the Guest of Honour to the Valedictory Function held on December 30, 2013.

National Conference on Implication of Climate Change on Himalayan Environment (March 20-21, 2014)

WIHG has organized a "National Conference on Implication of Climate Change on Himalayan Environment" jointly with Central University of Himachal Pradesh (CUHP) at Dharamsala during March 20-21, 2014. Prof. A.K. Mahajan of CUHP was the chairman of the conference and Dr. P.S. Negi, Scientist WIHG was the co-Chairman of the conference. The conference was inaugurated by Chief Guest Prof. Timothy A Gonsalves. Nearly 60 researchers from various institutions, universities and other technical organization were actively involved in the conference and more than 20 scientific/technical deliberations were presented during the different sessions. The conference included five technical sessions, (i) observations on present climate change, (ii) impact of climate change on biodiversity, (iii) Himalayan tectonics and its effects on climate change, (iv) effect of climate change on Himalayan glaciers and (v) investigation on paleoclimatic conditions.

AWARDS AND HONOURS

- Dr. Naresh Kumar has been awarded with 'Marie Curie Postdoc Fellowship' for one year within the European Programme "Talents up for an International House (TALENTS UP)" for carrying out research at International Centre of Theoretical Physics, Trieste, Italy (ICTP). The ICTP had also awarded him the Junior Associate.
- Dr. Sushil Kumar was appointed as convener and session Chairman in the AOGS-AGU held at Brisbane, Australia during June 24-28, 2013.
- Dr. Rajesh Sharma and Dr. Vikram Gupta have been nominated as Member and Alternate Member CED 39, respectively of Bureau of Indian Standard, New Delhi.
- Dr. R. Islam has been appointed as Visiting Fellow of HNB Garhwal University, Srinagar.
- Dr. Devajit Hazarika was awarded best paper presentation award in the Workshop on seismic microzonation & 3rd Annual Convention on Advances in Earthquake Science, Organized by Indian Seismological Research (ISR), Gandhinagar during January 4-6, 2014 for the paper titled *"Seismic Characteristics of Crust and Upper Mantle beneath Eastern Ladakh: constraints from RF analysis"*.
- Wadia Institute's Best Paper Award for the year 2012 was awarded to Drs. G Philip, S.S. Bhakuni and N. Suresh for their paper titled *"Late Pleistocene and Holocene large magnitude earthquakes along Himalayan Frontal Thrust in the Central Seismic Belt in the NW Himalaya, Kala Amb, India"* published in Tectonophysics.

VISITS ABROAD

- Sh M. Parkasham visited Vienna, Austria to attend the European Geosciences Union (EGU) General Assembly (GA) 2013, and to present the research contribution through Poster presentation during April 7-12, 2013.
- Dr. Naresh Kumar visited International Centre of Theoretical physics (ICTP), Trieste, Italy as Regular Associate of ICTP during May 14-June 30, 2013.
- Dr. Vikram Gupta visited Thimpu, Bhutan to attend Annual Project Meeting of the NORSAR project during May 27-29, 2013.
- Drs. B.N. Tiwari and Sushil Kumar visited Brisbane, Australia to participate in the 10th Annual Meeting of AOGS during June 24-28, 2013.
- Dr. D.P. Dobhal visited Oslo, Norway to attend "Glacier Mass balance study tour to Norwegian glaciers" during August 10-21, 2013.
- Dr. V.C. Tewari visited Germany and presented a key note and also another paper in the 28th Himalayan-Karakorum-Tibet Workshop, and the 6th International Symposium on Tibetan Plateau, held at Tubingen, Germany, during August 22-24, 2013.
- Dr. Naresh Kumar visited Shanghi and Chengdu in China and chaired a session on 'seismology' in the 'Joint China-India Workshop on Earthquake Disaster Mitigation' during September 15-21, 2013.
- Dr. Sushil Kumar visited Nepal to attend "International Workshop for Regional cooperation in Seismology and Earthquake engineering in South and Central Asia" during September 16-19, 2013.
- Drs. A.K. Gupta, Sushil Kumar, Ajay Paul and Naresh Kumar visited Reykjavik, Iceland to work on "Indo-Iceland Collaborative Project for earthquake prediction research" during October 6-14, 2013.
- Dr. Vikram Gupta visited National Geotechnical Institute (NGI), Oslo, Norway for discussion on joint research project "Earthquake Hazard and risk reduction on the Indian subcontinent" during 22nd October to 2nd November 2013.
- Drs. H.K. Sachan and Santosh K. Rai visited Bremen, Germany to attend 15 days training on stable isotope mass spectrometer at Thermo Fisher scientific manufacturing facility, during 27th October to 12th November 2013.

Ph.D. THESES

Name of Student	Supervisor	Title of the Theses	University	Awarded/ Submitted
Ms. Poonam Jalal	Dr S.K. Ghosh Prof. Y.P. Sundriyal	Source-sink relationship of Neogene sandstone from Ramganga sub-basin and its correlation with the other sub-basins of Himalayan Foreland"	HNB Garhwal University, Srinagar	Awarded
Ms. S. Vyshnavi	Dr. R. Islam Prof. Y.P. Sundriyal	Weathering history of granitic and basaltic rocks in parts of Garhwal Himalaya	HNB Garhwal University, Srinagar	Awarded
Sh. Anupam Yadav	Dr. Sushil Kumar Prof. Kusum Deep	Improving local and regional earthquake locations using an Advance Inversion Technique namely particle swarm optimization	IIT Roorkee, Roorkee	Awarded
Mr. Arun Kumar Rangnathan	Dr. Kishor Kumar Dr. Pradeep Joshi	Source rock evaluation for hydrocarbon generation potential of Subathu sub-basin, Lesser Himalayas	Univesity of Petroleum & Energy Studies, Dehradun	Awarded
Ms. Megha M Daga	Dr. D. R. Rao Prof. Santosh Kumar	Magmatic, metamorphic and crustal evolution of Shyok-Darbuk section, eastern Ladakh, India.	Kumaun University, Nainital	Submitted
Ms. Rakhi Rawat	Dr. Rajesh Sharma Prof. Santosh Kumar	Genesis and economic potential of graphite associated with Almora Crystallines, Kumaun Himalaya	Kumaun University, Nainital	Submitted
Sh. Dinesh S. Chouhan	Dr. Rajesh Sharma Prof. Santosh Kumar	Thermal structure and resource potential of Chiplakot Crystalline Belt, northeast Kumaun Himalaya, India.	Kumaun University, Nainital	Submitted

PARTICIPATION IN SEMINAR/SYMPOSIA/ WORKSHOP/ MEETINGS/ TRAINING COURSES

Workshop *'The 4th Third Pole Environment'* organised by WIHG, Dehradun jointly with TEP Programme Office, Beijing, April 1-3, 2013.

Participants: Anil K Gupta, Deepak Srivastava, K. Kumar, Rajesh Sharma, G. Philip, D.P. Dobhal and Pradeep Srivastava

Brainstorming on *'Science plan of the programmeon dynamics of glaciers in the Himalayas'* Wadia Institute of Himalayan Geology, Dehra Dun during April 20-21, 2011.

Participants : Anil K Gupta and D. P. Dobhal

Indo-UK Royal Society joint Workshop on 'Long term control on the rivers of Ganga Plains: defining the trajectory of Landscape change' held at Haridwar during April 22-23, 2013.

Participant: Rohtash Kumar

18th Convention of Indian Geological Congress and symposium on *'Minerals and Mining in India - the way forward'* held at Bhopal during April 27-29, 2013.

Participant: Rajesh Sharma

Brain Storming Workshop on *'Snow and glaciers and the Himalayan river system'* organised by State Centre on Climate Change, Shimla, H.P. during 29-30 May 2013.

Participant: D.P. Dobhal

5th Environment summit 2013 on the theme *'Mitigating E-waste & Metallic Hazard'* held on June 3, 2013 at Dehradun and organised by Confederation of Indian Industry, Northern Region (CII) and Uttarakhand Council of Science & Technology (UCOST).

Participant: T.N. Jowhar

Workshop on *'Modern perspectives in Himalayan Geosciences'* held at Wadia Institute of Himalayan Geology, Dehra Dun during June 11-12, 2013.

Participant(s): Anil K. Gupta, V.C. Thakur, Rohtash Kumar, P.P. Khanna, S.K. Ghosh, N.K. Saini, Kishor Kumar, Rajesh Sharma, G. Philip, R. Islam, D.R. Rao, Keser Singh, S.K. Bartarya, T.N. Jowhar, S.K. Parcha, D.P. Dobhal, P. Srivastava, V. Sriram, A. Paul, RJG Perumal, A.K. Singh, R.K. Sehgal,, S. Rajesh, G. Rawat, B.K. Mukherjee, Naresh Kumar, Swapnamita, D. Hazarika, N.K. Meena, P.K.R. Gautam and M. Parkasam

Workshop on *'The treatment of the Varunavat Parvat Landslide'* at Disaster Mitigation and Management Center (DMMC), Dehra Dun on June 13, 2013.

Participant: Vikram Gupta

Regional Workshop on *'Landslide disaster management in northwesternHimalayas'* organised by Geological Survey of India at Institute of Public Administration (IIPA) Shimla during June 19-20, 2013.

Participant: G. Philip

Brainstorming meeting on *'June 2013, Kedarnath tragedy; Focus on Damage Assessment and Mapping'* organised by WIHG, Dehradun, July 28, 2013.

Participant: Anil K Gupta and D. P. Dobhal

Workshop on *'Himalayan Adaptations, Water and Resilience (HI-AWARE) Research on Glacier and snowpack Dependent River Basins for Improving Livelihoods'* at The Energy and Resource Institute (TERI), New Delhi on August 12, 2013.

Participant: S.K. Bartarya

National Workshop on *'Uttarakhand Disaster 2013: Lesson Learnt'* at National Institute of Disaster Management (NIDM), New Delhi on August 19, 2013.

Participant: Vikram Gupta

'Mountain meteorology and landslides: a workshop on way forward with special reference to landslide in Uttarakhand' held at Wadia Institute of Himalayan Geology, Dehra Dun during September 2-3, 2013.

Participants: Anil K. Gupta, V.C. Tewari, G. Philip and Vikram Gupta

Asia Pacific Workshop on *'Forest Hydrology Water and Forest beyond traditional Forest Hydrology'* organised by Forest Research Institute, Dehradun, 23-25 September, 2013.

Participants: D.P. Dobhal and P.S. Negi

National conference on*'Uttarakhand Disaster: Contemporary Issues of Climate change and Development with a Holistic Approach'* organised bySri Dev Suman Uttarakhand Vishwavidhyalay Badshahithaul, Tehri Garhwal during October 25-27, 2013.

Participant: D.P. Dobhal

'Earth Sciences in India: Challenges and Emerging Trends - (ESICET-2013)' held at Indian Institute of Technology, Roorkee during November 07 - 09, 2013.

Participant: P.K. Mukehrjee

'XXIV Indian Colloquium of Micropaleontology and Stratigraphy' held at Wadia Institute of Himalayan Geology, Dehra Dun during November 18 20, 2013.

Participants: Anil K Gupta, V.C. Tewari, Meera Tiwari, Kishor Kumar, B.N. Tiwari, S.K. Parcha, K. Lokho, Pradeep Srivastava, R.K.Sehgal, J. Singh, S. Sarkar, M.Parkasam, N.K. Meena, Rajita Shukla, Ansuya Bhandari, Shivani Pandey, Suman Rawat, Harshita Joshi, Smita Gupta, Som Dutt, A. Yuvaraja and Rupa Ghosh

International Conference on *'Recent Developments in Stratigraphy'* held at Pune from 14-16th Dec. 2013.

Participant: S.K. Parcha

Workshop on *'Seismic microzonation& 3rd Annual Convention on advances in Earthquake Science'*, Organized by Indian Seismological Research (ISR), Gandhinagar during January 4-6, 2014.

Participant: D. Hazarika

'MANU Project review' meeting at HNB Garhwal University, Srinagar during January 17 18, 2014.

Participants: Vikram Gupta, Pradeep Srivastava and R.J.G. Perumal

'DST Autonomous Bodies Conclave Young Scientists' meeting at S.N. Bose Centre for Basic Sciences at Kolkata during January 28-29, 2014.

Participants: Vikram Gupta and R.J.G. Perumal

'IGCP Project 589' National Working Group members meeting held at GSI, Hyderabad on January 30, 2014.

Participant: V.C. Tewari

'101st Indian Science Congress' at JammuUniversity, Jammu during February 3-7, 2014

Participant: T.N. Jowhar

Training on *'Science, Technology and Emerging trend in Governance'* from Indian Institute of Public Administration, New Delhi, during February 3-7, 2014.

Participant: P.S. Negi

'Annual Training Conference-2013' at National Institute of Disaster Management (NIDM), New Delhi during February 6-7, 2014.

Participant: Vikram Gupta

'2nd Indo Norway workshop at PrithviBhawan', New Delhi during February 13-14, 2014.

Participant: Vikram Gupta

National Conference on *'Revisiting Development Paradigms for Uttarakhand'* held at Indian.

Participant: P.S. Negi

Training on *'All IndiaRajbhasa (Hindi)'* organized at Kausani (Bageshwer-Uttarakhand) by the Indian Language and CulturalCenter, New Delhi during March 6-8, 2014.

Participant: P.S. Negi

'National Student Convention and regional meeting of the Computer Society of India' at Bharti Vidyapeeth's Institute of Computer Applications and Management (BVICAM), Delhi on March 7-8, 2014.

Participant: T.N. Jowhar

National Conference on *'Implication of Climate Change on Himalayan Environment'*, at the Central University of Himachal Pradesh, Dharamsala during March 20-21, 2014.

Participants: V.C. Tewari, P.S. Negi, Indira Karakoti, Bhanu Thakur and Kapil Keserwani

Workshop on *'Computational Methods for source characterization and stress field analysis'* organized by North-East Institute of Science & Technology (NEIST), Jorhat, during March 21-26, 2014.

Participant: D. Hazarika

National seminar on *'Recent advance in Earth Sciences'* held at Sambalpur University, Sambalpur, Orisa during March 22-23, 2014.

Participants: S.S. Thakur

Roundtable Conference on *'Learning from the Uttarakhand Disaster June 2013 for the Indian Himalaya'* organized at FRI, Dehradun on March 26, 2014.

Participant: P.S. Negi

International seminar on *'Magmatism, Tectonism and Mineralisation-(MTM-2014)'*, held at Kumaun University Nainital during March 27-29, 2014.

Participants: Rajesh Sharma, P.K. Mukherjee and S. Khogen Kumar

LECTURES BY INSTITUTE SCIENTISTS

Name of Scientist	Venue	Date	Topic
Pradeep Srivastava	Wadia Institute of Himalayan Geology, Dehradun	02.04.2013	Melting glaciers and the Ganga River since 60 ka
Rajesh Sharma	Aligarh Muslim University, Aligarh	16.04.2013	Applications of Laser Micro Raman Spectroscopy in Geology
G. Philip	Wadia Institute of Himalayan Geology, Dehradun	18.04.2013	Tectonic landforms in Himalaya vis-à-vis large magnitude earthquakes
Rajesh Sharma	Kumaun University, Nainital	11.05.2013	Ore Geology
G. Philip	Indian Institute of Remote Sensing, Dehradun	12.08.2013	The Himalayan Tsunami: A re-look into the facts
P.K. Mukherjee	Archaeological Survey of India, Dehradun	02.09.2013	Building Stones and their Weathering Pattern
N. Suresh	Archaeological Survey of India, Dehradun	03.09.2013	Luminescence dating
N. K. Meena	WIHG, Dehra Dun	09.09.2013	Threat of the water bodies in the Himalaya
P.S. Negi	Wadia Institute of Himalayan Geology, Dehradun	09.09.2013	Himalayan Bio-diversity and Ecological and Non-ecological Disaster
S.K. Rai	Central Soil & Water Conservation Research and Training Institute (CSWCRTI), Dehradun	09.09.2013	Geochemical and isotopic studies in the Ganga River system: Implication to weathering and erosion in the Himalaya
S.K. Rai	Wadia Institute of Himalayan Geology, Dehra Dun	09.09.2013	Weathering and Erosion in Himalayan fluvial systems: Tracing extreme events
R.J.G. Perumal	Nation Security Council (NSC), New Delhi	17.09.2013	Active Faults in Indian Himalaya and Neighbouring Countries: Implications for Strategic Developments
D. Hazarika	Nation Security Council (NSC), New Delhi	17.09.2013	Seismogenic Zones of the Himalaya
V.C. Tewari	Nation Security Council (NSC), New Delhi	17.09.2013	Geological set up of the Himalaya
Vikram Gupta	Nation Security Council (NSC), New Delhi	17.09.2013	Various Engineering Geological issues in the Himalaya

P.S. Negi	National Geotechnical Facility (NGF), Dehra Dun	25.09.2013	Bio-engineering: an effective technique for landslides mitigation Invited lecture (in Hindi)
D.P. Dobhal	ICFRE Dehradun	24.10.2013	Climate change impact on glaciers - Observation and Facts
N.K. Meena	G.B. Pant Engineering College, Pauri, Uttarakhand	25.10.2013	Sustainable development in climate change scenario
D.P. Dobhal	Pari-Avaran Sahyog Society, New Cantt. Road, Dehradun	29.10.2013	Uttarakhand Disaster; special reference to Mandakini Valley
P.K. Mukherjee	Boarder Security Force (BSF), Doiwala	29.11.2013	Rocks and Minerals with special reference to Himalayan Terrain
Vikram Gupta	O.N.G.C., Dehra Dun	16.12.2013	Geological disasters in the Himalayan region and their management
R.J.G. Perumal	MS University of Baroda, Vadodara	21. 12. 2013	Active fault and Hazard Implications in Himalaya,
Pradeep Srivastava	MS University of Baroda, Vadodara	22. 12. 2013	Fluvial landscape of Himalaya: A reflection of Active Tectonics
R. Islam	HNB Garhwal University, Srinagar	23.12.2013	Lecture on "Earth Sciences: What, How and Why…." During the INSPIRE programme
G. Philip	Govt. College, Kottayam, Kerala	02.01.2014	Natural hazards in Himalaya with special reference to June 2013 Kedarnath Disaster
R.J.G. Perumal	SN Bose National Centre for Basic Sciences, Kolkata	28.01.2014	Paleoseismological evidence of great surface faulting along the Indian Himalayan Front: Timing, size, spatial extent and recurrence of great earthquakes
V.C. Tewari	GSI Training Institute, Hyderabad	31.01.2014	Global Geo-Scientific Challenges: Recent Natural Disaster in the Himalaya
SK Bartarya	People's Science Institute, Dehra Dun	14.02.2014	Aspects of Groundwater Management in Himalaya
V.C. Tewari	Geological Society of India, Bangalore	26.02.2014	Recent Natural Disaster in the Uttarakhand Himalaya and Future Geotechnical Remedial Measures
P.S. Negi	Hotel Madhuban, Dehra Dun	11.03.2014	Sustainable Development and Disaster: a tough Challenge in Himalayan Ecosystem for Confederation of Indian Industry
Devajit Hazarika	CSIR-North-East Institute of Science and Technology (NEIST), Jorhat	23. 03. 2014	Crustal Stress field and shear wave anisotropy: observations from local and teleseismic data

PUBLICATION AND DOCUMENTATION

The Publication & Documentation section during this year brought out the publications of (i) 'Himalayan Geology' volumes 34 (2) and 35 (1), (ii) 'Annual Report' of the Institute for the year 2012-13 in Hindi and English, (iii) Hindi magazine 'Ashmika' volume 19, (iv) Newsletter 'Bhugarbh Vani' volumes 3 (1-4) and 'Drishtikon' Volume 1 and (v) Abstract volumes for the workshop on Modern Perspective in Himalayan Geosciences (June 2013) and XXIV Indian Colloquium on Micropaleontology & Stratigraphy (November 2013). Apart from this, works pertaining to printing of publicity brochures/circulars, certificates, greeting cards, ACR forms, telephone directory etc., are also taken-up. Section was also involved in dissemination of the publications to individuals, institutions, life time subscribers, book agencies, national libraries, indexing agencies, under exchange program and maintaining the sale & accounts of publications. The section also provides the technical support services of printing and scanning to Scientists, Research Scholars and other staff of the Institute.

Himalayan Geology (journal) website http://www.himgeology.com is functioning with online enquiry, online prepaid subscription order and online manuscript submission facility under this section. All information regarding the journal including contents and abstracts is up-to-date on the website. The 'Himalayan Geology' is indexed in SCOPUS (Elsevier, Netherlands) and in Indian Citation Index (ICI) New Delhi. Under the Life Time Subscriber Scheme (LTSS) Membership for Himalayan Geology journal, 51 new members got registered; bring the total registered number to 422.

LIBRARY

The Library of Wadia Institute of Himalayan Geology is one of the finest libraries in the field of Earth Sciences in the country. The Library subscribed to a total number of 130 journals of which, 86 are International and 44 are Indian journals. In addition to this 12 titles of journals were received as gratis. A total number of 99 reference books are purchased and 13 books are received as gratis during the year. Presently library is subscribing to online with full text access to journals pertaining to several thrust area disciplines of the Institute.

The WIHG library has more than 3,500 carefully selected e-books, and during the period of report new e-books collections added, which include Springer Earth and Environmental Science e-books collection updated till the year 2010-2011 and Elsevier Earth and Planetary Science e-books collection updated till the year 2011-2013. During the year 179 titles from Wiley's Earth and Environmental Science subject collection are added, along with the archive of Special Papers published by the Geological Society of America (GSA) consisting of 503 titles. The Library has also purchased the archive volumes of the Geological Society London Special Publications published from 1964 to 2013. It has also purchased a complete collection of all published 50 volumes *of Treatise on Invertebrate Palaeontology* in searchable PDF format on DVD. The Institute has Repository which consists of 93 full text PDF files of Prof D.N. Wadia's publications, and 1420 PDF files of WIHG Scientists publications. Currently it is available on the intranet only. As a regular practice, the binding work of loose issues of journals was under taken by the Library, and a total number of 872 volumes of journals are bound.

The Library is member of National Knowledge Resource Consortium (NKRC) and receives the support of consortia in getting online access to Elsevier's, Wiley's and Springer Collections. In addition to this, WIHG Library has also online access to more than four hundred journals' titles other than subscribed by the Institute. The WIHG scientists were also provided books/journals on interlibrary loan from the Libraries of other organisations situated at Dehra Dun as and when required.

The Library has the small hub of computers for library users for accessing the e-books and e-journals and Internet surfing and the other e-resources available, either subscribed by WIHG Library or available through the NKRC. Further, the library serves as central facility for the photocopying work of the Institute.

S.P. NAUTIYAL MUSEUM

S.P. Nautiyal Museum of the Institute remains the main centre of attraction for the national and international visitors. The students in large groups from different schools, universities, colleges and from other Institutions visited the museum. During this year more than 3,000 people visited the Museum from different parts of the country, and from countries like, Iceland, United Kingdom, Canada, Austria, Moscow, USA, South Africa, Japan, Nepal, England, Iran, France and Australia.

The Museum observes Open Days on National Technology Day, Foundation Day, Founder's Day and National Science Day. Open Days for public are given wide coverage through print media, as a result of which large number of students and general public visited the museum on these occasions. A number of students continue to visit the museum for their respective school projects. Scientists and other dignitaries also visited the museum each year. As a part of awareness to general public and the students', brochures both in Hindi and in English are provided free of cost regarding the Institute activities, the Museum and the personal protection to be taken during earthquakes etc.

A new model of extinct species of Giraffe was prepared this year from waste material (sending the message of saving the environment) and displayed for general public along with new models of Extinct Horse and Elephant. The exhibit was also appreciated during the science outreach programme by the general public and by the dignitaries who visited the Institute.

A research scholar explaining to the school children and their teachers about the exhibits in the S.P. Nautiyal Museum.

TECHNICAL SERVICES

Analytical Services

During this period a total number of 5141 samples were analyzed using XRF, XRD, SEM and ICPMS which are nearly 62% more than those analyzed during previous year.

Lab. / Technique	Samples analysed		
	WIHG Users	Outside Users	Total
XRF	862	807	1669
ICP-MS	1300	900	2200
SEM-EDX	257	322	579
XRD	378	315	693
Total samples analysed			5141

Photography Section

During the year, around 5,500 images were clicked using digital cameras to cover the various functions, including Foundation Day, Founders Day, National Science Day, National Technology Day, New Years Day, Seminars/Symposia (4th TPE Workshop, IGU Workshop, 24th ICMS etc.) and superannuation get together for Institute staff organized in the Institute from time to time. Apart from this around 800 snaps were clicked for rock and fossil specimens. The colour printing of around 350 digital images was arranged from the market. No procurement of new cameras /accessories was undertaken during the reporting year as a majority of Scientists already have cameras issued permanently to them for use in the field and laboratory. Other scientists and research scholars are provided cameras from the pool as and when it is required.

Drawing Section

The Drawing Section catered to the cartographic needs of the Scientists of the Institute including the sponsored projects. During the year, the section has provided 67 geological maps/structural maps/geomorphological maps/seismicity diagrams for the scientists and research scholars of the Institute, besides the tracing of thirty six topographic sheets/aerial photo maps and nine geological columns have been prepared. The section has also provided name labels, thematic captions during different activities and functions of the Institute including writing work on the photo identity cards of the employees of the Institute.

Sample Preparation Laboratory

The sample preparation laboratory provided thin/microprobe/polished sections to the requirements of the Institute Scientists and Research Scholars. During the reporting year the laboratory provided 1,187 thin and polished sections to various users for carrying out microscopic, fluid inclusion and EPMA studies. The lab has also processed crushing/grinding of 1,489 rock samples for carrying out major, trace and REE analysis by ICPMS, XRF and XRD methods.

CELEBRATIONS

National Technology Day

The National Technology Day was observed on May 11, 2013. Open Day was observed on this day and Museum and other laboratories were kept open for public and for the school and college children. A large number of students and people visited the Institute museum and other laboratories.

Foundation Day Celebrations

The Institute celebrated the *'45th Foundation Day'* on June 29, 2013. The Chief Guest on the occasion was Padma Shri Prof. K.L. Chopra, Former Director, IIT Kharagpur and President, Society for Scientific values. He delivered the 'Foundation Day Lecture' on *'Nurturing Innovation and Entrepreneurship'*.

Padma Shri Prof. K.L. Chopra the Chief Guest delivering the 'Foundation Day Lecture'.

The Chief Guest also distributed awards to the best research papers published by the Institute Scientist(s) as well as the best workers in various categories of the Institute. The Best Paper Award was given to Dr. G. Philip et al. for their paper published in Tectonophysics. The best workers awards for the good work carried out during the year 2013-14 were given to the Sh. Chandra Shekhar (Sr. Tech. Officer), Sh. Rakesh Kumar (Technical Officer), Sh. N.K. Juyal (Jr. Tech. Officer), Sh. T.K. Ahuja (Jr. Tech. Officer), Sh. Rambir Kaushik (Sr. Tech. Assistant), Sh. Pankaj Chauhan (Sr. Tech. Assistant), Sh. S.S. Bhandari (Sr. Tech Assistant), Sh. B.K. Juyal (Accountant), Sh. O.P. Anand (Office Supdt.), Sh. S.S. Bisht (Assistant), Sh. A.S. Negi (Assistant), Smt. Kalpana Chandel (UDC), Sh. Shiv Singh Negi (UDC), Smt. Suman Nanda (UDC), Sh. Rahul Sharma (LDC), Sh. Vijay Ram Bhatt (LDC), Sh. Santu Dass (Section Cutter), Sh. R.M. Sharma (Sr. Lab. Technician), Sh. S.K. Thapliyal (Sr. Lab. Assistant), Sh. Rajender Prakash (Sr. Lab. Assistant), Sh. A.K. Gupta (Sr. Lab Assistant), Sh. Ansuya Prasad (Field-cum-Lab.Attdt.), Sh. Sanjeev Kumar (Field-cum-Lab.Attdt.), Sh. Rahul Lodh (Lab. Assistant), Smt. Rama Pant (Field Attendant), Sh. Girish Chander Singh (Guest House Attdt.-cum-Cook), Sh. Dinesh Saklani (Guest House Attdt.-cum-Cook), Sh. Surjan Singh (Driver), Sh. Jivan Lal (Attendant), Sh. Pritam Singh (Attendant), Sh. Chait Ram (Attendant), Sh. Rajesh Yadav (Driver), Sh. Rudra Chhettri (Attendant), Sh. L.S. Bhandari (Chowkidar) and Sh. Ramesh Rana (Attendant).

Prof. Anil K Gupta, Director, WIHG addressing the staff on Foundation Day.

Founder's Day Celebration

The Institute celebrated its Founder's Day on October 23, 2013 in the honour of Prof. D. N. Wadia. On this occasion 'Founder's Day Lecture' was organized by the Institute. The Chief Guest of the occasion Padma Shri Prof. A.K. Sood, Indian Institute of Science, Bangalore delivered the lecture on *"New Horizons in Driven Soft and Granular Matter"* The Founder's Day Lecture was well attended by students, the Institute staff and by some dignitaries of the Doon valley.

Chief Guest Padma Shri Prof. A.K. Sood, IISc, Bangalore along with Prof. Anil K. Gupta and Dr. P.P. Khanna occupying the dais on the 'Founder's Day' celebration.

National Science Day Celebrations

The Institute organized a week long activities as part of the *'The National Science Day-2014'* It started with a Science Quiz Competition, and the theme was *"Fostering Scientific Temper"*. The various educational institutions of Dehradun were invited for participation in the Science Quiz and Hindi Essay Competitions. A total of twenty eight educational institutions participated in the quiz competition and thirty educational institutes in the Hindi Essay competition. Besides these, Hindi and English slogan competition was also held on the third day in which scientists, staff and research scholars participated. To encourage the participation, the winners were awarded with the citation and token cash prizes.

The Institute observed Open Day on the National Science Day i.e. February 28, 2014. On this day all the laboratories were kept open to students and public. In total, fifty two educational institutions with more than 3,500 school children and a large number of college students and public from Dehradun and Mussoorie regions visited the Institute Laboratories. Scientists as well as the technical staff and research scholars explained the functioning of the various scientific instruments and its uses to the visitors.

School children in large number visiting the Institute on the 'National Science Day'.

Museum was kept open throughout the day for the visitors, in which various exhibits related to the Himalayan glaciers, Earthquakes, Landslides, Origin of Life, Volcanoes, Rocks Minerals, etc., were displayed. Like in previous years, this year also, a joint exhibition along with Indian Society of Remote Sensing Dehradun was organized and a documentary on the Chandrayan was shown to public and students.

An invited 'National Science Day Lecture' was delivered on *"Scoping future: Science for global sustainability"* by distinguished scientist Padma Shri Prof. Goverdhan Mehta, National Research Professor and Bhartia-Jubilant Chair at the University of Hyderabad. The lecture was attended by a large number of students of different schools, public and by the Institute staff. The occasion was also marked by distribution of prizes to the winners of the Science Quiz and Hindi Essay competitions.

Science Out Reach Programme

Under the Science outreach programme, the Institute participated in various exhibitions and programme in order to create awareness among the people about natural disasters like Earthquakes, Landslides, Flash floods etc., and also awareness program of Himalayan Geology to the students. The exhibit made of plastic waste became the point of attraction with the general public, students and the dignitaries present over there. It was an effort to create awareness in the public to save the Earth from pollution.

Padma Shri Prof. Goverdhan Mehta the Chief Guest delivering the 'National Science Day Lecture'.

DISTINGUISHED VISITORS TO THE INSTITUTE

- ? Mr. Olafur Ragnar Grimsson President of Iceland, Iceland
- ? Mr. S. Jaipal Reddy, Former Minister of Department Science and Technology, Government of India.
- ? Mr. Marianne Jeusen, Norwegian Embassy
- ? Padma Bhushan Dr. S.K. Joshi Former Director General CSIR
- ? Padma Shri Prof. Goverdhan Mehta, Former Director, Indian Institute of Sciences, Bangalore.
- ? Padma Shri Prof. A.K. Sood, Indian Institute of Sciences, Bangalore
- ? Padma Shri Prof. Harsh Gupta, Member NDMA, New Delhi
- ? Padma Shri Prof. K.L. Chopra, Former Director, IIT Khargpur
- ? Mr. V.K. Duggal, Member NDMA, New Delhi
- ? Prof. A.K. Awasthi, Pro-Vice Chancellor, Graphic Era University, Dehradun
- ? Dr. S.V. Srikantia, Former Deputy Director General, Geological Survey of India
- ? Dr. Sanjay Mishra Adviser DST, New Delhi
- ? Mr. B.S. Rawat, Director(AI), DST
- ? Mr. P.K. Tiwari, Ministry of Finance, New Delhi
- ? Mr. Jag Mohan, IPS Deputy Director SIB (MHA) Dehradun, India
- ? Mr. D.S. Sangwan, Ex 21 c, ITBP
- ? Lt. Gen A.T. Parnaik, Lt. Gen. DGBR
- ? Wg. Cdr. Satyam Kushwaha, NSCS, New Delhi
- ? Mr. L.C. Arora, Principal Secretary to Director General ITBP

STATUS OF IMPLEMENTATION OF HINDI

During the year under report, efforts for progressive use of Hindi were continued. The scientists and staff of the Institute were time and again apprised with the various orders and constitutional provisions of official Language Act to increase awareness for progressive use of Hindi in day-to-day work. Various incentive schemes for encouraging progressive use of Hindi were implemented. General orders, circulars and notices were issued in Hindi as well as in English. Orders/decisions regarding use of Hindi received from the Government of India from time to time were circulated to all the concerned officers in the Institute for compliance.

Hindi pakhwara was celebrated in the Institute from September 14-28, 2013, during which essay competition and debate for school children and Institute employees was organized. Dr Suchismita sengupta Pande, the Chief Guest on the occasion of inauguration of Hindi Pakhwara on September 14, 2013 delivered a lecture on '*Swami Vivekananda ka Himalaya prem evam unki Kritiyon mein Vagyanik avyav'*. Topic of Hindi essay for school children was *'Bhrashtachar Mukta Bharat ke prati Yuvayon kii Jimmedari'* and *'Vidyarthi Jeevan mein Internet ka Prayog: Kitna Upuogi'*. The topic of the debate for school chidren was *'Pariyavaran evam vikas'*. A nara competition, an essay competition on *'Mahilayon ke wooper bharti hinsarokne mein aam jan ki jiimmewari'*, and Swarachit Kavita Path was also organized for Institute employees on this occasion. During Hindi pakhwara a series of lectures was also organized, wherein eminent scientists and other experts gave invited talks on various topics. A Hindi Kavya goshthi was also organized during the Hindi Pakhwara in which renowned kavies, including Shri Surendra Sharma were invited for Kavita Path.

Dr. Suchismita Sengupta Pande, the Chief Guest along Prof. Anil K Gupta and Prof. V.C. Tewari occupying the dais during Hindi Pakhwara celebrations.

The Annual Report of the Institute for the year 2012-13 was published in Hindi. On the occasion of the '45th Foundation Day' of the Institute on June 29, 2013, the Hindi Magazine *'Ashmika'* volume 19 was released. The Institute Library has also got good collection of Hindi books for promotion of Hindi among the Institute's staff. This section consists of more than 2700 books consisting of poetry, drama, literature, short stories and novels by eminent authors on wide range of subjects. During the reporting period a total number of 212 books were added to the Hindi books collection.

(Left) Lecture being delivered by Dr Suchismita Sengupta Pande on the inaugural day of the Hindi Pakhwara. (Right) Padma Shri Prof. K.L. Chopra along with Prof. Anil K. Gupta and Prof. V.C. Tewari releasing the Hindi Magazine 'Ashmika'.

MISCELLANEOUS ITEMS

1. **Reservation/Concessions for SC/ST employees**

Government's orders on reservations for SC/ST/OBCs are followed in recruitment to posts in various categories.

2. **Monitoring of personnel matters**

Monitoring of personnel matters relating to employees of the Institute is done through various committees appointed by the Director/Governing Body from time to time.

3. **Mechanism for redressal of employee's grievances**

There is a Grievance Committee consisting of four Senior Scientists/Officers for redressal of employee's grievances. No request regarding grievance of any of the employee was received during the year by the Grievance Committee.

4. **Welfare measures**

The Institute has various welfare measures for the benefit of its employees. Various advances like House Building Advance, Conveyance Advance, Festival Advance, etc. are given to the employees. There is a salary Earner's Cooperative Society run by the Institute employees that provide loans to its members as and when required. The Institute also runs a canteen for the welfare of the employees. As a welfare measure, the Institute is providing recreational facilities to its employees.

5. **Mechanism for redressal of complaints of sexual harassment of women employees at work places.**

To inquire into the complaints of sexual harassment of women employees at work places in the Institute, a separate Committee has been constituted. The Committee consists of six members. The Chairman and two other members of the Committee are female officers, which includes a female officer from the Geological Survey of India. No complaint of sexual harassment of women employees at work places was received by the Committee during the year 2013-14.

6. **Status of Vigilance Cases**

No vigilance case was either pending or was contemplated against any of the employee of the Institute during the year 2013-14.

7. **Information on the RTI cases**

No applications for seeking information or appeals thereof under the Right to Information Act, 2005 were carried forward from the previous year 2012-13.

The details of information on the RTI cases during the year 2013-14 are as under:

Details	Opening balance as on 01.04.2013	Received during the year 2013-2014	Number of cases transferred to other public authorities	Decisions where requests/ appeals were rejected	Decisions where requests/ appeals accepted
1	2	3	4	5	6
Requests for information	Nil	26*	Nil	1	25
First appeals	Nil	11*	Nil	11	Nil

*Two applications and one appeal under the Right to Information Act, 2005 were carried forward to the next financial year 2014-15 and were disposed off during April, 2014.

6. **Sanctioned Staff strength (category wise)**

Group/ Category	Scientific	Technical	Administrative	Ancillary	Total
A	63	-	2	-	65
B	-	2	6	-	8
C	-	65	30	40	135
Total	63	67	38	40	208

9. **Sanctioned and released budget grant for the year 2013-2014**

Plan : Rs. 3,249.00 lakhs

Non-Plan : Rs. 43.50 lakhs

Total : Rs. 3,292.50 lakhs

BEREAVEMENT

Dr. Barun Kanti Choudhuri, Scientist F, passed away at an age of 58 years at Max Super Speciality Hospital, New Delhi on March 18, 2014. He was suffering from lung cancer which was detected very late. Despite fighting the disease bravely and suffering the ravages of chemotherapy and radiotherapy, he ultimately lost the battle. Dr. Choudhuri was born in Assam on 2nd July 1955 to late Mrs. Labanya Choudhuri and late Mr. P.K. Choudhuri (an IRS officer), and had his early education there. Later he joined I.S.M., Dhanbad for his Master Degree and obtained his Ph.D. under Late Prof. S. N. Sarkar, a renowned Structural Geologist & Geochronologist.

Dr. Choudhuri joined WIHG on 10th March 1981 as Scientist 'B' in the Structure & Tectonics (S&T) Group, and during his last days he was heading the Group. His career that spanned for more than 33 years in the Institute was manifested by his publications in national and international journals. His research area was extending from the North-Western Himalaya to North-Eastern Himalaya covering high mountain ranges of Karakoram, Ladakh, Himachal Pradesh, Garhwal-Kumaun and Arunachal Pradesh. He had participated in many expeditions including the one to Kedar Dome with renowned mountaineer Ms. Bachendri Pal. He also served as Technical Secretary to the Director, WIHG during the tenure of Dr. S. C. D. Sah and Dr. V. C. Thakur. He was also the OIC of various laboratories, and Chairman/Member of various Committees constituted by the Director.

Dr. Choudhuri was a very soft spoken, amicable, extremely helpful and easily approachable person. He is survived by his wife Mrs. Kuntala Choudhuri and daughter Ms. Arpita Choudhuri. His death is an unbearable loss not only to his family, but also to the Institute and the entire Geological fraternity.

STAFF OF THE INSTITUTE AS ON 01.04.2014

Scientific Staff

1.	Prof. Anil Kumar Gupta	Director
2.	Dr. V.C. Tewari	Scientist 'G'
3.	Dr. Rohtash Kumar	Scientist 'G'
4.	Dr. V.M. Choubey	Scientist 'G' (Retired on 31.03.2014)
5.	Dr. P.P. Khanna	Scientist 'G'
6.	Dr. (Mrs.) Meera Tiwari	Scientist 'G'
7.	Dr. S.K. Ghosh	Scientist 'G'
8.	Dr. N.K. Saini	Scientist 'G'
9.	Dr. Kishor Kumar	Scientist 'G'
10.	Dr. Rajesh Sharma	Scientist 'G'
11.	Dr. G. Philip	Scientist 'G'
12.	Dr. Rafikul Islam	Scientist 'G'
13.	Dr. B.N. Tiwari	Scientist 'G'
14.	Dr. D.Rameshwar Rao	Scientist 'G'
15.	Dr. B.K. Choudhari	Scientist 'F' (Expired on 18.03.2014)
16.	Dr. Keser Singh	Scientist 'F'
17.	Dr. S.K. Bartarya	Scientist 'F'
18.	Dr. P.K. Mukharjee	Scientist 'F'
19.	Dr. T.N. Jowhar	Scientist 'F'
20.	Dr. S.K. Parcha	Scientist 'F'
21.	Dr. H.K. Sachan	Scientist 'F'
22.	Dr. Sushil Kumar	Scientist 'E'
23.	Dr. A.K. Mahajan	Scientist 'E' (On Lien to Central Univ. of HP)
24.	Dr. D.P. Dobhal	Scientist 'E'
25.	Dr. Vikram Gupta	Scientist 'E'
26.	Dr. Suresh N.	Scientist 'D'
27.	Dr. Pradeep Srivastava	Scientist 'D'
28.	Shri V. Sriram	Scientist 'D'
29.	Dr. Ajay Paul	Scientist 'D'
30.	Dr. S.S. Bhakuni	Scientist 'D'
31.	Dr. A.K. Mundepi	Scientist 'D'
32.	Dr. P.S. Negi	Scientist 'D'
33.	Dr. R. Jayangondaperumal	Scientist 'D'
34.	Dr. A.K.L Asthana	Scientist 'D'
35.	Dr. A.K. Singh	Scientist 'D'
36.	Dr. (Ms) Kapesa Lokho	Scientist 'D'
37.	Dr. Khaying Shing Luirei	Scientist 'D'
38.	Shri B.S. Rawat	Scientist 'C' (Retired on 28.02.2014)
39.	Dr R.K. Sehgal	Scientist 'C'
40.	Dr. Jayendra Singh	Scientist 'C'
41.	Dr. Rajesh S.	Scientist 'C'
42	Dr. Gautam Rawat	Scientist 'C'
43.	Dr. B.K. Mukherjee	Scientist 'C'
44.	Dr. Naresh Kumar	Scientist 'C'
45	Dr.(Mrs) Swapnamita Ch.	Scientist 'C'
46.	Dr. Santosh Kumar Rai	Scientist 'C'
47.	Dr. Devajit Hazarika	Scientist 'C'
48.	Dr. Narendra K. Meena	Scientist 'C'
49.	Dr. Dilip Kumar Yadav	Scientist 'C'
50.	Dr. Param K.R. Gautam	Scientist 'C'
51.	Dr. Kaushik Sen	Scientist 'C'
52.	Dr. Satyajeet S. Thakur	Scientist 'C'
53.	Dr Sudipta Sarkar	Scientist 'B'
54.	Dr. Prakasam M.	Scientist 'B'
55.	Dr. Rajkumar Singh	Scientist 'B' (On Lien to IIT, Bhubneshwar)
56.	Dr. Vikas	Scientist 'B'

Technical Staff

1.	Shri Saeed Ahmad	Sr.Librarian, Gr.III(5)
2.	Shri M.M.S. Rawat	Sr.Tech.Officer, Gr.III(5)
3.	Shri B.B. Sharma	Sr.Tech.Officer, Gr.III(5)
4.	Shri A.K. Pandit	Sr. Artist cum Modellor, Gr.III(5)
5.	Shri Sanjeev K. Dabral	Sr. Tech.Officer, Gr.III(5)
6.	Shri Chandra Shekhar	Sr. Tech.Officer, Gr.III(5)
7.	Shri Samay Singh	Sr. Tech.Officer, Gr.III(5)
8.	Shri S.C. Kothiyal	Sr. Tech. Officer, Gr.III(5)
9.	Shri Rakesh Kumar	Tech. Officer, Gr.III(4)
10.	Shri Ravindra Singh	Tech. Officer, Gr.III(4)
11.	Shri H.C. Pandey	Tech. Officer, Gr.III(4)
12.	Shri N.K. Juyal	Tech. Officer, Gr.III(4)
13.	Shri T.K. Ahuja	Jr. Tech. Officer, Gr.III(3)
14.	Shri C.B. Sharma	Asstt. Engineer, Gr.III(3)
15.	Shri S.S. Bhandari	Sr. Tech. Assistant, Gr.III(2)
16.	Shri Rambir Kaushik	Sr. Tech. Assistant, Gr.III(2)
17.	Dr. Jitendra Bhatt	Sr. Tech. Asstt.(EDP), Gr.III(2)
18.	Shri Bharat Singh Rana	Sr. Tech. Assistant, Gr.III(2)
19.	Shri Pankaj Chauhan	Sr. Tech. Assistant, Gr.III(2)
20.	Km. Sarita Gautam	Technical Assistant, Gr.III(I)
21.	Sh. Rakesh Kumar	Technical Assistant, Gr.III(1)
22.	Shri V.K. Kala	Draftsman, Gr.II(5)
23.	Shri Navneet Kumar	Draftsman, Gr.II(5)
24.	Shri B. B.Saran	Draftsman, Gr.II(5)
25.	Shri Tarun Jain	Draftsman, Gr. II(1)
26.	Shri Lokeshwar Vashistha	S.L.T., Gr.III(2)
27.	Dr. S.K. Chabak	S.L.T., Gr.III(2)
28.	Shri R.M. Sharma	S.L.T., Gr.III(2)
29.	Shri C.P. Dabral	S.L.T., Gr.III(2)
30.	Shri S.K. Thapliyal	Sr. Lab. Assistant, Gr.II(5)
31.	Shri Shiv Pd. Bahuguna	Sr. Lab. Assistant, Gr.II(5)
32.	Shri Sashidhar Pd. Balodi	Sr. Lab. Assistant, Gr.II(5)
33.	Shri Rajendra Prakash	Sr. Lab. Assistant, Gr.II(5)
34.	Shri A.K. Gupta	Sr. Lab. Assistant, Gr.II(5)

35. Shri Tirath Raj	Sr. Lab. Asstt. (Photo.) Gr.II(5)
36. Shri Balram Singh	Sr. Elect-cum-Pump Opt.,Gr.II(5)
37. Shri Nand Ram	Sr. Elect-cum-Pump.Opt., Gr.II(5)
38. Shri Shekhranandan	Section Cutter, Gr.II(5)
39. Shri Santu Das	Section Cutter, Gr.II(5)
40. Shri Puneet Kumar	Section Cutter, Gr.II(1)
41. Shri Nain Das	Lab. Assistant, Gr.II(2)
42. Shri Rahul Lodh	Lab Assistant, Gr.II(3)
43. Shri Pratap Singh	F.C.L.A., Gr.I(4)
44. Shri Ram Kishor	F.C.L.A., Gr.I(4)
45. Shri Ansuya Prasad	F.C.L.A., Gr.I(4)
46. Shri Madhu Sudan	F.C.L.A., Gr.I(4)
47. Shri Hari Singh Chauhan	F.C.L.A., Gr.I(4)
48. Shri Ravi Lal	F.C.L.A., Gr.I(4)
49. Shri Preetam Singh	F.C.L.A., Gr.I(3)
50. Shri Sanjeev Kumar	F.C.L.A., Gr.I(1)
51. Shri Deepak Tiwari	F.C.L.A., Gr.I(1)
52. Shri Ajay K. Upadhaya	F.C.L.A., Gr. I (1)
53. Mrs. Rama Pant	Field Attendant Gr.I (3)
54. Shri R.S. Negi	Field Attendant Gr.I (3)
55. Shri Ramesh Chandra	Field Attendant Gr.I (3)
56. Shri Khusi Ram	Field Attendant Gr.I (3)
57. Shri Tikam Singh	Field Attendant Gr.I (3)
58. Shri Bharosa Nand	Field Attendant Gr.I (3)
59. Shri B.B. Panthri	Field Attendant Gr.I (3)
60. Shri M.S. Rawat	Field Attendant Gr.I (3)

Administrative Staff

1. Shri Dinesh Chandra	Registrar
2. Shri Harish Chandra	Fin. & Accounts Officer
3. Shri Manas Kumar Biswas	Store and Purchase Officer
4. Mrs. Manju Pant	Asstt. Fin. & Acctts Officer
5. Shri B.K.Juyal	Accountant (Retired on 28.02.2014)
6. Shri Hukam Singh	Office Superintendent
7. Shri S.S.Bisht	Accountant
8. Smt. Rajvinder K. Nagpal	Stenographer, Grade – II
9. Km. Richa	Stenographer, Grade – III
10. Mrs. Shamlata Kaushik	Assistant (Hindi)
11. Mrs. Sharda Sehgal	Assistant
12. Shri A.S. Negi	Assistant
13. Shri M.C. Sharma	Assistant
14. Shri S.K. Chhettri	Assistant
15. Shri Vinod Singh Rawat	Assistant
16. Shri S.K. Srivastava	U.D.C
17. Mrs. Prabha Kharbanda	U.D.C.
18. Shri R.C. Arya	U.D.C.
19. Mrs. Kalpana Chandel	U.D.C.
20. Mrs. Anita Chaudhary	U.D.C.
21. Shri Shiv Singh Negi	U.D.C.
22. Mrs. Neelam Chabak	U.D.C.
23. Mrs. Seema Juyal	U.D.C.
24. Mrs. Suman Nanda	U.D.C.
25. Shri Rahul Sharma	U.D.C.
26. Shri Kulwant S. Manral	L.D.C.
27. Sh. Vijai Ram Bhatt	L.D.C.
28. Shri Girish Chandra Singh	L.D.C.
29. Shri Rajeev Yadav	L.D.C.

Ancilary Staff

1. Shri Sohan Singh	Driver
2. Shri Shyam Singh	Driver
3. Shri Dinesh Pd. Saklani	Guest House Attendant cum Cook
4. Mrs. Kamla Devi	Bearer
5. Mrs. Deveshawari Rawat	Bearer
6. Shri S.K. Gupta	Bearer
7. Shri Chait Ram	Bearer
8. Mrs. Omwati	Bearer
9. Shri Jeevan Lal	Bearer
10. Shri Surendra Singh	Bearer
11. Shri Preetam	Bearer
12. Shri Mahendra Singh	Chowkidar
13. Shri Rohlu Ram	Chowkidar
14. Shri H.S. Manral	Chowkidar
15. Shri G.D. Sharma	Chowkidar
16. Shri Ashok Kumar	Mali
17. Shri Satya Narayan	Mali
18. Shri Ramesh	Safaiwala
19. Shri Hari Kishan	Safaiwala

Contractual Staff

1. Shri Neeraj Bhatt	Lower Division Clerk
2. Shri Dhanveer Singh	Lower Division Clerk
3. Shri R. Choudhury	Driver
4. Shri R.S. Yadav	Driver
5. Shri Rajesh Yadav	Driver
6. Shri Bhupendra Singh	Driver
7. Shri Manmohan	Driver
8. Shri Vijay Singh	Driver
9. Shri Sachin Kumar Aditya	FCLA
10. Shri Rudhra Chetri	Bearer
11. Shri Ramesh Chand Rana	Bearer
12. Shri Harish Kumar Verma	Bearer
13. Shri Kalidas	Chowkidar
14. Shri Pradeep Kumar	Chowkidar
15. Shri L.S. Bhandari	Chowkidar
16. Shri Umed Singh	Chowkidar
17. Shri Sang Bang Kach	Chowkidar

GOVERNING BODY/RESEARCH ADVISORY COMMITTEE/ FINANCE COMMITTEE/BUILDING COMMITTEE MEMBERS

Governing Body
(w.e.f. 1.4.2011)

Sl.	Name	Address	Status
1.	Dr. T. Ramasami	Secretary Dept. of Science & Technology Technology Bhavan, New Mehrauli Road New Delhi - 110016	Chairman
2.	Ms. Sheila Sangwan	Additional Secretary & Financial Adviser Dept. of Science & Technology Technology Bhavan, New Mehrauli Road New Delhi - 110016	Member
3.	Prof. (Mrs.) Archana Bhattacharyya	Emeritus Scientist Indian Institute of Geomagnetism Kalamboli Highway New Panvel (W) Navi Mumbai - 410218	Member
4.	Dr. V.P. Dimri	CSIR Distinguished Scientist National Geophysical Research Institute Uppal Road, Hyderabad - 500007	Member
5.	Prof. U.C. Mohanty	Centre for Atmospheric Sciences Indian Institute of Technology, Delhi Hauzkhas, New Delhi - 110016	Member
6.	Prof. M.P. Singh	124, Chand Ganj Extn. (Opposite CM-7) Sector 'B', Aliganj Lucknow (UP)	Member
7.	Prof. Shyam Lal	Physical Research Laboratory Navrangpura Ahmedabad - 380009	Member
8.	Prof. R.P. Tiwari	Department of Geology Mizoram University Aizawl - 796009	Member
9.	Prof. Anil K. Gupta	Director Wadia Institute of Himalayan Geology 33, General Mahadeo Singh Road Dehra Dun - 248001	Member Secretary
10.	Shri Dinesh Chandra	Registrar Wadia Institute of Himalayan Geology 33, General Mahadeo Singh Road Dehra Dun - 248001	Non-Member Asstt. Secretary

Research Advisory Committee
(w.e.f. 1.4.2011)

Sl.	Name	Address	Status
1.	Prof. Ashok K. Singhvi	Outstanding Scientist Physical Research Laboratory Navrangpura Ahmedabad - 380009	Chairman
2.	Prof. R.P. Tiwari	Department of Geology Mizoram University Aizawal - 796009	Member
3.	Shri Ashwagosha Ganju	Director Snow & Avalanche Study Establishment (SASE) Him Parisar Sector 37-A Chandigarh - 160036	Member
4.	Prof. D.M. Banerjee	Department of Geology Delhi University Delhi - 110007	Member
5.	Prof. Vishwas Kale	Professor of Geography Department of Geography University of Pune Pune - 411007	Member
6.	Dr. Rajeev Nigam	Scientist National Institute of Oceanography (NIO) Dona Paula Goa - 403004	Member
7.	Prof. Rajesh K. Srivastava	Department of Geology Banaras Hindu University (BHU) Varansi - 221005	Member
8.	Prof. Saibal Gupta	Department of Geology & Geophysics Indian Institute of Technology Kharagpur - 721302	Member
9.	Dr. G.S. Srivastava	(Ex-Deputy Director General, GSI) 193, Vivek Khand -3, Gomti Nagar Lucknow - 226024	Member
10.	Dr. V.M. Tiwari	Scientist National Geophysical Research Institute Uppal Road Hyderabad - 500007	Member

Sl.	Name	Address	Status
11.	DST Nominee	Department of Science & Technology Technology Bhavan, New Mehrauli Road New Delhi - 110016	Member
12.	Prof. Anil K. Gupta	Director Wadia Institute of Himalayan Geology 33, General Mahadeo Singh Road Dehra Dun - 248001	Member
13.	Shri R.S. Dattatreyam	Director Seismology Division India Meteorological Department Mausam Bhavan, Lodhi Road New Delhi	Member
14.	Dr. Sridevi Jade	Centre for Mathematical Modeling & Computer Simulation (C-MMACS) NWTC, Belur Bangalore - 560037	Member
15.	Dr. D.R. Rao	Scientist 'G' Wadia Institute of Himalayan Geology 33, General Mahadeo Singh Road Dehra Dun - 248001	Member Secretary

Finance Committee
(w.e.f. 1.4.2011)

Sl.	Name	Address	Status
1.	Prof. M.P. Singh	124, Chand Ganj Extn. (Opposite CM-7) Sector 'B', Aliganj Lucknow (UP)	Chairman
2.	Ms. Sheila Sangwan	Additional Secretary & Financial Adviser Dept. of Science & Technology Technology Bhavan, New Mehrauli Road New Delhi - 110016	Member
3.	Prof. Anil K. Gupta	Director Wadia Institute of Himalayan Geology 33, General Mahadeo Singh Road Dehra Dun - 248001	Member
4.	Shri Dinesh Chandra	Registrar Wadia Institute of Himalayan Geology 33, General Mahadeo Singh Road Dehra Dun - 248001	Member
5.	Shri Harish Chandra	Finance & Accounts Officer Wadia Institute of Himalayan Geology 33, General Mahadeo Singh Road Dehra Dun - 248001	Member Secretary

Building Committee
(w.e.f. 1.4.2011)

Sl.	Name	Address	Status
1.	Prof. Anil K. Gupta	Director Wadia Institute of Himalayan Geology 33, General Mahadeo Singh Road Dehra Dun - 248001	Chairman
2.	Ms. Sheila Sangwan	Additional Secretary & Financial Adviser Dept. of Science & Technology Technology Bhavan, New Mehrauli Road New Delhi - 110016	Member
3.	Shri Harsh Mani Vyas	G.M. (Infrastructure Development) Shed No. 32, Tel Bhawan Oil & Natural Gas Corporation Dehra Dun - 248001	Member
4.	Representative of Survey of India	Shri D.N. Pathak Superintending Surveyor Surveyor General's Office Survey of India, Hathibarkala, Dehra Dun - 248001	Member
5.	Dr. Rajesh Sharma	Scientist 'G' Wadia Institute of Himalayan Geology 33, General Mahadeo Singh Road Dehra Dun - 248001	Member
6.	Shri Dinesh Chandra	Registrar Wadia Institute of Himalayan Geology 33, General Mahadeo Singh Road Dehra Dun - 248001	Member
7.	Shri C.B. Sharma	Assistant Engineer Wadia Institute of Himalayan Geology 33, General Mahadeo Singh Road Dehra Dun - 248001	Member Secretary

STATEMENT OF ACCOUNTS

CA Vipul Kumar Singhal
(M.Com, IFRS, F.C.A.)
CA Gaurav Rajput
(M.Com, F.C.A.)
CA Manoj Kumar
(M.Com, F.C.A.)

VIPUL SINGHAL & ASSOCIATES
Chartered Accountants
H.O. : Maharaja Complex, Shop No. 2, Niranjanpur Dehradun (Uttarakhand) - 248001
B.O. : Shop No. 14, Baba Golden Tower, Opp. Thana Kotwali, Distt. Bijnor (Uttar Pradesh) -246701
Web : www.cavsassociates.com
E-mail : cavsassociates@gmail.com

Contact : 0135-2723911, 9412936655, 9411570320, 07409006006

AUDITOR'S REPORT

The Members of Governing Body,
Wadia Institute of Himalayan Geology,
33, GMS Road, Dehradun
Uttarakhand.

We have audited the accompanying Financial Statements of **WADIA INSTITUTE OF HIMALAYAN GEOLOGY, 33, GMS Road, Dehradun** for the year ended March 31st, 2014 which comprises Balance Sheet ,Income and Expenditure Account, Receipt and Payment Account and summary of significant accounting policies.

Society's management is responsible for the preparation of these Financial Statements in accordance with law. This responsibility includes the design, implementation and maintenance of internal control relevant to the preparation and presentation of the financial statements that give a true and fair view and are free from material misstatement, whether due to fraud or error.

Our responsibility is to express an opinion on these financial statements based on our audit. We conducted our audit in accordance with the Standards on Auditing issued by the Institute of Chartered Accountants of India. Those Standards require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the Society's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of the accounting estimates made by management, as well as evaluating the overall presentation of the financial statements.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Vipul Singhal & Associates
FRN 013105C
Chartered Accountants

In our opinion and to the best of our information and according to the explanations given to us, the financial statements give the information required by the Act in all material respects and give a true and fair view in conformity with the accounting principles generally accepted in India subject to our comments given in Annexure- "1":

a) in the case of the Balance Sheet, of the state of affairs of the Society as at March 31st, 2014;
b) in the case of the Income and Expenditure Account of the Surplus for the year ended on that date; and
c) in the case of the Receipt and Payment Account, of the cash flows for the year ended on that date.

FOR VIPUL SINGHAL & ASSOCIATES

CHARTERED ACCOUNTANTS

Vipul Singhal & Associates Chartered Accountants FRN 013108C

CA VIPUL KUMAR SINGHAL
PARTNER

FRN: 013108C
M.NO: 405071

Date: 04th Aug, 2014
Place: Dehradun

Annexure - 1 to the Main Audit Report

The following observations were noted during the course of audit for the financial year 2013-14. The same have been discussed with management and comments and explanations of the management thereon have also been obtained.

Sl.No.	Comments / Observations by Chartered Accountants	Replies and Action taken by the Institute
1.	The Institute is maintaining accounts on cash basis except interest accrued on investments, which is not in conformity with the generally accepted accounting policies adopted in India and as per the Accounting Standard 1 "Disclosure of Accounting Policies" issued by the Institute of Chartered Accountants of India. The "Uniform Accounting Format" of financial statements for the Central autonomous bodies as has been made compulsory by the Ministry of Finance w.e.f. 01.04.2001, and adopted by the Institute also, recommends accrual method of accounting.	Institute is receiving Grant-in-aid from Govt. of India on the basis of projection of expenditure submitted by the Institute. However, sufficient funds as against the projected amount are not being received. Hence the accounts are maintained on cash basis for the actual transaction during the year reported. Interest on investment out of the fund for GPF / Pension is taken on accrual basis.
2.	During the Financial Year 2013-14 all the grants related to recurring and non recurring has been routed through Income & Expenditure Account.	Noted.
3.	The Institute has not booked the current liability for the retirement benefit of the employees as per Accounting Standard 15 "Employees Benefits" as issued by the Institute of Chartered Accountants of India.	Since the accounts are maintained on actual requirement and on cash basis, the liability on account of retirement benefits is not being provided. The suggestion of the auditor is noted.
4.	The Financial Statements of the institute, projects sponsored by the other agencies and the CPF/GPF are prepared separately and not consolidated as per Accounting Standard 21 "Consolidation of financial Statement" as issued by the Institute of Chartered Accountants of India. The CPF/GPF are also part of the Institute as they do not have a separate legal identity.	The observation of the auditor has been noted for compliance in future.
5.	The internal control regarding fixed assets needed to be strengthened. The following observations are made: a) The Fixed Asset Register is not maintained by the Institute. b) The additions to fixed assets are not numbered properly. The Physical verification of the fixed asset for the Financial Year 2013-14 is due to be undertaken, upto the date of Audit.	The suggestion on the observation of the audit has been noted for compliance. Physical verification of assets for the Financial Year 2013-2014 is in progress and the report will be produced in next audit.
6.	The Institute is adopting the policy of charging depreciation on fixed assets on the basis of written down value method as per the rates specified in the Income Tax Act, 1961, however, the following observations are made: a) Full year depreciation is charged instead of six months, on assets purchased for the half year ending 31st March, 2014. As per the management the same policy had been adopted in the previous financial years also. b) The books are depreciated @ 15% p.a. instead of 60% p.a. on W.D.V basis as applicable to research institutes.	The observation of the auditor have been noted for compliance.

7.	The Institute has not bifurcated the advances indicating the period of outstanding given to staff and Parties. The Party Debtors amounting to Rs. 1,85,414.00 and Staff Debtors amounting to Rs 24,543.00 are outstanding since more than 4 years. The advance which could not be realized in due course should be written off with the approval of the competent authority. Rs 12,010.00 has been shown as credit balance in Party debtors and Rs 34,148.00 in Staff Debtor which should be taken to receipts after following nodal procedure.	Institute has made its best efforts to settle the outstanding advances lying against party and staff debtors. Most of the outstanding advances against staff debtors have been adjusted during the current financial year. However, some of the advances outstanding against party debtors for a number of years could not be settled. After following the nodal procedure for writing off of the outstanding advances, a proposal will be submitted to the competent authority for decision.
8.	Earmarked funds have the debit balance in Training Workshop Prog- ladakh of Rs 2,19,905.00, Annual Convention (IGU 2009) of Rs 41,275.00, WIHG-IGU Workshop 2013 of Rs 3,32,048.00, MMND Workshop of Rs 1,67,774.00 and Geomathematic Winter School Training of Rs 34,980.00. The same depicts that the amount had been expended from other funds specific for other purposes. The loan from WIHG should have been shown when the amount was utilized from other funds and the same should have been shown as current liability in the Institute accounts.	To organize training, workshops, other short term programmes etc., for which funds are provided by other granting agencies, are received occasionally in advance otherwise generally the funds are received after completion of the activities. For successful organization of the proposed activities, the required funds are spent from the Institute grant on refundable basis and reimbursement are received only after submission of the utilization certificate etc. Request for all the granting agencies have already been submitted for early release of the funds borrowed from the Institute account.
9.	Transactions in Consultancy activity has been merged into the Financial Statements of the Institute.	As per the suggestion from the Audit, the transactions of the activities have been merged into Institute account as this is the practical requirement for dissemination of the figures under the activity.
10.	Issues related to Service Tax: During the course of audit it is observed that the Institute has received advance payment against the services under Consultancy but the entries for Service tax etc. has been accounted for at the time of final adjustment. Further Rs 14,523.00 has been outstanding as Service tax payable which is due to be deposit till the date of Audit. As per the provisions of Service tax Act the service tax is mandatory to be deposited online if the amount of deposit exceed Rs 1,00,000.00 in a Financial Year but the institute has deposited service tax manually.	As per the suggestion and discussion the Institute authorities had with the audit, the service tax is now being accounted with each transaction and the outstanding amount of service tax for the year has been deposited during the current financial year. With regards to deposit of service tax online, efforts are being made accordingly.
11.	Issues related to Tax Deduction at Source: It is observed that the institute has not deducted TDS on some of the payment made to contractors for providing services such as Building Maintenance, AMC, Wages etc. We are thankful to the staff and the management for the co-operation extended to us during the course of audit.	The observation of the audit has been noted for compliance.
	For Vipul Singhal & Associates **Chartered Accountants** **CA Vipul Kumar Singhal** **[Partner, FCA]** **Dated : 04th August, 2014**	**(Harish Chandra)** **Fin. & Accounts Officer** **(Dinesh Chandra)** **Registrar** **(Prof. Anil K. Gupta)** **Director**

WADIA INSTITUTE OF HIMALAYAN GEOLOGY- DEHRADUN

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WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRADUN

BALANCE SHEET
(AS AT 31ST MARCH 2014)

(Amt in Rs...)

PARTICULARS	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
LIABILITIES			
Corpus/ Capital Fund	1	4638,31,020	3913,75,619
Reserves and Surplus	2	-	-
Earmaked/ Endowment Fund	3	10,91,661	11,57,844
Secured Loans & Borrowings	4	-	-
Unsecured Loans & Borrowings	5	-	-
Deferred Credit Liabilities	6	-	-
Current Liabilities & Provisions	7	72,81,882	74,02,614
TOTAL		**4722,04,563**	**3999,36,077**
ASSETS			
Fixed Assets	8	3178,17,013	3534,73,204
Investments from Earmaked/ Endowment Funds	9	36,889	34,017
Investment- Others	10	-	-
Current Assets, Loans & Advances	11	1543,50,661	464,28,856
TOTAL		**4722,04,563**	**3999,36,077**
Significant Accounting Policies	37		
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AUDITOR'S REPORT

"As per our separate report of even date"

FOR VIPUL SINGHAL & ASSOCIATES
CHARTERED ACCOUNTANTS

Vipul Singhal & Associates Chartered Accountants FRN 013109C

(CA VIPUL KUMAR SINGHAL)
PARTNER, F.C.A

(HARISH CHANDRA)	**(DINESH CHANDRA)**	**(PROF. ANIL K. GUPTA)**
Finance & Accounts Officer	**Registrar**	**Director**

Date : 4th Aug, 2014
Place : Dehradun

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2014

SCHEDULE 1 : CORPUS/CAPITAL FUND

(Amt in Rs…)

PARTICULARS	SCH	RECURRING FUND	NON-RECURRING FUND	CURRENT YEAR	PREVIOUS YEAR
Opening Balance		(409,18,161)	4322,93,780	3913,75,619	4360,83,683
Less: Capital Assets written off during the year	8	-	-	-	-
Add: Contribution towards Corpus / Capital Fund	13	-	-	-	-
Add: Transferred from WIHG Project		-	3,94,998	3,94,998	-
Add: Surplus/(Deficits) as per Income & Expenditure A/c		720,60,403	-	720,60,403	(447,08,064)
Add: Depreciation Reversed		-	-	-	-
BALANCE AS AT YEAR END		**311,42,242**	**4322,93,780**	**4638,31,020**	**3913,75,619**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF. ANIL K. GUPTA)
Director

Singhal & Associates
FRN 013108C
Chartered Accountants

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRADUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2014

SCHEDULE 2 : RESERVE & SURPLUS

(Amt in Rs...)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1 **Capital Reserve :**		
As per last account	-	-
Addition during the year	-	-
Less: Deduction during the year	-	-
2 **Revaluation Reserve :**		
As per last account	-	-
Addition during the year	-	-
Less: Deduction during the year	-	-
3 **Special Reserve :**		
As per last account	-	-
Addition during the year	-	-
Less: Deduction during the year	-	-
4 **General Reserve :**		
As per last account	-	-
Addition during the year	-	-
Less: Deduction during the year	-	-
TOTAL	-	-

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF. ANIL K. GUPTA)
Director

FRN 013108C

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2014

SCHEDULE 3 : EAR MARKED / ENDOWMENT FUND

(Amt in Rs.)

PARTICULARS	FUND WISE BREAK UP						TOTAL	
	TRAINING WORKSHOP PROG. LADDAKH	PR.MISHRA AWARD FUND	WOMEN COMPONENT	ANNUAL CONVENTION (I.G.U 2009)	RTF DCS FELLOWSHIP	WIHG - IGU WORKSHOP - 2013	CURRENT YEAR	PREVIOUS YEAR
a) Opening Balance of the Fund	(2,19,905)	34,017	5,00,000	(41,275)	2,70,000	-	5,42,837	4,90,147
b) Additions to the fund								
i) Donation / Grant	-	-	-	-	40,000	1,00,000	1,40,000	22,70,000
ii) Income from investments made on account of fund	-	2,872	-	-	-	-	2,872.00	2,595
iii) Other additions (Specify) Registration	-	-	-	-	-	12,000	12,000	-
TOTAL	(2,19,905)	36,889	5,00,000	(41,275)	3,10,000	1,12,000	6,97,709	27,62,742
c) Utilisation / Expenditure towards objectives of Fund								
i) Capital Expenditure								
- Fixed Assets (Equipments)	-	-	-	-	-	-	-	-
ii) Revenue Expenditure								
a) Salaries / Wages/ Allowances/honorarium	-	-	-	-	2,65,667	-	2,65,667	-
b) Rent / Contingencies/TA-DA/Advertisement	-	-	-	-	30,000	3,97,090	4,27,090	11,49,905
c) Other Administrative Expenses:								
- Advances to project fellows	-	-	-	-	-	-	-	-
d) Excess fund Transferred	-	-	-	-	-	-	-	-
e) lodging and boarding	-	-	-	-	-	46,958.00	46,958.00	10,70,000
f) Registration	-	-	-	-	-	-	-	-
iii) Grant refunded	-	-	-	-	-	-	-	-
iv)Transfer To WIHG	-	-	-	-	-	-	-	-
TOTAL	-	-	-	-	2,95,667	4,44,048	7,39,715	22,19,905
Balance Carried Forward	(2,19,905)	36,889	5,00,000	(41,275)	14,333	(3,32,048)	(42,006)	5,42,837

Contd.2

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN
SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2014

SCHEDULE 3 : EAR MARKED / ENDOWMENT FUND

(Amt in Rs...)

PARTICULARS	TSUNAMI EQUIPMENT	PMB MEETING 2009	ULF/VLF EQUIPMENTS	4TH TPE WORKSHOP	MMND WORKSHOP (DR. V. C. TIWARI)	BRAIN STORMING MEETING (DR. P. Srivastav)	TOTAL CURRENT YEAR	TOTAL PREVIOUS YEAR
Balance Brought forward							(42,006)	5,42,837
a) **Opening Balance of the Fund**	8,30,633	42,255	(1,57,881)	(1,00,000)			6,15,007	7,85,007
b) **Additions to the fund**								
i) Donation / Grant	-	-	1,57,881	-	-	3,50,000	5,07,881	-
ii) Income from investments made on account of fund	-	-	-	-	-	-	-	-
iii) Other additions (Specify)	-	-	-	-	-	-	-	-
Registration	-	-	-	-	-	-	-	-
Advance Adjusted	-	-	-	1,00,000	-	-	1,00,000	-
TOTAL	8,30,633	42,255	-	-	-	3,50,000	12,22,888	7,85,007
c) **Utilisation / Expenditure towards**								
Objectives of Fund								
I) Capital Expenditure								
- Fixed Assets (Equipments)	-	-	-	-	-	-	-	-
ii) Revenue Expenditure					39,252	2,15,514	2,54,766	-
a) Salaries / Wages/ Allowances	-	-	-	-	-	-	-	-
b) Rent / Contingencies/TA-DA	-	-	-	-	-	-	-	-
c) Other Administrative Expenses:	-	-	-	-	-	-	-	-
- Advances to project fellows	-	-	-	-	1,28,522	90,953	2,19,475	1,00,000
d) Excess fund Transferred	-	-	-	-	-	-	-	-
e) Lodging & boarding	-	-	-	-	-	-	-	-
iii) Grant refunded/transferred	-	-	-	-	-	-	-	70,000
iv)Transfer To WIHG	-	-	-	-	-	-	-	-
TOTAL	-	-	-	-	1,67,774	3,06,467	4,74,241	1,70,000
Balance	8,30,633	42,255	-	-	(1,67,774)	43,533	7,48,647	6,15,007
GRAND TOTAL							7,06,641	11,57,844

contd.3

AUDITOR'S REPORT

SCHEDULE 3 - EAR MARKED / ENDOWMENT FUND

(Amt in Rs...)

PARTICULARS	GEOMATHEMATIC WINTER SCHOOL TRAINING	BRAIN STORMING MEETING (MOES - DR. P. Srivastav)	INSPIRE FELLOWSHIP (RL Mishra)	TOTAL CURRENT YEAR	TOTAL PREVIOUS YEAR
Balance Brought forward				7,06,641	11,57,844
a) Opening Balance of the Fund				-	
b) Additions to the fund					
i) Donation / Grant	5,50,000	4,00,000	2,50,400	12,00,400	-
ii) Income from investments made on account of fund	-	-	-	-	-
iii) Other additions (Specify)	-	-	-	-	-
Registration	-	-	-	-	
TOTAL	5,50,000	4,00,000	2,50,400	12,00,400	-
c) Utilisation / Expenditure towards					
Objectives of Fund					
i) Capital Expenditure					
- Fixed Assets (Equipments)	-	-	-	-	-
ii) Revenue Expenditure					
a) Salaries / Wages/ Allowances	-	-	2,30,400	2,30,400	-
b) Rent / Contingencies/TA-DA	3,50,080	-	-	3,50,080	-
c) Other Administrative Expenses:	-	-	-	-	-
- Advances to project fellows	-	-	-	-	-
d) Excess fund Transferred	-	-	-	-	-
e) Lodging & boarding	2,34,900	-	-	2,34,900	-
iii) Grant refunded/transferred	-	-	-	-	-
iv)Transfer To WIHG	-	-	-	-	-
TOTAL	5,84,980	-	2,30,400	8,15,380	-
Balance	(34,980)	4,00,000	20,000	3,85,020	-
GRAND TOTAL				10,91,661	11,57,844

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

4(C)

(PROF. ANIL K. GUPTA)
Director

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2014

SCHEDULE 4 : SECURED LOAN & BORROWINGS

(Amt in Rs...)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1 Central Government	-	-
2 State Government	-	-
3 Financial Institution		
a) Term Loans	-	-
b) Interest accrued and due	-	-
4 Banks		
a) Term Loan		
- Interest accrued and due	-	-
b) Others Loans (Specify)		
- Interest accrued and due	-	-
5 Other Institution & Agencies	-	-
6 Debenture and Bonds	-	-
7 Others (Specify)	-	-
TOTAL	-	-

(HARISH CHANDRA)
Finance & Accounts officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

Singhal & Associates
FRN 013108C
Chartered Accountants

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2014

SCHEDULE 5 : UNSECURED LOANS & BORROWINGS

(Amt in Rs…)

	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Central Government	-	-
2	State Government (Specify)	-	-
3	Financial Institution	-	-
4	Banks		
	a) Term Loans	-	-
	b) Others Loans (Specify)	-	-
5	Other Institution & Agencies	-	-
6	Debenture and Bonds	-	-
7	Fixed Deposits	-	-
8	Others (Specify)	-	-
	TOTAL	-	-

SCHEDULE 6 : DEFERRED CREDIT LIABILITIES

(Amt in Rs...)

	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
a.	Acceptance secured by hypothecation of capital equipments and other assets	-	-
b.	Others	-	-
	TOTAL	-	-

(HARISH CHANDRA)
Finance & Accounts officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

Singhal & Associates
FRN 013108C
Chartered Accountants

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2014

SCHEDULE 7 : CURRENT LIABILITIES & PROVISIONS

(Amt in Rs...)

		PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
A.		**Current Liabilities**		
	1	Acceptance	-	-
	2	Sundry Creditors		
		a) For goods	-	-
		b) Staff/Others (As per Annexure '1')	3,76,447	19,58,217
	3	Securities from Suppliers (As per Annexure '17')	34,05,783	39,01,320
	4	Interest accrued but not due on		
		a) Secured Loans/ Borrowings	-	-
		b) Unsecured Loans/ Borrowings	-	-
	5	Statutory Liabilities		
		a) TDS Payable	-	-
		b) GPF/CPF	-	-
		c) NPS Subscription	-	-
		d) Uttaranchal Trade Tax	-	-
	6	Other Current Liabilities		
		Group Insurance	3,375	3,381
		Consultancy Activity	34,78,582	12,83,941
		PLI	120	120
		Expenses payable (As per Annexure '16')	17,575	2,55,635
		TOTAL (A)	72,81,882	74,02,614
B.		**Provisions**		
	1	For Taxation	-	-
	2	Gratuity	-	-
	3	Superannuation/ Pension	-	-
	4	Accumulated Leave Encashment	-	-
	5	Trade Warranties Claims	-	-
	6	Other Specify	-	-
		TOTAL (B)	-	-
		TOTAL (A + B)	72,81,882	74,02,614

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AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2014

SCHEDULE 8 - FIXED ASSETS

(Amt in Rs.)

	PARTICULARS	GROSS BLOCK				DEPRECIATION					NET BLOCK		
		COST AS ON BEGINING OF THE YEAR	ADDITION DURING THE YEAR	DED./WRITT. OFF / TRFD. DURING THE YR.	COST AT THE END OF THE YEAR	OPENING BALANCE	OPENING BAL. TFD FROM PROJECT	DEP DURING THE YEAR	DED./WRITT. OFF / TRFD DURING THE YR.	TOTAL	CURRENT YEAR	PREVIOUS YEAR	RATE OF DEP.
	Fixed Assets												
1	**Land**												
	a) Freehold	8,26,780	-		8,26,780	-	-	-	-	-	8,26,780	8,26,780	
	b) Leasehold	-			-	-				-	-	-	
2	**Building**												
	a) On Freehold Land (Main Building)	127,43,996	-		127,43,996	72,58,124		5,48,587		78,06,711	49,37,285	54,85,872	10%
	b) On Leasehold Land	-			-	-		-		-	-	-	10%
	c) Guest House cum Hostel/ Staff Quarter	100,93,765	-		100,93,765	57,37,652		4,35,611		61,73,263	39,20,502	43,56,113	10%
	d) Store Building	96,15,648	-		96,15,648	50,13,808		4,60,184		54,73,992	41,41,656	46,01,840	10%
	e) New Lab Complex(IVth Block)	85,11,316	-		85,11,316	48,47,474		3,66,384		52,13,858	32,97,458	36,63,842	10%
	f) Boundary wall (Dharamshala)	6,41,905	-		6,41,905	3,48,141		29,376		3,77,517	2,64,388	2,93,764	10%
	g) Staff Quarters Type III & IV - Phase I	118,48,397	-		118,48,397	48,52,037		6,99,636		55,51,673	62,96,724	69,96,360	10%
	h) Staff Quarters Type III & IV - Phase II	182,31,591			182,31,591	34,64,002		14,76,759		49,40,761	132,90,830	147,67,589	10%
	i) Mass Renovation of WIHG Building	269,84,584	38,03,977	-	307,88,561	26,98,458		28,09,010		55,07,468	252,81,093	242,86,126	10%
	j) Bank Building	17,96,289	-		17,96,289	7,35,599		1,06,069		8,41,668	9,54,621	10,60,690	10%
	k) Road & Cabling	6,13,781	-		6,13,781	2,51,349		36,243		2,87,592	3,26,189	3,62,432	10%
	l) Directors Residence	64,87,581			64,87,581	12,32,640		5,25,494		17,58,134	47,29,447	52,54,941	10%
3	**Plant, Machinery & Equipment**	4235,44,355	36,12,039	129,49,290	4142,07,104	2282,85,329		293,78,555	99,35,256	2477,28,628	1664,78,476	1952,59,026	15%
4	**Vehicles**	31,82,349		-	31,82,349	13,25,355		2,78,549		16,03,904	15,78,445	18,56,994	15%
5	**Furniture & Fixtures**	119,58,645	1,93,921	10,70,224	110,82,342	58,39,991		5,89,795	6,55,598	57,74,188	53,08,154	61,18,654	10%
6	**Office Equipments**	64,54,747	12,92,670	42,03,575	35,43,842	38,24,602		4,20,621	30,84,902	11,60,321	23,83,521	26,30,145	15%
7	**Field Equipments- WIHG**	16,66,858	37,490	3,88,717	13,15,631	9,93,038		92,948	2,97,058	7,88,928	5,26,703	6,73,820	15%
	- Consultancy Activity	18,044	-		18,044	13,128		737		13,865	4,179	4,916	15%
8	**Library Books**												
	a) Indegenous Books	1048,35,399	115,55,306	746	1163,89,959	587,40,191		86,47,528	418	673,87,301	490,02,658	460,95,208	15%
9	**Tube Well & Water Supplies**	2,08,974	-		2,08,974	1,52,030		8,542		1,60,572	48,402	56,944	15%
10	**Computer & printers**	50,17,570	8,03,319	-	58,20,889	32,80,275	-	15,24,368		48,04,643	10,16,246	17,37,295	60%
		6652,82,574	212,98,722	186,12,552	6679,68,744	3388,93,223	-	484,34,996	139,73,232	3733,54,987	2946,13,757	3263,89,351	
	Equipments (Project) (As per Annexure '18')	875,51,071	14,20,121		889,71,192	604,67,218	10,25,123	42,75,595		657,67,936	232,03,256	270,83,851	15%
	TOTAL OF CURRENT YEAR	7528,33,645	227,18,843	186,12,552	7569,39,936	3993,60,441	10,25,123	527,10,591	139,73,232	4391,22,923	3178,17,013	3534,73,202	
	TOTAL OF PREVIOUS YEAR	6539,74,039	998,30,181	9,70,575	7528,33,645	3407,37,270	-	592,81,971	6,58,800	3993,60,441	3534,73,204	3132,36,769	

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

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Director

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2014

SCHEDULE 9 : INVESTMENT FROM EARMARKED/ ENDOWMENT FUND

(Amt in Rs...)

	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	In Government Securities	-	-
2	Other Approved Securities	-	-
3	Shares	-	-
4	Debentures and Bonds	-	-
5	Subsidaries and Joint ventures	-	-
6	Others		
	a) Fixed deposit of Prof. Mishra Award Fund	36,889	34,017
	TOTAL	**36,889**	**34,017**

SCHEDULE 10 : OTHER INVESTMENT

(Amt in Rs...)

	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	In Govt. Securities	-	-
2	Other Approved Securities	-	-
3	Shares	-	-
4	Debentures and Bonds	-	-
5	Subsridaries and Joint ventures	-	-
6	Others	-	-
	TOTAL	-	-

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Singhal & Associates Chartered Accountants FRN 013108C

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2014

SCHEDULE 11 : CURRENT ASSETS, LOANS & ADVANCES

(Amt in Rs....)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
CURRENT ASSETS (A)		
Inventories		
a) Publications (Himalayan Geology Volumes) (As per Annexure '2')	4,16,149	4,88,702
Sundry Debtors (As per Annexure '3')	3,17,742	6,07,744
Cash Balance in Hand	42,219	5,347
Imprest Money - WIHG (As per Annexure '4')	52,000	58,500
Bank Balance		
a) With Scheduled Bank		
- On Saving Account(UBI S/A No. 518602170033001)	224,03,544	80,10,033
- On Saving Account(SBI) A/c No. 10022411762	27,283	45,450
- On Deposit Account (L/C Margin Money)	897,00,000	27,00,000
b) With Non- Scheduled Bank		
- On Current Account	-	-
- On Deposit Account (Includes Margin Money)	-	-
- On Saving Account (Projects)	-	-
Consultancy Activity		
Cash at Bank A/c No 563	70,74,358	23,95,418
FDR	296,25,995	274,47,254
Post Office Saving Accounts	-	-
TDS	10,35,934	8,39,332
TOTAL (A)	**1506,95,224**	**425,97,780**

SCHEDULE 11 : CURRENT ASSETS, LOANS & ADVANCES

(Amt in Rs…)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
LOANS & ADVANCES (B)		
Loans		
a) Staff (As per Annexure '5')	25,09,718	31,09,268
Advances & Other amount recoverable in cash or in kind or for value to be received		
a) On Capital Account	-	-
b) GPF / CPF	-	-
c) Others	-	
Income Accrued		
a) On Investments from earmarked/endowment fund	-	-
b) On other Investments	2,51,325	-
c) On Loans & Advances	-	-
d) Others (Including Projects/ Cheques/ Drafts & Imprests)	-	-
Claims Receivable - Consultancy Activity		
Consultancy Receivable	2,022	-
Security Deposit (As per Annexure '12')	8,92,372	7,21,808
TOTAL (B)	**36,55,437**	**38,31,076**
TOTAL (A + B)	**1543,50,661**	**464,28,856**

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Director

Singhal & Associates Chartered Accountants FRN 013108C

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRADUN

INCOME & EXPENDITURE ACCOUNT
FOR THE PERIOD ENDED 31ST MARCH 2014

(Amt in Rs...)

S.NO.	PARTICULARS	SCH.	CURRENT YEAR	PREVIOUS YEAR
A	**INCOME**			
	Income from sales/ services	12	-	-
	Grants/ Subsidies	13	3292,50,000	2000,00,000
	Fees/Subscription	14	51,000	23,370
	Income from Investments	15	6,66,704	7,89,354
	Income from Royalty, Publication etc.	16	39,664	59,523
	Interest earned	17	57,44,910	107,74,589
	Other Income	18	64,73,809	73,49,558
	Increase/ Decrease in Stock (Goods & WIP)	19	-	-
	TOTAL (A)		**3422,26,087**	**2189,96,394**
B	**EXPENDITURE**			
	Establishment Expenses	20	1781,28,463	1639,92,520
	Other Research & Administrative Expenses	21	359,42,465	403,22,588
	Expenditure on Grant/ Subsidies etc.	22	-	-
	Interest/ Bank Charges	23	8,576	466
	Depreciation Account	8	527,10,591	592,81,971
	Increase/ Decrease in stock of Finished goods, WIP& Stock of Publication	A-2	72,553	24,703
	Loss on sale of Assets	A-19	33,03,036	82,210
	TOTAL (B)		**2701,65,684**	**2637,04,458**
	Surplus/ (Deficit) being excess of Income over Expenditure (A - B)		720,60,403	(447,08,064)
	Transfer to Special Reserve (Specify each)		-	-
	Transfer to / from General Reserve		-	-
	BALANCE BEING SURPLUS /(DEFICIT) CARRIED TO CORPUS FUND		**720,60,403**	**(447,08,064)**

AUDITOR'S REPORT
"As per our separate report of even date"

FOR VIPUL SINGHAL & ASSSOCIATES
CHARTERED ACCOUNTANTS

Vipul Singhal & Associates FRN 013109C Chartered Accountants

(CA VIPUL KUMAR SINGHAL)
PARTNER, FCA

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

Date: 4th Aug, 2014
Place: Dehradun

<u>**WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN**</u>

<u>**SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING ON 31ST MARCH 2014**</u>

SCHEDULE 12 : INCOME FROM SALE / SERVICES

(Amt in Rs. .)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1 Income From Sales :		
a) Sale of Finished Goods	-	-
b) Sale of Raw Material	-	-
c) Sale of Vehicle		-
2 Income From Services :		
a) Labour & Processing Charges	-	-
b) Professional/Consultancy Service	-	-
c) Agency Commission & Brokerage	-	-
d) Maintenance Service (Equipment/ Property)	-	-
e) Others (Specify)	-	-
TOTAL	-	-

SCHEDULE 13 : GRANT & SUBSIDIES

(Amt in Rs. .)

ARTICULARS	PLAN Non Recurring	PLAN Recurring	NON PLAN	CURRENT YEAR	PREVIOUS YEAR
1 **Central Government**	212,98,722	3036,01,278	43,50,000	3292,50,000	2000,00,000
2 **State Government**	-	-	-	-	-
3 **Government Agencies**	-	-	-	-	-
4 **Institutions / Welfare Bodies**	-	-	-	-	-
5 **International Organisation**	-	-	-	-	-
6 **Others (Specify)**	-	-	-	-	-
TOTAL	**212,98,722**	**3036,01,278**	**43,50,000**	**3292,50,000**	**2000,00,000**

(HARISH CHANDRA)
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AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING ON 31ST MARCH 2014

SCHEDULE 14 : FEES/ SUBSCRIPTION

(Amt in Rs...)

		PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1		Entrance Fees	-	-
2		Annual Fees/ Subsription (WIHG Lib.)	51,000	23,370
			-	-
3		Seminar/ Programme Fees	-	-
4		Others(Specify)	-	-
		TOTAL	51,000	23,370

SCHEDULE 15 : INCOME FROM INVESTMENT

(Amt in Rs...)

		PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
		(Income on Investment from Earmarked/ Endowment fund transferred to fund)		
1		Interest		
	a)	On Government Securities	-	-
	b)	Other Bonds/ Debenture	-	-
2		Dividend	-	-
	a)	On Shares	-	-
	b)	On Mutual Funds Securities	-	-
3		Rent	6,66,704	7,89,354
4		Others (Specify)	-	-
		TOTAL	6,66,704	7,89,354

SCHEDULE: 16 INCOME FROM ROYALTY, PUBLICATION ETC.

(Amt in Rs...)

		PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1		Income from Royalty	-	-
2		Income From Publication (WIHG Volumes)	39,664	59,523
			-	-
3		Others (Specify)	-	-
4		Gratis to Life Members	-	-
		TOTAL	39,664	59,523

(HARISH CHANDRA)	(DINESH CHANDRA)	(PROF ANIL K. GUPTA)
Finance & Accounts officer	Registrar	Director

FRN 013108C

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING ON 31ST MARCH 2014

SCHEDULE: 17 INTEREST EARNED

(Amt in Rs…)

	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	**In Term Deposit :**		
	a) With Scheduled Bank	3,09,975	15,06,139
	b) With Non-Scheduled Bank	-	-
	c) With Institution	-	-
	d) Others	-	-
2	**On Saving Account :**		
	a) With Scheduled Bank	21,39,464	17,04,414
	b) With Non-Scheduled Bank	-	-
	c) Post Office Saving Account	-	-
	d) Others	-	-
3	**On Loans :**		
	a) Employees/ Staff :		
	-HBA	4,92,694	7,33,808
	-Conveyance Advance	61,401	67,438
	-Computer Advance	52,221	35,746
	b) -Others	-	46
4	**Interest on Debtor & Other Receivables :**		
5	**Interest - Consultancy Activity**	26,89,155	67,26,998
	TOTAL	**57,44,910**	**107,74,589**

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AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING ON 31ST MARCH 2014

SCHEDULE 18 : OTHER INCOME

(Amt in Rs.)

		PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1		**Profit on sale/Disposal of Assets**		
	a)	Owned Assets	-	-
	b)	Assets Acquired out of grant	-	-
		or received free of cost	-	-
2		**Overhead Charges**	8,96,000	8,10,000
3		**Fees for Miscellaneous Services** (As per Annexure'13')	5,67,000	7,85,486
4		**Miscellaneous Income** (As per Annexure '14')	46,74,595	55,97,538
5		**Leave Salary & Pension Contribution**	2,83,154	-
6		**Tender Form Fee**	53,060	51,732
7		**Others (Liquidated Damage)**	-	1,04,802
		GRAND TOTAL	**64,73,809**	**73,49,558**

SCHEDULE 19 : INCREASE/ DECREASE IN STOCK OF FINISHED GOODS & WORK IN PROGR

	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
A.	**CLOSING STOCK**		
	- Finished Goods	-	-
	- Work in Progress	-	-
B.	**LESS: OPENING STOCK**		
	- Finished Goods	-	-
	- Work in Progress	-	-
	NET INCREASE (DECREASE) (A-B)		-

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WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT
FOR THE YEAR ENDING ON 31ST MARCH 2014

SCHEDULE-20 ESTABLISHMENT EXPENSES

(Amt in Rs..)

	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
A.	Salary , Wages & Fellowship	536,00,189	605,89,287
	Visiting/research fellowship	47,47,103	46,29,038
B.	Allowances, Bonus & Honorarium		
	1. Allowances	598,10,623	545,40,887
	2. Bonus	3,74,668	4,28,826
	3. Honorarium	3,76,000	1,51,800
C.	Contribution to CPF	2,09,710	2,05,318
D.	Contribution to NPS	15,47,196	14,03,580
E.	Staff Welfare Expenses	-	-
F.	1.Expenses on Employees	-	-
	2.Retirement & Terminal Benefits	259,74,255	187,32,876
	3.TA on Retirement	1,19,627	1,85,105
G.	1.Leave Travel Concession	32,90,603	15,46,351
	2.Leave encashment on LTC	10,54,343	8,81,178
H.	Leave Salary & Pension Contribution	224,96,431	169,54,371
I.	1.Others (Medical Reimbursement)	44,02,985	36,14,584
	2.(Training Programme)- In India	1,24,730	1,12,607
	3.(Training Programme)- Abroad	-	16,712
	TOTAL	1781,28,463	1639,92,520

(HARISH CHANDRA)
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(PROF ANIL K. GUPTA)
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FRN 013106C

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING ON 31ST MARCH 2014

SCHEDULE 21 : OTHER RESEARCH & ADMINISTRATIVE EXPENSES

(Amt in Rs...)

		PLAN	NON PLAN	CURRENT YEAR	PREVIOUS YEAR
a.	Purchases	-	-	-	-
b.	Analytical & Dating charges	1,35,572	-	1,35,572	4,62,261
c.	Cartage & Carriage Inward	-	-	-	-
d.	Electricity, Power & Water Charges	42,20,022	-	42,20,022	47,61,470
e.	Insurance for Vehicle	95,818	-	95,818	91,888
f.	Repair & Maintenance			-	-
	1. Building & Garden	28,60,484	-	28,60,484	16,67,946
	2. Equipment & Others	17,95,779	-	17,95,779	37,28,747
g.	Excise Duty	-	-	-	-
h.	Rent, Taxes,Rate Contract & Service Charges	69,50,295	56,000	70,06,295	57,44,022
i.	Vehicle Running & Maintenance	7,38,178	-	7,38,178	5,76,224
j.	Postage, Telephone	-	9,78,272	9,78,272	8,73,737
k.	Subscription exps., Internet & bandwidth Charges	5,21,279	-	5,21,279	7,93,415
l.	Printing & Stationery	-	4,52,343	4,52,343	7,40,509
m.	Travelling & Conveyance exp./Field tour expedition	29,33,922	6,61,976	35,95,898	47,33,545
n.	Exps. On Seminar/Workshop ("As per Annexure 15")	31,93,694	-	31,93,694	40,11,049
o.	Guest House Expense	1,33,044	-	1,33,044	1,57,504
p.	TA/DA to GB/Committee members		10,07,364	10,07,364	15,31,372
q.	Auditor's Remuneration	-	28,652	28,652	7,865
r.	Hospitality Exps.	-	37,889	37,889	58,225
s.	Professional Charges/Legal Exps.	2,68,315		2,68,315	1,93,214
t.	Provision for Bad & Doubtful Debts/ Advances	-	-	-	-
u.	Capital/Fixed Assets written off/Loss	-	-	-	-
v.	Festival, Fair & Exhibition	-	4,77,469	4,77,469	4,64,561
w.	Freight & Forwarding Exps.	-	-	-	-
x.	Distribution Exps.	-	-	-	-
y.	Advertisement & Publicity	76,472	5,82,607	6,59,079	12,58,184
z.	Leveries	-	-	-	-
a(i)	Others (Specify)			-	-
	1. Foundation Day	-	67,777	67,777	1,39,321
	2. Contingency	7,40,459	-	7,40,459	9,96,734
	3. Chemical Glassware & Photo Goods	5,70,627	-	5,70,627	18,09,639
	4. Royalty	126	-	126	144
	5. Publication	1,13,590	-	1,13,590	2,32,892
	6. Certification Charges for ISO 9001 : 2008	1,57,304	-	1,57,304	-
	7.Computer Stationery/Peripherals	37,98,235	-	37,98,235	12,39,005
	8.Reprints & Research paper	5,500	-	5,500	18,137
	9.NSDL Service A/C		-	-	2,854
	10. Renovation, modification & oiling	-	-	-	21,62,890
	11. Insurance of Field Party	67,129	-	67,129	74,764
	12. Membership of Scientific Journals	96,558	-	96,558	8,000
	13. Anti Termite treatment		-	-	2,38,346
	14. Consultancy Activity Expenses	21,19,714		21,19,714	15,43,924
	TOTAL	**315,92,116**	**43,50,349**	**359,42,465**	**403,22,588**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT

FOR THE YEAR ENDING ON 31ST MARCH 2014

SCHEDULE 22 : EXPENDITURE ON GRANT/ SUBSIDIES ETC.

(Amt in Rs...)

	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
a)	Grant given to Institution/Organisations	-	-
b)	Subsidies given to Institutions/Organisation	-	-
	TOTAL	-	-

SCHEDULE 23: INTEREST/CHARGES

(Amt in Rs...)

		PLAN	NON PLAN	CURRENT YEAR	PREVIOUS YEAR
a.	**On Fixed Loan**	-	-	-	-
b.	**On Other Loan**	-	-	-	-
c.	**Bank Charges**	8,576		8,576	466
d.	**Others**	-	-		-
	TOTAL	**8,576**	-	**8,576**	**466**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF. ANIL K. GUPTA)
Director

FRN 013108C

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

RECEIPTS & PAYMENTS ACCOUNT
(FOR THE YEAR ENDED 31st MARCH 2014)

(Amt in Rs...)

PARTICULARS	SCH.	CURRENT YEAR	PREVIOUS YEAR
RECEIPTS			
Opening Balance	24	379,62,002	968,35,412
Grants - in - Aids	26	3292,50,000	2000,00,000
Grants - in - Aids/Other Receipts (Ear Marked)	27	18,85,674	339,72,595
Loan & Advances	28	1132,51,607	879,71,813
Loan & Advances (Ear Marked)	31	5,66,500	14,69,000
Fees/Subscription	14	51,000	23,370
Income from Investments	15	6,66,70[illegible]	7,89,354
Income from Royalty, Publication etc.	16	39,6[illegible]	59,523
Interest earned	17	57,44,916	107,74,589
Other Income	18	64,73,809	73,49,558
Investment (L/C Margin Money)	34	11,45,000	243,35,000
		4970,36,870	**4635,80,214**
PAYMENTS			
Establishment Expenses	20	1781,28,463	1639,92,520
Other Administrative Expenses	21	359,42,465	403,22,588
Expenditure on Grant/Subsidies Etc.	22	-	-
Interest/ Bank Charges	23	8,576	466
Loans & Advances	29	1131,03,300	834,40,522
Loans & Advances (Ear Marked)	32	4,66,500	15,71,595
Investment (L/C Margin Money)	35	881,45,000	27,00,000
Fixed Assets	36	199,62,438	996,00,616
Ear Marked Fund Expenses	33	20,54,729	22,19,905
Grant - in - Aid (Ear Marked) Refunded	30	-	317,70,000
Closing Balance	25	592,25,399	379,62,002
		4970,36,870	**4635,80,214**

AUDITOR'S REPORT
"As per our separate report of even date"

FOR VIPUL SINGHAL & ASSOCIATES
CHARTERED ACCOUNTANTS

(CA VIPUL KUMAR SINGHAL)
PARTNER, FCA

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF. ANIL K. GUPTA)
Director

Date : 4th Aug, 2014
Place: Dehradun

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF RECEIPT & PAYMENT AS ON 31ST MARCH 2014

SCHEDULE - 24 : OPENING BALANCE

(Amount in Rs...)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
Cash in Hand	5,347	13,479
Cash at Bank : Saving A/c UBI 518602170033001	80,10,033	785,09,223
Saving A/c SBI 10022411762	45,450	90,774
Imprest Money	58,500	43,500
Consultancy Activity		
Cash at Bank A/c No 563	23,95,418	25,80,426
FDR	274,47,254	155,98,010
TOTAL	**379,62,002**	**968,35,412**

SCHEDULE - 25 : CLOSING BALANCE

(Amt in Rs...)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
Cash in Hand	42,219	5,347
Cash at Bank : Saving A/c UBI 518602170033001	224,03,544	80,10,033
Saving A/c SBI 10022411762	27,283	45,450
Imprest Money	52,000	58,500
Consultancy Activity		
Cash at Bank A/c No 563	70,74,358	23,95,418
FDR	296,25,995	274,47,254
TOTAL	**592,25,399**	**379,62,002**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF. ANIL K. GUPTA)
Director

FRN 013108C

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF RECEIPT & PAYMENT AS ON 31ST MARCH 2014

SCHEDULE : 26 GRANT IN AID RELEASED BY DST FOR THE YEAR 2013-14

(Amt in Rs....)

S.NO	SANCTION NO. CURRENT YEAR	DATED	PLAN	NON-PLAN
1	AI/WIHG/003/2013/NP	06.08.2013	-	43,50,000
2	AI/WIHG/SAL/003/2013/1	25.04.2013	188,10,000	-
3	AI/WIHG/SAL/003/2013/2	23.07.2013	692,40,000	-
4	AI/WIHG/SAL/003/2013/4	07.02.2014	526,20,000	-
5	AI/WIHG/SC/003/2013/1	26.04.2013	15,67,000	-
6	AI/WIHG/SC/003/2013/2	23.07.2013	55,58,000	-
7	AI/WIHG/SC/003/2013/4	07.02.2014	17,75,000	-
8	AI/WIHG/GEN/003/2013/1	26.04.2013	70,26,000	-
9	AI/WIHG/GEN/003/2013/2	22.07.2013	235,74,000	-
10	AI/WIHG/GEN/003/2013/4	07.02.2014	192,80,000	-
11	AI/WIHG/CAP/003/2013/1	26.04.2013	59,35,000	-
12	AI/WIHG/CAP/003/2013/2	22.07.2013	548,15,000	-
13	AI/WIHG/CAP/003/2013/4	07.02.2014	968,50,000	-
14	AI/WIHG/ST/003/2013/1	07.02.2014	3,50,000	-
	Less : Transferred to MANU Project		(325,00,000)	-
	TOTAL		**3249,00,000**	**43,50,000**
	GRAND TOTAL			**3292,50,000**
	PREVIOUS YEAR			**2000,00,000**

SCHEDULE : 27 GRANT - IN - AID/OTHER RECEIPTS (EAR MARKED) AS ON 31ST MARCH 2014

(Amt in Rs....)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	NGF Project	-	311,00,000
2	IAS Bangalore	-	5,00,000
3	UKS - S&T, Vasant Vihar, Dehradun	-	25,000
4	UGC -RC	-	75,000
5	RES. Training Fellow	-	2,70,000
6	Training Workshop Programme (NW Himalaya)	-	20,00,000
7	Prof Mishra Award Fund	-	2,595
8	WIHG - IGU WORKSHOP - 2013	1,12,000	-
9	Brain Storming Meeting (DR. PS)	3,50,000	-
10	Brain Storming Meeting (MOES)	4,00,000	-
11	Geomathematic Winter School Training	5,50,000	-
12	Inspire Fellowship (RLM)	2,75,793	-
13	RTF - DCS Fellowship	40,000	-
14	ULF/VLF Equipment A/c	1,57,881	-
	Total	**18,85,674**	**339,72,595**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF RECEIPT & PAYMENT AS ON 31ST MARCH 2014

SCHEDULE - 28 : LOANS & ADVANCES/ LIABILITIES (RECEIPTS)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
Expenses Payable	1,68,303	1,759
Income Tax	114,29,226	103,11,707
GPF	213,17,600	219,07,900
Festival Advance	1,88,625	1,42,950
Conveyance Advance	3,23,783	2,38,211
Computer Advance	2,01,417	2,29,112
Sundry Debtors (Party)	380,48,016	160,58,318
Sundry Debtors (Staff)	93,23,299	102,32,559
House Building Advance	2,31,908	3,20,191
Security Payable	13,32,215	29,00,099
Subs. Of NPS	15,64,892	14,18,329
Group Insurance	9,43,413	2,29,441
PLI	828	5,251
Uttarakhand Trade Tax	3,47,077	18,72,351
C.P.F	8,81,449	7,39,513
Co-Operative Society	110,60,625	105,59,574
Refund of HBA	60,000	60,000
CPF Loan	29,100	37,500
GPF Loan	9,64,925	10,30,715
LIC Premium	17,10,558	26,35,533
HDFC (Dehradun)	9,76,594	12,95,935
Warm Clothing Advance	17,625	9,000
Income Tax (Contractor/ Party)	4,89,816	9,66,359
Service Tax	-	6,153
M.C ON NPS	15,64,892	14,18,067
M.C ON CPF	2,09,710	2,05,672
A.C.W.F New Delhi	500	6,000
Leave Salary Pension Contribution	-	7,011
CSIR-B.I	-	2,28,209
CSIR- A.T	-	1,63,545
Dr Rajkumar Singh	-	2,61,463
Indo Iceland	-	12,90,000
Consultancy Activity	21,94,641	11,83,386
PM Rahat Fund	2,13,993	-
Dr B. N. Tiwari	1,27,257	-
Dr S. K. Parcha	3,19,000	-
Dr Jayangondaperumal	1,49,402	-
Dr A. K. Singh	3,18,471	-
Bhagirathi (PS) Project	35,00,000	-
Yamunotri (VG) Project	25,00,000	-
Centre for Glaciology	5,00,000	-
Serial Publication, New Delhi	675	-
Satish Prasad Bahuguna	200	-
MPGO Project	41,572	-
TOTAL	**1132,51,607**	**879,71,813**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF RECEIPT & PAYMENT AS ON 31ST MARCH 2014

SCHEDULE - 29 : LOANS & ADVANCES/ LIABILITIES (PAYMENTS)

(Amt in Rs....)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
Expenses Payable	4,06,363	10,593
Security Payable	18,27,752	15,45,714
Sundry Debtors (Staff)	93,20,019	107,36,031
Sundry Debtors (Party)	377,58,014	156,76,851
Conveyance Advance	24,000	4,00,540
Computer Advance	60,200	-
Income Tax	114,29,226	103,11,707
G.P.F.	213,17,600	219,07,900
Festival Advance	1,57,500	1,69,050
Group Insurance	9,43,419	2,28,417
PLI	828	5,251
Uttarakhand Trade Tax	3,47,077	18,72,351
C.P.F	8,81,449	7,39,513
Co-Operative Society	110,60,625	105,59,574
CPF Loan	29,100	37,500
GPF Loan	9,64,925	10,30,715
Subs. of NPS	15,64,892	14,18,329
LIC Premium	17,10,558	26,35,533
HDFC (Dehradun)	9,76,594	12,95,935
Warm Clothing Advance	41,250	1,125
Income Tax (Contractor/ Party)	4,89,816	9,64,669
Service Tax	-	6,153
Other Recovery (HBA-AKG)	60,000	60,000
Management Contribution on NPS	15,64,892	14,18,067
Management Contribution on CPF	2,09,710	2,05,672
A.C.W.F New Delhi	500	6,000
Accrued Interest on FDR	2,51,325	-
Leave Salary Pension Contribution	-	7,011
Consultancy Activity	86,160	1,81,107
TDS Recoverable	1,96,602	9,214
PM Rahat Fund	2,13,993	-
Security Deposit	1,70,564	-
Dr B. N. Tiwari	1,27,257	-
Dr Jayangondaperumal	1,49,402	-
Dr A. K. Singh	3,18,471	-
Dr Rajkumar Singh	2,61,463	-
Km Vadinaro Imsong	2,28,209	-
Km Anett Sungla	1,63,545	-
Indo Iceland	12,90,000	-
Bhagirathi (PS) Project	35,00,000	-
Yamunotri (VG) Project	25,00,000	-
Centre for Glaciology	5,00,000	-
TOTAL	**1131,03,300**	**834,40,522**

(HARISH CHANDRA)	(DINESH CHANDRA)	(PROF ANIL K. GUPTA)
Finance & Accounts Officer	Registrar	Director

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF RECEIPT & PAYMENT AS ON 31ST MARCH 2014

SCHEDULE - 30 : GRANT - IN - AID (EAR MARKED) REFUND

(Amt in Rs....)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
NGF Project	-	311,00,000
IAS Bangalore	-	5,00,000
UKS - S&T, Vasant Vihar, Dehradun	-	25,000
UGC-RC	-	75,000
NFWSHPSI (Dr K Kumar)	-	70,000
TOTAL	-	317,70,000

SCHEDULE - 31 : LOANS & ADVANCES/ OTHER RECEIPTS, EAR MARKED (RECEIPTS)

(Amt in Rs....)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
Dr Pradeep Srivastava- Training workshop programme laddakh	-	14,69,000
4th T.P.E. Workshop	1,00,000	-
WIHG - IGU Workshop - 2013	40,000	-
MMND Workshop (Dr V.C. Tiwari)	50,000	-
Brain Storming Meeting (Dr PS)	2,98,250	-
Geomathematic Winter School Training	78,250	-
TOTAL	5,66,500	14,69,000

SCHEDULE - 32 : LOANS & ADVANCES/ OTHER PAYMENTS , EAR MARKED (PAYMENTS)

(Amt in Rs....)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
DR. Rajesh Sharma - 4TH TPE Workshop	-	50,000
DR. Kishore Kumar - 4TH TPE Workshop	-	50,000
DR Pradeep Srivastava- Training workshop programme laddakh	-	14,69,000
Prof Mishra Award Fund	-	2,595
WIHG - IGU Workshop - 2013	40,000	-
MMND Workshop (Dr V.C. Tiwari)	50,000	-
Brain Storming Meeting (Dr PS)	2,98,250	-
Geomathematic Winter School Training	78,250	-
TOTAL	4,66,500	15,71,595

FRN 013108C

(HARISH CHANDRA)	**(DINESH CHANDRA)**	**(PROF ANIL K. GUPTA)**
Finance & Accounts Officer	Registrar	Director

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF RECEIPT & PAYMENT AS ON 31ST MARCH 2014

SCHEDULE - 33 : EAR MARKED FUND EXPENSES

(Amt in Rs...)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
Training Workshop Programme (QSANWH Laddakh)	-	22,19,905
MMND Workshop (Dr V.C. Tiwari)	1,67,774	-
Brain Storming Meeting (Dr PS)	3,06,467	-
Geomathematic Winter School Training	5,84,980	-
Inspire Fellowship (RLM)	2,55,793	-
RTF-DCS Fellowship	2,95,667	-
WIHG - IGU Workshop - 2013	4,44,048	-
TOTAL	20,54,729	22,19,905

SCHEDULE - 34 : INVESTMENTS (RECEIPTS)

(Amt in Rs...)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
Letter of Credit/ Fixed deposit	11,45,000	243,35,000
TOTAL	11,45,000	243,35,000

SCHEDULE - 35 : INVESTMENTS (PAYMENTS)

(Amt in Rs...)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
Letter of Credit/ Fixed deposit	881,45,000	27,00,000
TOTAL	881,45,000	27,00,000

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF. ANIL K. GUPTA)
Director

Singhal & Associates Chartered Accountants FRN 013108C

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF RECEIPT & PAYMENT AS ON 31ST MARCH 2014

SCHEDULE - 36 : FIXED ASSETS

(Amt in Rs...)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
Equipments :		
-WADIA	36,12,039	599,40,015
Field Equipment	37,490	-
Computer & Printers	8,03,319	37,14,739
Office Equipment	12,92,670	46,500
Building Construction	38,03,977	269,84,584
Books & Charts	115,55,306	85,74,657
Furniture & Fixture	1,93,921	5,69,686
TOTAL	**212,98,722**	**998,30,181**
Equipments :		
-PROJECTS	14,20,121	-
TOTAL	14,20,121	-
GRAND TOTAL	**227,18,843**	**998,30,181**
Add: (Profit)/Loss on asset		
- Vehicle	-	86,598
- Equipment	30,08,197	(3,882)
- Library Books	(418)	(506)
- Furniture & Fixtures	2,95,257	-
Less :- Fixed Assets Written Off		
- Vehicle	-	8,69,831
- Library Books	746	1,412
- Equipment Indeginious	129,49,290	13,990
- Field Equipment	3,88,717	-
- Office Equipment	42,03,575	-
- Computer	-	85,342
- Furniture & Fixtures	10,70,224	-
Add: Depreciation Fund reversed		
- Vehicle	-	5,90,983
- Library Books	418	506
- Equipment	133,17,216	3,882
- Computer	-	63,429
- Furniture & Fixtures	6,55,598	-
Projects	14,20,121	-
	199,62,438	**996,00,616**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE '1'
(SUNDRY CREDITORS AS ON 31st MARCH 2014)

(Amt in Rs…)

S.NO.	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	C.D.S. Project (PB)	-	15,000
2	Dr. S. K. Parcha	3,19,000	-
3	CSIR -B.I	-	2,28,209
4	CSIR- A.T	-	1,63,545
5	Indo-Iceland	-	12,90,000
6	Dr. Rajkumar Singh (NIO Goa)	-	2,61,463
7	C. D. S. Project (PB)	15,000	-
8	Serial Publication, New Delhi	675	-
9	MPGO PROJECT	41,572	-
10	Sri Satish Prasad Bahuguna	200	-
	Total	**3,76,447**	**19,58,217**

'ANNEXURE '2'
(PUBLICATION AS ON 31st MARCH 2014)

(Amt in Rs…)

S.NO.	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	**Opening Stock of Himalayan Geology Volume**	**4,88,702**	**5,13,405**
2	Less : Closing Stock of Himalayan Geology Volume	4,16,149	4,88,702
	Decrease In Stock	**72,553**	**24,703**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF. ANIL K. GUPTA)
Director

FRN 013108C

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRADUN

ANNEXURE '3'
{ PARTY DEBTORS AS ON 31st MARCH 2014 }

(Amt in Rs…)

S.NO.	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Sh. Dharam Singh Manral	5,000	5,000
2	Registrar Banaras University	2,500	2,500
3	M/s NRSA, Hyderabad	(11,634)	(11,634)
4	M/s Associated Cement Corp.	39,320	39,320
5	M/s Cement Corporation Of India	6,409	6,409
6	Registrar Roorkee University	3,250	3,250
7	M/s C.Z.Instruments	18,622	18,622
8	M/s Indian Photographics Co.	6,876	6,876
9	M/s Scientronics Inst. Co.	3,004	3,004
10	I.I.P. D. Dun	7,200	7,200
11	M/s Airport Handling Service	58,493	58,493
12	M/s Philips Electronics Inf.	3,193	3,193
13	M/s Indian Rave Earth Ltd.	3,221	3,221
14	M/s Instrument Traders	2,481	2,481
15	M/s Bharat ICP Corp.	3,000	3,000
16	M/s Survey Of India	5,000	5,000
17	M/s Eureka Forbes	1,300	1,300
18	M/s Jakson Enterprises	16,545	16,545
19	M/s Gatan House, Hyderabad	(376)	(376)
20	M/s Track Cargo, Delhi	1,17,458	1,17,458
21	M/s. Cameca, France	-	3,16,882
22	Shri H. G. Malik (Advocate)	14,000	-
23	M/s. Insa, New Delhi	12,880	-
	TOTAL	**3,17,742**	**6,07,744**

(HARISH CHANDRA)
Finance & Accounts officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

Singhal & Associates
FRN 013108C
Chartered Accountants

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE '4'
[IMPREST MONEY AS ON 31ST MARCH 2014]

(Amt in Rs...)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Dr.V.C. Tiwari	2,000	2,000
2	Dr. N. K. Saini	1,000	1,000
3	Shri Tapan Banerji	-	15,000
4	Shri O. P. Anand	(2,000)	500
5	Shri S. K. Parcha	9,000	9,000
6	Dr. N. Sivasidhya	-	2,000
7	VIC Imprest	-	1,000
8	Shri Manas Kumar Biswas	5,000	5,000
9	Shri Tajender Kumar Ahuja	2,000	2,000
10	Shri C. B.Sharma (JE)	2,000	2,000
11	Dr. B. K. Chowdhury	2,000	2,000
12	Dr. Kishore Kumar	7,000	7,000
14	Dr. H. K. Sachan	5,000	5,000
15	Shri Rambir Kaushik	5,000	5,000
16	Mrs. Anita Chowdhary	2,000	-
17	Km Richa Kukreja	10,000	-
18	Sri Girish Chand Singh	2,000	-
	TOTAL	52,000	58,500

ANNEXURE '5'
[STAFF ADVANCES AS ON 31ST MARCH 2014]

(Amt in Rs...)

S.NO	PARTICULARS	ANNEXURE	CURRENT YEAR	PREVIOUS YEAR
1	Festival Advance	6	70,125	1,01,250
2	Conveyance Advance	7	3,47,555	6,47,338
3	House Building Advance	8	7,16,098	9,48,006
4	Computer Advance	9	4,88,687	6,29,904
5	Advance for Expenses (Staff Debtors)	10	7,63,428	7,66,708
6	Warm Clothing Advance	11	23,625	-
7	Consultancy Activity		1,00,200	16,062
	TOTAL		25,09,718	31,09,268

Vipul Singhal & Associates Chartered Accountants FRN 013108C

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

'ANNEXURE '6'

(FESTIVAL ADVANCE AS ON 31st MARCH 2014)

(Amt in Rs...)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Shri S. K. Chabak	1,875	1,875
2	Shri C. P. Dabral	1,875	1,875
3	Shri B. B. Panthari	1,875	1,875
4	Smt. Rama Pant	1,125	1,875
5	Shri Ramesh Chand	1,125	1,875
6	Shri Nain Dass	1,875	2,625
7	Shri Khushi Ram	1,050	1,200
8	Shri Anand Singh Negi	-	1,875
9	Shri Madhu Sudan	1,875	2,625
10	Shri Vinod Singh Rawat	-	2,625
11	Shri Hari Krishan	750	3,750
12	Shri Ramesh	1,125	1,125
13	Shri Ram Khilawan	-	1,875
14	Shri Navneet Kumar	1,125	1,875
15	Shri Nand Ram	1,875	2,625
16	Shri A. K. Gupta	-	2,625
17	Shri Shyam Singh	2,250	3,000
18	Shri S. K. Srivastava	-	2,625
19	Shri Shekhar Nand	1,050	1,200
20	Shri Ram Kishore	1,875	2,625
21	Shri Pratap Singh	1,125	1,875
22	Shri Ansuya Prasad	1,875	2,625
23	Shri Shiv Prasad Bahuguna	1,875	2,625
24	Shri Shashidhar Prasad Balodi	1,875	2,625
25	Shri S. K. Thapliyal	1,050	1,200
26	Shri Satish P. Bahuguna	-	2,625
27	Shri Balram Singh	3,375	2,625
28	Shri Tirath Raj	1,875	1,875
29	Shri Sohan Singj	1,875	1,875
30	Shri Hari Singh Chauhan	1,875	1,875
31	Shri Rahul Sharma	1,875	2,625
32	Shri Kulwant Singh Manral	1,875	2,625
33	Shri Pankaj Chauhan	-	3,750
34	Mrs. Kalpana Chandel	1,875	3,000
35	Shri S. K. Gupta	1,875	1,875
36	Shri Surendra Singh	-	3,750
37	Shri Chait Ram	1,125	1,875
38	Mrs. Seema Juyal	1,500	2,250
39	Shri Santu Das	1,425	1,575
40	Mrs. Neelam Chabak	1,875	1,875
41	Shri Ravi Lal	1,125	-
42	Shri Pretam Singh	1,050	4,950
43	Shri Bharat Singh Rana	1,125	1,875
44	Smt. Omwati	1,875	1,875
45	Shri Preetam Singh	1,125	1,875
46	Shri M. C. Sharma	1,875	-
47	Mrs. Prabha Kharbanda	1,875	-
48	Shri Vijay Ram Bhatt	1,875	-
49	Shri Bhupender Singh	2,250	-
50	Shri Puneet Kumar	1,125	-
51	Shri Jeevan Lal	1,875	-
	TOTAL	**70,125**	**1,01,250**

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ANNEXURE '7'
{ CONVEYANCE ADVANCE AS ON 31ST MARCH 2014 }

(Amt in Rs...)

S.NO.	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Shri C. P. Dabral	9,884	15,020
2	Dr. A. K. Mahajan	-	8,979
3	Smt. Rama Pant	-	2,168
4	Shri Ramesh Chand	-	2,268
5	Shri Khushi Ram	-	1,982
6	Dr. P. P. Khanna	22,400	41,600
7	Dr. B. N. Tiwari	31,522	44,566
8	Smt. Manju Pant	-	60
9	Shri Param Kirti Rao Gautam	14,000	26,000
10	Shri Balram Singh	-	34
11	Shri Samay Singh	1,15,345	1,38,805
12	Shri Rakesh Kumar	5,821	9,937
13	Dr. Devajit Hazarika	4,748	9,884
14	Dr. A. K. L.Ashthana	39,850	93,250
15	Shri Chander Shekhar	10,000	1,30,000
16	Shri S. K. Gupta	7,745	11,165
17	Shri Madhu Sudan	19,704	24,852
18	Shri Navneet Kumar	15,425	19,541
19	Shri Shyam Singh	16,111	20,227
20	Shri Lokeshwar Vashist	-	24,000
21	Mrs. Prabha Kharbanda	11,000	23,000
22	Sri Chait Ram	24,000	-
	TOTAL	**3,47,555**	**6,47,338**

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ANNEXURE '8'
[HOUSE BUILDING ADVANCE AS ON 31st MARCH 2014]

(Amt in Rs...)

S.NO.	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Dr. Mrs. Meera Tiwari	-	2,128
2	Dr Rajesh Sharma	1,09,104	1,55,856
3	Shri. Anand Singh Negi	23,800	38,140
4	Mrs. Rajvinder Nagpal	76,584	93,576
5	Shri. Ansuya Prasad	9,080	20,960
6	Shri. Chander Shekher	-	22,660
7	Shri. D. Rameshwar Rao	456	10,740
8	Dr. George Philip	13,760	68,720
9	Shri Rakesh Kumar	1,45,940	1,65,980
10	Dr. A.K Singh	3,37,374	3,69,246
	TOTAL	**7,16,098**	**9,48,006**

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WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRADUN

ANNEXURE ' 9'
[COMPUTER ADVANCE AS ON 31st MARCH 2014]

(Amt in Rs...)

S.NO.	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Shri S.K Chabak	18,200	20,600
2	Shri C P Dabral	13,600	16,000
3	Dr. A K Mahajan	11,513	33,499
4	Shri Lokeshwar Vashist	13,600	16,000
5	Shri B K Juyal	-	16,000
6	Shri Hukam Singh	12,800	16,000
7	Shri Vinod Singh Rawat	13,600	16,000
8	Shri Abhey Kumar Pandit	13,600	16,000
9	Shri Mms Rawat	-	1,752
10	Shri V K Kala	13,600	16,000
11	Shri. Navneet Kumar	6,000	12,000
12	Shri Ram Kishore	13,600	16,000
13	Shri Ramesh Chandra Arya	16,000	18,400
14	Shri Shiv Prasad Bahuguna	14,600	17,000
15	Shri Shashidhar Prasad Balodi	8,800	16,000
16	Shri Satish Prasad Bahuguna	-	16,000
17	Shri Rajender Prakash	10,200	13,800
18	Shri Tirth Raj	-	3,300
19	Shri S S Bisht	13,600	16,000
20	Shri S K Shrivastava	-	3,000
21	Mrs Prabha Kharbanda	16,000	18,400
22	Shri Ramesh Kumar Sehgal	13,600	16,000
23	Shri Chander Shekher	13,600	16,000
24	Shri S C Kothiyal	13,600	16,000
25	Shri Samay Singh	13,600	16,000
26	Shri Santu Dass	16,000	18,400
27	Mrs.Neelam Chabak	19,400	21,800
28	Dr Sushil Kumar	13,600	16,000
29	Shri Rakesh Kumar	14,600	17,000
30	Dr.A.K.Singh	4,649	12,653
31	Dr. Khyanshing Luirei	6,000	12,000
32	Dr. Ajay Paul	16,000	18,400
33	Shri Pankaj Chauhan	17,425	20,600
34	Smt. Rama Pant	22,800	-
35	Shri Madhu Sudan	12,000	18,000
36	Shri Ansuya Prasad	8,500	14,500
37	Mrs. Anita Chowdhary	7,000	13,000
38	Shri B.B. Saran	7,000	13,000
39	Shri Kaushik Sen	12,000	18,000
40	Shri Ramesh Chand	-	10,000
41	Shri Nain Dass	20,000	24,800
42	Mrs Seema Juyal	28,000	-
	TOTAL	**4,88,687**	**6,29,904**

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WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRADUN

ANNEXURE '10'
[STAFF DEBTORS AS ON 31st MARCH 2014]

(Amt in Rs...)

S.NO.	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Sh.Shaid Farooq	2,500	2,500
2	Sh.Rohlu Ram	1,711	1,711
3	Sh. G.D. Sharma	(1,419)	(1,485)
4	Sh. S.S.Rawat	1,878	1,878
5	Km. L.Nair (Jrf)	5,136	5,136
6	Sh. R.M. Sharma	22,209	19,436
7	Sh. S.K.Sharma (Jrf)	225	225
8	Sh. R.N.Pandey	1,300	1,300
9	Sh. S.K. Mehra (Jrf)	5,000	5,000
10	Sh. Bharosa Nand	663	3,052
11	Sh. Hari Singh Manral	-	3,219
12	Sh. Rakesh Mohan (Jrf)	4,173	4,173
13	Sh. Alok Kumar Singh	1,300	1,300
14	Sh. Tikam Singh	-	1,158
15	Scientist Incharge	(32,729)	(32,729)
16	Dr.Kishore Kumar	-	(1,120)
17	Dr.Sushil Kumar	-	1,07,390
18	Dr.A.K.Singh	-	10,000
19	Dr. Iqrar Ahmed	1,320	1,320
20	Sh. Kali Dass	1,780	1,773
21	Shri Bharat Singh Rawat	-	300
22	Dr.V.C.Tiwari	1,95,954	1,75,575
23	Shri Gautam Rawat	-	73,980
24	Shri Bhupender Kumar	-	75
25	Dr. Swapnamita Chowdhury	-	90,000
26	Shri H.C.Pandey	-	1,26,900
27	Dr.B.K.Chowdhury	1,46,836	4,023
28	Shri D.P.Chowdhury	-	1,240
29	Shri Satish Prasad Bahuguna	-	19,400
30	Sh Laxman Singh Bhandari	-	2,400
31	Sh Chandan Bora	-	(500)
32	Shri Narendra Singh	-	77,244
33	Km Vatinaro Imsong	-	16,000
34	Shri P.S. Negi	1,02,529	2,649
35	SH. Rameshwar Roa	-	42,185
36	Shri M. S. Rawat	12,384	-
37	Prof. A. K. Gupta	2,55,600	-
38	Shri B. S Rawat	78	-
39	Shri Anil Kumar, S. R. A.	31,500	-
40	Dr. Devajit Hazarika	3,500	-
	GRAND TOTAL	**7,63,428**	**7,66,708**

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WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRADUN

ANNEXURE '11'
(WARM CLOTHING ADVANCE AS ON 31st MARCH 2014)

(Amt in Rs...)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Shri Ramesh Chand	1,875	-
2	Sri M. S. Rawat	2,250	-
3	Sri Khushi Ram	2,250	-
4	Sri Hari Kishan	2,250	-
5	Sri Ramesh	2,250	-
6	Sri Ram Kishore	2,250	-
7	Sri Chait Ram	1,875	-
8	Sri Ravi Lal	2,250	-
9	Sri Pretam Singh	2,250	-
10	Sri Preetam Singh	1,875	-
11	Sri Rahul Loadh	2,250	-
	TOTAL	23,625	-

ANNEXURE '12'
(SECURITY DEPOSIT AS ON 31ST MARCH 2014)

(Amt in Rs...)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	M/s BOC India Ltd. Faridabad	16,000	16,000
2	M/s. UPCL (Security Against Electricity)	5,95,912	4,28,348
3	M/s. Garhwal Jal Sansthan	460	460
4	M/s. Lal Brothers	9,000	9,000
5	M/s. Indian Oxygen Ltd.	52,000	52,000
6	M/s. Vallay Gas Service	500	500
7	M/s. BSNL (Security Against Telephones)	2,15,500	2,15,500
8	M/s. Bharti Airtel Co.	3,000	-
	TOTAL	8,92,372	7,21,808

ANNEXURE '13'
(FEES FOR MISCELLENOUS SERVICES AS ON 31ST MARCH 2014)

(Amt in Rs...)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Licence Fees	1,86,489	1,97,181
2	Transportation Charges	27,300	37,830
3	Electricity & Water Charges	3,53,211	5,50,475
	TOTAL	5,67,000	7,85,486

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WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE '14'
[MISCELLANEOUS INCOME AS ON 31ST MARCH 2014]

(Amt in Rs...)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Private trunkcalls	-	311
2	Other Receipts		
	a)Misc.	11,140	68,290
	b)Vehicle charges (Pvt. Purpose)	20,990	34,700
	c) Consultancy Receipts	43,73,861	54,88,063
	d) 24th ICMS Conference 2013	2,46,000	-
3	Xerox Charges	-	5,994
4	Fee For Information Act-2005	190	180
5	Insurance Damage Claim	2,414	-
6	EMD Forfeited	20,000	-
	TOTAL	**46,74,595**	**55,97,538**

ANNEXURE '15'
[EXPENSES ON SEMINAR/ WORKSHOPS AS ON 31ST MARCH 2014]

(Amt in Rs...)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	**Seminar/Workshop/Conference**		
	a) Expenses on Conference in India	4,07,769	5,41,317
	b) Expenses on Conference held abroad	1,76,093	8,07,440
	c) Professor D.N. Wadia Lecture Series	68,988	49,819
	d) Expenses on IAS 2012 Meeting	-	26,12,473
	e) 4th T.P.E. Workshop	11,69,105	-
	f) 24th ICMS Conference 2013	13,71,739	-
	TOTAL	**31,93,694**	**40,11,049**

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ANNEXURE '16'
[EXPENSES PAYABLE AS ON 31ST MARCH 2014]

(Amt in Rs....)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	DR Trilochan Singh	-	2,50,000
2	UHPM Project	1,627	1,627
3	EPGPS (PB)	500	500
4	QCTLKH	940	1,008
5	FCRA Project	504	504
6	AKJ (FNA) Project	-	494
7	Ganga Basin	504	504
8	EREC (SKP) Project	504	504
9	ILTP- NEMFIS (VR) Project	494	494
10	Dr. V. M. Choubey	10,000	-
11	C. S. I. R (AS)	1,000	-
12	ESRS (ACN) Project	564	-
13	HMGI (PCS) Project	938	-
	TOTAL	**17,575**	**2,55,635**

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WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE '17'
{ SECURITY PAYABLE AS ON 31ST MARCH 2014 }

(Amt in Rs…)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Sri. J.P. Singh	1,000	1,000
2	M/S. Nautiyal & Co.DDun	-	42,521
3	M/S. Zamil Parvez, DDun	2,000	2,000
4	Sri. K.N.Sahni DDun	5,000	5,000
5	Atikul Rehman	5,000	5,000
6	M/s. Pentech Instrument	2,000	2,000
7	ONGC Retired Officers Coop. Society	50,000	50,000
8	M/s Virender Elec.	2,100	2,100
9	Guardwell Security Services	50,000	50,000
10	M/s Radix Technologies	5,000	5,000
11	IR Tech Services N.Delhi	6,000	6,000
12	EICON Technology DDN	20,000	20,000
13	Pest Control India Ltd	86,896	50,066
14	Tej Technology Hybd	20,000	20,000
15	Polutn Equipt Cont Ndel	9,000	9,000
16	M/s. Cetac Technology	3,76,540	3,76,540
17	Mahindra & Mahindra Ltd	1,813	1,813
18	M/s. Algade Sas	58,350	58,350
19	M/s. Rawat Sanitation	1,246	1,246
20	M/s. Mountarian Equipment	4,850	4,850
21	M/s. Dev Associates	70,000	70,000
22	M/s. Dec-N-Trap, N.Delhi	15,23,278	13,30,062
23	M/s. Bil Trading N Del	20,000	20,000
24	Indian Book House Ddn	2,000	2,000
25	SWJ Associates	3,091	3,091
26	M/s. Doon Light Asso. , DDun	1,02,468	2,44,185
27	M/s. Sulaksh Inters. Delhi	2,00,000	11,64,039
28	Shri S.K. Goyal, Contractor	-	3,55,457
29	M/s. Sharda Infra Engr.	1,44,196	-
30	M/s. Shashi Buildcon Pvt. Ltd.	39,055	-
31	M/s. Progressive Engr. Service	75,000	-
32	M/s. A. R. Enterprises	1,45,900	-
33	M/s. Raj Power, Delhi	1,87,000	-
34	M/s. Shekhawati Elect. Engnr	1,87,000	-
	TOTAL	**34,05,783**	**39,01,320**

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WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE IF

(Amt in Rs...)

PARTICULARS	GROSS BLOCK: COST AT THE BEGINNING OF THE YEAR	GROSS BLOCK: ADDITION DURING THE YEAR	GROSS BLOCK: DED./WRITTEN OFF / TRFD. DURING THE YR.	GROSS BLOCK: COST AT THE END OF THE YEAR	DEPRECIATION: OPENING BALANCE	DEPRECIATION: OPENING BAL. TFD FROM PROJECT	DEPRECIATION: ON ADDITIONS	DEPRECIATION: DED./WRITT OFF / TRFD DURING THE YR.	DEPRECIATION: TOTAL	NET BLOCK: CURRENT YEAR	NET BLOCK: PREVIOUS YEAR	RATE OF DEP.
Projects												
1 GPS Equipment	130,83,695	-	-	130,83,695	95,18,513	-	5,34,777	-	100,53,290	30,30,405	35,65,182	15%
2 Neotectonic Project (S. Kumar)	3,14,552	-	-	3,14,552	2,28,840	-	12,857	-	2,41,697	72,855	85,712	15%
3 Neotectonic Project(VCT)	32,760	-	-	32,760	23,832	-	1,339	-	25,171	7,589	8,928	15%
4 CSIR Project(VCT)	40,000	-	-	40,000	29,100	-	1,635	-	30,735	9,265	10,900	15%
5 PAC(AP) Project(TS)	3,45,430	-	-	3,45,430	2,51,304	-	14,119	-	2,65,423	80,007	94,126	15%
6 SNWH Project (SKP)	16,150	-	-	16,150	11,750	-	660	-	12,410	3,740	4,400	15%
7 PILOT Project(JTG)	2,49,442	-	-	2,49,442	1,81,472	-	10,196	-	1,91,668	57,774	67,970	15%
8 SDB Project(SK)	5,05,504	-	-	5,05,504	3,67,759	-	20,662	-	3,88,421	1,17,083	1,37,745	15%
9 LSZ Project(NSV)	19,314	-	-	19,314	14,052	-	789	-	14,841	4,473	5,262	15%
10 DFSZ Project (HKS)	5,88,352	-	-	5,88,352	4,28,032	-	24,048	-	4,52,080	1,36,272	1,60,320	15%
11 IIIA Project (AB)	33,878	-	-	33,878	24,647	-	1,385	-	26,032	7,846	9,231	15%
12 HRGH Project (NRP)	1,85,980	-	-	1,85,980	1,35,301	-	7,602	-	1,42,903	43,077	50,679	15%
13 ESS Project(SKP)	4,64,499	-	-	4,64,499	3,37,928	-	18,986	-	3,56,914	1,07,585	1,26,571	15%
14 SHA Project (AKM)	71,360	-	-	71,360	51,915	-	2,917	-	54,832	16,528	19,445	15%
15 EHA Project (TNB)	1,60,966	-	-	1,60,966	1,17,104	-	6,579	-	1,23,683	37,283	43,862	15%
Balance Carried Forward	**161,11,882**	-	-	**161,11,882**	**117,21,549**	-	**6,58,551**	-	**123,80,100**	**37,31,782**	**43,90,333**	

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WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE II'

(Amt in Rs...)

	PARTICULARS	GROSS BLOCK				DEPRECIATION					NET BLOCK		
		COST AT THE BEGINNING OF THE YEAR	ADDITION DURING THE YEAR	DED./WRITTEN OFF / TRFD. DURING THE YR.	COST AT THE END OF THE YEAR	OPENING BALANCE	OPENING BAL. TFD FROM PROJECT	ON ADDITIONS	DED./WRITT OFF / TRFD DURING THE YR.	TOTAL	CURRENT YEAR	PREVIOUS YEAR	RATE OF DEP.
	Balance Brought Forward	161,11,882	-	-	161,11,882	117,21,549	-	6,58,551	-	123,80,100	37,31,782	43,90,333	
16	ILHDR Project (RK)	7,13,860	-	-	7,13,860	5,19,340	-	29,178	-	5,48,518	1,65,342	1,94,520	15%
17	SSTH Project	45,08,227	-	-	45,08,227	32,79,777	-	1,84,268	-	34,64,045	10,44,182	12,28,450	15%
18	RMGC Project (SJS)	16,03,022	-	-	16,03,022	11,66,323	-	65,505	-	12,31,828	3,71,194	4,36,699	15%
19	PTS Project (HR)	90,112	-	-	90,112	65,470	-	3,696	-	69,166	20,946	24,642	15%
20	CE Project (NSM)	56,421	-	-	56,421	41,047	-	2,306	-	43,353	13,068	15,374	15%
21	ESTG Project	1,01,611	-	-	1,01,611	73,922	-	4,153	-	78,075	23,536	27,689	15%
22	FBP MT Project (MT)	1,29,149	-	-	1,29,149	93,957	-	5,279	-	99,236	29,913	35,192	15%
23	EPGPS PRO (PB)	56,06,753	-	-	56,06,753	40,78,966	-	2,29,168	-	43,08,134	12,98,619	15,27,787	15%
24	LHZ SILROOT PROJECT (GP)	1,09,958	-	-	1,09,958	79,997	-	4,494	-	84,491	25,467	29,961	15%
25	UHPM PROJECT (HKS)	80,409	-	-	80,409	57,572	-	3,426	-	60,998	19,411	22,837	15%
26	BSS (KPJ) PROJECT	43,790	-	-	43,790	31,857	-	1,790	-	33,647	10,143	11,933	15%
27	FMD (AKD) PROJECT	1,88,392	-	-	1,88,392	1,37,057	-	7,700	-	1,44,757	43,635	51,335	15%
28	SSR-NCR PROJECT	96,57,406	-	-	96,57,406	70,25,854	-	3,94,733	-	74,20,587	22,36,819	26,31,552	15%
29	MGGS-NCS PROJECT	96,903	-	-	96,903	70,498	-	3,961	-	74,459	22,444	26,405	15%
30	EGLLT PROJECT (NSV)	7,03,060	-	-	7,03,060	5,11,483	-	28,737	-	5,40,220	1,62,840	1,91,577	15%
31	APNAH-I PROJECT (NSV)	74,940	-	-	74,940	54,520	-	3,063	-	57,583	17,357	20,420	15%
32	RPL PROJECT (VG)	4,13,306	-	-	4,13,306	2,80,810	-	19,874	-	3,00,684	1,12,622	1,32,496	15%
33	ILTP (K)	25,350	-	-	25,350	17,223	-	1,219	-	18,442	6,908	8,127	15%
	Balance Carried Forward	403,14,551	-	-	403,14,551	293,07,222	-	16,51,101	-	309,58,323	93,56,228	110,07,328	

FRN 013108C

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE 1F

(Amt in Rs...)

	PARTICULARS	GROSS BLOCK				DEPRECIATION					NET BLOCK		
		COST AT THE BEGINNING OF THE YEAR	ADDITION DURING THE YEAR	DED./WRITTEN OFF / TRFD. DURING THE YR.	COST AT THE END OF THE YEAR	OPENING BALANCE	OPENING BAL. TFD FROM PROJECT	ON ADDITIONS	DED./WRITT OFF / TRFD DURING THE YR.	TOTAL	CURRENT YEAR	PREVIOUS YEAR	RATE OF DEP.
	Balance Brought Forward	403,14,551	-	-	403,14,551	293,07,222	-	16,51,101	-	309,58,323	93,56,228	110,07,328	
34	EGMS PRO. (PB)	8,45,448	-	-	8,45,448	6,15,072	-	34,556	-	6,49,628	1,95,820	2,30,376	15%
35	LHZ PRO.(GP)	60,315	-	-	60,315	43,879	-	2,465	-	46,344	13,971	16,436	15%
36	SEISMOCITY (TNB)	25,000	-	-	25,000	18,188	-	1,022	-	19,210	5,790	6,812	15%
37	CSIR (KNK)	2,08,237	-	-	2,08,237	1,51,494	-	8,511	-	1,60,005	48,232	56,743	15%
38	PBEKS (SKP)	1,66,478	-	-	1,66,478	1,21,114	-	6,805	-	1,27,919	38,559	45,364	15%
39	ONGC (RANGA RAO)	28,183	-	-	28,183	20,503	-	1,152	-	21,655	6,528	7,680	15%
40	CSIR (V-RAIVERMAN)	50,800	-	-	50,800	36,958	-	2,076	-	39,034	11,766	13,842	15%
41	PGC PROJECT (AKS)	69,591	-	-	69,591	50,314	-	2,892	-	53,206	16,385	19,277	15%
42	PBBD (VCT)	87,760	-	-	87,760	63,846	-	3,587	-	67,433	20,327	23,914	15%
43	MBGH (JTG)	24,41,537	-	-	24,41,537	17,76,242	-	99,794	-	18,76,036	5,65,501	6,65,295	15%
44	TOTAL STATION	24,14,225	-	-	24,14,225	17,56,372	-	98,678	-	18,55,050	5,59,175	6,57,853	15%
45	CDS (PB) PRO	41,52,662	-	-	41,52,662	30,21,100	-	1,69,734	-	31,90,834	9,61,828	11,31,562	15%
46	SEISMO GPS (PB) PRO	148,46,853	-	-	148,46,853	97,96,951	-	7,57,485	-	105,54,436	42,92,417	50,49,902	15%
47	DDBC (BS)	3,83,004	-	-	3,83,004	2,78,639	-	15,655	-	2,94,294	88,710	1,04,365	15%
48	SIACHIN GLR (HKS)	95,160	-	-	95,160	59,291	-	5,380	-	64,671	30,489	35,869	15%
49	EBEC (SKP) PRO	10,10,208	-	-	10,10,208	6,70,607	-	50,940	-	7,21,547	2,88,661	3,39,601	15%
50	ECD(BB) PROJECT	103,26,133		-	103,26,133	64,07,913		5,87,733	-	69,95,646	33,30,487	39,18,220	15%
51	GANGA BASIN PROJECT	51,521		-	51,521	24,627		4,034	-	28,661	22,860	26,894	15%
	Balance Carried Forward	775,77,666	-	-	775,77,666	542,20,332	-	35,03,600	-	577,23,932	198,53,734	233,57,331	

FRN 013108C

Singhal & Associates Chartered Accountants

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE 1F

(Amt in Rs...)

	PARTICULARS	GROSS BLOCK				DEPRECIATION					NET BLOCK		
		COST AT THE BEGINNING OF THE YEAR	ADDITION DURING THE YEAR	DED./WRITTEN OFF / TRFD. DURING THE YR.	COST AT THE END OF THE YEAR	OPENING BALANCE	OPENING BAL. TFD FROM PROJECT	ON ADDITIONS	DED./WRITT OFF / TRFD DURING THE YR.	TOTAL	CURRENT YEAR	PREVIOUS YEAR	RATE OF DEP.
	Balance Brought Forward	775,77,666	-	-	775,77,666	542,20,332	-	35,03,600	-	577,23,932	198,53,734	233,57,331	
52	AFNAH II (NSV)	40,000		-	40,000	19,120		3,132	-	22,252	17,748	20,880	15%
53	ILTP- NEMPS(AKM)	42,453		-	42,453	23,617		2,825	-	26,442	16,011	18,836	15%
54	ECGHR (GP)	3,09,670		-	3,09,670	2,25,288		12,657	-	2,37,945	71,725	84,382	15%
55	MGIE(BRA)	51,17,709		-	51,17,709	34,77,088		2,46,093	-	37,23,181	13,94,528	16,40,621	15%
56	GEES (BKC)	44,63,573		-	44,63,573	25,01,773		2,94,270	-	27,96,043	16,67,530	19,61,800	15%
57	NRDMS PROJECT	-	13,43,415	-	13,43,415	-	9,77,347	2,01,512	-	11,78,859	1,64,556	-	15%
58	ESR PROJECT (ACN)	-	76,706	-	76,706	-	47,776	11,506	-	59,282	17,424	-	15%
	TOTAL	875,51,071	14,20,121	-	889,71,192	604,47,218	10,25,123	42,75,595	-	657,67,936	232,03,256	270,83,851	

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF. ANIL K. GUPTA)
Director

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE '19'
[PROFIT/LOSS ON SALE OF ASSET AS ON 31ST MARCH 2014]

(Amt in Rs…)

PARTICULARS	SCH	CURRENT YEAR	PREVIOUS YEAR
Vehicle			
Gross Value	8	-	8,69,831
Less: Accumulated Dep	8	-	5,90,983
Net Value		-	2,78,848
Less: Sold during the Year	18	-	1,92,250
Loss on sale	(A)	-	**86,598**
Library Books			
Gross Value	8	746	1,412
Less: Accumulated Dep	8	418	506
Net Value		328	906
Less: Sold during the Year	18	746	1,412
(Profit)/Loss on sale	(B)	**(418)**	**(506)**
Equipment			
Gross Value	8	175,41,582	13,990
Less: Accumulated Dep	8	133,17,216	3,882
Net Value		**42,24,366**	10,108
Less: Sold during the Year	18	12,16,169	13,990
(Profit)/Loss on sale	(C)	**30,08,197**	**(3,882)**
Furniture & Fixtures			
Gross Value	8	10,70,224	85,342
Less: Accumulated Dep	8	6,55,598	63,429
Net Value		**4,14,626**	21,913
Less: Sold during the Year	18	1,19,368	21,913
(Profit)/Loss on sale	(D)	**2,95,257**	-
Total (Profit)/Loss (A+B+C+D)		**33,03,036**	**82,210**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF. ANIL K. GUPTA)
Director

Singhal & Associates, Chartered Accountants, FRN 013108C

WADIA INSTITUTE OF HIMALAYAN GEOLOGY,
33, GMS ROAD DEHRADUN

SCHEDULE FORMING PART OF ACCOUNTS FOR THE YEAR ENDED 31ST MARCH, 2014

SCHEDULE – 37: SIGNIFICANT ACCOUNTING POLICIES

1. ACOUNTING CONVENTION

   The financial statements are prepared on the basis of historical cost convention, unless otherwise stated and on the cash method of accounting except interest accrued on fixed deposit.

2. INVESTMENTS

   Investments classifieds as "long term investments" are carried at cost.

3. FIXED ASSETS

   a) Fixed Assets are stated at net book value as recommended in the "Uniform Accounting Format" of financial statements for the Central Autonomous Bodies as made compulsory by the Ministry of Finance w.e.f. 01.04.2001.
   b) Additions to fixed assets are taken at cost of acquisition, inclusive of freight, duties and taxes, incidental and direct expenses related to acquisition.

4. DEPRECIATION

   a) Depreciation is provided on Written down Value method as per rates specified in the Income Tax Act, 1961.

   b) When an asset is discarded or sold or deleted, the original cost is deducted from the gross block, the W.D.V. is deducted from the W.D.V. block and accumulated depreciation on the asset upto the date of deletion is deducted from accumulated depreciation of the respective block.

   c) In respect of addition to/ deduction from fixed assets during the year, depreciation is considered on full yearly basis.

WADIA INSTITUTE OF HIMALAYAN GEOLOGY,
33, GMS ROAD DEHRADUN

5. MISCELLANEOUS EXPENDITURE

   Deferred revenue expenditure, if any, will be written off over a period of 5 years from the year it is incurred.

6. ACCOUNTING FOR SALES & SERVICES

   The consultancy services provided by the institute is accounted for on net service basis.

7. GOVERNMENT GRANTS / SUBSIDIES

   a) Government grants of the nature of contribution towards Capital Cost and Revenue cost are transferred to Income & Expenditure account and the surplus or deficit after deducting all the expenses is transferred to Capital / Corpus fund.

   b) Grants towards Earmarked / Endowment Funds are directly transferred to the respective fund account.

   c) Government grants / subsidy are accounted on realization basis.

(Harish Chandra) **Finance & Accounts Officer**	**(Dinesh Chandra)** **Registrar**	**(Prof. Anil K. Gupta)** **Director**

Date : 04th Aug, 2014
Place: Dehradun

Singhal & Associates
FRN 013108C
Chartered Accountants

WADIA INSTITUTE OF HIMALAYAN GEOLOGY,
33 GMS ROAD, DEHRADUN

SCHEDULE FORMING PART OF ACCOUNTS FOR THE YEAR ENDED 31[ST] MARCH, 2014

SCHEDULE – 38: CONTINGENT LIABILITIES AND NOTES ON AC

1. CONTINGENT LIABILITIES

(Amount in Rs.)

a)	Claims against the Entity not acknowledged as debts		- Nil -
b)	In respect of		
	i)	Bank Guarantees given by /on behalf of the Entity	- Nil -
	ii)	Letter of credit opened by Bank on behalf of the entity	8,81,45,000
	iii)	Bills discounted with banks	- Nil -
c)	Disputed demands in respect of		
	i)	Income –tax	58,36,245
	ii)	Sales tax	- Nil -
	iii)	Municipal Taxes	- Nil -
d)	In respect of claims from parties for non-execution of orders, but contested by the Entity		- Nil -

2. CAPITAL COMMITMENTS

Estimated Value of contracts remaining to be executed on capital account and not provided for (net of advances)		
a)	Construction of Building	- Nil -
b)	Other Assets	-Nil -

3. LEASE OBLIGATIONS

Future obligations for rentals under finance lease arrangements for plant and machinery amount to Rs.Nil	- Nil -

4. CURRENTS ASSETS, LOANS AND ADVANCES

In the opinion of the Institute, the current assets, loans and advances have a value on realization in the ordinary course of business, equal at least to the aggregate amount shown in the Balance Sheet.

5. TAXATION

In view of there being no taxable income of the Institute under income tax Act, 1961, no provision for Income Tax has been considered necessary

WADIA INSTITUTE OF HIMALAYAN GEOLOGY,
33 GMS ROAD, DEHRADUN

6. FOREIGN CURRENCY TRANSACTIONS

a)	Value of Imports Calculated on C.I.F basis:		
	i)	Purchase of finished goods	- Nil -
	ii)	Raw Materials & Components (including in transit)	- Nil -
	iii)	Capital goods	- Nil -
	iv)	Stores, Spares and Consumables	- Nil -
b)	Expenditure in foreign currency		
	i)	Travel (for attending Seminar/Conference abroad)	- Nil -
	ii)	Remittances and Interest payment to Financial Institutions / Banks in Foreign Currency	- Nil -
	iii)	Other expenditure	
		Commission on Sales	- Nil -
		Legal and Professional Expenses	- Nil -
		Miscellaneous Expenses	- Nil -
c)	Earnings		
	i)	Value of Exports on FOB basis	- Nil -
	ii)	Grants for Projects	- Nil -

7. The payments to auditors during the F.Y. 2013 -14 is as follows:

Remuneration to auditors		
i)	As Auditors	28652/-
	Taxation matters	- Nil -
	For Management Services	- Nil -
	For Certification	5,000/-
ii)	Others	- Nil -

8. Separate Financial Statements have also been prepared for:

a)Wadia Institute of Himalayan Geology.
b) Contributory/ General Provident Fund.
c) Pension Fund.
d) Consolidated financial statement of projects sponsored by other Agencies.
e) Individual financial statements of Projects sponsored by other agencies.

9. Corresponding figures for the previous year have been regrouped / rearranged, wherever necessary.

10. Annexed Schedules & Annexures are an integral part of the Balance Sheet as on 31st March, 2014, Income and Expenditure Account and Receipt & Payment for the year ended on 31st March, 2014.

(Harish Chandra)
Finance & Accounts Officer

(Dinesh Chandra)
Registrar

(Prof. Anil K. Gupta)
Director

Date : 04th Aug, 2014
Place: Dehradun

Singhal & Associates
FRN 013108C
Chartered Accountants