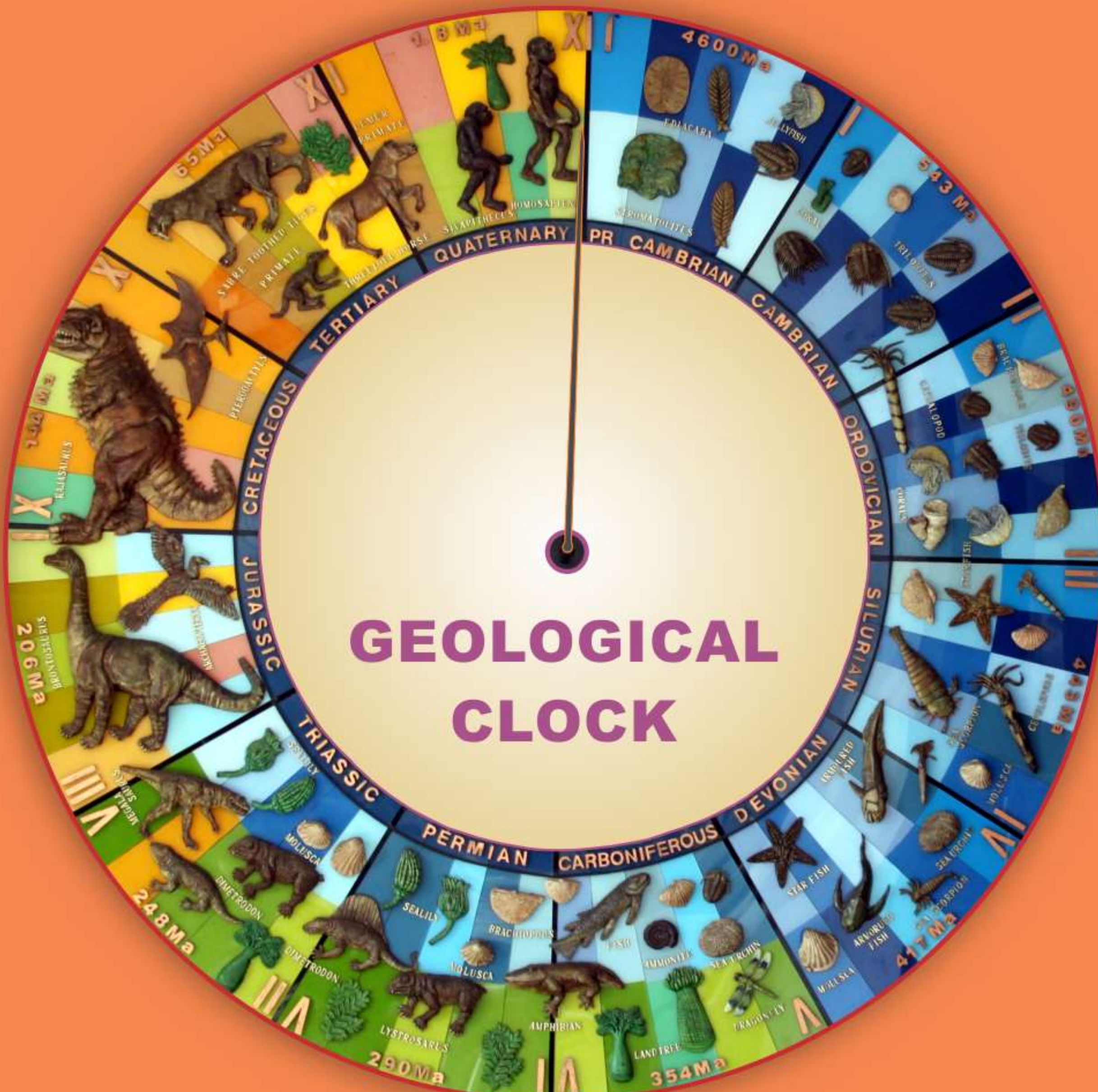
ANNUAL REPORT
2012-2013



WADIA INSTITUTE OF HIMALAYAN GEOLOGY
DEHRADUN

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

ANNUAL REPORT
2012-13

WADIA INSTITUTE OF HIMALAYAN GEOLOGY

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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 & Hydro-logical 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, Dehra Dun, an autonomous Institute nurtured by the Department of Science and Technology, Government of India has the mandate to carry out high quality research in thrust areas of Himalayan geology related to the geodynamic evolution of the Himalaya, Himalayan Tectonics and Indian monsoon, Himalayan glaciers and their impact on Himalayan and adjoining rivers, earthquake and land slide studies. Research activities of the Institute have been grouped into the following five Thrust Area Themes in the 12th Five Year Plan:

- TAT-1 : Geodynamic Evolution of the Himalaya and Adjoining Mountains
- TAT-2 : Indian Monsoon-Tectonic Interaction and Exhumation of the Himalaya
- TAT-3 : Earthquake Precursors Studies and Geo Hazard Evaluation
- TAT-4 : Biodiversity - Environment Linkage
- TAT-5 : Himalayan Glaciers: their role in Indian Monsoon variability and Hydrological changes in the Ganga Basin

The progress made in each thrust area themes during the year 2012-13 are elaborated in the succeeding sections, and the glimpse of the prominent achievements in respective themes are summarized below:

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

The stress patterns of different seismic regimes of the NW Himalaya are investigated based on focal mechanisms of regional earthquakes of magnitudes $\geq$ 3.0. The stress tensor inversion study shows compressional stress regime for the Chamba-Kangra and the Garhwal-Kumaun regions and extensional regime for Kinnaur region and the NE corner of the Kumaun region. The average thickness and Poisson's ratios of crust are estimated across the northwest Himalaya and eastern Ladakh applying *H-k* stacking method on receiver functions (RF) of teleseismic earthquakes recorded at 20 BBS stations of Kinnaur (HP) and Ladakh networks operated by WIHG, Dehra Dun. The studies show that the Poisson's ratio beneath the Lesser Himalaya and the Higher Himalaya range between 0.249-0.253 and crustal thickness of ~50-52 km, and in Tethyan Himalaya the Poisson's ratio is higher (0.269 - 0.273) and has crustal thickness of ~60 km, while the Poisson's ratio is much higher (0.280-0.303) and the crustal thickness is ~80 km beneath eastern Ladakh.

Detailed structural analysis of the folding pattern in the Chamba Thrust Sheet reveals that the SW vergent Chamba syncline and the NE vergent Tandi syncline and the two anticlines are parts of a large scale structure described here for the first time as the *Hadsar-Chobia box fold*. The structural studies in the Ladakh region also showed three stages of ophiolitic mélange obduction; initially as the Sapi-Shergol Ophiolitic Mélange in western Ladakh during latest Cretaceous to early Paleocene time, then as Khalsi Ophiolitic Mélange in Central Ladakh during early Eocene, and finally the Zildat Ophiolitic Mélange during late Eocene to Oligocene time.

The structure and textural relationships observed at exposure scale along the Dhauli Ganga valley in Garhwal suggest that widespread *in-situ* partial melting of sillimanite+K-feldspar gneiss resulted in the formation of migmatite and resultant melt accumulation near the South Tibetan Detachment Zone (STDZ) during various deformation events. The studies carried out on the gneisses from the lower structural levels of the Higher Himalayan Crystalline and the Chhiplakot Klippen suggested that they were derived from different sources, thereby negating the commonly argued concept of the nappe rocks of the Lesser Himalaya to have their root zones in the Higher Himalaya.

The pre-Himalayan granulite facies metamorphism has been observed in the mafic and pelitic xenoliths arrested in the Kinnaur Kailash Granite, Baspa valley, NW Himalaya. The petrological studies of the Abor mafic and felsic rocks occurring in the core of the Siang window of the Eastern Himalaya are characterized by continental rift volcanism, implying that they were emplaced during lithospheric extension.

Lazulite, an Mg rich phosphate mineral has been reported for the first time from the inter veined quartz in Berinag quartzite near MCT (Sobla) in northeast Kumaun.

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

The geomorphological and sedimentological studies attempted on the Quaternary deposits from village Nyoma to Dah section of the Indus River showed that the bedrock uplift rates vary from 2-5 mm/yr and that the thrust contact between the Ladakh Batholith and Indus Molasses is neo-tectonically active, and that the incision in this zone is in response to the uplift due to the Pleistocene-Holocene crustal shortening in the Indus Molasse. The field studies of the muticyclic Quaternary deposition mainly in the form of multi levels of fluvial depositional terraces and alluvial fan between Pandoh and Talwara along a part of the Beas valley in the Panjab re-entrant and adjoining Lesser Himalaya suggest that, the depositional phases are interrupted by incision phases resulting from tectonic deformation and/or climatic variation.

Lake-core samples were collected from the Tso Morari Lake, Ladakh to study and understand the late-Quaternary paleoclimate of the region. Composite ring-width chronology using tree ring-width series of *Cedrus deodara* and *Pinus gerardiana* growing in the Kinnaur region was developed, and was further used to reconstruct longest (AD 1295-2005) river discharge, a record first of its kind in the Indian region.

TAT-3: Earthquake Precursors Studies and Geo Hazard Evaluation

The database creation of continuous observations of high quality geophysical time series that is useful for earthquake precursory research is continued, and over six years observation indicates few favorable results of pre- and co-seismic changes in different geophysical fields related to local seismic events. It had also been observed that few occasions marked anomalous change mainly influenced by non-seismic external events (hydrological/environmental) while few signatures related to seismic events may be masked within noise. The synthesis of the seismic records of ~4581 events recorded by 21 BBS station run by WIHG during last one year, which include 732 local, 2498 regional and 1351 teleseismic events, suggest that the hypocenters of these earthquakes are mainly distributed at shallow depth of upto 20 km. The use of the Horizontal to Vertical Spectral Ratio (HVSR) technique of Microtremor constitutes an effective and inexpensive approach to site response and soft soil thickness estimations, and it has been used in Doon valley, Uttarakhand.

New paleoseismic evidences along Himalayan Frontal Thrust in the northwestern Indian Himalaya suggests two scenarios, a single-event surface rupturing for a minimum fault length of ~450 km or two-events of different lateral extent with a minimum length of ~250 km. A new active fault trace has been recognized in the northwestern Frontal Himalaya near Chamuhi in the Soan Dun, and from the studies carried out including the OSL dating, it is suggested that the displacement of the Quaternary deposit occurred after the deposition of 51 ka sediments, due to a late Pleistocene seismic activity.

The studies of the geoengineering properties of rocks suggest that, among all the textural parameters, grain size is the main textural parameter that dominantly controls the seismic wave velocity, particularly in monomineralic dominated rocks like quartzite, while in polymineralic rocks like gneisses and leucogranite, it is the strength of preferred orientation of platy minerals that greatly influence the seismic wave velocity.

TAT - 4: Biodiversity - Environment Linkage

Diverse assemblages of ichnofossils have been reported for the first time from the Chandratal section of the Spiti Basin which reflects Neritic and Abyssal environments. The detailed analysis of the ichnofossils and other faunal occurrences on the other hand substantiates the assignment of Early Cambrian age to the Dhaulagiri Formation of Tal Group, and also reflect the shallow marine depositional environment conditions. Also, a shallow marine to near shore environmental condition followed by different stages of regression and transgression is inferred on the basis of identified calcified green algae in the carbonate beds from the Ordovician-Silurian successions of Pin valley of the Spiti Basin.

A new tillodont, *Anthraconyx hypsomylus*, is described from the early Eocene of western India which provides additional evidence of affinities between the Vastan local fauna and Euroamerican vertebrate faunas. New micro-vertebrate (very short ranging rodents), a murid *Antemus chinjiensis* and a cricetid *Megacricetodon* cf. *sivalensis* were described from the famous Miocene ape locality of Ramnagar (J & K), and on correlation with equivalent horizons, it was found this assemblage has a striking similarity with faunal assemblages from Chinji type section, Lower Siwalik fauna of Daud Khel, Pakistan and Dang valley Nepal.

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

The Dokriani glacier measuring around 7.0 sq km in the Bhagirathi and Chorabari glacier measuring around 6.6 sq km in the Alaknanda river basin of the Garhwal Himalaya are being monitored under this thrust area theme programme, and found that the annual mass balance measured during the last year is negative, and the total recession of the snout at centre part of the glaciers was measured ~20 m and ~8.5 m, and that the present snout elevation is ~3920 m asl and ~3865 m asl respectively for Dokriani and Chorabari glaciers. The geomorphological mapping between Bhojbas (3796 m) and Gaumukh (4040 m) of the Gangotri Glacier depicts several mountain streams which can be potential hazardous avalanche chutes in certain circumstances.

The Asi Ganga tributary of the Bhagirathi valley witnessed a cloudburst in August 2012 resulting into disastrous flash flood in the downstream regions creating havoc and loss to life and property, and the documentation of such extreme events by Wadia Institute in the Himalaya will help to evaluate the risk posed by these natural hazards.

The isotopic study of thermal spring along the large stretch of the Garhwal Himalaya show that they also contribute to a significant degassing of CO_2 to the atmosphere and their by may have an impact on the long term climate of the Earth.

A detailed systematic investigation of catchment areas between rivers Ganga and Sharda in Uttarakhand Himalaya is proposed with a broader view of preparing a geochemical dispersion database of important elements.

Academic Pursuits

The Institute also made its presence felt in Academies and under the on-going research programs pursued during the year, the Institute has published 66 papers, out of which 50 papers were published in SCI journals with equal number of papers being in press or communicated. Three research scholars were awarded Ph.D. thesis, while four theses were submitted for the award. Sixteen scientists have also visited abroad to participate in various seminar/symposia/ workshop/training courses. The Institute had made significant contributions in the fields of Paleoclimatology, Sedimentology and Structure & Tectonics that has led to awards of *'National Geoscience Award-2011'* and *'K Naha Award'*, conferred by the Ministry of Mines, Government of India and Geological Society of India, Bangalore respectively.

To disseminate and share knowledge emerging from more recent research findings, the Institute organized National Conference on Green Earth with focus on the Himalaya, and 78th Annual Meeting of the Indian Academic of Sciences, Bangalore. It had also organized Training Workshop on Quaternary setup of arid NW Himalaya: main focus on Ladakh, and a Meeting of Indo-Norwegian Bilateral Project on Geo-thermal Energy.

The Institute 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 33(2) and 34(1), and Hindi magazine Ashmika volume 18, along with newsletter 'Bhugarbh Vani' volume 2 (1 to 4).

Other Highlights

Hindi pakhwara was celebrated in the Institute from September 14-28, 2012, during which 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 2011-12 was published in bilingual form (Hindi and English). Various incentive schemes for encouraging progressive use of Hindi were also implemented.

Obituary

The Institute places on record the untimely sad demise of Dr. K.K. Purohit, Scientist 'F' who was not only a prolific Scientist but was very good human being, and served this Institute for more than 32 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 significance of the splay faults and imbrications developed across the leading edge of western part of the Nahan salient was studied. Analysis of structural data towards south of salient curvature reveals that the maximum stress direction of splay faults is different from that of the general NE-SW oriented maximum stress in the Himalayan range. It may imply the influence of tectonic propagation of leading edge of thrust wedge on young splays formed towards foot wall of the Main Boundary Fault (MBF) that shaped the Nahan salient. The tectonic slivers of the Lesser Himalayan hanging rocks occur at the base of hanging wall (Eocene Subathu rocks) of the MBF that represents one of the younger splays of the Main Boundary Thrust (MBT). It suggests deep seated nature of thrusting associated with the MBF, which along with its associated closely spaced hanging wall thrusts altogether form imbricate structure of the MBT system. It is thus envisaged that the formation of salient is controlled by dip amount of thrust planes, basin geometry and variation in thickness of rocks, and depth of detachment plane beneath the Lesser Himalaya.

MT studies in NW Himalaya

Pillibhit-Malpa profile is completed for dimensionality and directionality analyses. Dimensionality test indicate that regional geoelectrical structure is two dimensional. Few observations suggest higher order of complex resistive subsurface structure along the profile. The MT responses are being inversely modeled for subsurface geo-electric structure. This year our main emphasis, however, was to look into our previous data sets in collaboration with other geophysical and geological information's for tectonic interpretations. Correlating the geo-electrical structure obtained along Bijnaur-Mallari profile with the confined micro-seismicity (Himalayan Seismic Belt or HSB) in NW Himalaya, role of fluids in micro seismicity of HSB is observed. In the compressional regime of the Himalaya, the upward propagation of fluid fluxes through the over pressured zones allows to see mega thrust and shear zone as locales of concentrated seismicity. The Long period Magneto Telluric (LMT) data in the MCT zone and at STD indicate complex variations of resistivity at a particular depth. This is manifested in the phases of one polarization. Phases beyond 90° at these stations for particular periods are being modeled with anisotropic characterization of subsurface layers or structures.

Further, along the Yamunotri-Gangotri-Saharanpur profile LMT studies have been initiated, which is parallel to the proposed corridor in Satluj River valley where multiple investigations are being carried out. We have taken-up LMT/GDS (Geomagnetic Depth Sounding) measurements at seven places. Each place is occupied for a period of one month. Time series of these stations are being processed for estimation of apparent resistivity curves. Also, as a pilot experiment, we have started MT observations continuously at MPGO, Ghuttu for monitoring temporal variations of resistivity, if any. Monitoring temporal changes in measured MT responses from the large fluidized regions of the crust and their extension upward into the brittle crust could reveal measurable potential earthquake precursors.

Seismic studies in NW Himalaya

The overview of past seismicity along the NW Himalaya exhibits along-strike segmentation that is intricately controlled by the subsurface topographic ridges formed on the under-thrusting Indian Plate, as well as by windows and nappe structures located in the overriding Himalayan wedge. The segmentation exists for thrust dominated large magnitude earthquakes ($M>6$) seated on the active detachment and for moderate and small magnitude earthquakes concentrated in a narrow HSB close to surface trace of the MCT. Numerical calculations of stress distribution favour that the degree of seismicity in the HSB is a good proxy, to the presence of mid-crustal ramp connecting the locked section of active detachment beneath the Lesser and Higher Himalayas to aseismically slipping detachment beneath the Higher Himalaya. Further, the gap or diffused pattern in the concentrated seismicity in the HSB is in agreement with mapped high electrical conductive structure, and suggests ramp structure that may be absent where under-thrusting Delhi-Hardwar ridge interacts with the Himalaya arc. In the nappe dominated tectonics, the accommodation of the accumulating strains on the listric thrust faults, produces increased frequency of moderate magnitude earthquakes and thereby possibly influences the stress level on the detachment. This may explain the relatively less seismicity in the Simla region that may also be influenced by the active Kaurik Chango Fault in the Higher Himalaya, as the former casts a stress shadow on the latter (Fig. 1).

The crustal structure of the Himalaya varies from south to north. To investigate the subsurface structure and seismogenic layers, 3D velocity inversion was carried out in the source zone of 1905 Kangra earthquake (M8.0) in the NW Himalaya using local data of 159 earthquakes. Inverted velocity tomograms up to a depth range of 18 km show significant variations of 14% in Vp and Vs and 6% in the Vp/Vs across the major tectonic zones in the region. Synthesis of seismicity pattern, velocity structure, distinctive focal mechanisms coupled with nature of stress distribution allow mapping of three different source regions that control regional seismotectonics (Fig. 2). Accumulating strains are partly consumed by sliding of the Chamba Nappe to the southwest through reverse-fault movements along the Chamba/Panjal/Main Boundary Thrusts. This coupled with normal-fault type displacements along the Chenab Normal Fault in the north account for low magnitude widespread seismicity in upper 8-10 km of the crust. At intermediate depths from 8 to 15 km, adjusting to residual compressive stresses, the detachment or lower end of the MBT slips to produce thrust dominated seismicity. Nucleation of secondary stresses in local NE-SW oriented structure interacts in complex manner with regional stresses to generate normal type earthquakes below the plane of detachment.

Further, the stress patterns of different seismic regimes of the NW Himalaya are investigated based on focal mechanisms of regional earthquakes of magnitudes ≥ 3.0 The study shows thrust faulting in Chamba - Kangra and Garhwal-Kumaun regions and normal faulting in Kinnaur and northeast corner of the

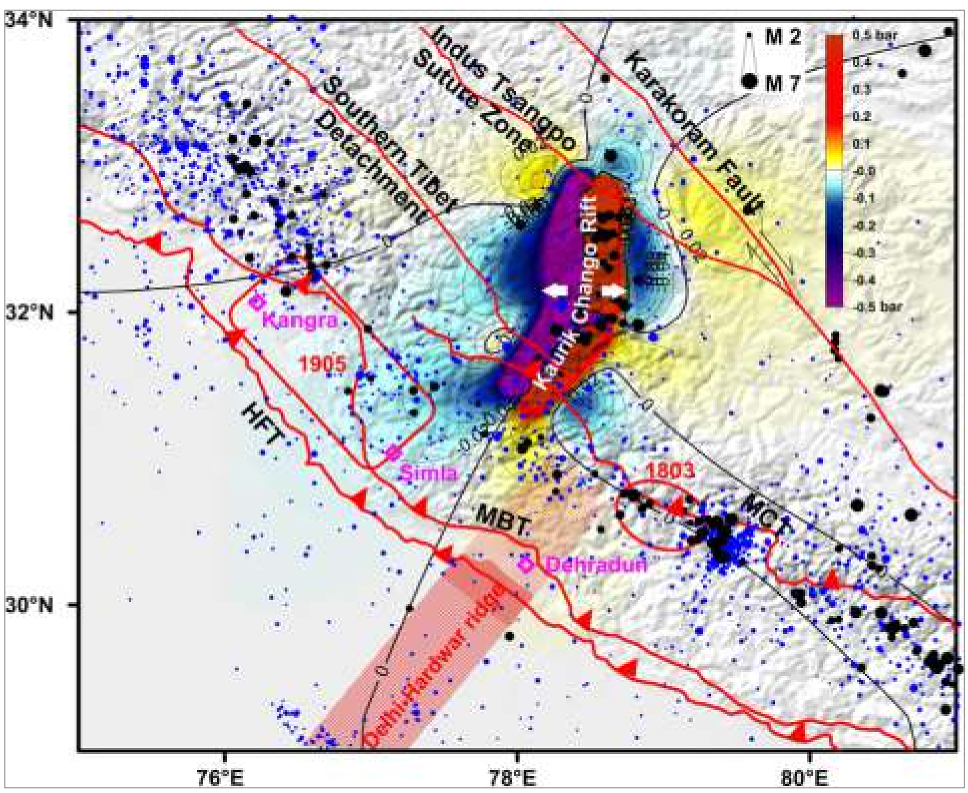

Fig. 1 : Coulomb stress change (in bar) on the Himalayan detachment due to normal slip on the Kaurik Chango rift. It appears that the active rifting in the north casts stress shadow on the part of the Himalayan detachment which suppresses the seismicity in the Simla region (Arora et al., 2012).

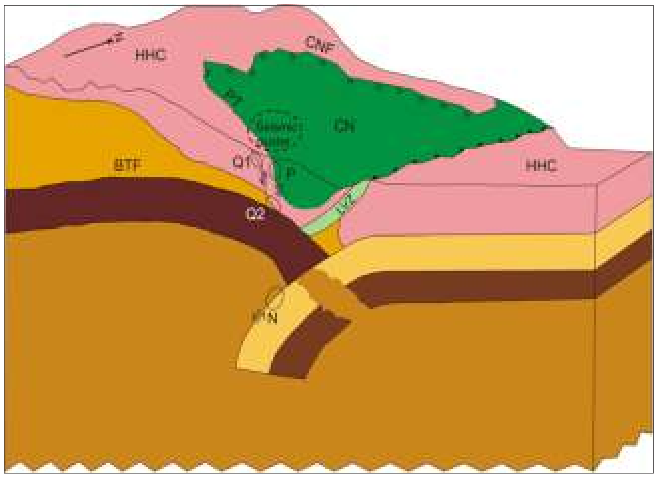

Fig. 2 : Tectonic cartoon summarizing principal seismotectonic components of the Kangra-Chamba region (Kumar *et al.*, 2013). In the collision regime of the Himalaya, clusters labeled as Q1, Q2 are due to thrust motion on the MBT, whereas clusters P and R are manifestations of strain consumption due to the sliding of the Chamba nappe towards SW. Cluster N at depth below the plane of Basement Thrust Fault, later defining locus of large earthquake, is consequence of interaction of two orthogonal structures. The confinement of clusters Q1, Q2, P and N in different depth sections to a single vertical column explain the major clustering of epicentres.

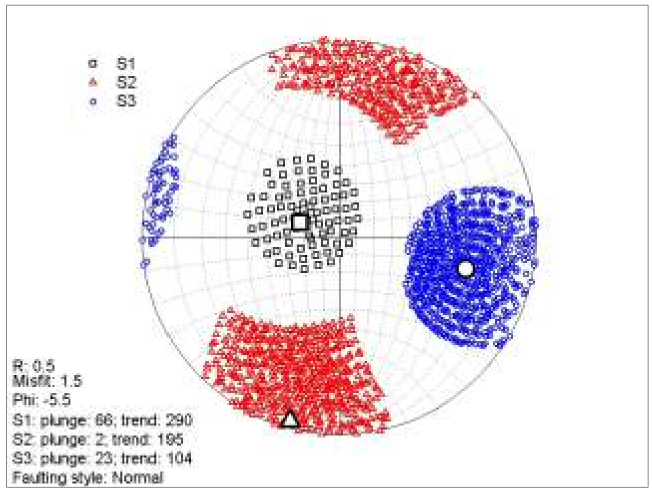

Fig. 3 : The obtained results of Stress Tensor Inversion using fault plane solutions for Kumaun region. The 95% confidence limits are defined by the black, red and the blue dots for the greatest (S1=σ1), intermediate (S2=σ2) and least (S3=σ3) principal stresses, respectively. This STI plot shows normal faulting with east-west extension.

Kumaun regions. Pressure and tension axes are determined from the fault plane solutions, and are projected on the tectonic map to evaluate the linkage of stress pattern with tectonic elements. It has been observed that most of the P-axes orientations are aligned toward northeast with their nodal planes along NW-SE direction, showing conformity with ongoing stress and the trend of major thrusts. In contrast, the inferred fault planes of normal faulting mechanisms observed at Kinnaur and NE corner of the Kumaun regions trend along N-S direction with T-axes along E-W direction. It indicates the effect of E-W extension in these two regions, which are parts of the South Tibetan Detachment (STD) zone. Thus stress tensor inversion study shows compressional stress regime for the Chamba - Kangra and the Garhwal-Kumaun regions and extensional regime for Kinnaur region (Fig. 3) and the NE corner of the Kumaun region.

The tectonic activity of the NW Himalaya portrayed through the Fault Plain Solutions (FPS) indicates a general trend of the Himalayan thrusting. However, there is some deviation on the regional scale. Near the STD, the two regions show extensional activity, but the strike of this activity is perpendicular to the general trend of tectonics of the Himalaya region.

Variation of average Poisson's ratio and crustal thickness across the northwest Himalaya and eastern Ladakh

The focus of the study has been the estimation of crustal Poisson's ratio, which is important parameter for characterizing physical property of the underlying crust. The average thickness and Poisson's ratios of crust are estimated across the northwest Himalaya and eastern Ladakh applying *H-k* stacking method (Zhu and Kanamori, 2000) on receiver functions (RF) of teleseismic earthquakes recorded at 20 Broad Band Seismological (BBS) stations of Kinnaur (Himachal Pradesh) and Ladakh networks operated by WIHG, Dehra Dun (Fig. 4). Nearly 200 teleseismic earthquakes are selected from the Kinnaur network from 10 stations. Till January 2012, the Ladakh seismological stations recorded about 300 teleseismic earthquakes which are suitable for this study. Except for Tso-Morari (TSMR) station, each station show reliable values of crustal thickness and *Vp/Vs* ratio (ratio of *P* and *S* wave velocity) or Poisson's ratio. The *Vp/Vs* ratio is related to Poisson's ratio (σ) by the relation $\sigma = 0.5 \times [1-\{1/(k^2-1)\}]$, where $k=Vp/Vs$. An example of *H-k* stacking results at Chumathang (CHUM) station, which is shown in figure

6. The analysis obtained from 20 stations in the profile show increase in crustal thickness by ~30 km from south to north of the profile. The average crustal thickness in the Lesser Himalaya (BNJR station) and the Higher Himalaya (e.g. at SARA and PULG stations) are within the range ~50-52 km which increases to ~60 km in the Tethyan Himalaya, north of the STD (e.g. at MUDH, KAZA and LOSR stations) and further increases up to ~80 km beneath eastern Ladakh. The estimated Poisson's ratio obviously varies along this profile. The Poisson's ratio beneath the Lesser Himalaya (at BNJR) and the Higher Himalaya (e.g. at SARA and PULG stations) range between 0.249 - 0.253, which is a common value for continental crust. The Poisson's ratio estimated in the Tethyan Himalaya is higher (0.269 - 0.273) as compared to the Lesser Himalaya and the Higher Himalaya. In the Ladakh seismological stations, the Poisson's ratio varies within the range of 0.280-0.303, which is much higher than the common value of continental crust. Average Poisson's ratio of crust is generally sensitive to mineral composition of underlying rocks; however its value is also affected by the presence of fluid content and partial melt. The Poisson's ratio is low in the felsic rocks with high silica content whereas its value is high for mafic rocks. Based on lower value of Poisson's ratio along with local geology and rock types, the study suggests felsic composition of the crust beneath the Lesser and the Higher Himalaya. The estimation of Poisson's ratio at stations over the Tethyan Himalaya show higher value as compared to the stations located in the Lesser Himalaya and Higher Himalaya. Comparatively higher Poisson's ratio beneath the Tethyan Himalaya may not be due to change in bulk composition in the crust. The Tethyan Himalaya is mostly composed of weakly metamorphosed marine sediments. The increase in Poisson's ratio may be the effect of fluids which are expelled from the underthrust sedimentary rocks of the Tethyan Himalaya deposited on northern margin of the Indian plate. The most plausible explanation of unusually high Poisson's ratio in the crust beneath Ladakh should be the effect of partial melt originated in the mid-crust as evidenced by results from inversion of receiver functions.

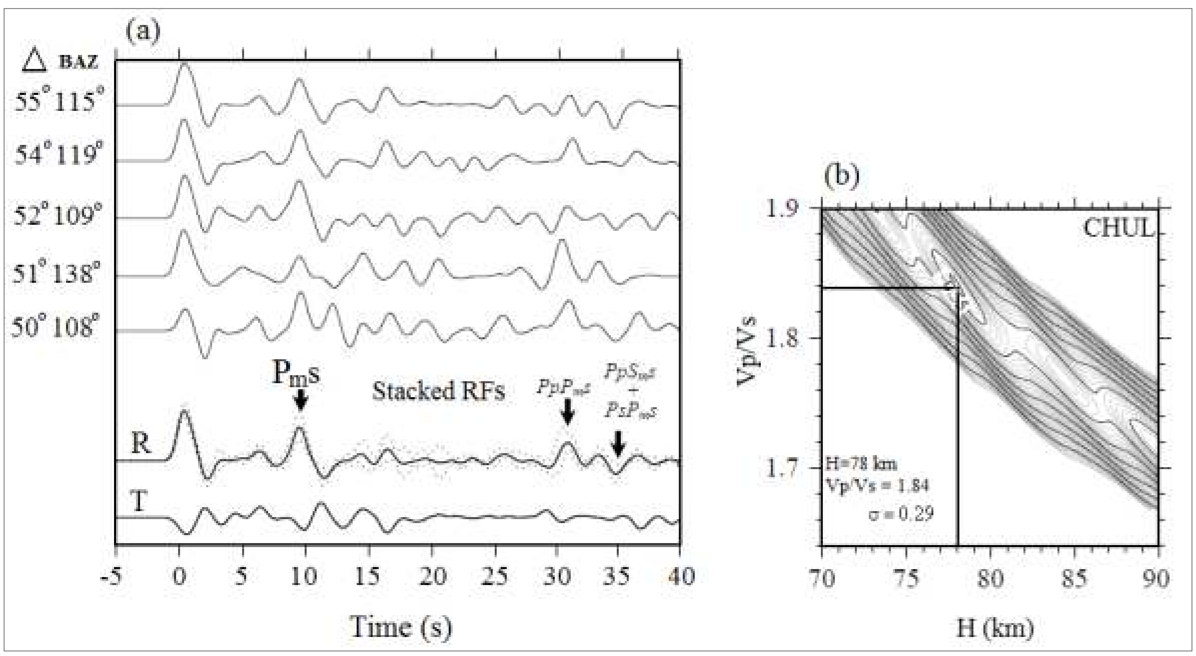

Fig. 4 : (a) Example of CHUL receiver functions (BAZ: *108°-138°* and epicentral distance: 50°-55°) selected for estimation of Vp/Vs ratio using H-k stacking algorithm. The top five waveforms are individual radial RFs. The stacked radial RF (thick waveform) with ±1 S.D. bounds (doted waveforms) is plotted beneath the individual radial RFs. The stacked tangential RF is shown at the bottom. (b) The Vp/Vs versus crustal thickness (*H*) for CHUL radial RFs is shown in (a). The crustal thickness beneath CHUL is ~78 km, and the average Poisson's ratio is 0.29 (Vp/Vs ratio: 1.84).

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

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

Among the major thrust systems that strikes along the Himalayan Arc from west to east; the Himalayan Frontal Thrust and its present day tectonic activity is a topic of much scientific debate and investigations. The Himalayan Frontal Thrust that divides the Indo-Gangetic plain to the south and the sub-Himalaya to the north is considered tectonically active through numerous palaeo-seismological observations. Investigators carried out trench excavation surveys across the Himalayan Frontal Thrust and reported occurrences of two large magnitude earthquakes during the past 650 years, and alarmed about a possible rupture and great earthquakes in this region. These observations raised serious questions about the possibility of stress accumulation and its criticality along the Himalayan Frontal Thrust, and in fact it's seismic potential, especially when we consider the expected deformation of such a frontal system in a southward propagating wedge thrust environment. In such a propagating wedge system, the extent of deformation of HFT should bear the brunt of seismic moment release along the seismically active Main Central Thrust. However, there were little instrumental data to substantiate the seismic potential of HFT either through strain accumulation or through its present day movement. This accentuates the need to instrumentally monitor the deformation of HFT through Global Positioning Systems tool.

Keeping in view, the continuously operating Global Positioning System (GPS) data available in the north western Himalaya for the period of two years from 2010 and 2011 has been analysed by us in order to know the present day activity of the Himalayan Frontal Thrust (HFT) in the Dehra Dun re-entrant. Also, we do not know how the local and regional seasonal loading/unloading is affecting the GPS measured vertical uplift and subsidence rates in the frontal region? We are reporting here first time the initial results obtained through instrumental observations on the deformational behaviour of Frontal Himalaya, from the Nahan Salient to the Dehra Dun re-entrant. The results show, HFT at this portion of the Frontal Himalaya is kinematically dormant and hence contributing little to the expected southward propagation of the frontal thrust system and hence have near zero stress accumulation. However, the rate of vertical deformation in the Frontal Himalaya that only related to the ongoing collision process could not be resolved directly through the vertical GPS observations, for which, a multi-component approach to remove the seasonal loading and unloading effects may be required to taken-up. A few of our observations on vertical GPS positional anomalies show that local and regional hydrological effects are predominant, especially from those stations in the Frontal Himalaya. The data from the frontal region clearly indicates how the vertical GPS displacement anomalies behave in tandem with the subsurface water loading mainly in response to the annual seasonal charge/discharge. Further, we have also observed that in the Himachal Himalaya between MBT and MCT the thrust system is kinematically active and hence have relatively larger compressive strain accumulation. Although the vertical uplift rates are not as accurate as that of the horizontal velocity fields, but during the period of observation the station situated in the Kangra re-entrant that exist between MBT and MCT shows a subsidence rate of -2.69 ± 1.11 mm/yr. A campaign mode site selection has been carried out in the areas adjoining to Dehra Dun re-entrant and Nahan Salient. In order to extent our study in the Frontal part of Himachal Himalaya, and at its southern region we are expanding our GPS network to the Himachal Himalaya and also to a stable platform in the Bundelkhand Massif.

Measurement of seismic anisotropy provides information about the quantitative deformation of the upper mantle in the region. Azimuthal variation of Pn velocity provides evidence of the presence of anisotropy in the upper most mantle. This information along with the surface tectonic features indicates recent deformation style in the region. The depth extent of anisotropy can be constrained comparing Pn velocity anisotropy with the anisotropy obtained using SKS splitting analysis.

In this study 246 regional events with Pn as first arrival, recorded at 11 broad band stations operated in the NE syntaxial region of Arunachal Pradesh during 2007-08 are analyzed for azimuthal velocity variation in the upper mantle. The Pn travel time are computed using simple linear fit, time-term method and modified time-term method with azimuthal anisotropy factors. Also a two-station time difference method was used to determine the travel times in the upper mantle for the region east of tiding suture zone.

In an earlier study using SKS splitting analysis the fast polarization direction for this region was found to be N76°E. This preliminary analysis shows, the Pn fast direction azimuth is N23°E with a change in velocity of 4.8 % and nearly parallels the APM direction (N18°E) in this region. The mean crustal delay of 7.02 s compares well with the velocity structure obtained for this region from other studies. The disagreement of fast direction with that of SKS splitting clearly indicates varying contributions to anisotropy from different depths. Analysis with additional observations is in progress to better constrain the distribution of anisotropy with depth.

TAT-1.3
Tectonics of the Shillong Plateau, northeastern India

(Swapnamita C. Vaideswaran)

Field work has been carried out along the road sections and major rivers in the Khasi and Jaintia Hills in Meghalaya, and in Assam covering the Shillong Plateau region, wherein several terraces have been identified. Samples for OSL dating were collected for analysis, and the expected results of which will provide an idea of the aggradation and degradation phases of the region vis-à-vis its tectonic history.

Base maps using GIS have been prepared. The drainage maps and the estimation of geomorphic indices of a few major rivers were done along sections which seemed influenced by significant tectonic regime in the plateau. In the north of the plateau occurrence of lakes speculated to be created by the earthquake of 1897 have been extensively studied in field, and also in the lab using remote sensing and GIS. Samples from submerged tree trunks have been collected for carbon dating. From our analysis it has been understood that encroachment of the Kulsi River towards east and flooding during heavy rainfall conditions led to the formation and inundation of the lakes, and also its extension. The region around Chandubi-Rani represents an old flood plain, however, the results from the carbon dating from the submerged tree trunks will provide a clue, when the extension of the lake occurred.

TAT-1.4
Tectonic evolution of Shyok Suture and Karakoram Fault Zone Rocks and their bearing on Tibet Uplift

(H.K. Sachan, Koushik Sen, S.K. Paul and Barun K. Mukherjee)

Age of initiation and tectono-magmatic evolution of the Karakoram Fault Zone

In the eastern part of Ladakh, the dextral strike-slip Karakoram Fault Zone (KFZ) bifurcates into two strands called as Pangong Strand and Tangtse Strand. The region bounded by Pangong and Tangtse strands is called the Pangong Transpression Zone (PTZ) and it consists of diorites, which have transformed to migmatite, orthogneiss and a pluton of two-mica leucogranite called as the Darbuk Pluton. Mesoscopic foliation of gneisses is steeply dipping to near vertical with a strike (around 140-150º) parallel to the regional trend of the KFZ. Mylonites indicate a dextral, top-to-the south sense of shear. Mesoscopic evidences also suggest that deformation/re-mobilization of the diorite and felsic magmatism is synchronous. Anisotropy of Magnetic Susceptibility (AMS) reveals concordant mesoscopic and magnetic fabric for the orthogneiss. However, the magnetic fabric of the two-mica leucogranites at the centre of the Darbuk Pluton is oriented at a high angle to the regional trend of the KFZ. U-Pb geochronology of zircons from the diorite gneiss gives a crystallization age of 63.6 ± 1.5 Ma and also shows younger zircon growth at ~50 Ma, ~30 Ma down to ~13 Ma. One two-mica leucogranite sample from the Darbuk Pluton gives a common Pb chord lower intercept of 22.7 ± 0.5 Ma with the five youngest concordant analyses yielding a $^{206}Pb/^{238}U$ age of 19.62 ± 0.57 Ma, that is interpreted as the age of crystallization of the pluton. It is inferred that, following crystallization of calc-alkaline granites at ~65 Ma, the PTZ underwent partial melting due to underthrusting of the Indian lithosphere beneath Eurasia accompanied by granulite metamorphism due to asthenospheric upwelling. Partial melting and melt migration in the KFZ continued till 13 Ma. The younger ages of partial melting can be correlated with timing of amphibolites facies metamorphism reported previously in this region. Our study imply that, contrary to previously believed ~15 Ma age of initiation for the KFZ, non-coaxial deformation and magmatism initiated in the KFZ at

~23 Ma. The Darbuk Pluton is syntectonic with this deformation event and was emplaced in a dilational zone within the PTZ. Crystallization age of the Darbuk pluton signifies the timing of initiation of KFZ at ~23 Ma.

Exhumation History of the Karakoram Fault Zone

In the Tangtse shear zone, the microstructures of mylonitic leucogranite exhibit superposition of high-temperature deformation followed by low-temperature deformation. The mylonites show fluid immiscibility, containing brine and carbonic inclusions. The occurrence of carbonic and brine-rich inclusions in the oscillatory-zoned plagioclase indicates that they were trapped during the formation of the leucogranite. Eventually, these fluids record a near-isobaric drop in temperature to <450°C at the amphibolite-greenschist facies transition, when the zone of fluid mixing was established. The ^{40}Ar-^{39}Ar biotite ages indicate that the area cooled down to 400-350°C over 10.34-9.48 Ma, and this period also coincides with a major phase of fluid infiltration and trapping of secondary reequilibrated carbonic and saline-aqueous inclusions. The 10.34-9.80 Ma period record a low-temperature deformation at greenschist conditions, when the involved fluid evolved followed a near-isobaric path at ~2 kbar. Subsequently, between 9.80 Ma and 9.48 Ma, the sudden drop in pressure (1.75-0.5 kbar) caused by mylonites produced reequilibrated fluid inclusion textures. These observations suggest that the Karakoram fault zone rocks show a single progressive deformation event with bimodal fluid evolution, in which the carbonic- and brine-rich inclusions were available prior to high temperature deformation during the initiation of the Karakoram fault zone. The trapping of secondary inclusions between 10.34 Ma and 9.48 Ma with pressure decrease of ~2-0.5 kbar yields an average uplift rate of 1 mm yr^{-1} for the Karakoram fault zone.

Fluid Inclusion petrography and stable isotope analysis of the calc-mylonites of Karakoram Fault Zone

The calc-mylonite is exposed along the Pangong-Tso strand of Karakoram fault at Muglib locality. This calc-mylonite has ^{13}C and ^{18}O composition in the range of -3.2 to 4.77 PDB per mil and -1.14 to 28.54 SMOW per mil respectively. The isotopic composition depicts that the source of carbon is from marine, whereas the depletion in ^{18}O may be due to externally derived waters or metamorphic fluids or meteoric waters. The preliminary fluid inclusion petrography of calc-mylonites reveal the presence of two type of fluid inclusions namely monophase (gaseous) and biphase aqueous inclusions and re-equilibrated inclusions. Monophase inclusions are present in random nature whereas the biphase aqueous inclusions present in the form of trails as well as in isolated form.

Diachronous evolution of the Indus Suture Zone

The Indus Suture Zone (ISZ), was considered to form as the result of a single eastward progressing collision event in the Himalaya initiated in late Paleocene to early Eocene time as it is observed in Ladakh region. The study exhibits that the ophiolitic mélange obducted on to the surface at least in three stages; initially as the Sapi-Shergol Ophiolitic Mélange (S-SOM) in western Ladakh during latest Cretaceous to early Paleocene time and then as Khalsi Ophiolitic Mélange (KOM) in Central Ladakh during early Eocene. It is interesting to note that rocks of the basal flyshoid marine sediments overlain by fluvio-marine or fluvial sediments of the Indus Formation are deposited over the volcanogenic sediments of the Dras volcanic. The KOM obducted southward on to these volcanogenic sedimentary rocks demarcates the subsequent second generation eastward migrating stage of ISZ. Finally, the Zildat Ophiolitic Mélange (ZOM) obducted both on to the Indus Formation in the western part and the Tethyan sedimentary sequence in the eastern part of southeastern Ladakh during late Eocene to Oligocene time in space and time, thereby indicating the diachronous nature of Indus Suture Zone (ISZ) between the Indian and Tibetan-Karakoram blocks from west to east. The re-aligned collision boundary is generated due to anticlockwise rotation of the Indian Plate and simultaneous eastward welding of India-Asian plates.

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

(Sumit K. Ghosh and R. Islam)

The present assessment of the geological, geochemical and isotopic constraints recognizes that recycling of continental crust through mantle is a viable mechanism but not a dominant process. The rationalization for proposing this study in the Lesser Himalayan domain lies in its exceptionally long stratigraphic records, atleast Paleoproterozoic to early Phanerozoic time span. The present understanding about crustal evolution comes chiefly from detrital modes, and geochemical data gather on sedimentary and the associated mafic rocks. In this regard we have reviewed the published and our own data sets and noted following interpretation:

The stratigraphic scheme of the Outer Lesser Himalaya (OLH) is consisting of Jaunsar and Mussoorie groups, and the Inner Lesser Himalaya (ILH), consisting of Damtha and Tejam groups. In contrast to the OLH, age constraints in the ILH are sparse, which has limited understanding of the relationships among its contemporary lithostratigraphic units. Based on geological aspects, number of criteria for distinguishing one another is proposed, assuming the ILH is older than the OLH. For example, the ILH, the sedimentary rocks show higher degree of diagenesis and low-grade metamorphism. The zone is invariably covered by crystalline metamorphic masses, which is now isolated due to erosion, show green schist to upper amphibolite grade of metamorphism. The siliciclastic succession of ILH (Berinag-Rampur-Rudraprayag) is characterized by syn-sedimentary basic magmatism, and acid tuff, which in the OLH is relatively rare. The ILH reveals the presence of two important Palaeo-Mesoproterozoic siliciclastic-carbonate cycles, namely the Sundernagar-Rampur-Berinag-Damtha and Shali-Deoban. The ages of Damtha/Rampur Group have been constrained ca. 1.8 Ga from the interbedded metabasalt flows. The Tejam Group consists of Deoban Formation in the Garhwal and is suggested equivalent to the Gangolihat Dolomite of Kumaun. The Jaunsar Group is constrained as early Neoproterozoic based on its stratigraphic position below the 692 Ma diamictite and cap-carbonate of the Blaini formation, with a regional unconformity (?).

The gradual shift from argillite (mud) dominated to siliciclastic (sand) dominated (Rautgara Formation) and sub-aerially erupted volcanics-dominated sequence of the ILH, as well as the occurrence of several gravelly beds favour unstable basin that was gradually shallowing. The studied interval of the OLH generally thins northward from the shallow water (siliciclastic) in the central part relatively coarser and away on either sides are comparatively deeper water/low energy margins (argillites and fine-siliciclastic), which may possibly be due to the presence of palaeo high. From the facies distribution pattern, a northwest-southeasterly trending palaeo-shoreline may be envisaged. Laterally, inter-fingered muddy and sandy facies was noticed representing the shore face region particularly in the Tiuni and Shivpuri sections, and its offshore region towards west is characterized by abundant muddy facies. This therefore hints that the east landward side may be in the form of an embayment. Interestingly, the syn-sedimentary/penecontemporaneous basic magmatic activity is noticed prominently in this part of the sedimentary succession. Palaeocurrent direction of these sediments suggests a southern Aravalli-Delhi fold belt provenance.

From the existing data set we have further initiated to look into relationship aspects of Chandpur and Chail Formation of the Lesser Himalayan domain. The following information's are gathered: The Chandpur Formation consists of banded greyish green to dark green, shale, slate, phyllite and quartzite, whereas in the northern part, these rocks gradually change to chlorite-sericite phyllite, followed by chlorite biotite schists and show very well developed foliation and crenulation cleavages. It is also referred to as Pauri phyllite around Srinagar area of the Garhwal Lesser Himalaya. An isolated body of mylonitic gneiss occurs within the Chail or Chandpur metasedimentary package. In the western sector of the Himalaya, at the base of the Chail formation, highly deformed gneisses are exposed and are termed as mylonitic augen gneiss. These rocks belong to green schist to lower amphibolite facies metamorphic grades. Resemblance in mineralogy and grade of metamorphism of these rocks (Chail or Pauri) is more likely to be correlatable to the classic Chail metamorphites of the Himachal Himalaya. Geochemical investigation of these argillite packages are initiated which include major, trace and rare earth elements. The work is in progress for further refinement.

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)

Orthogneissic Migmatite

Detailed Mineralogical and geochemical investigation was carried out by sampling various parts of the migmatite components. In this work, fractionation and elemental mass balance of migmatization processes are deciphered. Salient outcome of the study are as follows:

- Quartzo-feldspathic Orthogneissic protolith from HHC is equally potential to produce leucogranite in two stages. Higher degree of partial melting followed by substantial fractionation of plagioclase (20-30 %) seems to be the operative process. This contrasts the otherwise considered pelitic and psammite gneisses as protolith for early-middle Miocene leucogranite magmatism.
- Peak temperature of partial melting was ~700^{0}C as revealed by the Biotite and Zircon thermometry independently. However, re-equilibration of ternary feldspars solvus temperature at around 475^{0}C suggest rather slow cooling rate implying slower exhumation of HHC.
- Trace elements and REE geochemistry suggest more plagioclase melting in preference to K-feldspar. There is many fold enrichment in LREEs in the residue (melanosome) while that of the melt (leucosome) is equally depleted producing a mirror image pattern of each other.

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

(Keser Singh and T.N. Jowhar)

Hadsar-Chobia box fold, Chamba syncline

The geometric relationship of the regional SW-vergent Chamba syncline and the NE-vergent Tandi syncline occurring within the Tethyan rocks, south of the HHC, remains unexplained so far. Detailed structural analysis of the folding pattern in the Chamba Thrust Sheet reveals that the SW vergent Chamba syncline and the NE vergent Tandi syncline and the two anticlines are parts of a large scale structure described here for the first time as the *Hadsar-Chobia box fold*. The box fold has developed over a ductile-brittle substrate represented by the Chamba Thrust. The box fold model explains the development of the opposite vergent Chamba and Tandi synclines during the same deformation phase (D_1) of the SW directed Himalayan orogeny. The assumption of a local NE directed nappe stacking as suggested by earlier workers, is not required to explain the formation of the NE vergent Tandi syncline, now representing the eastern flanks of the box fold. This study negates the assumption of *NE-directed deformation* (as proposed by some workers) prior to *SW-directed deformation* during Himalayan orogeny.

Field relations of migmatites in Joshimath-Malari section

Dr. Keser Singh, Dr. P.K. Mukherjee jointly with Prof. A.K. Jain have carried out field work in migmatite region of Joshimath-Malari section. Structure and textural relationships observed at exposure scale were compiled to better understand, the development of the migmatites and structural controls on melt induced weakening, shearing and style of deformation. Widespread *in-situ* partial melting of sillimanite+K-feldspar gneiss resulted in the formation of migmatite and resultant melt accumulation near the South Tibetan Detachment Zone (STDZ) during various deformation events along the Dhauli Ganga valley in Garhwal. The oldest migmatite phase, designated as the Me_1, parallels the main foliation S_m as the stromatite layers and concordant leucogranite bands. Younger melt phases Me_2, Me_3 and Me_5 are recorded along small-scale ductile thrusts, extensional fabric and structure less patches, respectively. It is only the Me_4 melting phase that is evidenced by large-scale melt migration along cross-cutting irregular veins. These were possible conduits for migration and accumulation of melt into larger early Miocene leucogranite bodies like the Malari Granite.

P-T estimates of the Higher Himalayan Crystallines

P-T estimates have been done on samples from the Higher Himalayan Crystallines (HHC) in the Garhwal Himalaya along Sainj-Bhatwari-Lohari Nag-Gangotri section in order to place quantitative constraints on the conditions attained during the regional metamorphism. P-T calculations were carried out using computer program TWQ version 2.34 (Berman, 2007), WEBINVEQ (Gordon, 1998), BGT (Jowhar, 1999) and THERMOCALC (Powell and Holland, 2001). These studies reveal increase in both pressure and temperature across the Main Central Thrust (MCT) from south to north. Temperature increases from 500 to 750^{0}C and pressure from 6 to 10 kbar across the MCT zone. Computations on estimation of uncertainties on these P-T estimates using Monte Carlo method and numerical error analysis were also done. Pseudosections were generated using some chemical data taken from the published literature from the Himalayas and Alps and also new data generated from the Garhwal Himalaya to understand evolutionary history of metamorphic rocks from the Higher Himalayan Crystallines in this region.

Methods for Estimation of Structural State of Alkali Feldspars

There is much interest in characterizing the variations in feldspar structures because of the abundance and importance of feldspars in petrologic processes and also due to their general significance in mineralogical studies of exsolution and polymorphism, especially order-disorder. With the appearance of new analytical and rapid methods of X-ray crystallographic study and computational techniques, the significance of feldspars in igneous and metamorphic rocks has increased tremendously. Methods for estimation of structural state of alkali feldspars was reviewed and discussed.

The difference in symmetry of sanidine and microcline is due to order-disorder relations of Si and Al atoms over tetrahedral sites. The distribution of Al and Si in tetrahedral sites in maximum microcline (Low microcline) is of the highest degree of order and microcline has a lowest structural state. On the other hand, sanidine, with the highest structural state shows random Al-Si distribution in tetrahedral sites. In between these two end members maximum microcline and sanidine, several intermediate structural states e.g. orthoclase and intermediate microcline exist. Various ordering parameters have been used to designate the state of Al-Si distribution in alkali feldspars. Although, the coefficient of order, the triclinicity, the Ragland parameter and obliquity indicate the structural state in quantitative manner, we can only draw broad generalizations with their help as regard to the actual physical environment during the formation of the alkali feldspar. On the other hand, Thompson X, Y and Z ordering parameters are more useful because it relates Gibbs function, entropy, enthalpy etc. with the Al-Si distribution.

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)

Sutlej valley, NW Himalaya

The study in the Pooh area of Sutlej valley (NW Himalaya) has shown that, the Haimanta groups of rocks have undergone garnet to staurolite grade of metamorphism. The grade of metamorphism gradually increases from south to north direction with increasing structural level, which suggests normal sequence of metamorphism. Rock shows prominent S_2 foliation. Petrography shows that staurolite and kyanite has grown parallel to S_2 foliation. External schistosity (i.e. $S_i \sim S_2$) has warped around staurolite indicate syn-S_2 staurolite. A few samples contain st-grt-chl coexisting phase. In garnet grade rocks, external schistosity warped around the garnet, internal schistosity in garnet (represented by trails of quartz grains) are at high angle to external foliation. A few garnets have overgrown the S_2 schistosity.

Pre-Himalayan granulite facies metamorphism, NW Himalaya

Mafic and pelitic xenoliths occurring within the early Palaeozoic Kinnaur Kailash Granite (KKG), Baspa valley (NW Himalaya) recorded pre-Himalayan regional metamorphism ranging from amphibolite to granulite facies prior to the intrusion of the ~500 Ma old KKG. Such report of granulite facies pre-Himalayan metamorphism is first of its kind from the Indian parts of the Himalayan orogenic belts. Granulite facies metamorphism is recorded by the mafic xenolith sample XN10, which contains the characteristic two-pyroxene assemblage (Fig. 5) and records peak temperature of ~840°C. Its upper pressure limit deduced from P-T pseudosection is 8.5 kbar. Exsolution of orthopyroxene from clinopyroxene in the rock occurred during cooling after peak metamorphism (Fig. 5A). The pseudosection modeling P-T calculations show that garnetiferous mafic xenoliths have attained the metamorphic P-T condition of 8.0 kbar and 730°C. They are characterized by coronae of garnet around plagioclase and clinopyroxene (Fig. 5B), and of sphene around ilmenite. It is interpreted that these corona textures have been formed during cooling after peak metamorphism (Fig. 6). Pelitic xenoliths of the Baspa valley record temperatures between 490 and 730ºC and pressures between 7.0 and 9.2 kbar. These P-T conditions indicate lower to middle amphibolite facies metamorphism of the xenoliths. P-T data from core and rim compositions of garnets show that these rocks underwent prograde metamorphism with decreasing pressure.

Since, the pelites are schistose rocks and not

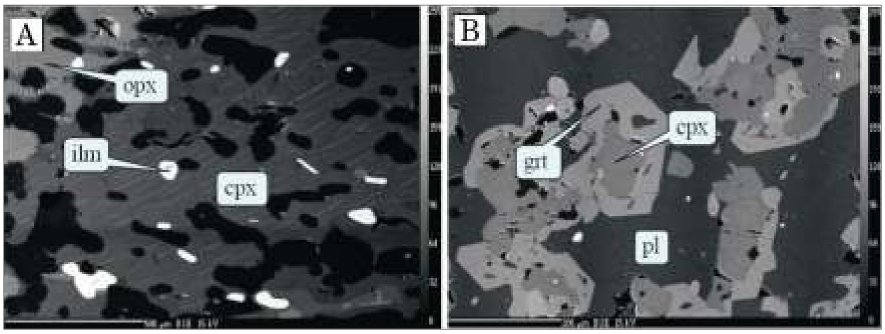

Fig. 5 : (A) Back scattered electron image (BSE) of two-pyroxene mafic granulite showing a discrete grain of orthopyroxene and exsolution needles of orthopyroxene in clinopyroxene host; (B) BSE image of garnetiferous clinopyroxene amphibolite (sample XN11) showing garnet corona around clinopyroxene.

hornfelsic in nature, they could not have formed by thermal effect of the KKG. The granulite metamorphism of mafic xenoliths also could not have been caused by the intrusion of the KKG because such granite plutons have insufficient latent heat to cause high grade metamorphism of country rocks. Therefore, it is reasonably concluded that the pelitic and mafic xenoliths had undergone regional metamorphism at conditions of lower amphibolite to granulite facies before the intrusion of the KKG at ~500 Ma. Quartz, feldspar and mica in the pelitic xenoliths commonly show optical evidences of crystalloplastic deformation which indicate that the rocks were already sheared, in addition to being regionally metamorphosed before being engulfed by the KKG. The HHCS attained temperatures of upper amphibolite facies during Himalayan metamorphism, at which time the imprints of pre-Himalayan high grade metamorphism would not have been completely obliterated from the rocks. In such as a scenario of polyphase metamorphism, important criteria such as growth zoning in garnets and inclusion suites in minerals need to be interpreted with care while making inferences on the Himalayan metamorphism of the HHCS. Since pelites of the HHCS were already sheared before the Himalayan deformation as indicated by the pelitic xenoliths, the present day shear fabrics of the HHCS need not be attributed solely to the Himalayan orogeny.

Peak pressures obtained from xenoliths show that the rocks were metamorphosed at depth of ~20-27 km and later brought up to shallow depth by the KKG in the form of xenoliths. This implies that the KKG magma originated from a minimum depth of 27 km prior to its intrusion into the HHCS and Tethys Himalaya.

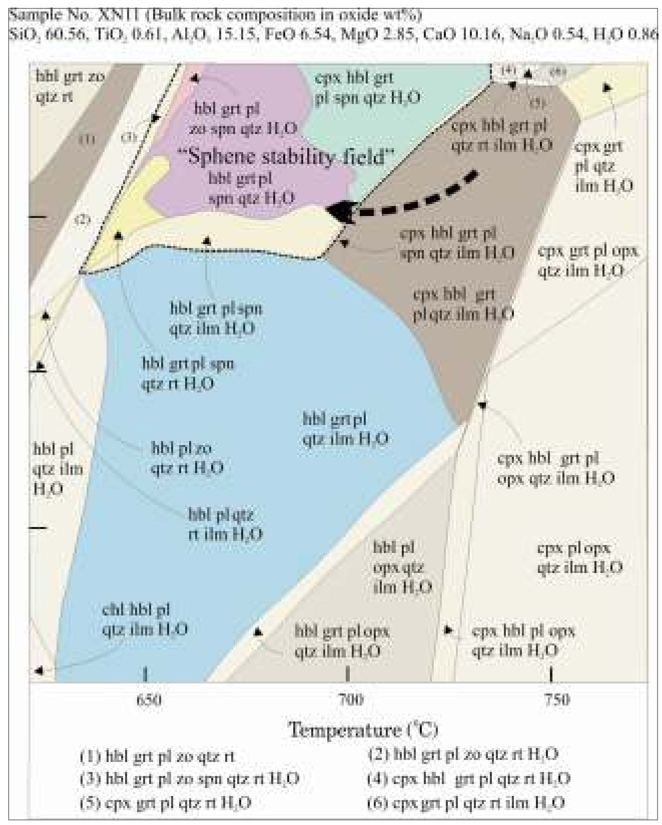

Fig. 6 : P-T pseudosections for mafic xenolith (sample XN11) in the NCFMASHT system shows stability field of the characteristic mineral assemblage of sample XN11: cpx-hbl-grt-pl-qtz-ilm-H_2O in P-T range of 700-750°C and 7-9 kbar. Stability field of all sphene-bearing assemblages is outlined by bold dashed line. Arrows shows possible near-isobaric cooling path from peak mineral assemblage.

Occurrence of two metamorphically and petrologically distinct xenoliths suggests that the ascending KKG magma has incorporated these xenoliths from different crustal depths. The pelitic xenoliths were incorporated into the KKG magma at mid-crustal level under amphibolite condition, whereas mafic xenoliths were entrained in the magma from the lower crust, under granulite facies conditions. The present study of pre-Himalayan metamorphism of xenoliths provides inputs on crustal evolution of the northern fringe of the Indian plate and sheds light on paleogeographic extent of the Indian plate during Precambrian time. Further, our studies suggests an off-craton metamorphic belt of amphibolite- to granulite-facies must have occurred north of the Aravalli-Bundelkhand Craton during Precambrian time, which served as the basement for the deposition of Tethyan Himalayan sediments.

Geochemical characterization of CC and HHC, NW Himalaya

The Chhiplakot Crystallines (CC) in the Kumaun Himalaya is generally considered to be the erosional remnants of the thrust sheets whose roots are considered to be in Higher Himalayan Crystallines (HHC) to the north of the MCT. Studies have been carried out on the gneisses from the lower structural levels of the HHC, and the CC that occur as klippen within the Lesser Himalaya which suggested that, the gneisses of the HHC and the CC have distinctive contrast in their petrological and geochemical characteristics, and indicate their derivation from different sources. In view of the differences observed in the petrochemistry of the gneisses of the HHC and the CC, we are of the opinion that it is not easy to directly support the commonly argued concept of the nappe rocks of the Lesser Himalaya to have their root zones in the Higher Himalaya.

Occurrence of Lazulite at Sobla, NW Himalaya

Lazulite, an Mg-rich phosphate mineral [$(MgAl_2(OH)_2(PO_4)_2$] has been reported for the first time from the inter veined quartz in Berinag quartzite near MCT (Sobla) in northeast Kumaun. It is formed from the phosphorous present within the host quartzite and Mg (± Fe) from the breakdown of minerals such as biotite in gneissic rocks in Central Crystallines.

Eastern Syntaxial Belt, NE Himalaya

The petrological studies of the Abor volcanic, which outcrop in the core of the Siang window in the Eastern Himalaya, comprise voluminous mafic volcanics with subordinate amount of felsic volcanic. The mafic magmatisms in the core of the Siang window in the Eastern Himalaya, are preserved in the form of extrusives, volcano-sedimentary sequences, sills/dykes and intrusives. In the last three decades, the mafic magmatic rocks of the Eastern Himalaya particularly from the Siang Window have been studied. However, most of the earlier reports are restricted on the mafic volcanics cropping out in the core of the Siang Window. Till date no reports on gabbroic intrusives in Siang Window of Eastern Himalaya is available. Hence, during this year a detail petrological and geochemical studies of gabbroic intrusives of the Siang window have been carried out to evaluate their petrogenesis and tectonic environment.

Carbonate and calcareous-quartzite of Miri-Buxa Group in the Siang window of Eastern Himalaya intruded by mafic rocks of gabbroic affinity. These intrusive rocks are low-Ti tholeiites (Ti/Y = 379-478; Nb/La = 0.99-1.88) and characterized by enriched LILE-LREE, depleted in HFSE with minor REE fractionation [$(La/Yb)_N$ = 2.72-3.35)]. Geochemical behaviour of the incompatible trace elements with the rare earth elements abundances indicates their cogenetic nature and their emplacement in a continental rift tectonic environment. The liquidus olivine temperature of these mafic rocks ranges from 1262 to 1380°C showing a gentle decrease of [Mg] with a steep increase of [Fe]. These charters thus imply that the rocks are either related to the extent of common source or fractionational crystallization of plagioclase and clinopyroxene from a single batch parental magma. Petrogenetic modeling of [Mg]-[Fe] and REE indicates that these mafic intrusives probably derived from a mantle source similar to komatiitic composition at moderate to high degree (8-20%) of partial melting.

TAT-1.9

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

(R.S. Rawat and Rajesh Sharma)

Limited $\delta^{34}S$ ‰ values are obtained for galena occurring in magnesite of Jhirauli, and pyrite in carbonate-talc assemblage of Rai-Agar area. Their host rocks are representative of magnesite-talc assemblage of Kumaun Himalaya. The sulphur isotopic data showed that the pyrite have lower $\delta^{34}S$ ‰ values (ca. -1.9 to 3.5) in comparison to the galena (ca. 18.4 to 18.8). These values collectively rule out the possibility of magmatic sulphur, and with the fluid inclusions data it further indicates the involvement of basinal biogenic activity in the sulphide deposition.

The Laser Micro Raman Spectroscopy of carbonaceous material from Almora Crystallines show first order Raman spectra between 1100 to 1800 cm^{-1}, wherein the Raman peaks are at 1355 cm^{-1}, 1582 cm^{-1} and at 1620 cm^{-1}. The identified G-band is positioned at 1580 cm^{-1}, whereas the defects bands vary widely and at times are absent pointing to high crystalline nature of graphite. In general, the obtained G-bands are between 1578.19 and 1583.56 cm^{-1}, standard deviation range from 4.84 to 0.75, whereas the defect bands vary widely from 1351.08 to 1359.52 cm^{-1}. The Raman spectra of the studied graphitic samples indicate that the carbonaceous material has been converted to ordered graphite probably after the regional metamorphism of the host Almora Crystallines. The higher range of calculated graphite temperatures from Raman data, as compared to those reported from Nepal and elsewhere from Almora Crystallines is indicative of presence of well crystalline graphite in the mineralized zones. They are likely to represent the peak metamorphic temperatures attained by the host rocks. The microthermometry coupled with Raman spectroscopy of fluid species in graphite bearing assemblage, confirm the presence of $CO_2 + N_2 + CH_4$ fluid buffering in the graphite assemblage. Although the CO_2 homogenization temperatures are widely varying, however, the lower range of about +7°C is noteworthy, suggesting that the isochors of the graphite bearing schists are positioned at higher PT level. The presence of significant $N_2 + CH_4$ fluid in the graphitic samples is unusual to the metamorphics from the Himalayan region, and points to their derivation by way of the involvement of organic material during metamorphic processes.

The sulphide mineralized samples of Garsa-Mahun-Naraul section in Garsa valley, Diar-Masu-Tarain section, and the U-mineralization in Rampur quartzites in Parvati valley of Kulu area, Himachal Himalaya have also been focused. Disseminated chalcopyrite and pyrite is observed in quartzite, whereas chalcopyrite, covelite and chalcocite and galena are present in metabasites. In Diar area, sulphide mineralization is enriched in metabasites, whereas in Naraul the chalcopyrite fills the fractures and pore spaces in quartzite. Fine veinlets of U-mineral are observed in the Manikaran Quartzite. Both ductile and brittle deformation of sulphide minerals is evident from shattering of pyrite grains and remobilized infillings by

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)

The Indus River is one of the largest rivers on Indian continent that originates from Mount Kailas passes through Karakoram zone, Ladakh Batholith and through various tectonic units of Indus Suture Zone (ISZ). Thus the landscape along this river has potential to unravel responses of Indus River to the neotectonic evolution of ISZ and to arid climate of trans-Himalaya. The synoptic study of Quaternary evolution of the Indus River in these connections has not been done judiciously.

This study focuses this aspect using the remote sensing data ASTER DEM (30 m), SRTM (90 m) and Toposheets (1:50,000), field geomorphological mapping and Optically Stimulated Luminescence (OSL) Dating technique. The study area includes the stretch of river from village Nyoma to Dah, where the Indus River shows marked change in its channel pattern and geomorphic configuration. There are thick sedimentary fills of wide braided channel from Nyoma to Nimu, and several levels of bedrock strath terraces are observed from Nimu to Dah, where rivers flows into a thin gorge. The geomorphological and sedimentological studies have been attempted on the Quaternary deposits of Indus River in this area. The dating of strath terraces indicated the bedrock uplift rates varying from 2-5 mm/yr and that the thrust contact between the Ladakh Batholith and Indus Molasses is neo-tectonically active. These results surprisingly matched with the incision rates (2-12 mm/yr) of NW Himalayan syntaxis. Hence this area is tectonically active, equally to North western syntaxis of Himalayan (Nanga Parbat). The Indus molasses is highly deformed and thrusted with south dipping sequence of thrusts and high angled reverse faults. We envisage that the bedrock incision in this zone is in response to the uplift due to the Pleistocene-Holocene crustal shortening in the Indus Molasse.

TAT-2.2

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

(B.N. Tiwari)

Exotic murid rodent Parapodemus sp. from Middle Siwalik of Mohand

In Mohand section, a mudstone unit showing traces of gastropod shells yielded a local Siwalik microfaunal assemblage through bulk maceration. The fossil assemblage consists of gastropods, ostracods, charophytes, fish teeth and an isolated murid molar. Fossil locality is on the right bank of Mohand Rao (stream), and is approximately 21 km towards Mohand from Dehra Dun. Middle and Upper Siwalik horizons are exposed in the Mohand Rao and along the Saharanpur-Dehra Dun road as both are cutting approximately across the strike of the succession. Occurrence of the taxon questions the temporal aspect of inferences drawn in previous studies, and bears reflection of the Vallesian Crisis in the Late Miocene Siwalik Fauna.

Rodent fossils from Dharmsala Group in Himachal Pradesh

While constraining Cenozoic evolution of the Himalaya through enlightening fossils we find that Dharmsala Group (intervening Subathu and Siwalik) in Kangra valley and adjoining coevals yield sporadic fossils. Thus, the first record of fossil rodents from Dharmsala Group is an important addition to an earlier report of dinothere from these horizons. The rodent material from grey facies of the Group comprises an isolated molar and fragments of a tooth and an incisor. Available crown details in conjunction with distinctive dimensions of the molar, 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.

Terrestrial Miocene Micromammalian Remains from Kutch

Following our recent work on the early Miocene terrestrial vertebrate fauna of Kutch, we focused in bulk

Fig. 7 : Kutch early Miocene hominid views.

processing for microfossils from Miocene beds exposed near Tapar, and Pasuda villages, near Anjar in eastern Kutch. Besides, a number of megavertebrate fossils representing diverse groups (rhinos, anthracotheres, proboscideans, ruminants) were also recovered in the field. The microvertebrates, particularly isolated rodent teeth and a possible bat molar, generally of short vertical ranges assume considerable biostratigraphic significance. In Cenozoic terrestrial sequences, rodents-based biostratigraphy is of particular importance, making rodent teeth a much sought after component of the fauna. Similarly, fossil bats are of great importance in long-distance correlation. The most significant record from these horizons is hominid dental material (Fig. 7) found associate with early Miocene assemblage; the material has been prepared and is currently under study by a team of workers from India and US.

TAT-2.3

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

(N. Suresh and Rohtash Kumar)

The Himalayan region witnessed active orogenic deformation, and the convergence are accommodated along various boundary thrusts which resulted in topographic uplift, and also controlled the Indian monsoon system. The individual and coupled impacts of climate and tectonic instabilities impact sediment flux, creation and/or destruction of accommodation space and changes in dispersal system through time and space. The sedimentary successions record history of deposition, bypass or erosion. The causes of aggradation and incision history of a landform are in response to changes in accommodation space, and can be addressed in the chronologically constrained Quaternary succession. The aggradation and degradation phases can be identified from the terrace deposits of major Himalayan rivers, and is controlled by allogenic forcing in space and time. The most felt need of the contemporary research is to understand how the allogenic forces controlled the landscape evolution in the Punjab re-entrant.

The first field work under 12th plan project was carried out along a part of the Beas valley in the Panjab re-entrant and adjoining Lesser Himalaya, between Pandoh (H.P.) and Talwara, to study the late Quaternary deposits. The Beas River flows across a series of thrusts, namely the Chail Thrust, Main Boundary Thrust (MBT), Jawalamukhi Thrust, Soan Thrust and Himalayan Frontal Thrust. Four levels of terraces (T1 to T4) were identified between Pandoh in the north and Talwara in the south.

In the hanging wall of MBT, four levels of terraces, resting over Lesser Himalayan bed rock were identified, with the T4 at the highest level and T1 at the lowest from the Beas River bed (Fig. 8a). At Pandoh, the T4 terrace sequence is 29 m thick and comprises gravel, pebbly sand and granular to coarse sand, and are lithified (Fig. 8b). The clasts are angular and consist of quartzite, limestone and slate. The sand is dark grey, fine- to coarse-grained, and is parallel and trough cross stratified (Fig. 8b). No granite clast is observed in the T4 terrace. The T3 terrace is 42 m thick sequence of gravel and sand and comprises dominantly quartzite, limestone, and slate. However, compare to T1 the clast size and roundness drastically increase with presence of around 2% granite clast (Fig. 8c). The T2 is similar in composition to T3, but gradually the percentage of granite clast increases to nearly 5%, however, T1 is poorly exposed. Further downstream, at Niyul village, the T4 terrace is very extensively developed with similar composition, however, T3 terrace is unique, comprises dominantly angular to sub angular granite and phyllite clast (2 m diameter) followed by rounded quartzite and limestone. The quartzite clasts are imbricated whereas the granite is randomly oriented and are deposited by hyper concentrated flow. At Mandi, the T4 terrace, on the right bank of Beas River, is about 20 m thick, very

Fig. 8 : Terrace deposits along Beas River: (a) four levels of terraces, resting over Lesser Himalayan bed rock, in the hanging wall of MBT at Pandoh; (b) T4 terrace sequence comprises lithified gravel (angular clasts of quartzite, limestone and slate), pebbly bed and parallel and trough cross stratified granular to coarse sand; (c) the T3 terrace consists of dominantly quartzite, limestone, slate however, compare to T4 the clast size and roundness drastically increase with presence of granite clast; and (d) the T3 terrace, resting over Siwalik rocks, comprises gravels (dominated by quartzite, volcanics, granite and undifferentiated Lesser Himalayan rocks) embedded in red matrix at Nadun.

compact and comprise of gravel and sand similar to those observed at Pandoh. The gravels consist dominantly of quartzite followed by limestone, slate and granite. The T3 is 23 m thick and comprises gravels, pebbles, sand and mud. The T2 is 20 m thick and consists of gravel, sand and mud. The gravels are clast to matrix supported, and are poorly sorted, fining upward and imbricated, and is dominantly comprised of quartzite followed by granite, limestone and slate. The sand is grey coloured, trough cross stratified and at places gritty.

All these terraces, except T4, are also observed in the footwall of MBT, but are resting over Siwaliks. South of MBT the terrace sequences were documented from Nadun area. The T3 terrace comprises gravels, dominated by quartzite, volcanics, granite and undifferentiated Lesser Himalayan rocks, and is embedded in red matrix (Fig. 8d). However, no Siwalik clast is observed. The T2 terrace comprises quartzite, volcanic and granite. The T1 terrace is very extensive and comprises dominantly of quartzite, both white and pink, granite, volcanic and limestone. In this locality, alluvial fan deposition from the Siwalik mountain was also observed. The sequence dominantly comprises gravel (red matrix) and sand lenses (red), and the clast composition is dominated by quartzite (90%) followed by granite and volcanics.

The multicyclic deposition, mainly in the form of multi levels of fluvial depositional terraces and alluvial fan suggest that, the depositional phases are interrupted by incision phases resulting from tectonic deformation and or climatic variation. The stratigraphy of these terrace deposits together with chronology is under progress 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

An extensive field work has been carried out in the Tso Morari, Ladakh during September, 2012 to recover lake-core samples (Fig.9) for late-Quaternary paleoclimatic study. Two cores, each 5 meter long, have been recovered from the northern fringe of the Tso Morari Lake. The water depth at the coring station-1 is ~4.5 meter, while the same is ~5 meter for coring station-2. The distance between the two coring stations is roughly around 250 meters while the core-2 is located more toward deeper part of the lake along WSW direction. Both the cores have been bisected into two equal halves in the core cutting unit of the Institute. One halve of the core has been sliced into 0.5 cm interval, while the other into 1 cm interval. The samples were air-dried and prepared for magnetic susceptibility studies. The magnetic susceptibility data represent considerable variability from older to younger sediments during the late Quaternary. Certain horizons have been marked for age-dating which will help to explain this variability over time span. Rest of the samples is under process for further analysis of sedimentological, geochemical and biological proxies.

Fig. 9 : Coring at Tso Morari Lake, Ladakh

Late-Quaternary paleomonsoon study in the NW Himalaya

Field work was carried out in the Rewalsar Lake, NW Himalaya during October, 2012 to recover lake-core samples for the late-Quaternary paleoclimatic study. One 14 m long core has been recovered from the central part of the Rewalsar Lake, Himachal Pradesh (HP). The water depth at the coring station is 5 m approximately. The 12 m long core, recovered from the Renuka lake, HP, was sliced contiguously at two different resolutions, 1 cm and 2.5 mm respectively. The upper two meters of the core samples were analyzed for major and trace elements, whereas four meters of samples were analyzed for environmental magnetic parameters. The magnetic susceptibility data represent considerable variability from older to younger sediments during the late Quaternary. In the Renuka lake section also, certain horizons have been marked for age-dating which will help to explain this variability over time span. Rest of the samples is under process for further analysis of sedimentological, geochemical and biological proxies.

Late-Quaternary paleomonsoon study in the Indo-Gangetic plain

Field work was carried out in the Ramnagar, Varanasi and Deoghat, Mirjapur areas of Uttar Pradesh during October-November, 2012 to perform high-resolution cliff sampling at identified section of Ganga and Belan rivers (Figs. 10 and 11). Calcrete nodules and rizocretions have also been recovered from the relevant horizons. Samples were recovered for analyzing sedimentological, geochemical and biological proxies to interpret paleoclimate, paleo-ecology and paleo-

Fig. 10 : Cliff section along the Belan River, near Deoghat, Mirjapur, U.P.

Fig. 11 : Sample collection from the river cliff section.

vegetation of the Gangetic plain during the late-Quaternary. Around 180 numbers of samples have been collected at contiguous 5 cm interval from 9 m steep cliff at Oriya Ghat, Ramnagar, Varanasi, U.P. On the other hand, 400 samples have been collected at contiguous 5 cm interval from around 10 m high cliffs on either side of the river Belan at Deoghat, Mirjapur, U.P., of which around 180 samples from Oriya Ghat, Ramnagar, Varanasi have been processed for analyzing grain size, magnetic susceptibility, major and minor elements and stable isotope for carbon, oxygen and nitrogen.

TAT-2.5
Climate Variability and Treeline Dynamics in Western Himalaya

(P.S. Negi and Jayendra Singh)

Field work has been conducted in the month of October for 12 days to study the alpine treeline dynamics and associated climate variability in Alaknanda catchment, especially in Chorabari Glacier valley. The treeline reference points established with masonry (size 2x1.5x1.5 m) at the elevation of 3600 m asl (N 30^{0}42′36″ and E79^0 03′ 12″) and at 3460 m (30^{0}41′ 52″ and E 79^0 03′ 87″) along the Mandakini Nadi were revisited to study the floristic composition, and its invasion to the erstwhile snow/glacier regime (Fig. 12). Two more reference points have also been marked and studied, the results of which are consistent to the earlier investigated treeline dynamics rate i.e., 10 m/yr. The samples of dominant species from treeline composition were collected, prepared for onwards identification form standard herbarium. In order to validate the treeline dynamics and to develop climate responsive tree-ring chronologies for climate reconstructions, tree cores of *Betula utilis* has been collected from different ecotones and treeline elevation transects. Aerosols monitoring instrument are being procured for further installation in the study area. A preliminary survey of Gangotri valley in Bhagirathi River catchment has also been carried out to understand the treeline dynamics and associated ecological affinities related to the climate change implications. Tree-rings samples of *Betula utilis* from limited area were also collected to understand long-term climatic variability. The tree cores were mounted on the wooden slot and being processed for further analysis.

Cedrus deodara ring-width chronology was developed from the Purbani, Kinnaur, western Himalaya. The chronology was tested for the climate change studies. The results revealed that trees growing in river catchment area under precipitation stressed conditions could be utilized in developing river discharge records back in time. Composite ring-width chronology for the first time from India using together tree ring-width series of *Cedrus deodara* and *Pinus*

Fig. 12 : Alpine treeline with masonry reference point (3600 m asl) at Chorabari Glacier valley in Alaknanda catchment.

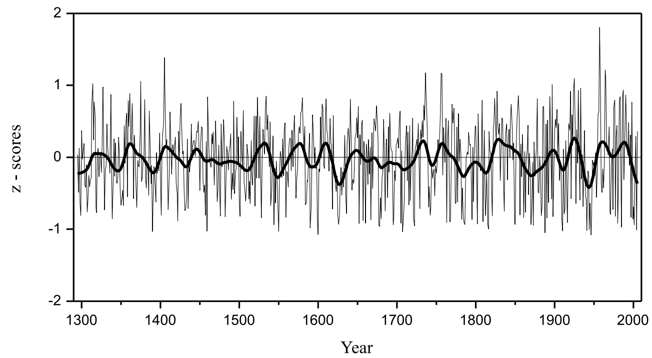

Fig. 13 : Satluj river discharge (pDec-July) reconstruction (AD 1295-2005), bold line is 30 year smoothing spline.

gerardiana growing in the Kinnaur region was developed. The composite ring-width chronology was further used to reconstruct previous year December to current year July (pDec-July) Satluj River discharge extending back to AD 1295 (Fig. 13). This is longest (AD 1295-2005) so far tree-ring based river discharge record from the Indian region.

TAT-2.6

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

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

Major ions and stable isotopes were measured in the samples collected from the Indus, Shyok and Nubra Rivers. The results obtained have been used to infer about the nature of weathering (silicate vs. carbonate) in this drainage. Stable isotopes ($d^{13}C_{VPDB}$) range from 0.4 to -5.7‰ and silica from 73 to 280 mE. Variation of $d^{13}C_{VPDB}$ measured in dissolved Inorganic Carbon (DIC) with concentration of SiO_2 (Fig.14) in Indus River waters shows that the alkalinity in these rivers is linked with silicate weathering. Therefore the silicate weathering seems to serve as a dominant mechanism to produce the alkalinity in these Rivers. This observation is also supported by the fact that the silicates (granites, gneisses, schist etc) in Indus valley comprises mainly of minerals including quartz, plagioclase, alkali feldspar biotite and muscovite and dissolution of which can produce the silica and alkalinity together. The possibility of significant silicate weathering in the Indus River system also finds support from the fact that it is flowing through the Indo-Psongpo Suture zone with a high tectonic activity and highly fractured/sheared rocks that are prone to weathering. Further work is underway.

In the Himalayan zone of Ramganga river flight of terraces are observed at Gairsain, Ganai, Caukhutia, Masi, Sanana, Sinala, Naula Siyalde, Jamariya village, Dhargaon Bhatkot, along Ramganga near Kurmar village, Bhikiasain Marchula, Dhikala and Kalagarh suggest vertical aggradation and lateral shifting of the river channel. Lacustrine deposits at Janal in Dharu Gadhera are observed during field investigation. Thick sand deposits about 17 m high relief observed along Bugoti Nala a tributary of Ramganga river at Kurali Bagota section seems to be deposited by Ramganga

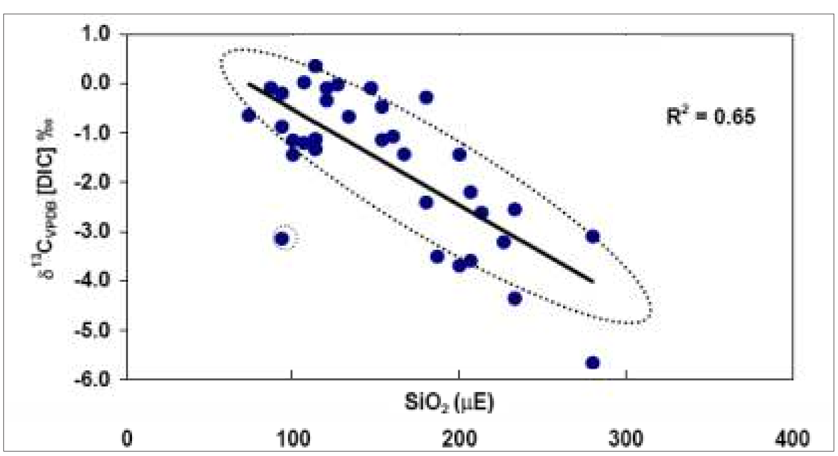

Fig. 14 : Variation of $d^{13}C_{VPDB}$ [DIC] with concentration of SiO_2 in Indus River system indicating the Alkalinity in these rivers is linked with silicate weathering. Dotted ellipse shows a linear trend. R^2 of this trend exclude one sample with dotted circle from a local stream flowing near Baralacha La region.

itself. The actual configuration of these terraces will unfold the past-tectonic and past-climatic responses of this fluvial system in the Himalaya. In the Ganga plain this river shows minor incision and wide lateral shift leaving behind series of meander lakes that bear the signature of past climatic changes and also varying hydrological regime of this river. The morphometric analysis of the basin has a particular relevance to geomorphology of the area. The seventh order Ramganga basin is having 11915 first order streams followed by 2599 second order, 592 third order, 125 fourth order, 31 fifth order, 3 sixth order, and finally 1 seventh order streams numbered from origin of the streams at Dudhatoli ridge to Kalagarh from where river Ramganga entered into the plain. The impact of the morphological characters on the terrain is reflected by the drainage basin of the area. The repetitive calculated values of all the morphometric parameter of 38 fifth order intrabasins for different lithotectonic units were processed in the form of scattered diagrams. The morphometric parameter of aerial aspect like drainage density, stream frequency, texture ratio, form factor, circularity ratio, and elongation ratio suggests that the basin are controlled by altitude (climate) as well as the nature of bed rocks. Pairwise relationship between various parameters suggests that the development of drainage is typical for higher crystalline zone where as the drainage in lower areas represents a normal development under fluvial conditions. The morphometric parameters under relief aspect viz basin relief, relative relief, relief ratio, dissection index, ruggedness index and slope have been analyzed to workout homogeneity in landform units.

In addition to the above, major ion , trace elements and stable isotope ($\delta^{13}C_{DIC}$ and $\delta^{18}O$) were also conducted in the ground waters of the upper Ganga plain (covering Ramganga-Ganga stretch) to trace the pollution near the major industrial cities like Moradabad, Lucknow, Kanpur and Varanasi. Results indicate the presence of elevated levels of Arsenic (As) abundances (up to 173 ppb against permissible limit of 10 ppb) in certain parts of Badaun region. Suspended load recovered from these waters also have slightly higher concentrations of As and Fe, and hence indicate that As might be adsorbed on the surface of iron rich particles. Further studies and interpretations are underway.

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 and Santosh K. Rai)

Synthesis of the data had been carried out during this year to understand the climate variability in the Himalayan region. The tree core samples in the form of increment core of *Cedrus deodara* were collected from seven locations in the Kinnaur, Himachal Pradesh. The ring-widths of each tree core were measured with 1micron accuracy, and dated each tree-ring to the level of calendar year of their formation, which revealed that the oldest tree sampled from the area is more than millennia long. Tree cores collected from the Meghalaya are being processed, which would provide valuable information of climate variability in the past.

The cave samples were also collected from Arki and adjoining areas in Himachal Pradesh. Uranium series methodology dating showed that four speleothems collected from the caves of Meghalaya and one speleothem from Himachal Pradesh belongs to various time period, ranging from Recent to late Early

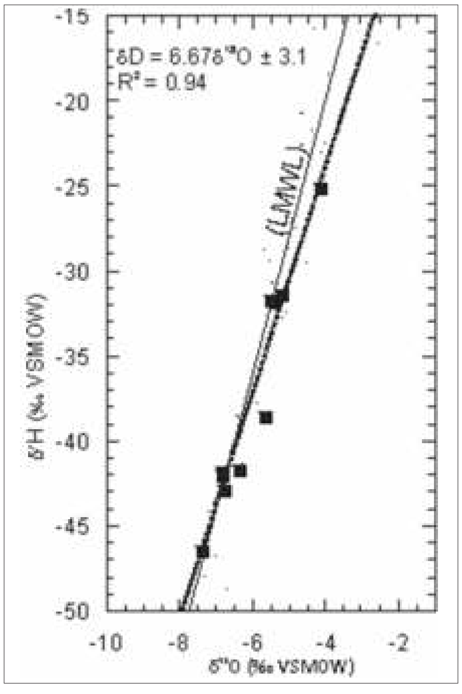

Fig. 15 : d^2H vs $d^{18}O$ plot with Local Meteoric Water Line (LWML).

Pliestocene. The stable isotope analyses of 318 subsamples at millimetre scale of one speleothem from Meghalaya showed that $d^{18}O$ varies from -5.0 to -6.5. The study of thin section study reveals the presence of fluid inclusion in the speleothem samples of the Meghalaya.

The analysed water samples of Meghalaya caves and drip water nearly follow the Local Meteoric Water Line (LMWL) which is found indistinguishable from the Global Meteoric Water Line (GMWL) indicating meteoric origin of water. The $d^{18}O$ values range from -6.8 to -5.2 ‰ in the Umsynrange cave, -7.7 to -5.5 ‰ in the Mawkhyrdop cave and in Mawrkyrdop stream water $\delta^{18}O$ value remains -6.4 ‰. The $\delta^{18}O$ values of Mawkhyrdop cave are more negative because this area receives highest amount of rainfall (10,000 to 12,000 mm). The $\delta^{2}H$ values range from -42.8 to -31.8 ‰ in the Umsynrange cave, - 46.4 to -31.7 ‰ in the Mawkhyrdop cave and remains -41.6‰ in the Mawkhyrdop stream water. The small deviation of $\delta^{2}H$ vs $\delta^{18}O$ plot of the analysed water from the LWML shows evaporation effect and it signifies as river/surface water characteristics (Fig. 15). Further to assess the water quality, major cations and anions of water samples were analysed, which showed calcium and sulphate values above maximum permissible limit for drinking water as per the BIS standard in the karst aquifer water of Mawkhyrdop cave.

To understand the possible role of microorganisms in carbonate deposition used to decipher paleoclimate and paleomonsoon, cave samples of Sahastradhara caves were analysed. The cellular structures and diatoms of microbiological origin have been found in the petrographic thin sections and further confirmed in the Scanning Electron Microscopy (Fig. 16). The microbial fossils observed are semi circular filamentous structure of cyanobacteria (Fig. 16a) and a well preserved spheriodal cell (Fig. 16b). Combined SEM and Energy Dispersive X-ray Microanalysis (EDX) of these microbes have been done and shown in figures 2b and 2d respectively. The predominance of Ca is recorded in the microbes in EDX analysis, however Si, K, S, Mg and Cl is also present in minor amount in some of the microbes such as diatoms etc. Microscopic studies of the stalactites and stalagmites from the Sahastradhara caves show normal, wavy as well as

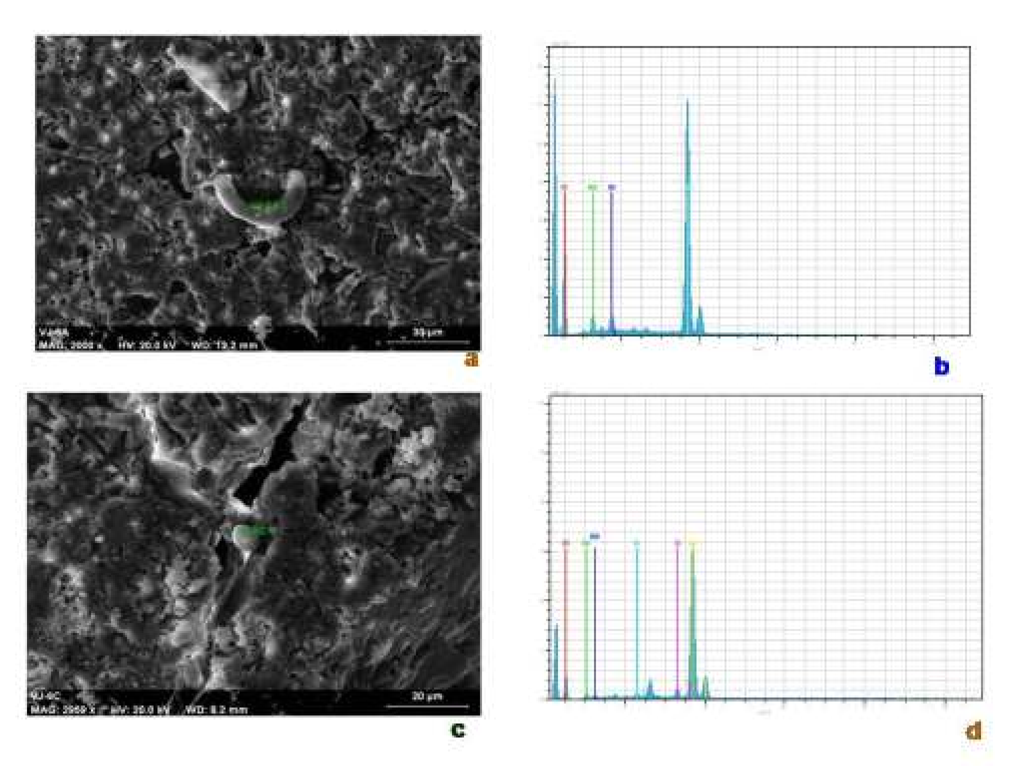

Fig. 16 : Scanning Electron microphotographs and EDX of the filamentous and spheroidal microorganisms from the Sahastradhara.

crenulated laminations of precipitation. The microfacies of the speleothems show micrite, sparite sparry dolomite, radiaxial fibrous calcite. Possibly the Mg has triggered the formation of radiaxial fabric. Various types of light (carbonate) and dark (organic) laminae of various thicknesses are observed, and are related to the microclimatic decadal scale seasonal variations. The interlaminar spaces are highly recrystallized due to intense diagenetic process. More than 200 μ dolorhombs have been found in the diagenetic change.

The petrographic identification of the Mg calcite is further confirmed by the XRD peaks of calcite. The SEM-EDX combined study of the filamentous and spheroidal microbes and diatoms have shown the presence of mainly Ca in the cells and suggest microbial origin. Study of modern cave drip waters and stalagmites demonstrate that the stalagmites were deposited in or very near to isotopic equilibrium. The $\delta^{18}O$ isotope data of drip water from Sahastradhara cave in Dehra Dun during the monsoon season (August and September, 2007-2011) varies from -4.58 ‰ to 5.14 ‰ (VPDB). This study in combination with other study have interpreted that the western part of Indian Summer Monsoon (ISM) in Oman and Yemen, the oxygen isotope ratios of stalagmite calcite primarily show variations in the amount of rainfall with more negative $\delta^{18}O$ indicating higher monsoon rainfall.

The oxygen and carbon isotopic analysis of the drip water and speleothem samples collected from this pre-monsoon and during monsoon season is in progress. It is concluded that, the speleothems are very significant for the paleoenvironmental and paleoclimatic records in addition to the geomicrobiological process in the Sahastradhara cave system.

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)

The Institute is operating 41 Broad band seismographs in the NW Himalaya and a network consisting 8 Broad band seismographs in Sikkim Himalaya and other Geophysical equipments. The data is being acquired and analyzed continuously by the networks. During July 2007 and March 2013, a total of 18,026 events have been detected which includes 3739 local events, 5741 regional events, and 8546 teleseismic events (Fig. 17). 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. Variations of Vp/Vs ratio have been studied for the period July to February 2013 (Fig. 18). No anomalous pattern or any other precursor phenomenon is identified during the one year period between April 2012 and March 2013, a total of 3248 events have been detected which includes 315 local events (Figs. 19 and 20), 1033 regional events, and 1900 teleseismic events. The seismic moments for 578 shallow focus earthquakes range from 5.6×10^{11} Nm to 7.14×10^{14} Nm. These earthquakes are found to have very low stress drops; 235 events have less than 1 bar, and for 201 events between 1 bar and 10 bars. The maximum stress drop is found to be 41.9 bars for an earthquake of magnitude 4.9. It is significant to note that the seismicity pattern of Garhwal-Kumaun region as recorded in the present network suggests that, the region south of MCT trending along Munsiari thrusts and faults is seismotectonically active. The region continues to record shallow focus events with low stress drop values. Detection threshold of magnitude 1.8 events have been

TAT - 3 : EARTHQUAKE PRECURSORS STUDIES AND GEO HAZARD EVALUATION

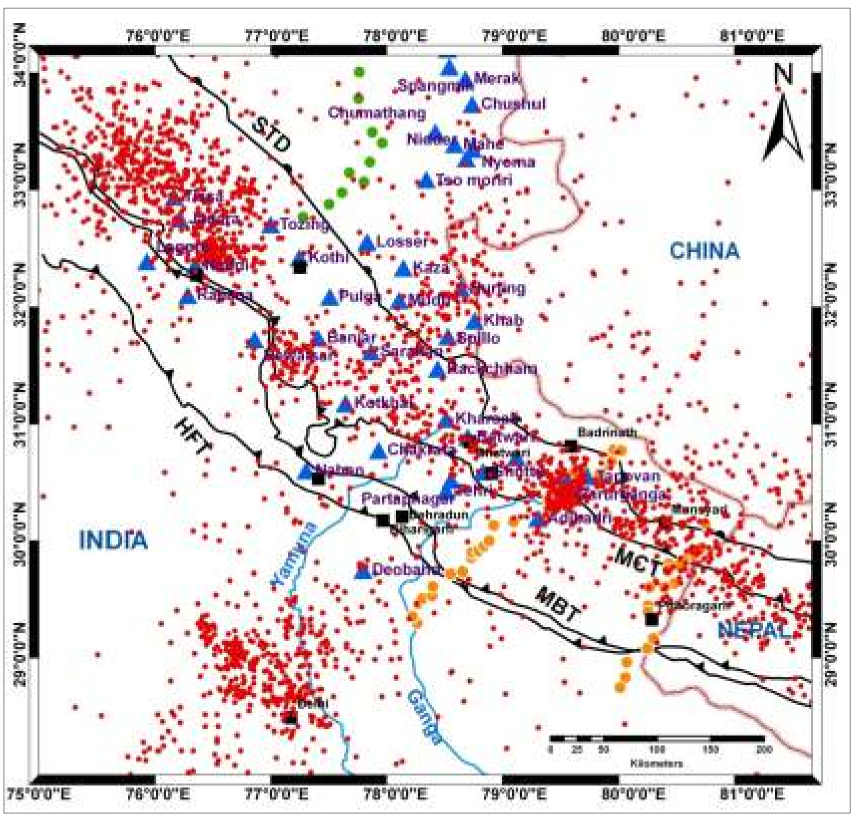

Fig. 17 : Seismicity plot for the events recorded from 2007 till March 2013.

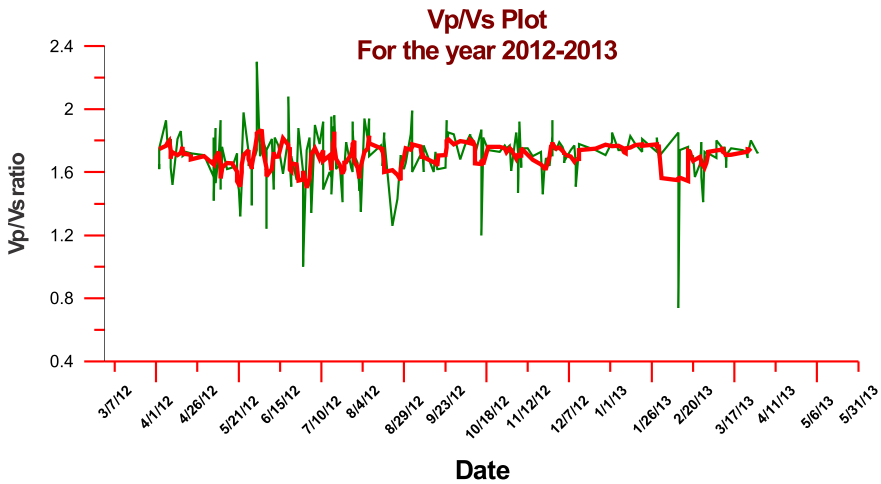

Fig. 18 : VP/VS plot for the events recorded from April 2012 till March 2013.

achieved. On-line data of 10 stations is also shared with 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.

Earthquake data are collected from seismic stations of Tehri network (Garurganga, Bhatwari and Badshahi Tahul seismic stations) and Ladakh network. The data extracted is processed for location of earthquake parameters. Local and regional earthquakes recorded by Kangra-Chamba network are also processed and analyzed for the period 2011-2012. This database is being used for different seismological studies such as source mechanism study and stress and strain analysis in the Himalaya. Also, during this period aftershock data of Sikkim earthquake of 18th September 2011 was collected, and events are extracted from eight numbers of broadband seismic stations for further

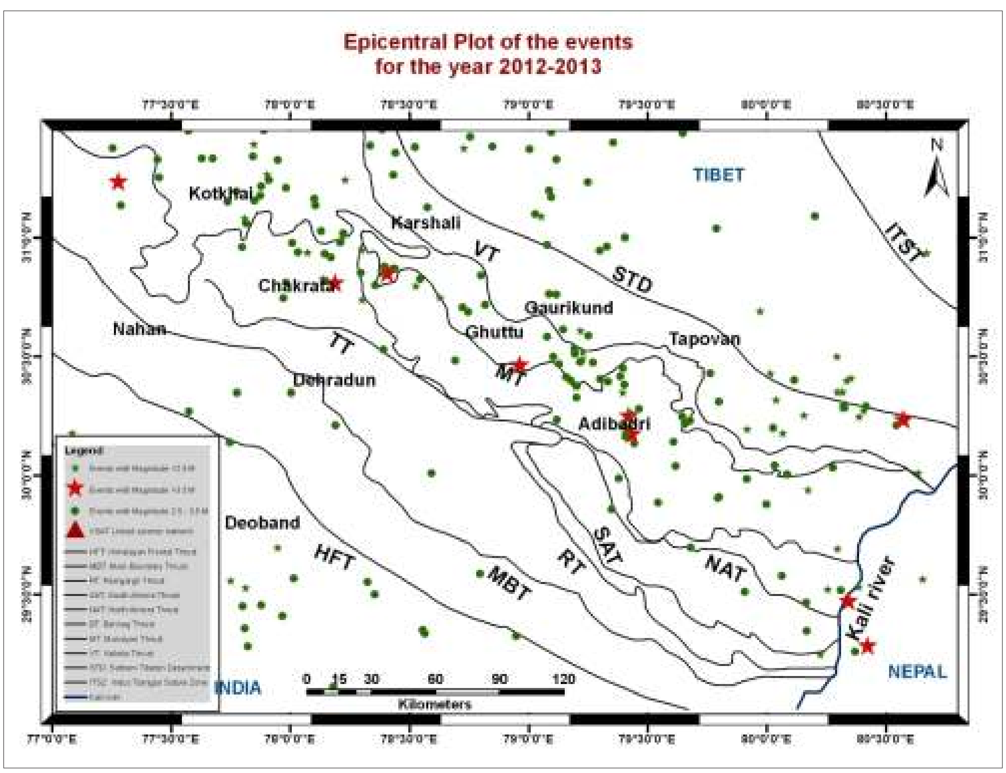

Fig. 19 : Seismicity plot for the events recorded from April 2012 till March 2013.

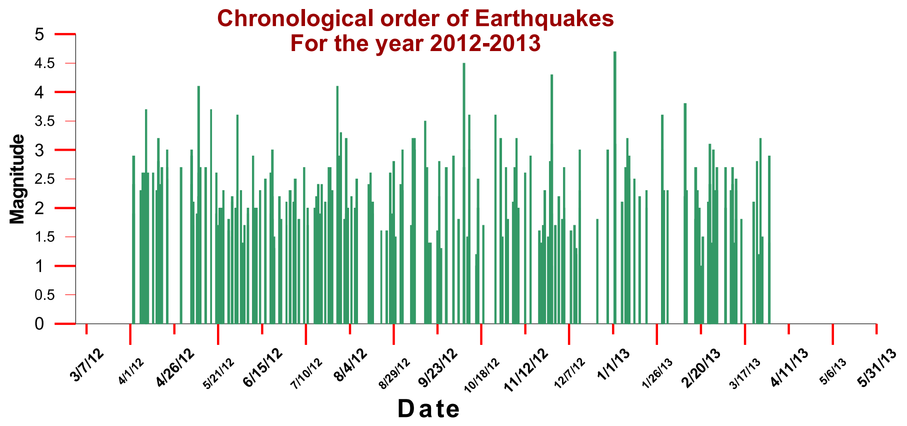

Fig. 20 : Magnitude vs Date plot for the events recorded from April 2012 till March 2013

analysis of seismicity and seismoctectonic of the region.

Active Tectonics of Himalayan Thrust/Fault System in NW Himalaya

The Institute is operating a broad band digital seismic network, consisting 41 stations, in the NW Himalaya shows a concentrated belt of local earthquakes in the Main Central Thrust (MCT) Zone and the physiographic transition zone between the Higher and Lesser Himalaya. However, there is quiescence of such activity in the Himalayan frontal zone where surface rupture and active faults are reported (Thakur et al., 2007). The hypocenters of these earthquakes mainly are distributed at shallow (up to 20 km) depth. Recent moderate magnitude earthquakes including 1991 Uttarkashi (Mb 6.6) and Chamoli (Mb 6.8) occurred on the same seismic belt where elastic strain is accumulating. GPS measurements indicate the segment between the southern extent of seismicity zone and the HFT is locked. The great earthquake originating in the locked segment may rupture the plate boundary fault and can propagate to the Himalaya front.

B-value estimation in the NW Himalaya using a MATLAB code base for Earthquake precursory studies

A systematic study of b-values in NW Himalaya has shown that within the vicinity of forthcoming large earthquakes there is initially a decrease and then increase in b-value and finally approaching to normal. The moderate Uttarkashi (1991) and Chamoli (1999) earthquakes triggered in the NW Himalaya, India, shows the same phenomenon. The study region Northwest Himalayan and the adjoining regions fall in the most intense seismic zone. Earthquakes of varying intensities have hit the region in the past and similar threats remain imminent. In the last 105 years, the main earthquakes occurred are the Kangra earthquake of 1905 (Ms=8.0), the Kinnaur earthquake of 1975 (M=6.8), Dharchula earthquake of 1980 (Mw=6.5), Uttarkashi earthquake of 1991 (Mb=6.6), Chamoli earthquake of 1999 (Mb=6.8) and the Kashmir earthquake of 2005 (Mw=7.6), which resulted in tremendous loss of life and property. In this work detailed study of the frequency-magnitude distribution has been carried out using MATLAB code base written for this purpose. Three improvement measures pointed to the past error to calculate b-values have been proposed: (1) Uniform magnitudes, Completeness: Data with magnitudes ≥ 3. (2) De-clustering: To avoid dependent data, the catalogue is de-clustered by deleting all the fore shocks and aftershocks; (3) discard the magnitude point in which some earthquakes are missing, and then computed the b-value using Gutenberg-Richter relation; and using Maximum likelihood method. The b-values all approach to 1.0 for twenty four sets of various precision and sources. Total 2151 well-located earthquakes, recorded in NW Himalaya during 1985-2012 have been analysed for b-value estimation. Error estimation of b-value has also carried out. The results demonstrate that the moderate earthquake between 6 and 7 are well consistent with b-value behaviour from the well constraints data of 28 years earthquakes.

Seismic wave attenuation characteristics from seismic coda analysis

Digital seismogram data of 75 earthquakes that occurred in Garhwal Himalaya region during 2004 to 2006 and recorded at different stations been analyzed to study the seismic coda wave attenuation characteristic (Fig. 21).

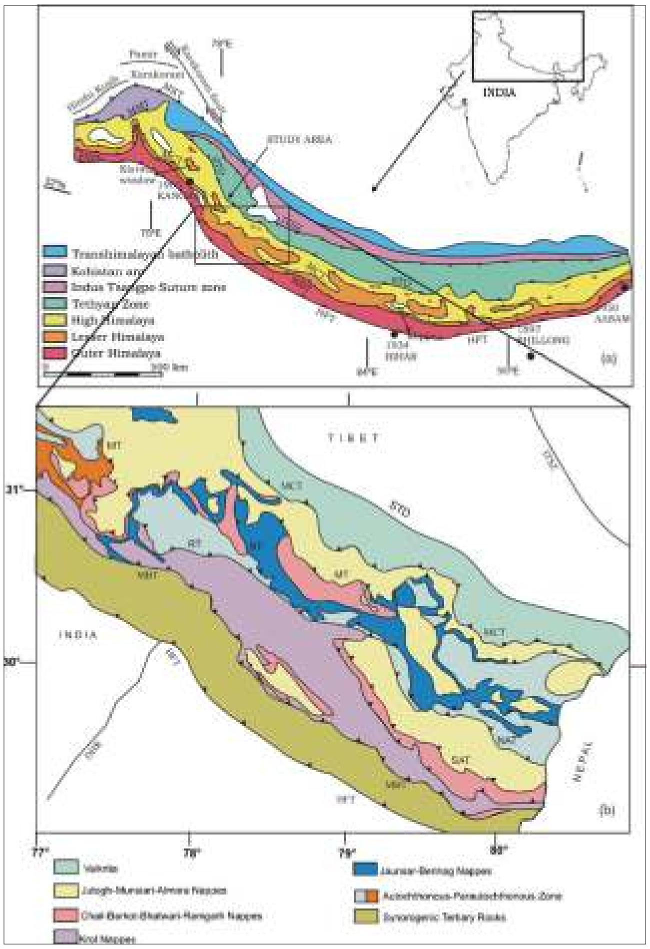

Fig. 21 : Map of study area, modified after Valdiya, 1980.

Seismic coda wave attenuation, Q_c, characteristic in this region is studied using 128 seismic observations from local earthquake events with hypocentral distance less than 250 km and magnitude range between 1.0 to 4.0. Coda wave attenuation Q_c is estimated using the single

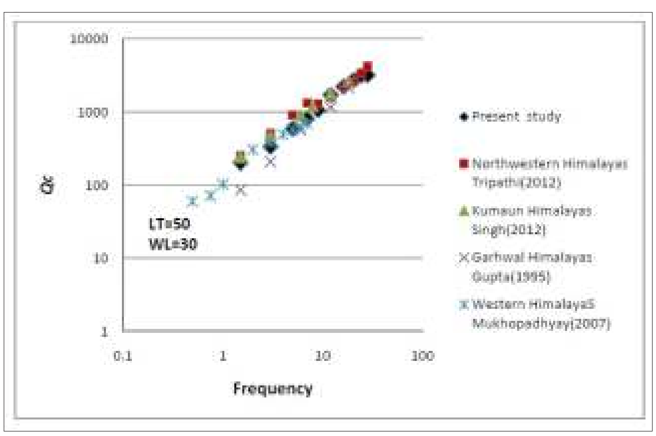

Fig. 22 : Comparison of estimated Qc with other studies of Himalayas.

isotropic scattering model. The coda wave is consider to be composed of single back scattered waves from randomly distributed inhomogeneities. Q_c values are estimated at 10 central frequencies 1.5, 3, 5, 7, 9, 12, 16, 20, 24 and 28 Hz using several starting lapse-times and coda window-lengths. Lapse time is considered from the origin of an earthquake. The Q_c values are frequency dependent. In the considered frequency range they fit the frequency dependent power-law $Q_c=Q_0f^n$. The frequency dependent power law for 10 sec lapse-time 10 sec coda window-length is $Q_c = 47.42\ f^{1.012}$, which correlates well with the values obtained in other seismically and tectonically active and heterogeneous regions of the world. The variation of coda attenuation has been estimated for different lapse-time and window-length combinations to observe the affect with depth. Results indicate that in the study region the heterogeneity decreases with increasing depth (Fig. 22). Attenuation parameter Q_c is an important factor for understanding the physical mechanism of seismic wave attenuation in relation to the composition and physical condition of the Earth's interior (Sato, 1992) and it is also an indispensable parameter for the quantitative prediction of strong ground motion for the viewpoint of engineering seismology. Hence numerous studies of Q_c have been carried out worldwide by using different methods and concentrate on seismically active zones and densely populated area.

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)

The critical analysis of different geophysical time series indicates that every time series is influenced by local, regional and external field. The observations show that the time-variability of the gravity field is influenced by soil moisture and ground water fluctuations. The flux of radon emission in the soil is strongly dependent on environmental factors like temperature and hydrology. These influences are the major deterrents in the isolation of weak precursory signals particularly at the time of occurrence of small magnitude earthquakes. The different parameter geophysical data recorded at MPGO Ghuttu have proved critical in identifying the parameters determining the time variability of each time series. This quantification has been benefited by the thoughtful selection and recording of meteorological and hydrological parameters that influence the various geophysical signals. Having recognized this, the next execution phase of the programme involves establishing physical and statistical models to estimate and eliminate effects of solar-terrestrial, hydrological/environmental factors on different geophysical time series. Some test applications in progress demonstrate that if effects of environment and hydrology are not recognized and corrected for some perturbations, they will falsely be identified as earthquake precursors. On the other extreme, some precursory signals are masked by factors other than stress-induced changes. Some results obtained for the current data set are as follow :

Geomagnetic and Electromagnetic Observations

The electromagnetic field variations and geomagnetic field variations are continuously monitored at Ghuttu, Bhatwari and Adibadri stations of Garhwal Himalaya. In absence of continuity in the electric power supply at Bhatwari and Adibadri, it is becoming little bit difficult to maintain continuous operation of ULF band EM units at these stations. In order to isolate precursory seismo-EM signatures from natural EM variations, different methodologies have been adapted and a new index has also been proposed. Efficacy of this new index depends upon simultaneous observations of ULF band EM observations at two or more sites. Polarization ratio and behaviour of spectral exponent in the power law relation $S(f)= f^{\beta}$ have been used successfully in discriminating the seismo EM signals of moderate earthquakes. Temporal variations of fractal dimension reflect nonlinear dynamics of earthquake preparation processes in the area. Night time difference plots are utilized for the continuous data of three observatories to identify the tectono-magnetic signals. Earthquakes within radius of 100 km from MPGO Ghuttu stations are considered for analysis to search precursory signals. Figure 23 depicts an example for an earthquake of magnitude 4.5 that occurred on May 15, 2009 at 54 km distance towards NE direction from Ghuttu.

Seismo-magnetic effects are the localized changes in geomagnetic field intensity which in some manner appear to be associated with earthquake occurrence. Although exact mechanism for these changes is still debatable but Piezo-magnetic effect, electro-kinetic phenomenon etc is invoked to explain the possible occurrence of these localized changes. Modeling of these changes based on earthquake parameters (epicenter distance, focal depth and magnitude) are in process so that a definite prognostic value can be given to these observations.

Radon and borehole data

The radon data, generally known as a key parameter of earthquake precursors is being monitored at two places. One observation is in a 68 m borehole along with few other parameters and other observation is in a 10 m borehole. In 68 m borehole the recording is performed at two depth points, at 10 m depth is the collection within the soil and at 50 m depth the collection of radon is

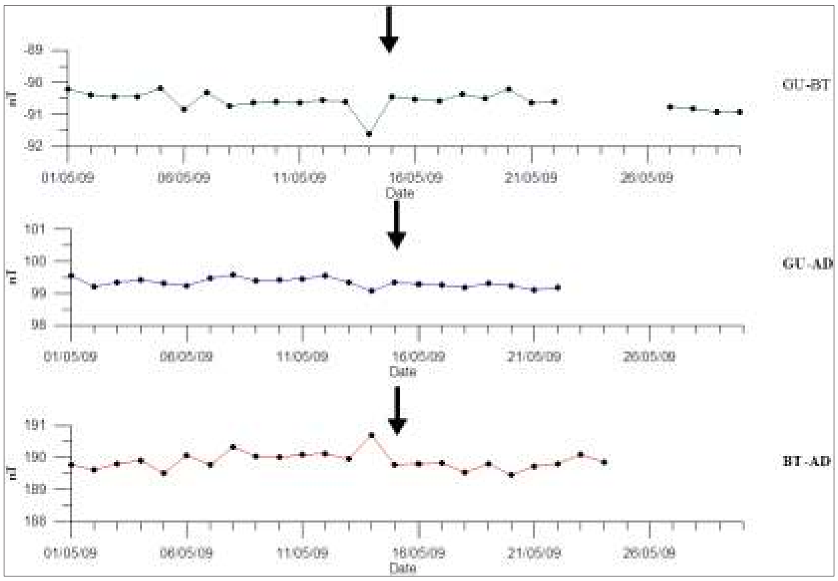

Fig. 23 : Differential plot for total magnetic field.

within water table. To simplify the data processing and to remove the high frequency variations, the raw data of radon time series with measurements at 15 minutes resolution are averaged to 1 h and one day intervals. The variations in the continuous time series of the radon and other parameters are shown in figure 24.

The six years data from 2007 to 2012 of radon, atmospheric temperature and atmospheric pressure show prominent annual cyclicity. The strong seasonal variations in radon show high values in the summer months (July-September) and low values in the winter months (December-February) closely followed the similar variations in atmospheric temperature and groundwater level fluctuations with time lag of few days. The average values of internal air temperature in the borehole at 10 m depth are nearly constant except during the rainfall period. During the rainy season the increase in water level causes a marginal drop in borehole temperature of 0.3˚C every year. On the

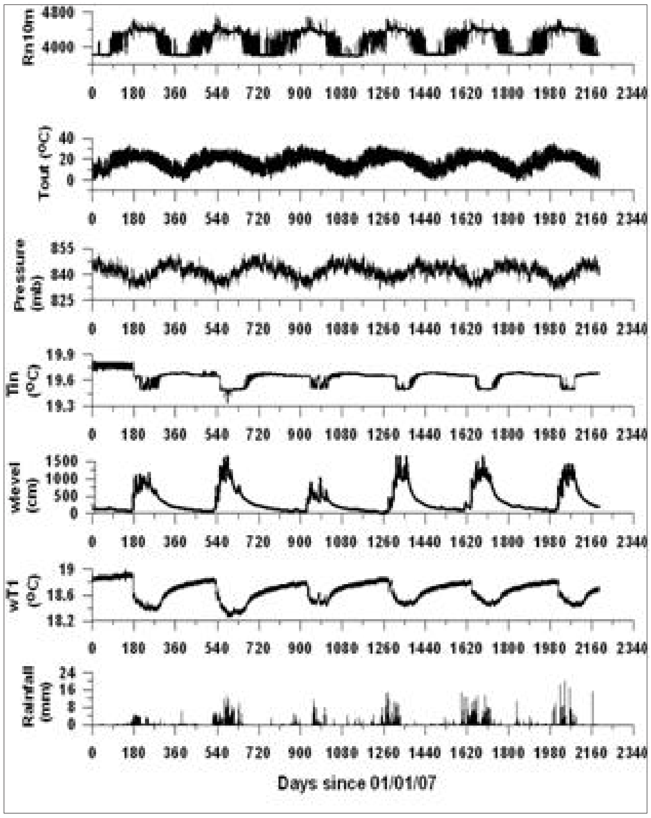

Fig. 24 : Daily mean time series of radon (Rn10m) and other environmental measurements (atmospheric temperature (Tout), atmospheric pressure, internal borehole air temperature (Tin), water level (Wlevel), borehole water temperature (wT1) and rainfall) for the period 2007 to 2012.

seasonal scale, rainfall shows a negative relationship with atmospheric pressure. The increase in water level is closely associated with the rainfall intensity in the catchments area. The water level, rainfall and borehole temperature do not exhibit diurnal periodicities but display seasonal dependences.

GPS monitoring

Space geodetic techniques have evolved as an important tool for monitoring deformation of the earth's crust. Permanent Global Positioning Systems (GPS) have been established by Wadia Institute of Himalayan Geology (WIHG), Dehradun at several sites in the Himalaya for crustal deformation study.

As a part of this reservoir study, we analyzed the existing GPS data that was acquired in twelve bench mark stations (HNBG, BHAL, MOTN, GWAD, OKHL, KANG, NEGI, RAZA, TIPR, KUTH, JAAK and JUDA) on campaign mode between the years 2006 and 2008, The observations were taken twice a year corresponding to the filling and drawdown cycles of the Tehri reservoir. We are monitoring a permanent station at Ghuttu located 60 km north from the dam site. TOPCON receivers are used in the data acquisition. The GPS raw data is acquired in TPS format. Conversion to RINEX format was performed for further analysis through utilities TPS2RIN and TEQC. The software GAMIT Version 10.32 has been used for next phase of processing and estimation of three dimensional relative positions of ground stations and satellite orbits. In addition to our campaign mode stations we used data from IGS stations, namely, BAHR, TEHN, POL2, KIT3, WUHN, KUNM, IISC, HYDE, BAN2 and DGAR stations. We obtained the time series data for our twelve sites to check the component variations; however we illustrated the time series of one station JUDA (Fig. 25). The processing of the entire campaign mode GPS data was done with reference to ITRF05. The analysis of deformation due to the reservoir loading and unloading was performed. We obtained velocity vectors with respect to our permanent Ghuttu station. The velocity vectors in the three campaign surveys show a motion of 12-51 mm, 28-86 mm and 40-114 mm with respect to ITRF05. The velocity of the permanent station at Ghuttu is 38.06 mm/yr with reference to ITRF05. We have estimated ground motion exhibited by our 12 bench mark locations with respect to the station at Ghuttu. The produced velocity vectors show the ground motion between ~0.69-1.50 mm with reference to the Ghuttu in

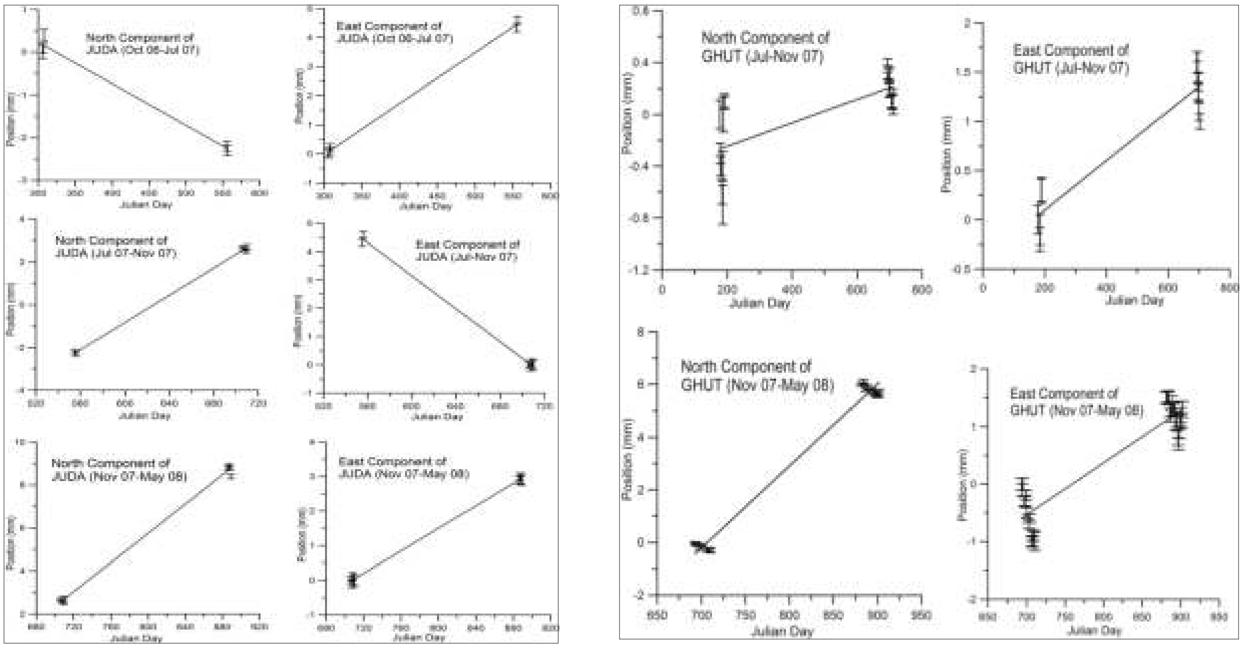

Fig. 25 : Horizontal component variations of the station JUDA corresponding to different campaign surveys between 2006 and 2008.

the different filling-drawdown cycles of Reservoir (Fig. 26).

We also tried to detect any significant precursor in the GPS time series of GHUT station before triggering the Kharsali earthquake event of M 4.9 in 2007. We analyzed the time series of GHUT and observed some anomalous changes (Fig. 27).

Free Earth Oscillation observed using Superconducting Gravimeter data

The Superconducting Gravimeter (SG) installed at MPGO, Ghuttu (only instrument in Himalaya) collects sub μGal level temporal variation of gravity recorded at 1 SPS. Continuous gravity data collected during last six years at Ghuttu indicates that the highly sensitive gravity variation to sub Gal level is influenced by tidal effects, atmospheric pressure and hydrological effects. These surplus effects sampled in the gravity measurement are removed to continuously monitor the variation for any unusual change. The atmospheric pressure variation is also observed at the same sampling rate through integrated probe for SG equipment to remove the pressure effects from gravity data. The observatory is also recording continuous data of water level fluctuation in a 68 m deep borehole and the rainfall density using rain gauge. The hydrological effects are removed using these data sets. The SG has been calibrated using the absolute gravimeter to remove the tidal effects.

Great earthquake of magnitude 8.7 was occurred on April 11, 2012 in the Sumatra coastal region of Indian Ocean. In this region a devastating M9.2 Tsunami generated earthquake was occurred on December 26, 2004 which has caused over 3,00,000 causalities in the coastal region including south Indian region. This time also the Tsunami was expected and declared by USGS, however, it was taken back. The earthquake size was capable for generating the Tsunami however the focal depth (30 km) was much more compared to 2004 earthquake and size was less. The SG is the most sensitive instrument suitable for carrying out minor vibrations of Free Earth Oscillations (FEO). We observed frequencies of several spheroidal oscillations (Fig. 28) in the SG data of Ghuttu excited by this great earthquake. The periods of many FEO, including the gravest mode ${}_0S_2$ and breathing mode ${}_0S_0$ show reasonable agreement with earlier studies and validate the quality of the data recorded for envisaged objectives with the continuous long-period data being registered. Further, some of the large earthquakes from the Sumatra-Java section and elsewhere have excited the FEO. Such datasets, once corrected for tidal and other

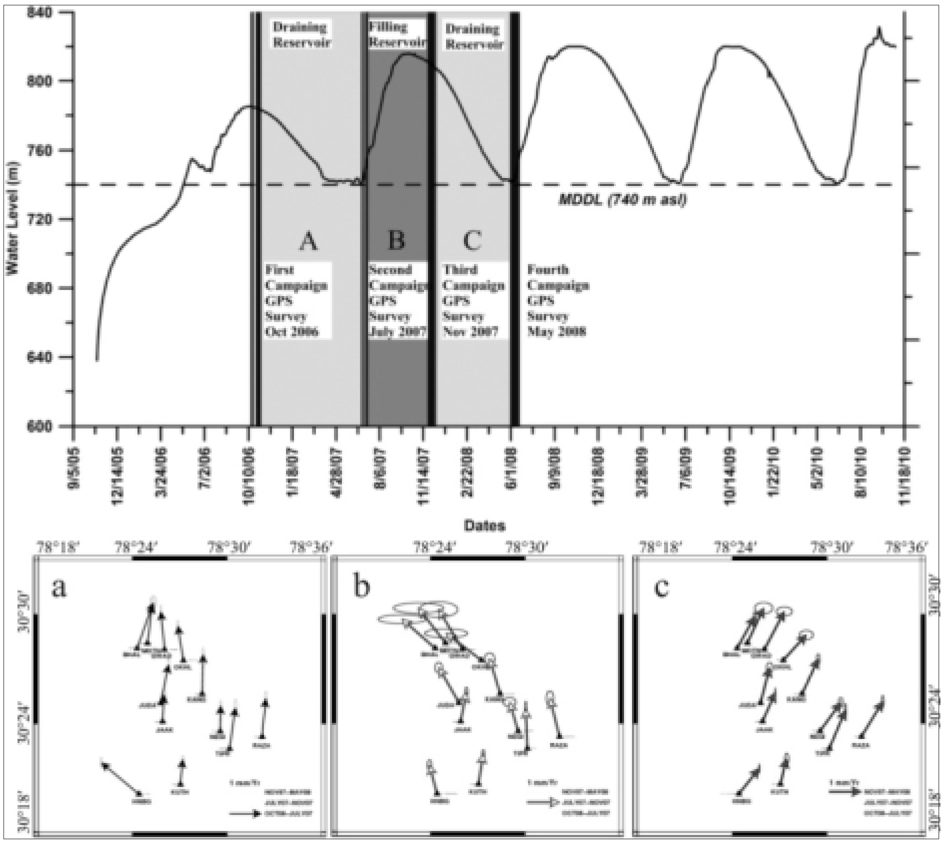

Fig. 26 : Water level data of the Tehri Reservoir from 2005 to 2010. GPS data was collected in campaign mode in 2006, 2007 and 2008 corresponding to A) draining period (Oct. 2006 to July 2007), B) while the reservoir was filling (July to Nov. 2007) and again C) when the reservoir was draining (Nov. 2007 to May 2008). Figure also shows GPS velocity vectors with respect to Ghuttu permanent station. The motion of the ground was observed to be away from the reservoir area (a and c) during drawdown period (A and C) and inwards (b) during filling period (B).

long-period variations, could permit establishing the true nature of low-order gravest mode. The detail study is in progress for the data of other 6 large magnitude earthquakes occurred during the 2007-2012. The identification and correction of data will be useful for further earthquake precursory research.

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 and A.K. Mundepi)

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

The earthquake damage is generally larger over soft sediments than of firm rock outcrops. 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, then the damages of seismic events could be minimized. In this study, the geophysical approaches (H/V method) were applied in the Doon valley, as it is convenient and inexpensive, and the rapid city growth makes a microzonation study necessary for the city development. Nakamura (1989) demonstrated that the H/V ratio of the ambient noise records is related to the

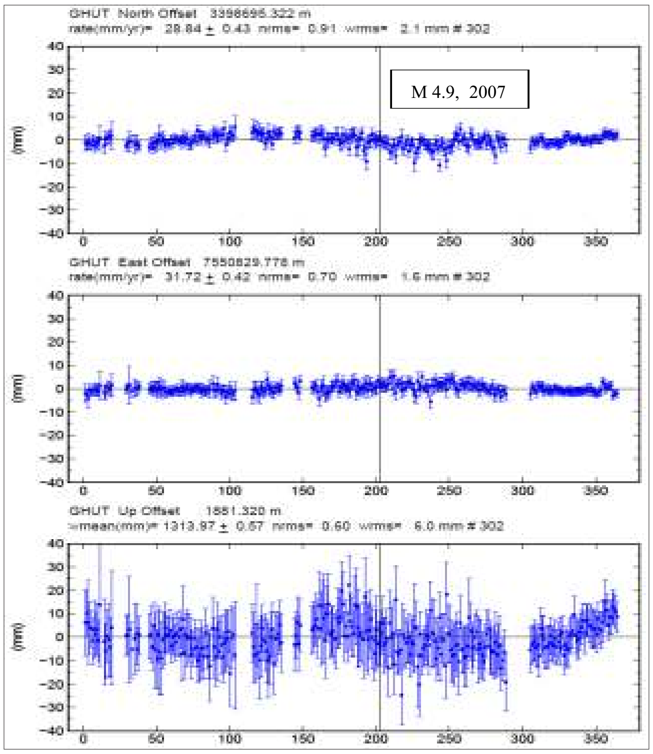

Fig. 27 : The plot showing horizontal and vertical offset variation of GHUT station for the year 2007 and black dark line showing the Kharsali earthquake at Julian day 203.

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 sample/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 valley (Fig. 29). First of all, the data was visually analyzed to remove singularities (if any). Then 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 (Nakamura, 1989) method, using the GEOPSY software. The fundamental frequency was calculated for each point (Fig. 30).

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

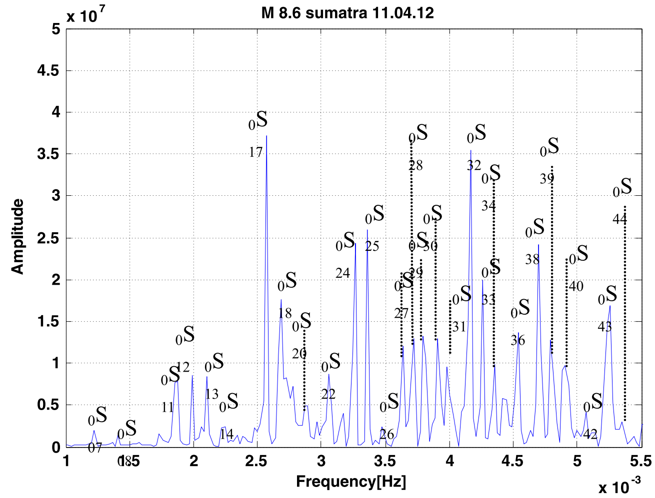

Fig. 28 : Different Free Earth Oscillations (FEO) observed using the gravity data of Superconducting Gravimeter at MPGO, Ghuttu at the time of occurrence of M8.7 earthquake in the Sumatra region.

Siwalik group (Fig. 31). Variations within short distance may be due to variation in compactness of sediments. The results reflect the 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.

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, A.K. Dubey, B.K.Choudhury, Khayingshing Luirei and D.K. Misra)

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)

A new active fault trace has been recognized in the northwestern Frontal Himalaya near Chamuhi in the

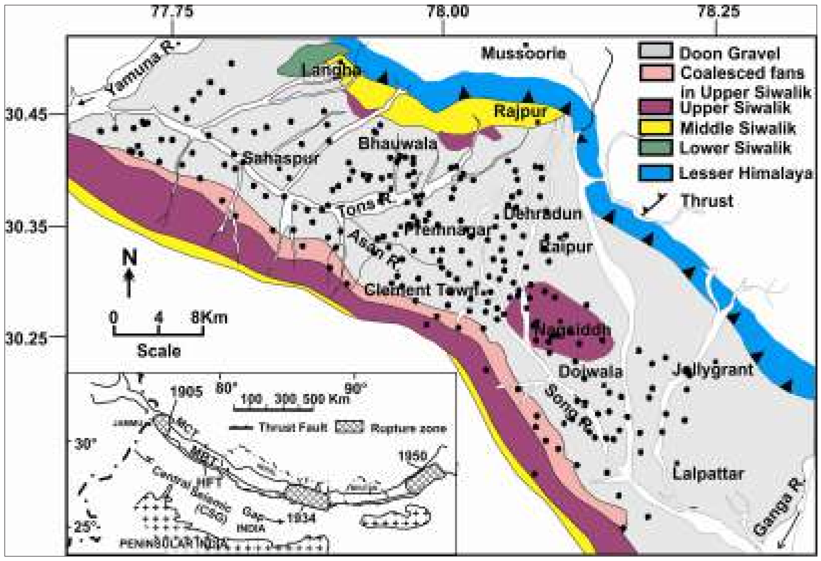

Fig. 29 : Geological environment in Doon valley (after Nossin, 1971) and location of observation/ survey points (black dots). Inset: Tectonic map of Himalayan region showing central seismic gap and rupture zones (shaded) of great earthquakes (modified from Khattri, 1999).

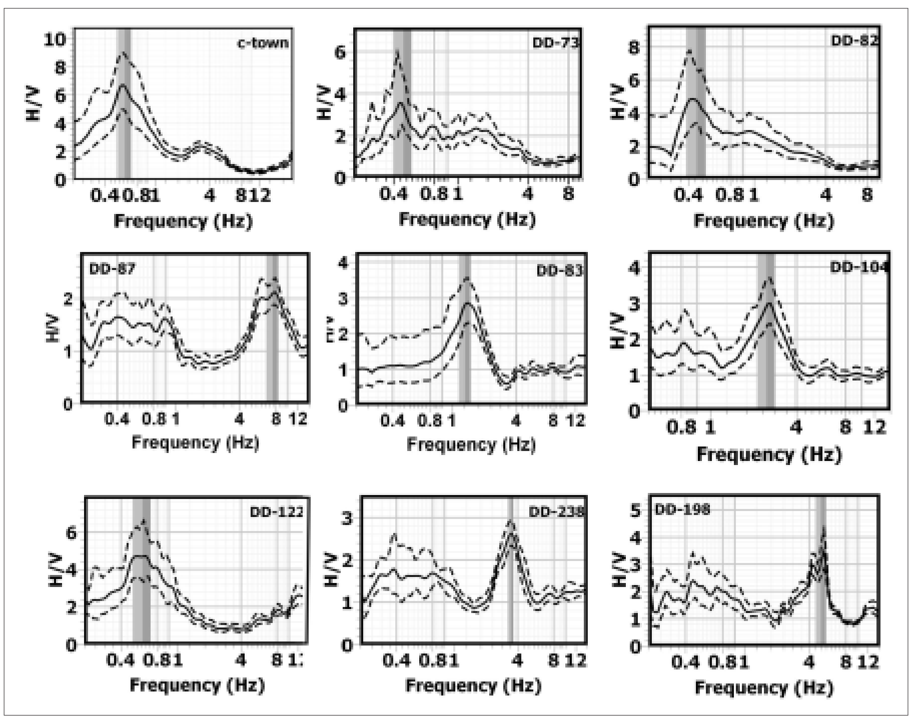

Fig. 30 : Some representative HVSR; the solid line, upper and lower dashed lines represent average, median and standard deviation of H/V spectral ratio, respectively.

Soan Dun. This fault, falls between the HFT and the Soan Thrust, is distinctly traceable on both the satellite images and topographic map. The fault follows the summit of the Chamuhi-Bari ridge, which is constituted by the Upper Siwalik and post Siwalik sediments comprising of conglomerates with thin bands of sandstone. The Quaternary sediments overlying the rounded Siwalik ridge consist of alluvial deposits along the stream beds and colluvial and debris material resting on hill-slopes. The uplift of the Quaternaries in this

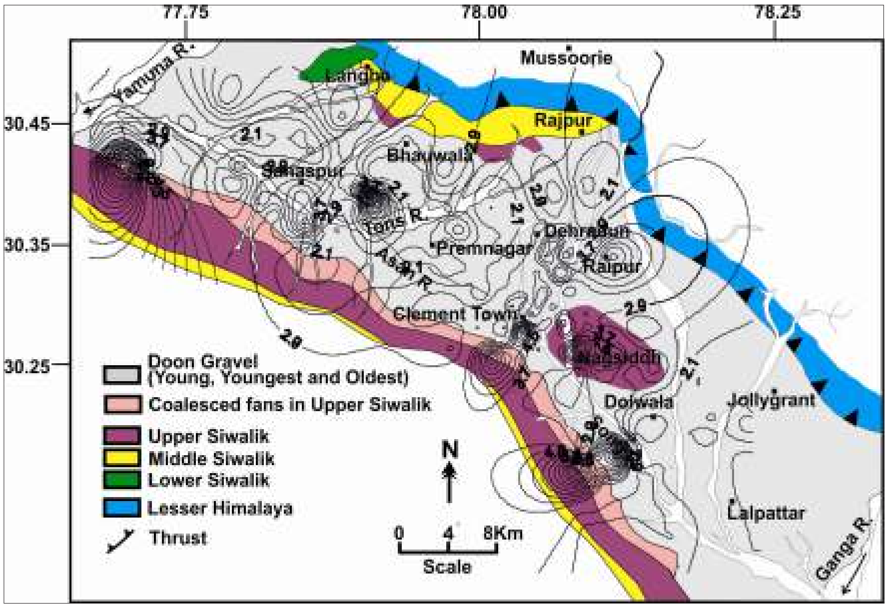

Fig. 31 : Contour map of predominant frequency obtained from HVSR in the Doon

region marks the vertical displacement along a fault system. The total traceable extent of the fault is nearly 5 km between Chamuhi and Bari. The up throw of 8-10 m across the fault marked by isolated topographic highs and knick points indicate the trace of the fault, and is well-defined topographic expression in the field between Chamuhi and Bah Khushala. The fault trends NNW-SSE, and it dies down with two small strands towards SSE near Chamuhi village. The quartzite pebbles in the elongated Quaternary deposits in the fault zone show signs of shattering. Small sagged ponds and elongated depression have also been observed in alignment within the fault zone. The depressions are subsequently being partially filled with clayey and sandy deposit. The Quaternary cover on the up-thrown block has been eroded away at places, and is being removed to use the sand and clay for filling the low ground and reclaim for agriculture. The shattered pebbles and the disposition of the Quaternaries also indicate its relation with abrupt release of strain due to discrete tectonic events. The mechanism of deformation hence has a definite genetic link with occurrence of a large magnitude earthquake and its aftershocks. Based on the OSL ages pertaining to crucial locations of the fault zone, we infer here that the displacement of the Quaternary deposit must have occurred after the deposition of 51 ka sediments, due to a late Pleistocene seismic activity. At the same time in the adjacent Pinjaur Dun, the reactivation of the Nalagarh Thrust in the late Pleistocene, and the generation of a large magnitude earthquake have also been reported by Philip et al. (2011). Hence we reason here that, the activity along the Chamuhi fault zone is quite likely to be similar, if not contemporaneous, to the seismic activity in the Pinjaur Dun along major thrust zone e.g. the Nalagarh Thrust and the Pinjaur Garden fault (Malik and Mathew, 2005).

The available satellite data has been studied for identification of new active fault traces. The Late Pleistocene earthquake fault identified at Nalagarh shows its extension towards further east of Nalagarh in Pinjaur Dun. OSL samples have been collected to establish the chronology of the latest tectonic activity along the above fault. The active fault system in Ghatiwala in the eastern Pinjaur Dun has also been checked in the field to assess the possibility of trench excavation survey in the Pinjaur dun. Selected field checks have also been carried out along the HFT region between Kala Amb and Ropar to locate discrete surface expression of the Himalayan Frontal Thrust for further paleoseismic investigations.

TAT - 3.4b

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

(R.J. Perumal, Pradeep Srivastava, A.K. Dubey, and B.K.Choudhury)

New paleoseismic evidences garnered at the Bhatpur trench along Himalayan Frontal Thrust (Fig. 32)

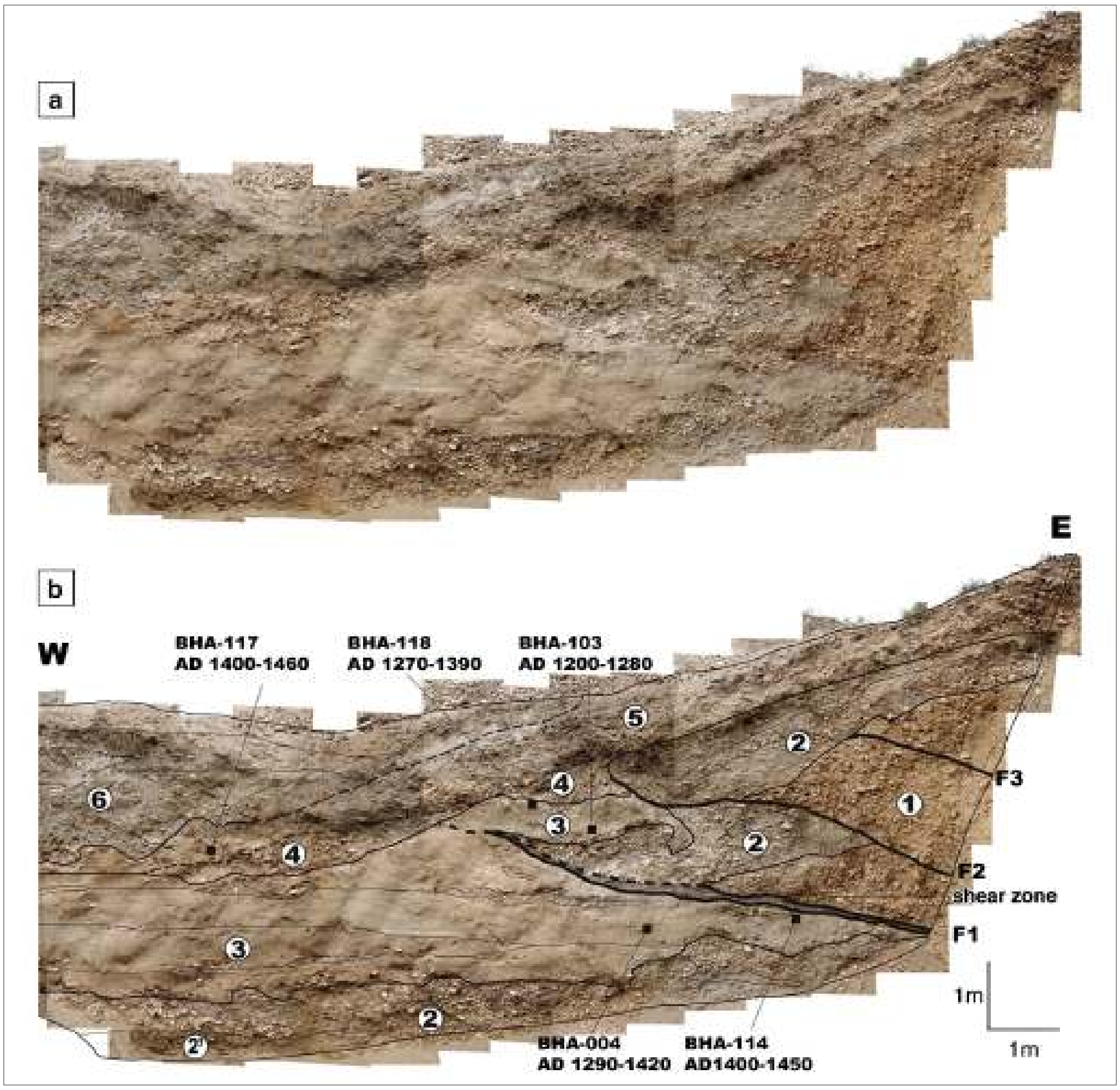

Fig. 32 : Photo trench log of Bhatpur trench site that lies in frontal limb of Januari anticline along the HFT.

suggests two scenarios of the latest surface rupturing earthquake event in the northwestern Indian Himalaya: (1) a single-event surface rupturing for a minimum fault length of 450 km, or (2) two-events of different lateral extent (Fig. 33). According to the former scenario, the latest surface rupture occurred between A.D. 1404 and 1422. The latter scenario suggests the latest surface rupture occurred between A.D. 1404 and A.D. 1460 in the northwestern extent from Kala Amb to Hajipur with ~9.0 m of coseismic displacement over a minimum fault length of 200 km**.** Yet another surface rupture event in the southeastern extent from Kala Amb to Ramnagar has occurred between A.D. 1282 and A.D. 1422, with displacement ranging from 16.0 m to 26.0 m, and a minimum surface rupture length of 230 km (Kumahara and Jayangondaperumal, 2013).

The October 8, 2005 Mw 7.6 earthquake occurred along the Balakot-Bagh Fault as out-of sequence thrust in Jammu & Kashmir Himalaya (Avouac et. al., 2006; Thakur et.al., 2006; Kaneda et.al., 2008; Jayangondaperumal and Thakur, 2008). Recent deformation study carried out at intermediate time scale by Vignon (2011) in the Reasi region of Jammu & Kashmir Himalaya reveals that more than half of the convergence in the western part of NW Indian Himalaya occurs along out-of sequence thrust, and thus the strain release is being partitioned. These observations arise

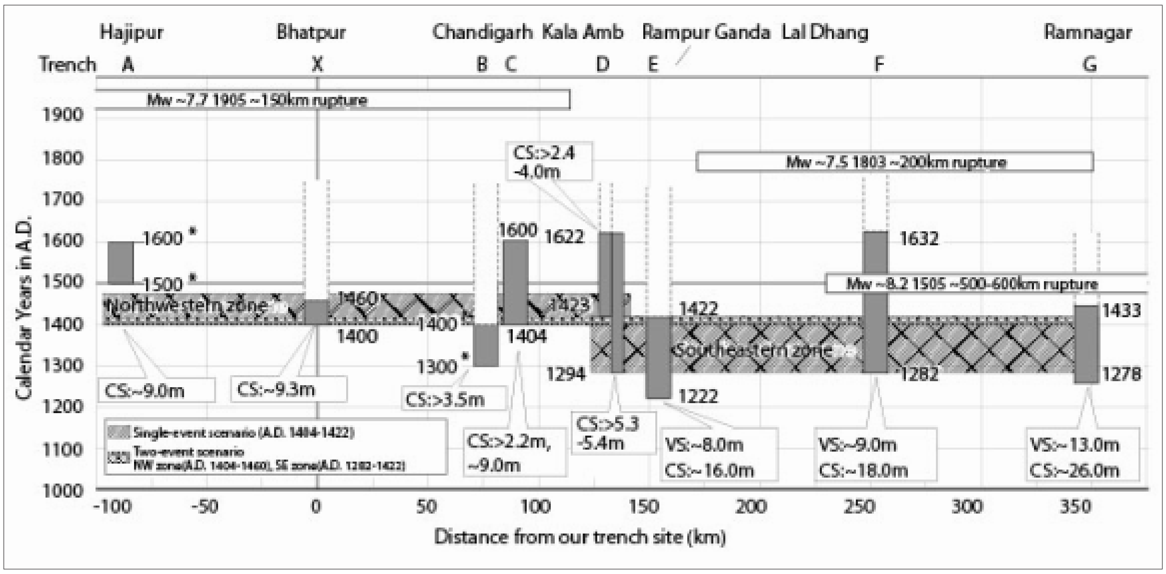

Fig. 33 : Summary of space-time diagram of previous trench sites together with displacement data.

two fundamental questions: (i) what is the convergence rate along the Main Frontal Thrust (MFT) or Himalayan Frontal Thrust (HFT), which itself is characterized by blind thrust anticline, and (ii) does the geometry of the syntax favour the observed out of sequence deformation? Answer to these questions is a key for testing various seismo-tectonic models that would be necessary to understand the origin of the J & K seismic gap.

Furthermore, prior paleoseismological studies were conducted along HFT near Hajipur in Punjab sub-Himalaya (Malik et.al., 2010) and near Jaijon, in Himachal Sub Himalaya (Kumahara and Jayangondaperumal, 2013). Sparse paleoseismological data on timing, style, recency, and repeat time exists for the intervening area between LOC (line of control) and Hajipur.

In order to achieve what as been said above, a detailed tectonic geomorphic field work was carried out in the westernmost part of NW Indian Himalaya at Kachriyal village (located at or near LOC), and along Manwar Tawi River. The detailed field work includes: mapping of disjointed surfaces along the active fault(s) were performed using both robotic total station and RTK survey methods. 10 sites have been chosen for optical dating from disjointed landforms to constrain the abandonment ages of these surfaces. Strath terrace mapping along active fault/fold zone Manwar Tawi was performed to infer the vertical uplift rate. 10 charcoals and 5 sediments samples for optical dating were collected to infer the bed rock incision rate.

We embarked upon a trench investigation in the Jammu region to place a preliminary constrain on the timing and recurrence of earthquake in this region using fault scarp observed along the active mountain front at Kachriyal village, Line of Control, Jammu & Kashmir sub-Himalaya. Natural exposure along the stream near Kachriyal village was examined for a detailed investigation. The microtopographic map was prepared using RTK. The detailed structures observed in the natural exposure were mapped using robotic total station by constructing a meter grid. 5 OSL samples were collected to constrain the timing of latest deformation.

We have also 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 Vaishnodevi 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 is one of the main emergences of the Main Himalayan Thrust during a great earthquake. The work is in progress.

TAT-3.4c

Morphotectonic evolution of the Himalayan frontal belt between Kosi and Kali rivers, Kumaun Himalaya

(Khayingshing Luirei and D.K Misra)

The mountain front of Dabka-Baur rivers section represents one of the most active segment of the present study area. The mountain front is almost 22 km in length, the mountain front sinousity (S_{mf}) value is just over 1, the analyzed S_{mf} value is 1.09. The mountain front is defined by tectonic escarpment running almost E-W at places the escarpment measures about 100 m in height. Drainage longitudinal profile of stream flowing across the mountain front shows change in stream gradient just near the mountain front which is defined by the HFT, in some cases streams exit into the plain in the form of 8 to 10 m high water falls. Slope profile drawn across the mountain front shows abrupt change in elevation with steep profile along the mountain front. From field observation and SRTM image it assumed that Dabka River has migrated more than 10 km westward due to uplift along the HFT. The stream valleys of Kusum Raula, Kacharpani Sot and Nauli Gad are very wide and are disproportionate with their present size of active channel. It is assumed that due to relatively more uplift along the HFT than down cutting by the river Dabka River has migrated westward. The present stream valleys of Kusum Raula, Kacharpani Sot and Nauli Gad are the paleochannels of Dabka River. Recent tectonic activity in the form of growing anticline in the Middle Siwalik rocks is observed west of Ramnagar, the deformation have been imprinted in the overlying Quaternary terrace deposit, the terrace sediments in the hinge zone of the anticline are tilted by 28° toward S. At Ramnagar the mountain front is defined two prominent levels of terraces.

Tanakpur area is characterized by wide development of accumulation landforms i.e., terraces and fans. The highest fan is designated as Batna Gad fan the distal section of the fan is faulted by the HFT, and almost E-W running escarpment is observed. The escarpment is not continuous as some portion has been eroded while in some portion younger fans have overlain the older sediments. In some section of the escarpment, the scarp measures more than 100 m. Stream gradient profiles of streams flowing across the escarpment have high gradient index showing perturbation in the longitudinal profiles. The mountain front particularly between Kathgodam and Tanakpur is characterized by arcuate nature because of swing in strike of the bed rocks.

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)

Petrophysical and mechanical (PM) properties of the rocks are primarily controlled by its mineral constituents and various textural parameters. Similar rock-types in different tectonic set-ups may be characterized by different mineralogical compositions and textural properties because they might have suffered different deformational processes. During the year, emphasis is made on the quantification of various PM properties of quartzites, granitoids, gneisses, metabasics and dolomite collected from different tectonic set-ups along with their mineralogical and textural constituents. These included the quantification of density, porosity, seismic wave velocity, unconfined compressive strength (UCS), point load tests, and various textural parameters like aspect ratio, grain size, grain shape, shape preferred orientation and the quantification of mineral constituents using XRD and XRF studies. All these parameters were measured as per the standard testing procedures. Seismic wave velocities were measured in the cylindrical cores using Ultrasonic Pulse Transmission technique (UPT), whereas the quantification of various textural properties viz. grain shape (grain boundary suturing and aspect ratio), grain size, shape preferred orientation (κ), and Texture Coefficient (TC) was done using thin sections.

The inter-relationships among mineral constituents, various textural parameters, UCS, Schmidt hammer rebound (R-) value, seismic wave (both P- and S-waves) velocity and their attenuation characteristics were obtained using regression analyses, and are summarized as follows:.

- An inverse relationship has been observed between velocity and attenuation characteristics, and positive linear relationship between SHR value and the UCS for all the studied rock types
- In dolomite, there is an inverse relation between velocity and porosity.

An empirical relation between SHR and UCS for the studied rocks has been marked by the following equation:

UCS = 12:398E0.0365SHR

with a correlation coefficient of 0.82.

With the increase of feldspar/quartz ratio in leucogranites and (amphibolite+pyroxene)/feldspar ratio in metabasics the P-wave velocity increases, whereas in quartzite, gneisses and granitic gneisses it is the textural parameters that greatly influence the Vp and Vs. Among all the textural parameters, grain size is the main textural parameter that dominantly controls the seismic wave velocity, particularly in quartzite. For gneisses and leucogranite/granitic-gneiss (polymineralic rocks), it is the strength of preferred orientation of platy minerals that greatly influence the seismic wave velocity.

The strength of rocks primarily depends on the quantity and the orientation of the weak minerals like mica. It acts as void, where the cracks initiate and propagate easily under loading. In contrast, quartz acts as a barrier for the propagation of cracks under loading, therefore its presence increases the strength of the rocks.

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)

The Lesser Himalayan sequence is considered one of the best developed sections of Cambrian successions, exposed in five different synclines. Mussoorie Syncline, being one of the five synclines, exposes Cambrian Tal Group. In Mussoorie Syncline, the arenaceous member of Deo-Ka-Tibba (Lower Tal) Formation has yielded considerable number of trace fossils. Banerjee and Narain (1976) were the first to report trace fossil Aulichnites from the arenaceous member. The reported trace fossils mainly belong to Skolithos and Cruziana ichnofacies, with an abundance of arthropod traces like *Diplichnites*, *Merostomichnites*, *Dimorphichnus*, *Monomorphichnus*, *Protichnites* and *Tasmanadia* (Singh and Rai, 1983; Kumar et al., 1983; Singh et al., 1984; Bhargava, 1984; Rai, 1987). In contrast, there are limited reports of trace fossil from the Dhaulagiri Formation. The published reports include trace fossils Paleophycus and Skolithos along with arthropod traces of Lower Cambrian affinity from 'A' member of Dhaulagiri Formation (Bhargava, 1984; Bhargava et al., 1998; Rai, 1987). The lower most part of Dhaulagiri Formation on the Mussoorie-Dhanaulti road section has yielded Early Cambrian trace fossils similar to the arenaceous member of the Deo-Ka-Tibba Formation. The reported trace fossils are *Monomorphichnus* isp., *Dimorphichnus* isp., *Diplichnites* isp. A, *Planolites* isp., *Skolithos* isp., *Merostomichnites* isp., ?*Neonereites* isp., along with various scratch marks and burrows (Tiwari and Parcha, 2006). In the present study nine ichnogenera viz. *Dimorphichnus* isp, ?*Diplichnites* isp., *Monomorphichnus* isp, *Nereites* isp., *Palaeopasichnus* isp., *Palaeophycus* isp., *Planolites montanus*, *Planolites* isp., *Skolithos* isp., *Treptichnus* isp. are described from the Dhaulagiri Formation of Tal Group. The detailed analysis of the ichnofossils indicates that the entire succession of Tal Group reflects shallow marine conditions in general and in Mussoorie Syncline in particular. The above ichnofossil assemblage along with earlier ichnofossils and other faunal occurrences substantiates the assignment of Early Cambrian age to the Dhaulagiri Formation.

TAT-4.2

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

(S.K. Parcha)

The 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 conditions. Equally it will resolve some paleobiological problems, and will helpful in marking inter and intra system boundaries

Diverse assemblages of ichnofossils have been reported for the first time from the Chandratal section. The ichnofossils were collected along road side from the Chandratal-Kunzum La road side of Spiti Basin. The Ichnotaxa collected from this section are: *Chondrites*, *Dimorphichnus*, *Isopodichnus*, *Lockeia*, *Monomorphichnus*, *Nereites*, *Palaeophycus*, *Planolites*, and *Skolithos* along with some scratch marks. The ichnofossils shows diversity in their behavior from dwelling, feeding, resting to grazing, and were produced by invertebrates, mainly arthropod and annelid. The presence of *Dimorphichnus*, *Lockeia*, *Isopodichnus* and *Skolithos* represents high energy environment, whereas, *Chondrites*, *Nereites* and *Paleophycus* indicates low to moderate energy conditions. The abundance and diversity of ichnofossils represents two ichnofacies, *Skolithos* and *Nereites*. These ichnofacies reflects Neritic and Abyssal environments.

The Middle Cambrian succession of the Parahio valley in general and Debsakhad section in particular is dominated by trilobites. 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* were reported from the lower Middle Cambrian succession of Debsakhad section. The species were differentiated on their morphological features and based on multivariate analysis. The multivariate analysis method is applied here as a supplement 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 Middle Cambrian.

In the Pin section, the thin sections of the carbonate beds have shown the occurrence of abundant dasycladacean green algae along with other microfossils. Three Dasycladacean algae were identified from the carbonate horizons of the Ordovician- Silurian successions in the Pin valley of the Spiti Basin. The identified algae are: *Dasyporella* sp., *Vermiporella* sp. and *Moniliporella* sp. The most common dasycladacean algae identified in the carbonate beds is *Dasyporella*, which is accompanied by *Vermiporella* and *Moniliporella*. These are the epifaunal marine chlorophyte group, which indicate the shallower part of the infralittoral stage as indicated by the presence of Dasycladaceae in abundance, which indicates shallow water. Owing to their natural tendency to form calcareous skeletons, the dasyclads algae have an extensive fossil record that extends from Cambrian to the Present. The calcareous algae are abundant and widespread in various facies of Ordovician and Silurian carbonate complexes, which provide a useful index of paleoenvironmental conditions. The present assemblage of calcareous algae is useful in deciphering the paleoenvironment of this region during the Ordovician-Silurian times. Dasyclads are important as they are well-known environmental facies indicator, and are used for stratigraphic correlation. The present described calcareous algae from Spiti Basin mainly resembles with that of North America, Tarim Basin, Baltica and Kazakhstan flora, which indicate a cosmopolitan nature of these calcareous algae. In the light of the studies carried out an attempt is made to correlate these with the analogous successions of the Kinnaur and with the other well-known sections of the world. On the basis of presently identified calcified green algae in the carbonate beds of the Spiti Basin, it has been inferred that, a shallow marine to near shore environmental conditions followed by different stages of regression and transgression for the Ordovician-Silurian successions.

Apart from this, during the field studies in the Barsu-Guriual Ravine section of Kashmir Himalaya a rich assemblage of ichnofossils were collected. This is the first report of ichnofossils from this section. The studies ichnofossils shows the presence of *Planolites, Skolithos, Paleophycus*, The detail studies of these trace fossils is still going on.

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)

Field work was carried out for 24 days in Nagaland and Manipur, along with some reconnaissance survey in the new localities. The processing of rock samples collected from the Disang Formation of Eocene age and Barail Formation of Oligocene age from the Naga Hills is in process. Geochemistry analysis of XRF, XRD and REE analysis for sediments were also carried out. Sedimentological studies involving thin sections and petrography are in the process. Foraminifers were recovered from the Disang Formation of Manipur, and the specimens are in the process of identification and SEM microphotography. These findings are important since till date, no reports are available for dating of age, and to understand the paleoenvironment of Disang Formation of Manipur. Miocene foraminifers were also recovered from the Surma Formation of Naga Hills. The findings of these foraminifers from the different formations through the geological time (Eocene and Miocene) will help in the interpretation of geological evolution of the study area through the geological ages.

Maceration and processing of the collected rock samples from the ophiolite mélange belt of Indo-Myanmar range is in progress using different methods, as the exotic limestones are hard and indurated. Some of the identified planktonic forams are: *Globotruncana linneiana, Pseudotextularia excolata, P. elegans, Heterohelix globulosa, Rugoglobigerina* *hexacamerata*?. More specimens are to be identified. These foraminiferal studies will help to understand the collision of the Indian and the Myanmar plates. Ichnofossils were discovered in the field from the Barail Formation of Oligocene age from the inner fold belt of the Naga Hills. The systematic study and inferences for depositional paleoenvironment is in the process.

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 mammal fauna from NW sub-Himalaya

The study of Early Eocene land mammal fauna in reference to India-Asia convergence and faunal dispersals was continued. New collections were made from the NW sub-Himalayan as well as western Indian sections.

New skeletal elements of the early Eocene bird *Vastanavis* were described from western India (Fig. 34) and the relationships between this taxon and the recently described *Avolatavis* from the early Eocene of North America were analysed. *Vastanavis* differs from *Avolatavis* in the presence of a crista medianoplantaris on the tarsometatarsus and in claw morphology, but a fossil from the early Eocene London clay, which was previously assigned to Vastanavidae, closely resembles *Avolatavis* in these features and all other osteological aspects. A morphologically distinctive distal humerus of a small bird of uncertain phylogenetic affinities was also identified.

A new tillodont, *Anthraconyx hypsomylus*, is described from the early Eocene of western India (Fig. 35). The tillodonts are characterized by enlarged chisel-shaped gliriform second incisors, which became evergrowing in the most derived forms. The new form *A. hypsomylus* is the smallest Eocene tillodont and is distinguished by having the most buccally hypsodont cheek teeth of any known esthonychine. The closest dental resemblances are to North American *Esthonyx* and *Azygonyx* and European *Plesiesthonyx*. Apart from having extreme buccal hyposodonty, the new tillodont further differs from *Azygonyx* and *Esthonyx* in having a stronger postmetacristid and from *Esthonyx* in having a better developed molar hypoconulid, which is lingually

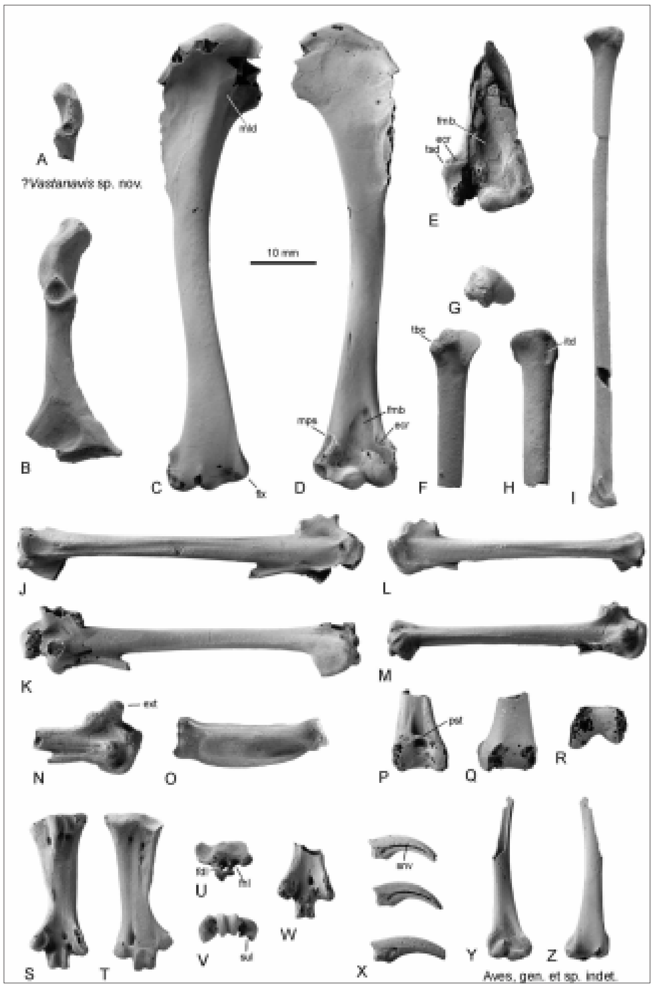

Fig. 34 : Newly reported bones of *Vastanavis* (A-X) and an undetermined bird (Y, Z) from the early Eocene of western India.

shifted and separated from entoconid and hypoconid by distinct notches; and a relatively shorter dP/4, about same length as M/1. The new tillodont mammal provides additional evidence of affinities between the Vastan local fauna and Euroamerican vertebrate faunas as earlier inferred from the bulk of the Vastan Early Eocene mammal fauna.

Fresh attempts to collect continental vertebrate remains from the crucial Late Paleocene horizons resulted in the find of some crocodilian remains from the Kakara Formation. This material is being studied on priority.

Study of bauxite deposit from Reasi area, J&K

Jangalgali Formation consisting dominantly of rhyolite, andesite and bauxite lies unconformably over

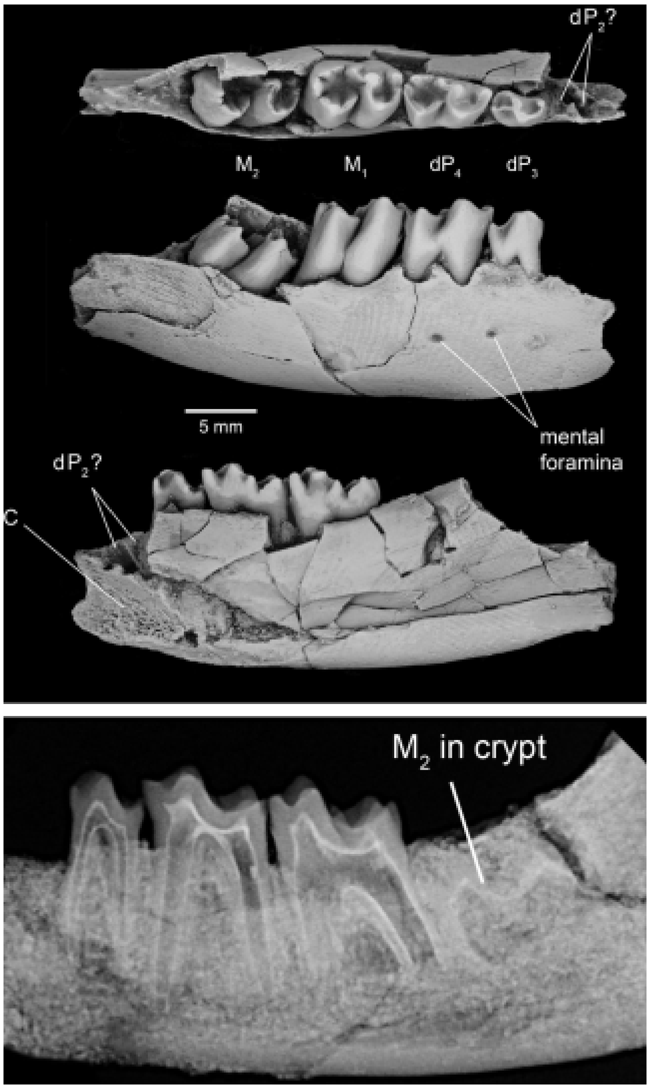

Fig. 35 : Holotype of tillodont mammal *Anthraconyx hypsomylus*, n. gen. n. sp. from early Eocene of western India; part of dentary is removed to expose M/2 . Top to bottom: dorsal, lateral, and medial views. Bottom image is a radiograph of holotype dentary, showing unerupted M/2 and no calcification of permanent P/3-4.

Neoproterozoic Sirban Limestone and is overlain unconformably by Late Paleocene-Middle Eocene Subathu sediments. Its stratigraphic age corresponds with the commonly believed timing of primordial collision of India with Eurasia, and therefore the lithologies may hold some answers to questions like the physico-chemical effects of collision.

Mineralogical and geochemical characters of bauxite deposits of Reasi area, J & K were investigated to get insights into their economic potential. Bauxite is 3 m thick, occurs unconformably over Neoproterozoic Sirban Limestone in and around Salal village. It is pisolitic with 20-30 volume percent spherical pisolites of variable dimensions. It consists of diaspore and kaolinite with minor amounts of zircon. It is Al-rich (55 wt % Al_2O_3) and iron poor (Fe_2O_3 = 2.5 wt %). It has exceptionally higher concentrations of zirconium (~1500 ppm). Their chondrite-normalised REE patterns are LREE depleted, and HREE enriched. The relatively high loss on ignition values (15 wt %) are due to the presence of alteration derived clays.

A total of 15 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.

TAT-4.5

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

(R.K. Sehgal)

New micro-vertebrate discoveries were reported from the Lower Siwalik Subgroup of NW Himalaya. Two very short ranging rodents, a murid *Antemus chinjiensis* and a cricetid *Megacricetodon* cf. *sivalensis* were described from the famous Miocene ape locality of Ramnagar (J & K). In the recent years, integration of magnetic polarity stratigraphy, tephrochronology and mammalian biostratigraphy has led to the establishment of a very high resolution biochronological framework for the fresh water Siwalik deposits of Indian sub-continent (Badgley *et al*. and references there in). This biochronological scheme has become very useful for intra-regional correlation and precise age assessment of various Siwalik fossils sites that have not been dated geochronologically. No magnetostratigraphic data is available for the Lower Siwalik sediments of Ramnagar. In order to provide a biochronological framework to fossil bearing Ramnagar site, the newly described rodent material (Sehgal and Patnaik, 2012) and the rodents reported by earlier workers were integrated into the detailed stratigraphic framework provided by Basu (2004). In the type section, the stratigraphic range for *Antemus chinjiensis* is between 13.8 Ma and 12.7 Ma; and that of *Megacricetodon* cf. *sivalensis* is between 13.8 Ma and 12.5 Ma. Similarly the last appearance of *Kanisamys potwarensis* is marked as 13.2 Ma. By applying the well established high resolution Siwalik rodent biochronology, the Ramnagar assemblage can now be safely constrained between at least 13.2 Ma and 13.8 Ma.

In addition, a *Sivapithecus* (Primate) molar was also described from the horizon stratigraphically older than the rodent site. Recent reports from the type section have shown the first appearance of *Sivapithecus* at 12.8 Ma. As the present specimen of *Sivapithecus* was discovered from the horizon older than the rodent site, so it could be potentially important in the context to increase the First Appearance Datum of *Sivapithecus* to at least 13.2 Ma.

A fairly rich and diversified mammalian assemblage (mega-vertebrates) is described from Ramnagar (J&K). In the light of new faunal discoveries, an attempt was made to revise the mammalian biostratigraphy of Ramnagar area, and its faunal correlation was made with the equivalent horizons within the Siwaliks of Indian sub-continent. In all 46 mammalian taxa have been reported from Ramnagar area. Twelve mammalian species have been reported for the first time from this area, by the author. These include: *Antemus chinjiensis*, *Megacricetodon* cf *sivalensis*, *Eomellivora necrophila, Vishnuonyx chinjiensis*, *Percrocuta carnifex, Gaindatherium browni, Hippopotamodon haydeni, Hemimeryx pusillus, Dorcabune nagrii, Progiraffa* sp., *Giraffa priscilla* and *Miotragocerus gradiens*. The correlation of Ramnagar assemblage depicts that this assemblage has a striking similarity with faunal assemblages from Chinji type section, Lower Siwalik fauna of Daud Khel, Pakistan and Dang valley Nepal. No fauna belonging to the Kamlial Formation is so far recorded from India, thus it can be opined that the Ramnagar assemblage represents the oldest Siwalik fauna in India.

A new collection of mammalian fauna (mega-vertebrates) was been described from the Siwalik sediments of Nurpur area (Kangra region). *Hippopotamodon vinayaki and Hydaspitherium megacephalum* have been described for the first time from this area, and both of these are marker for the Dhok Pathan Formation in the type section. On the basis of new fossil findings the Siwalik sediments exposed around Nurpur have been considered as equivalent to the Dhok Pathan Formation of the Middle Siwalik Subgroup. Earlier these were referred as belonging to the Lower Siwalik. Further it is also noticed that the red bed successions exposed in the Siwalik Group are time transgressive, and do not necessarily represent Lower Siwalik, as was considered for a long time.

For the first time, the mammalian faunal dispersal patterns during the Miocene period have been interpreted. Preliminary studies 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.

Reconnaissance field work was also carried out in Ladakh Molasse Group and the Murree Group (both pre-Siwalik) for micro-vertebrates potential. So far only fragmentary bones were noticed. Future research may lead to useful findings.

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 formation of global rift basins and passive margins around 650 Ma is a major event in the Earth's Ediacaran (Neoproterozoic) history. Extreme paleoclimatic events like icehouse and greenhouse events have been recorded from all over the world including Blaini-Krol successions of the Lesser Himalaya and their equivalents from the Tethyan Himalaya (Tewari and Sial, 2007; Tewari, 2007, 2009, 2010 a,b, 2012). The detailed facies analysis, paleoenvironmental reconstructions and stable isotopic excursions are very useful for the high resolution Ediacarn chemobiostratigraphy and its subdivision in the central Lesser Himalaya. Establishment of the four divisions of the Ediacaran (Yangtze-630-580 Ma; Avalon-580-560 Ma; White Sea-560-550 Ma and Nama-550-540 Ma) in the Krol belt based on possible Ediacaran fossils, sedimentary facies and stable isotopes requires a systematic and multidisciplinary investigation. The project is aimed to focus on the selected sections in the Krol belt from Solan in Himachal to Nainital in Uttarakhand, and Tethyan basin in Spiti.

The carbonate petrography, microfacies analysis, SEM, cathodoluminescence of selected carbonates and C-O isotopic variations in the Deoban-Blaini-Krol carbonate facies has been done during the year. Stratigraphically, this Lesser Himalayan succession is now globally correlatable with the Tonian-Cryogenian-Ediacaran (Neoproterozoic) period (Fig. 36).

Chemostratigraphy has diverse applications to investigate the rock record, such as reconstructing paleoenvironments, paleoclimates, determining the tectonic setting of sedimentary basins, indirect dating and establishing regional or global correlations. Light stable isotope geochemistry, including carbon, oxygen, sulfur and nitrogen isotopes, is the most widely applied chemostratigraphic tool for the Neoproterzoic carbonate successions. Large negative $\delta^{13}C_{carb}$ excursions (Fig. 37) are significant features of the Neoproterozoic Era (Tewari, 2012 and the references therein) and have been considered as consequences of multiple glaciations marked by the rapid precipitation of overlying cap carbonates. Well preserved records of major glacial events have been recognized as follow : (i) Akademikerbreen glaciation at approximately 850 Ma, (ii) Sturtian glaciation with possibly two pulses between approximately 750 Ma, (iii) Marinoan glaciation at 635 Ma (Tewari and Sial, 2007; Tewari, 2007, 2012) designated this Neoproterozoic Marinoan glaciation as Blainian glaciation in the entire Lesser Himalaya, and (iv) Gaskiers glaciation at approximately 580 Ma. The isotopic variations, such C and Sr isotopes, within the Neoproterozoic successions have been interpreted as global or regional, with periods of higher tectonic activity and unusually high erosion of continental crusts alternating with tectonically relatively quiet periods. $\delta^{13}C_{carb}$ and $\delta^{18}O_{carb}$ data for all Neoproterozoic (570 to 880 Ma) global carbonates shows insignificant $\delta^{13}C_{carb}$ variations similar to the Upper Krol carbonates (Fig. 37), between the time-equivalent post-Marinoan (Blainian) carbonates. The shelf- or ramp-slope carbonates from the Upper Krol carbonates of the Mussoorie-Garhwal synclines (Outer and Lesser Himalaya) in general show much lighter $\delta^{13}C_{carb}$ values than the near platform-shelf facies from the Deoban-Gangolihat belt (inner belt carbonates). The oscillation of negative C-isotopic composition observed in the pink microbial cap carbonate of the Blaini Formation in India

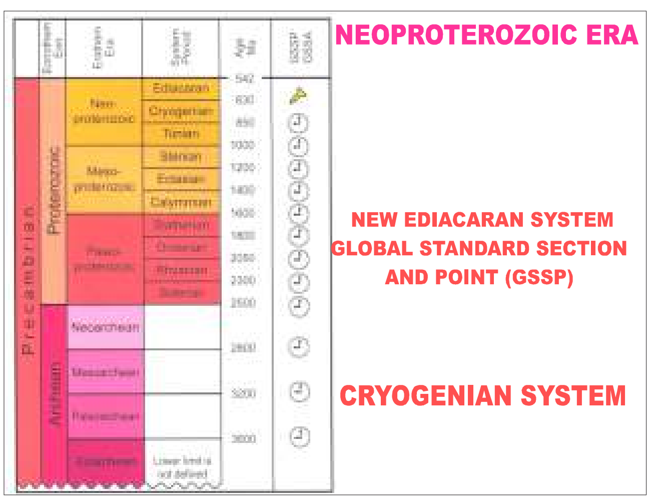

Fig. 36 : Ediacaran Global Strato type section (Australia).

and Nantuo cap carbonates of China resulted from mixing, caused by biological pumping of different proportions of a light carbon reservoir from deeper to shallower water, by upwelling processes during Neoproterozoic deglaciation. A rapid rise of the post-glacial sea level would have reduced the oceanic circulation and provided favorable conditions to maintain isotopic stratification. Study of Neoproterozoic carbonate successions from the Krol Formation of the Lesser Himalaya is very promising with regard to understanding the chemical evolution of paleoenvironments and paleoclimate at a local and global scale, where detailed lithofacies, diagenetic changes and cathodoluminescence petrography can be combined with stable isotope analysis. The severe diagenetic control of these series, combined with litho- and micro-facies analyses, highlighted that the more disturbed C and O isotopic signals exhibit a strong covariance of $\delta^{13}C$ and $\delta^{18}O$ (Fig. 37). The $\delta^{13}C$ trends in the Ediacaran (Neoproterozoic) carbonates for regional and global chemostratigraphic correlation reflect pristine paleoocean chemistry.

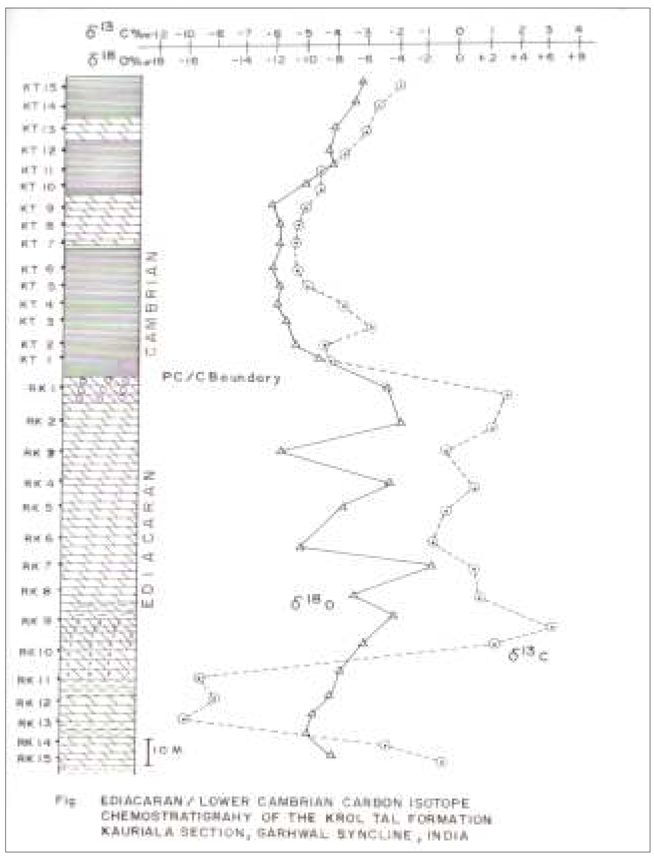

Fig. 37 : Ediacaran C- isotope Chemostratigraphy of the Lesser Himalaya.

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 change and water budget. The Dokriani (7.0 sq km) and Chorabari (6.6 sq km) glaciers in Bhagirathi and Alaknanda river basin respectively, Garhwal Himalaya are being monitored for the present study.

Data on mass balance and snout position and meteorological parameters were collected on both the glaciers during October 2011- October 2012 period. The ablation/accumulation stakes which are placed in October, 2011 were re-measured in first week of May, 2012 to estimate the net winter balances. Disappeared or lost stake were recovered and new stakes were placed in the nearby location by the steam drill. These stakes were drilled up 6 to 7 m deep in ablation zone and 2 to 4 m in accumulation zone. Snow/firn and ice densities measurement were done at several location in accumulation zone, as well as, in the ablation area. Ablation stakes were measured weekly during the entire ablation period for the monthly balance, as well as, net summer ablation. The net winter accumulation measurement was made by probing of snow depth and snow pits measurements. The data obtained from the stake measurements was used in final calculation of net annual mass balance for the budget year 2011-2012. Beside this, the debris covered mapping/distribution has been carried out for the Chorabari glaciers. In the Himalaya, especially in central and eastern parts, most of the ablation area of the glaciers is debris covered. Debris is commonly found over the glaciers surface and has a significant control on the rate of glacier-ice ablation. The debris-cover influences the terminus dynamics, and modifies the 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. The Chorabari is one of the glaciers in the region having large debris covered ablation area.

Annual Mass Balance and Snout Retreat

Annual mass balance of the Dokriani and Chorabari glaciers for the period 2011-2012 calculated was negative, with specific balance of (-) 0.35 m w.e. and (-) 0.73 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 Equilibrium Line Altitude (ELA) was estimated from the field observation as well as vertical mass balance gradient and found at an average altitude of 5080 m. 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 20 m for Dokriani and 8.5 m for Chorabari glaciers. The present snout elevation is 3920 m asl and 3865 m asl for Dokriani and Chorabari respectively.

Debris covered mapping and glacier melting

The ablation stakes were used to map and plot the debris thickness in the ablation area of Chorabari glacier. Based on these two parameters, the ablation area was divided into three zones: clean ice (debris free), thin debris-cover, (≤5 cm) and thick debris-cover (>5 cm). As a consequence, the maximum debris thickness measured was more than 50 cm in the lower ablation zone near the glacier terminus (Fig. 38). In order to study the debris thickness influence on ablation process, the area was again divided into four different altitude zones: (i) below 4300 m asl; (ii) between 4300 m asl and 4500 m asl; (iii) between 4500 m and 4800 m asl, and (iv) between 4800 m and 5100 m asl. Ablation stakes were measured every 5 to 10 days during the entire summer period (May to October, 2012), to estimate the net melting at different altitudes. Surface ablation rates are generally increased in the presence of a thin debris-cover, but are significantly reduced when a thickness (>5 cm) of debris increases. A thin and patchy debris-cover reduces the albedo and elevates shortwave radiation

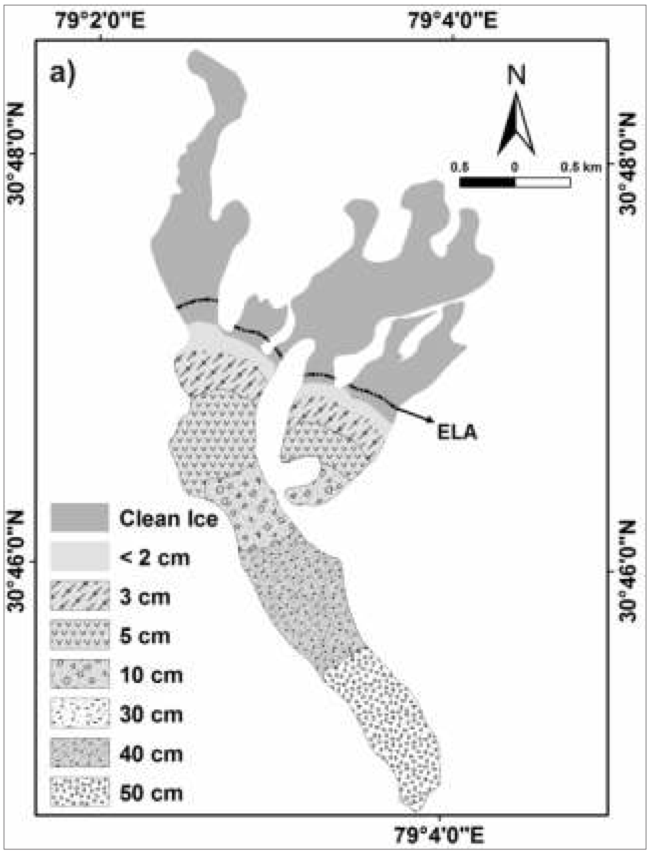

Fig. 38 : Debris covered thickness and distribution map of Chorabari glacier.

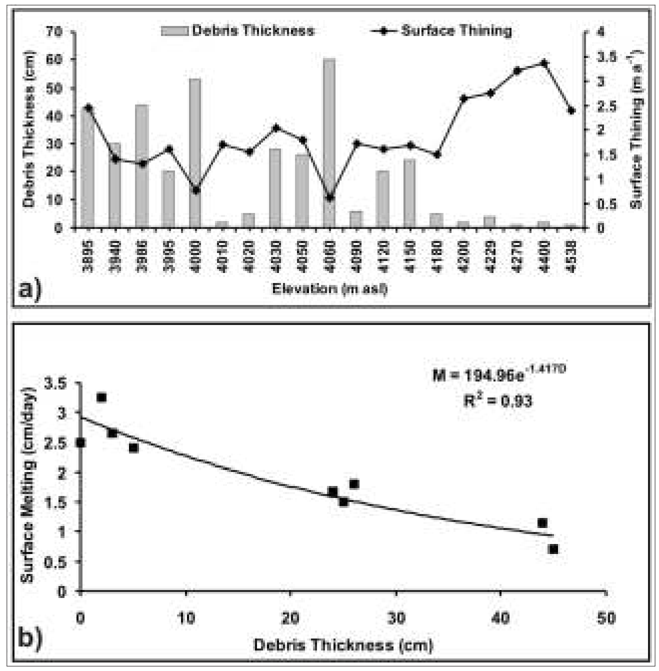

Fig. 39 : Relationship between debris thickness and ice melting along the centre line of the glacier during observation periods (a) and relationship between debris thickness and annual melting (b).

absorption, whereas ablation rates are strongly reduced due to the insulating effect of thicker debris.

In order to evaluate the influence of debris cover on melting, nine stakes were monitored for the period of 50 days, from 10th June to 30th July 2012. The stakes were located between 3800 m asl and 4500 m asl at different places of thick debris cover (20-50 cm), thin debris (1-2 cm) cover, and debris free surface. The melting obtained for a thick debris-covered surface was 0.8 cm/day and for debris free surfaces and thin debris cover it was 2.5 and 3.3 cm/day respectively (Fig. 39a). Thus, it is observed that melting reduces substantially with increase in debris thickness. The total melting in ablation zone during the entire ablation period is larger in the upper and terminus ablation areas where the glacier surface has thin or is debris free. The exponential relationship between surface melting and debris thickness plotted shows a good correlation (R^2=0.93) (Fig. 39b). 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 to greater than 5 cm ablation rates decreases. The local mass balance of debris-covered glaciers is distinctly non-linear and non-monotonic with elevation.

TAT-5.2

Assessment of potential hazards in the Glaciated regions: its causes and consequences

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

The year was primarily devoted to the preparation of the base map in the laboratory and the geomorphological and the hazard mapping of the Gangotri Glacier and its environs in the field. Number of avalanche tracks and active landslides were identified between Bhujbas and the present snout of the glacier. Geomorphological mapping between Bhojbas (3796 m) and Gaumukh (4040 m) depicts remnants of nine terminal moraines and five lateral moraines that constitute mainly, the boulders of granites, granitic gneisses and gneisses. These terminal moraines show different recessional phases of the glacier, while the lateral moraines depict

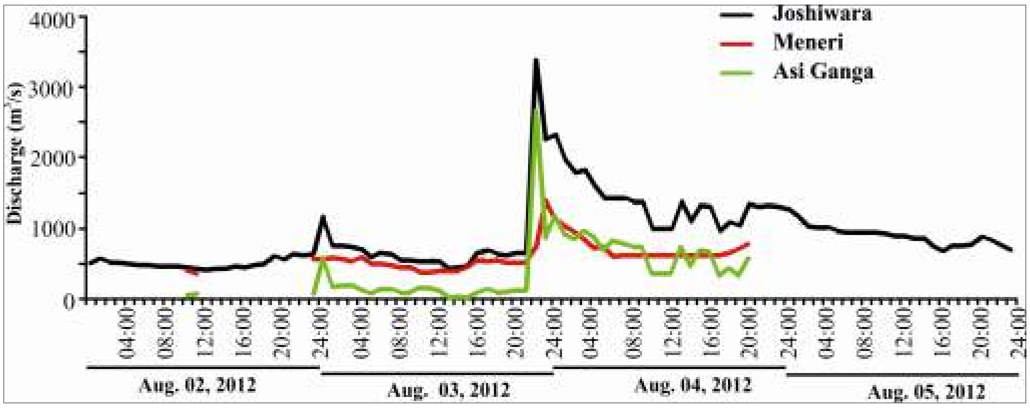

Fig. 40 : Hourly discharge of river Bhagirathi at Joshiwara depicting the discharge characteristics of Asi Ganga during August 2 - 5, 2012.

the volume change during recessional phases of the glacier. The geomorphology map shows several mountain streams which can be potential hazardous avalanche chutes in certain circumstances. Lichenometry study for these terminal moraines has also been carried out. The spatial positions of these terminal moraines along with the presence/absence of the *Rhizocarpon geographicum* species of lichen on these moraines were investigated. Furthermore, since the glacier is under a state of continuous recession along a linear path from NW to SE, the colonisation delay of the *Rhizocarpon geographicum* species of lichen, which was so far unknown in the area, has also been interpreted and has been found to be different for different rock types. Dating of these moraines is underway.

In addition to the above study, we also investigated a hazard event in the Asi Ganga tributary of the Bhagirathi valley. The valley witnessed a cloudburst in August 2012 resulting into disastrous flash flood in the downstream regions creating havoc and loss to life and property. The causes and consequences of this flash flood in the Asi Ganga valley has been studied. It has been reported that most of the damages in the area are primarily related to the disposition of the Quaternary material. The hydrograph depicts that the normal hourly discharge in the Bhagirathi river at Joshiwara Barrage near the Uttarkashi township is ~ 660 m^3/sec, that rose to about 3400 m^3/sec during the flash flood (Fig. 40). The river water in the area rose to about 3-4 m submerging and damaging most of the lifelines located along the sides of the Asi Ganga and the Bhagirathi river. The documentation of such extreme events in the Himalaya will help to evaluate the risk posed by these natural hazards, associated with secondary hazards like flash flood and landslides. Further work to map the loose Quaternary deposits lying on either side of the river and/or the areas prone to be affected by the flash flood is underway.

TAT-5.3
Hydrogeology of Himalayan springs

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

The study of major ions, silica and stable isotope (δD, $\delta^{18}O$ and $\delta^{13}C$ DIC) of hot springs and river waters covering a stretch of ~150 km in the Main Central Thrust (MCT) zone of the Garhwal Himalaya was undertaken to trace their provenance (meteoric vs. deep magmatic fluids, etc.) and the process of degassing operating in the region. Field observations indicate that geothermal springs are located close to the MCT defining the tectonic boundaries between Higher and Lesser Himalaya. The strong variations in their chemical composition suggest their varied origin and/or the mixing of different water masses during their transport to the surface. Silica based estimates for all geothermal springs shows their average reservoir temperature of 115±15^{0}C, with a highest of 134^{0}C being observed at Jankichatti (HS-18) in Yamuna valley. Among the major ions, alkalinity content varies by an order of magnitude from 1697 µM to 21553 µM whereas the abundances of chloride and sodium varies from 95 µM to 21985 µM and 436 µM to 25908 µM, respectively. Such elevated levels of Cl and Na indicate deep source, and are unlikely from the surface waters in a continental set-up. The observations of this study are similar to those studies started in 1970s by the Geological Survey of

India (GSI) which indicate that the chemical composition of thermal springs in the region has not changed much over the last ~40 years. The $\delta^{18}O$ and δD plot indicate that all the spring (except HS-17 from Suryakund and HS-9 from Helang) fall along the Global Meteoric Water Line (GMWL) suggesting an affinity of these samples with meteoric waters. This could be a result of possible mixing with thermal fluids at depths which is consistent with earlier studies on the thermal springs in different parts of the Himalaya. As the samples from Suryakund (HS-17) and Helang (HS-9) situated on the MCT zone fall off the GMWL, they may have relatively deeper source component(s). The deuterium excess of geothermal waters ranges from -0.05 to 14.2 with a mean of 10.2±3.6. As a part of this study an attempt is also made to estimate the altitude effect through the geothermal springs of Garhwal Himalaya with heights varying from around 1160 to 3090 m and $\delta^{18}O$ values from -7.5‰ to -13.1‰. The study estimates a gradient of altitude effect -0.24±0.03 per 100 m (n=18), which provided evidence for the recharge environment of the thermal ground waters similar to Jura Mountains of northern Switzerland (Siegenthaler et al., 1983). Isotopic studies show that $\delta^{13}C$ (DIC) values of these springs vary from -8.5‰ (HS-12, Jhaya) to +4.0‰ (HS-5, Tapoban). These thermal waters have significant discharge (25-400 ltr/min) and cover a large stretch of the Garhwal Himalaya with a significant contribution in degassing of CO_2 to the atmosphere. Therefore the active mountain belt of the Himalaya may be a plausible source of CO_2 which may have an impact on the long term climate of the Earth.

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, R. Islam and K.K. Purohit)

A week's field work was carried out in Udham Singh Nagar and 52 samples of sediments/soil were collected. Samples were dried, sieved and processed for their geochemical analysis. The coordinates of all the samples were plotted on topographical map to produce location map of the samples. A detailed systematic investigation of catchment areas between rivers Ganga and Sharda in Uttarakhand Himalaya is proposed with a broader view of preparing a geochemical dispersion database of important elements. The latter include environmentally sensitive elements like As, Cd, Cu, Pb, Mo, Ni, Se and Zn. In addition, the routine elements of academic interest, such as the major and minor elements like Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K, P, and trace elements like Zr, Sr, Nb, Ba, Rb, Y, Th and U would also be estimated, to understand their mobility and impact on environment. The detail work is in progress.

Preparation of standard reference material

Two more reference materials collected earlier from Himalaya: DG-H and AM-H were given the status of International Reference Samples by International Association of Geoanalysts (IAG).

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Project

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

(Naresh Kumar, Gautam Rawat, Devajit Hazarika, V.M. Choubey, D.D. Khandelwal and Vishal Chauhan)

The opening of cracks and influx of fluids in the dilatants zone of impending earthquake is expected to induce short-term changes in physical/chemical/ hydrological properties during earthquake build up cycle. These are the anomalous fluctuations and should be reflected in time-varying geophysical fields on local and regional scale. With this main objective, eleven geophysical parameters are being recorded in continuous mode at Multi-Parametric Geophysical Observatory (MPGO), Ghuttu in Garhwal Himalaya for earthquake precursory research. The critical analysis of various geophysical time series indicates anomalous behaviour at few occasions. However, the data is also influenced by many external fields/forces, and these external influences are the major deterrent for identification of anomalous changes and thus for isolation of precursory signals. The recent work is focused on the data adoptive techniques to estimate and eliminate effects of solar-terrestrial, hydrological/ environmental factors for delimiting the data to identify short-term precursors at the time of occurrence of strong and large magnitude earthquakes close to the observatory. Although any significant earthquake is not reported close to the observatory yet some weak precursory signals and co-seismic changes have been identified in few parameters related to the occurrence of moderate and strong earthquakes. We are trying to experiment new and existing methodologies to categorize the recorded data with the size and the hypocentre distance of the earthquake.

Strong motion recoded by digital acceleraograph

The MPGO Ghuttu is equipped with MS2004+ Force-Balance Accelerograph of SYSCOM an instrument that has recorded ground acceleration data at the time of occurrence of strong earthquake in the Garhwal Himalaya and surrounding regions. At this station the strong motion data is being recorded in trigger mode at 200 samples per second. During the reporting period, the accelerograph sketched strong ground vibrations at Ghuttu at the time of occurrence of 10 earthquakes of local and regional distances. The waveforms of these earthquakes are analyzed for estimation of Peak Ground Acceleration (PGA) at the recording site. The PGA values are important parameter for seismic hazard analysis and also to look after the other geophysical data for any anomalous change during this strong vibration on the MPGO site. Most of the earthquake records are within 100 km from the MPGO observatory. The estimated values of PGA range between 0.572-4.0 cm/s^2. The highest PGA value recorded during this period is 4.0 cm/s^2.

Radon data collection in Borehole

In the year 2012 total 6 earthquakes of moderate magnitude (M > 3.0) occurred in the Garhwal and Kumaun regions of NW Himalaya. Out of these six events the lowest magnitude was 3.0 located in the Pithoragarh district of Uttarakhand that occurred on November 15, 2012. The earthquake of maximum magnitude was 4.8 occurred on November 27, 2012 within Uttarkashi district. The continuous radon data of both sites (Kopardhar and Dhopardhar) does not show pre-seismic or co-seismic radon anomalies related to earthquakes of June 01, 2012 (3.7M); July 28, 2012 (4.5M); October 26, 2012 (3.5M) and November 15, 2012 (3.0M). However the earthquake of the magnitude 3.9 occurred on May 10, 2012 in the Chamoli district show precursory phenomena in soil radon probe located at 10 m depth in a borehole at Kopardhar site. Sudden decrease of radon concentration started from May 4, 2012 i.e., five days prior to earthquake and regains the radon level on the day of earthquake again. On the other hand, the water level started rising on May 10, 2012 and reached to its maximum value on May 13, 2012. An increase of 40 cm water level is observed in three days. It is significant to mention here that no rainfall occurred in the region during this period. Therefore, we consider the sudden radon drop in figure 41 is probably caused by a tectonic disturbance, and may be considered as precursory signature of 3.9 M earthquake that occurred on May 10, 2012.

Seasonal Variation observed in the GPS time series

Continuous GPS data since May 2007 from the MPGO observatory have been analysed together with several

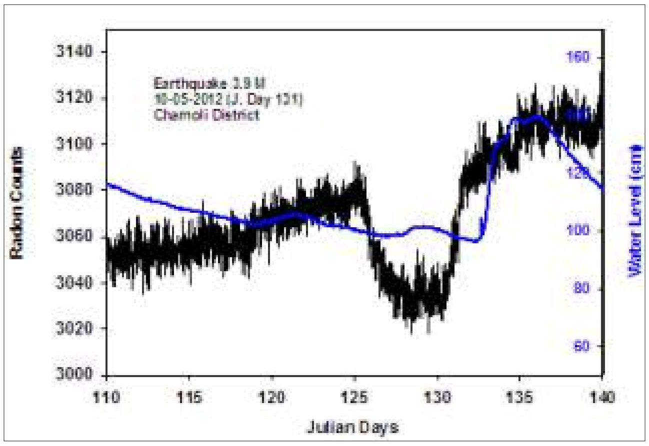

Fig. 41 : The variation of radon concentration in 10 m borehole and the level of water table at MPGO, Ghuttu.

IGS sites surrounding the Indian plate using GAMIT software of version 10.35. The site position estimates and their rates were estimated in ITRF2008 by stabilizing more stable continuous sites and core IGS reference sites using GAMIT/GLOBK, GLORG. In ITRF2008 the Ghuttu GPS site moves at the rate of about 43.31 mm/yr towards N47°. It appears that after the monsoon period (September-October) the site experiences northward movement which reaches at its peak during the end of winter and starting of summer (April-May). Afterwards, the site experiences slight southward movement as shown in figure 42. Thus during summer southward movement produces extension in the Himalaya, while in the winter the northward movement produces contraction.

At MPGO Ghuttu, continuous measurements of rainfall, atmospheric pressure and water table are also made. We tried to correlate the variation in displacement obtained through GPS with other parameter which indicates that the rainfall, water table and atmospheric pressure are nicely correlated. The low of displacement occurs 2-3 months after the high rainfall in the region (Fig. 42), indicating no direct relation between the two. However, the peak water storage in the Ganga plains, derived from GRACE data (Fig. 43) correlates well with the low in displacement. The peak in the water storage in the Ganga plains occurs after about two months of the monsoon season. The already exist hypothesis proposed that the annual cycle of water storage in the Ganga plains causes southward movement in the Himalayan region during the summer period and northward movement during the winter period. It is explained by the analogy of the flexure of the beam when subjected to the load at its centre.

The seismicity of the NW Himalaya recorded by the local network of WIHG was also analysed to observe the seasonal variation for the same period. We did not find any significant increase in the seismicity of HSB during the winter period in each year, however, when we stacked the month wise seismicity during the period 1999-2010, a moderate increase in frequency of earthquakes (M>2.5) during December to March was noticed (Fig. 43). The apparent lag between the seismicity and the peak in displacement may not be real, and we suggest that the case is similar to that of Nepal. Thus the variation in the seismicity in the Garhwal Himalaya too is influenced by the seasonal variation in the deformation rate.

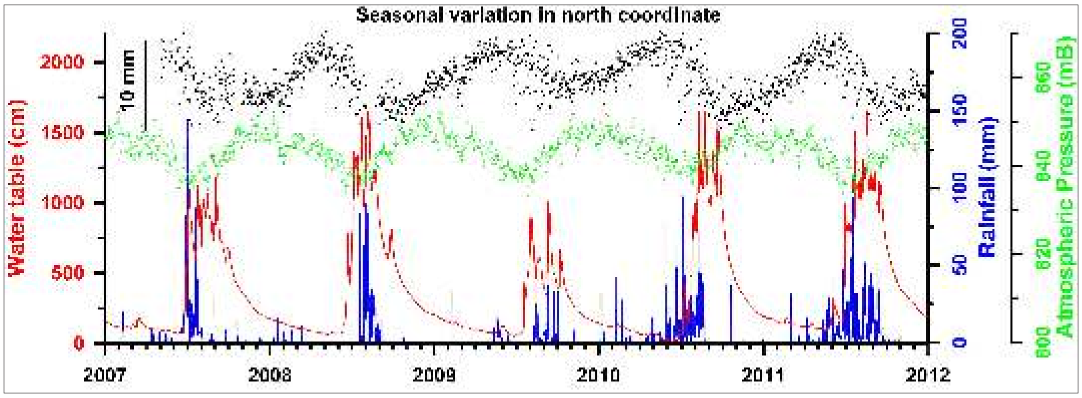

Fig. 42 : Variation in the north coordinate at Ghuttu (black dots) with rainfall (blue), water table (red), atmospheric pressure (green). For clarity in viewing, we have not shown the error bars in the coordinate variation.

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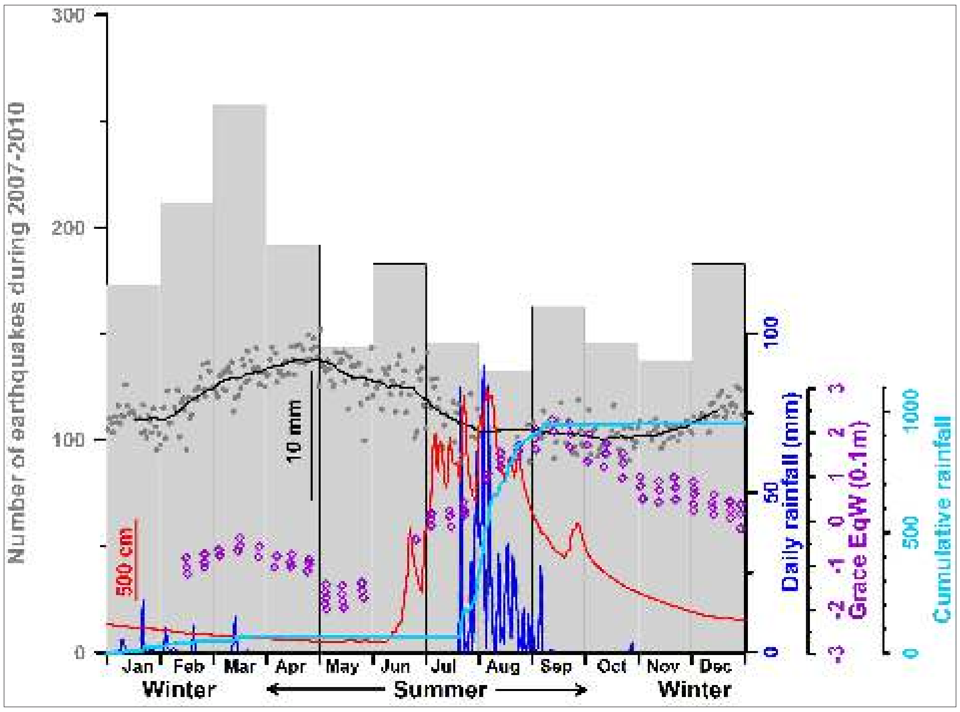

Fig. 43 : Variations in various quantities noticed on yearly basis. Stacked monthly variation of seismicity (gray bars) during 1999-2010. Gray dots show north component of displacemnt at Ghuttu and the black curve is the moving average best fitting curve. Rainfall (blue), cumulative rainfall (light blue), water table (red) and Grace equivalent water storage (voilet).

Geomagnetic, Electromagnetic investigations for earthquake precursory signatures

Seismomagnetic effects are the localized changes in geomagnetic field intensity which in some manner appear to be associated with earthquake occurrence. Although exact mechanism for these changes is still debatable, but Piezomagnetic effect, electro-kinetic phenomenon etc is invoked to explain the possible occurrence of these localized changes. Despite the high precision of most modern equipments, isolation of stress induced perturbations continues to be a challenging issue. However, use of advanced statistical methods, fractal analysis and data adaptive methodologies proved fruitful in isolating inter-planetary/terrestrial induced changes from tectonic perturbations. For example, the method of principal component analysis applied to simultaneously recorded data of total magnetic field observations at three places, which suggest that there was anomalous behaviour in magnetic field before the occurrence of Mw 5.0 Kharsali earthquake of July 23, 2007. The results from this statistical analysis supported the observation of differential analysis of magnetic field, a conventional method of magnetic field analysis for identifying tectono-magnetic field. We routinely apply these methodologies to explore the time variability of magnetic field time series. For the ULF band time series, polarisation analysis and fractal method is applied. Polarization analysis (Hayakawa et al., 1996) is performed using the ratio S_Z/S_H, where S_Z and S_H are the spectral densities of vertical and horizontal magnetic field components in the selective frequency band. Fractal analysis is done to observe the non-linear dynamics of earthquake preparation process.

For the DFM data, we are calculating geomagnetic transfer function utilizing three component magnetic field variations. Robust methods for estimating transfer functions are employed. Geomagnetic transfer function tells how the vertical magnetic field variations are linked to horizontal magnetic field variations thereby pointing changes in conductivity variation below the observation point. Ideally there should not be temporal variation of these geomagnetic transfer functions. Any change in the geomagnetic transfer function indicates that there is change in the subsurface conductivity variation.

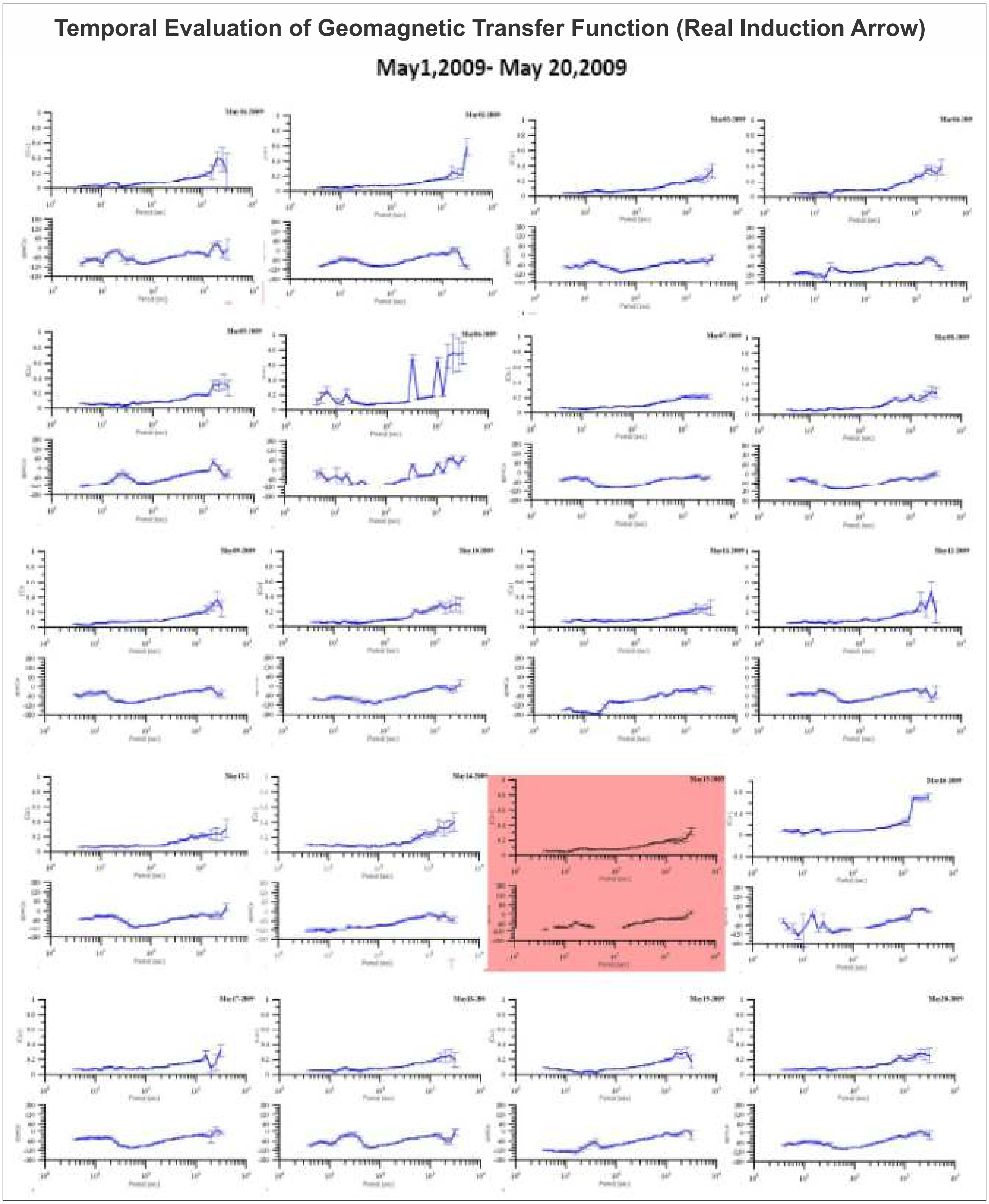

Fig. 44 : Temporal evolution of real part of geomagnetic transfer function (May 1- 20, 2009).

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Although there is no earthquake of considerable magnitude (> 4.5) in the vicinity of MPGO Ghuttu after Kharsali earthquake, we have analysed earthquakes occurring within 100 km radius of MPGO Ghuttu. Figure 44 depicts the temporal evolution of real part of geomagnetic transfer function for a period of 20 days with reference to the earthquake occurred on May 15, 2009 of magnitude 4.5, and 54 km away in the NE direction from Ghuttu.

Gravity measurement using superconducting gravimeter

During earthquake generation process, a change in the gravity near to earthquake source is expected which may be related to deficiency or enhancement in the mass towards the observation point in the different zones of the earthquake rupturing model. Consequently there should be increase or decrease in the gravity, the exact amount should depend upon the size of the earthquake and the distance of the earthquake source. These changes are now easily detected and recognized during co-seismic period (Imanishi *et al.*, 2004) using highly sensitivity superconductive gravimeter (SG) which can measure gravity to sub Gal level. However, the gravity measurement to μGal level is influenced by many factors such as tidal forces, atmospheric pressure, changes in the level of water table, moisture etc.

In the residual after removing all the effects mentioned above, a sudden shift of 52 nm/s^2 observed during the occurrence of Kharshali earthquake (Mw 5.0) occurred on July 22, 2007 which was recognized as co-seismic change. This was a well preserved co-seismic change observed through SG at this high seismic zone of the Himalaya which is also noticed at other station using SG data. Taking this into consideration, we processed and analyzed the data related to other earthquakes of 4.1 and above magnitude recorded within about 200 km distance during 2011-2012. It is noticed that, the co-seismic change in gravity is identified whenever any earthquake of M4.5 occurred within a distance of 100 km. However, a well preserved co-seismic change (Fig. 45) was also noticed at 220 km distance during the time of occurrence of M 5.7 in the Dharchula region (India-Nepal Border) on April 4, 2011. The co-seismic change of 37 nm/s^2 is visible in the 1 sec sampling SG data after removing all the effects. In the expanded part (inset of Fig. 45) of about four hours duration, where the highly oscillating part due to seismic waves is removed, the base shift is clearly visible. Careful analysis of this data set indicates that the co-seismic change depends upon magnitude (occurred only when M4.5) and the epicenter distance. It directly relates to the dislocation and readjustment of some subsurface part near to earthquake source due to rupturing of the region based on dilatancy diffusion model.

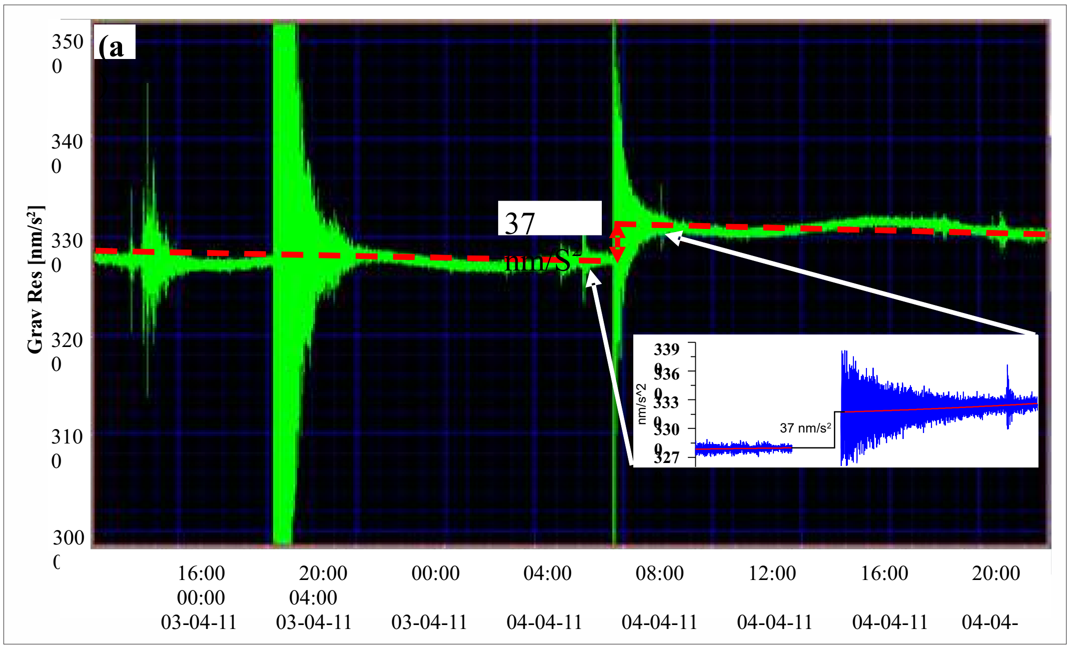

Fig. 45 : Prominent co-seismic change observed during M5.7 earthquake in the gravity data of Superconducting gravimeter (Kumar et al., 2013).

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

(A. Krishnakanta Singh)

Although intensive geological investigations and systematic mapping in different parts of the Naga-Manipur Ophiolites (NMO) have established the stratigraphy and tectonics, till date no reports on gabbroic intrusives in the southern part of the NMO, i.e. the Manipur Ophiolite Complex (MOC) is available. Hence, the project work was focused on the mafic intrusive rocks of the MOC and discusses their geochemical characteristics and tectonic significance.

Based on the field occurrences, textures-mineralogy and whole-rock compositions the mafic intrusives are classified into two types i.e. type-I (Gabbro intrusives) and type-II (basalt-dolerite dykes). These rocks display uniform mineral assemblages and textural relationships. They are mainly composed of plagioclase, clinopyroxene and Fe-Ti oxides. The average modal abundances of the constituting mineral phases are estimated to be 70-73 vol. % plagioclases, 25-30 vol. % clinopyroxene, 4-6 vol. % hornblende, 3-4 vol. % Fe-Ti oxides, while chlorite, epidote and sericite are secondary components. Basalt and dolerite dykes (type-II) are fine to medium grained consisting of plagioclase (40-55 vol. %), clinopyroxene (up to 20 vol. %), hornblende (up to 3 vol. %), Fe-Ti oxides, epidote and sericite. Under the microscope they show porphyritic and variolitic textures. These mafic rocks are moderately to highly altered, as the replacement of plagioclase with sericite and epidote, clinopyroxene with amphibole and/or chlorite are observed. At places, plagioclase is partly or completely enclosed in intercumulus amphiboles giving rise to pseudo-subophitic and pseudo-ophitic textures, respectively. The groundmass has also undergone variable degrees of alteration.

Both the type-I and type-II mafic intrusives emplaced are subalkaline-tholeiitic affinity with Fe-enrichment. The type-I resembling enriched-type mid-ocean ridge basalt (E-MORB) shows moderate LREE enrichment (La_N/Sm_N = 2.5-2.6), slightly enriched MORB normalized HFSE patterns possibly represent melts derived from enriched MORB sub-oceanic mantle sources by small degree of partial melting. The other type-II has normal-type mid-ocean ridge basalt (N-MORB) geochemical features, as it exhibits nearly flat to depleted LREE (La_N/Sm_N = 1.0-0.6), flat MORB normalized HFSE patterns with slight LREE/HREE depletion (Ce_N/Yb_N = 1.37-0.46). It might have been derived from depleted MORB type sub-oceanic mantle source. The MORB signature displayed by these mafic intrusives indicates that they are dismembered fragments of oceanic crust generated at mid-ocean spreading ridge system and support the hypothesis that the Manipur ophiolites was initially formed in the divergent plate margin.

Project
VSAT linked Seismic Network for Seismic Hazard studies in Garhwal Himalaya

(Ajay Paul)

A seismic network of 10 Broad Band Seismograph (BBS) were installed in June/July 2007. Each station is equipped with Trillium-240 (broadband) seismometer and of high dynamic range (> 138 dB) Taurus data acquisition system (DAS). All the stations of the network are connected to the Central Recording Station (CRS) at Dehradun by VSAT. The CRS is located at Dehradun and the remote stations are located seven in Uttarakhand, two in Himachal and one in Uttar Pradesh (Fig. 46). The data is being acquired and analyzed continuously by the network. Till March 2013, a total of 18,026 events have been detected which includes 3739 local events, 5741 regional events, and 8546 teleseismic events. For the period 2012-13, totally 5620 events were detected including 780 local events, 3491 regional events, and 1349 teleseismic events. The space time pattern are regularly being examined to demarcate enhanced/quiescence that invariably precede the large earthquakes in this region. Some of the earthquake swarm activity has also been observed. The change in the velocity ratio Vp/Vs is one of the precursor phenomenon. This ratio decreases and then recovers shortly before a major earthquake. Variations of Vp/Vs ratio have been studied for the period April 2012 to March 2013. 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 (Fig. 18). The chronological order of local events for the period April 2012 to March 2013 is shown in figure 20. No anomalous pattern or any other precursor phenomenon is identified during the one year period between April 2012 and March 2013. The source

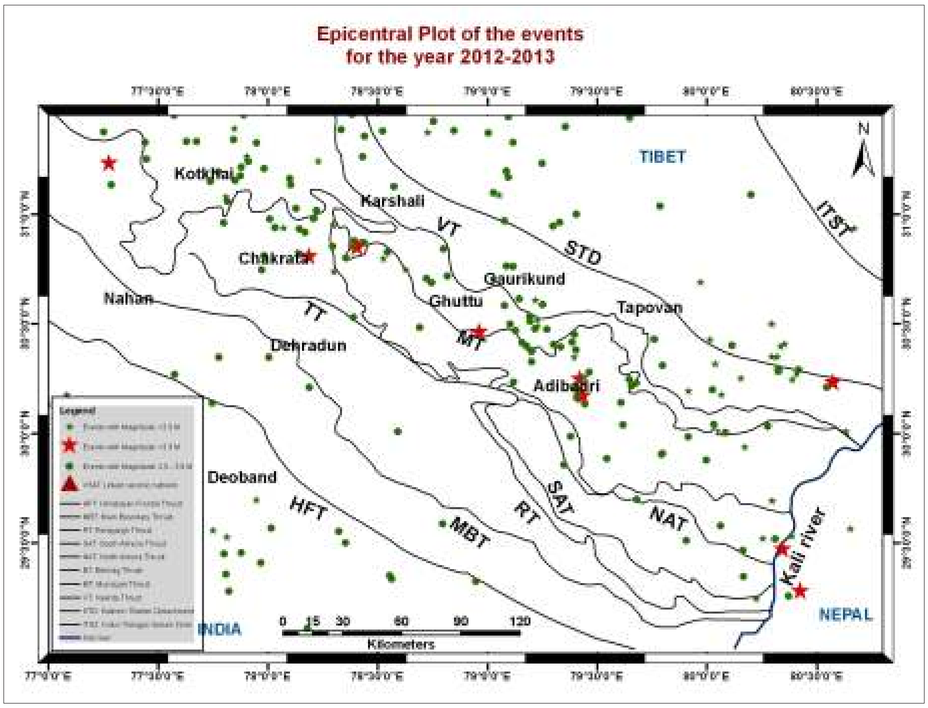

Fig. 46 : VSAT network and the seismicity plot for the events recorded from April 2012 till March 2013.

parameters of the events have been evaluated. The seismic moments for 467 shallow focus earthquakes range from $5.6x10^{11}$ Nm to $7.04x10^{14}$ Nm. These earthquakes are found to have very low stress drops, 197 events have less than 1 bar for 191 events between 1 bar and 10 bars. The maximum stress drop is found to be 41.9 bars for an earthquake of magnitude 4.9. It is significant to note that the seismicity pattern of Garhwal-Kumaun region as recorded in the present network suggests that the region south of MCT trending NNE-SSW along thrusts and faults is seismotectonically active. The region continues to record shallow focus events with low stress drop values. Though this part of Himalaya has enough amount of accumulated strain energy but the hypocentral parameters of last twenty years indicate that the upper crust is releasing energy frequently in the form of micro earthquakes. This may be attributed to the rock mass constituting the upper crust in the region has low strength for accumulation of strain energy and the rocks undergo brittle fractures and adjustments.

Seismicity pattern and earthquake mechanics has been studied from the data for the period April 2005 to June 2008 in Garhwal-Kumaun region. 1D velocity model has been computed using local earthquakes. It has been found 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 (Fig. 47). The striking feature of seismicity in Garhwal-Kumaun Himalaya is the narrow belt of seismicity (Fig. 46) that follows trend of the MCT zone extending throughout the study region from west to east.

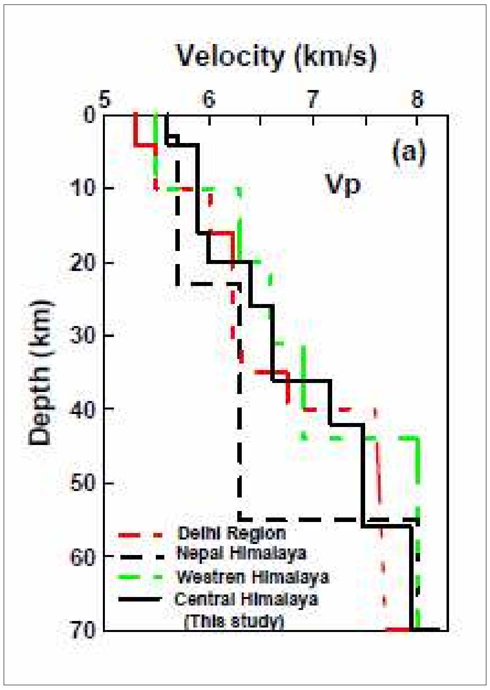

Fig. 47 : Initial and final velocity models for P wave.

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

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

The existing data sets have been re-processed based upon a new processing methodology to improve the accuracy of satellite data with the ship-borne data. The highlights of results are as follows: The latest Earth Gravity Model (EGM2008) has been used to improve the existing marine geoid data over the Northern Indian Ocean by removing the deeper earth effects upto harmonics 50. It has been observed that the new version of satellite derived gravity data matches well with the available ship borne data with Root Mean Square Error (RMSE) varying from 5.1 to 7.8 mGal. Moreover, the spatial resolution of the data has been improved from earlier 24 km to 16-18 km. We have utilized this improved gravity data to study the enigmatic 85°E Ridge anomaly. Analysis based upon the continuation of anomalies shows that around 40% of the present day negative gravity field of the 85°E Ridge is contributed by the subsidence of the mantle lithosphere and hence affected the overall ridge compensation. Residual geoid anomalies of Carlsberg Ridge in the Northwestern Indian Ocean region have been generated and efforts have been made to compute the Ridge basal heat flux anomalies.

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

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

The equipments have been deployed, one at Pithoragarh in Uttarakhand at south of MBT, while the other was installed in the Ladakh region. Data sets from these two stations are yet to be arrived for further analysis.

Project
National Geotechnical Facility (NGF)

(Anil K. Gupta, V.C. Tewari, B. Venkateswarlu, G. Kalyan Kumar, Ruchika Tandon and Mohd. Sazid)*

**Project Director w.e.f. October 2012*

A National Geotechnical Facility center (NGF) was created at Dehradun (Fig. 48) under the ambit of Wadia Institute of Himalayan Geology, Dehradun, to carry out research on geotechnical aspects of the Himalaya such as landslides, GPR and other natural hazards.

Fig. 48 : Research activities of the NGF.

Ground Penetrating Radar experiments (GPR) surveys were carried out in NGF campus, survey colony premises, pavement analysis in Dehradun. Also carried out in Luhri Hydro Electric Project at Audit (power station) and around Rohtang Tunnel (dam site). The GPR used has 50 and 100 Central Frequency Antenna, 1500 MHz Central Frequency Antenna, and with a total cable length available is ~30 m.

As part of landslide and natural hazard studies, the soil dynamics and earthquake engineering, seismic hazard analysis, land slide, liquefaction analysis, deep foundations and geotechnical behavior of problematic soils have been carried out. Along with this quantitative petrography, petrophysical, mechanical properties and slope stability for the Luhri hydropower project, and geological mapping of an Audit were carried out. The studies include 100 core samples and 40 thin sections for measurement of various rock fabric and geotechnical properties in the laboratory. Engineering rock blasting and numerical modeling studies were also carried out.

Project

Fluid flow in Ladakh Accretionary Prism, Indus Suture Zone: Implications for modeling of fluid process of subduction regime

(H.K. Sachan)

Field work has been carried out in the Ladakh, especially covering Lato-Upshi, Nimu-Chilling section of Ladakh accretionary prism, as well as, in Shergol ophiolitic mélange. Thin section petrography of calcite-quartz veins are carried out, which shows that there is marked development of recrystallization, and deformed fabric. Preliminary fluid inclusion studies reveal the presence of high-saline brine along with CH_4 and CO_2 gases, with moderate salinity of aqueous biphase inclusions. The detailed study is under progress. The calcite and quartz veins are analyzed for carbon and oxygen isotope compositions. The preliminary results are as follows:

In the Lato-Miru-Upshi (LMU) area, the calcite veins exhibit oxygen isotope ratios in the range of 10 to 17 ‰ VSMOW, and in Nimu-Chilling area (NC) also it varies from 10 to 18 ‰ VSMOW. On the other hand, the carbon isotope values (inorganic + organic carbon) range from -10 to -7 ‰ and -4.1 to +1.3 ‰ VPDB, respectively in LMU and NC. The carbon isotopic values of calcite veins may be depleted by the organic carbon present in host rock, the sandstone. The $\delta^{13}C$ values of calcite veins show a large range that can only be interpreted as a mixing between two carbon sources, a low $\delta^{13}C$ and a high $\delta^{13}C$ component. The first component is probably organic carbon present in the sedimentary rocks, and the second component with a minimum $\delta^{13}C$ value near -10 ‰ likely corresponds to deeper source of carbonate. The oxygen isotopic values of quartz from subgroup-I, LMU section is in range from 14 to 17 ‰ VSMOW and from 22.30 to 22.37 ‰ VSMOW, whereas in subgroup-II, the NC section gives the oxygen isotopic value of quartz in range from 15 to 17 ‰ VSMOW and from 23.27 to 23.33 ‰ VSMOW.

Project

Siwalik Mammalian faunas of the Himalayan foothills

(A.C. Nanda)

The work is regarding the writing of the monograph on Siwalik Mammalian faunas of the Himalayan foothills, and is divided into two parts. The first part deals with general chapters, whereas in second part systematic palaeontology of mammalian fossils is provided. The general chapters deal with pre-Siwalik successions, history of vertebrate fossils in Indian subcontinent, different classifications of the Siwalik Group, prevailing confusions in the Siwalik stratigraphy and proposed Standard Reference Sections in India, stratigraphy of the fossiliferous areas and recent advances, relation of the Siwalik faunas with the post-Siwalik and recent faunas, palaeoenvironment and palaeoecology, and mammalian faunas and its bearing on the uplift of Himalaya. In addition, a faunal list of the Siwalik Group, based on recent work in India and Pakistan, is also compiled. About 450 species, represented by 224 genera, are listed. The Recent Mammalian Fauna of India contains 398 species, and thus comparatively rich Siwalik faunas prevailed between 18- 0.6 million years ago. The first Siwalik vertebrate fossil was collected in 1832 from the area lying southwest of Dehra Dun valley and since then different workers of different countries contributed to the Siwalik stratigraphy and palaeontology. The present work includes all 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), Upper Siwaliks of Chandigarh and Jammu regions of India. In addition, works carried out in various fossil localities of Pakistan, Nepal and Myanmar are taken into consideration. Pakistan 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. Upper Siwaliks of Surai Khola and Rato Khola, Nepal are discussed. Middle and Upper Siwalik faunal elements occurring in the Irrawaddy Group of Myanmar are also commented.

Recent Mammalian Fauna of India has its origin in the Siwalik and for the first time this relation is worked out. Elements of Recent Fauna start appearing around 10 million years ago and became prominent at 2 million years. 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 Standard Reference Sections are recognised. While erecting these sections, the stress was on the fossil contents and availability of magnetostratigraphic data. Except Boulder Conglomerate Formation, the lower and upper boundaries of these sections are recognised. As Kamlial fossils are not known from the Indian Siwalik, the Standard Reference Section for the Kamlial Formation is not recognised. The faunal lists of fossiliferous areas are prepared and included in the work.

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, Giraffidae (Order Artiodactyla).

The first draft of the monograph is nearly complete and under revision. The work is being reviewed by the experts. Over 600 pages have already been typed and work is illustrated by more than 50 plates, several figures and tables.

Project

Role of tectonic-climate interaction in morphogenic evolution of Dhauladhar range during Late Quaternary in Kangra and Chamba regions of Western Himachal Pradesh

(V.C. Thakur)

Kangra region

Dhauladhar range (D-range) of the outer Lesser Himalaya trending NW-SE, and lying between the Beas and Ravi rivers, frames the northern margin of the Cenozoic foreland basin in the Kangra re-entrant sub-Himalaya. The altitude at the water divide of the D-range decreases from 5000 m in the southeast to 2800 m in the northwest along the regional Himalayan trend (Fig. 49). The structural and tectono-stratigraphic framework is continuous and same along the D-range. The range can be divided along regional trend into two sectors based on climate and tectonic features, the eastern sector with altitude between 5000 m and 4000 m and the western sector with altitude between <4000 m and 2800 m. The intermontane Kangra basin (K-basin) lies south of the eastern sector. Two large fans, the Kangra and the Palampur fans, are recognized in the basin. We have studied the K-basin (K-basin) tectonics and carried Optical Stimulated Luminescence (OSL) dating of the basin fill of the Kangra fan sediments. South of the Kangra fan of the K-basin, we have mapped the strath terraces over the Jawalmukhi Thrust (JT) along the Banganga river and dated the strath surfaces. The intermontane K-basin is developed within the northern part of the foreland basin on the southern margin of the eastern sector with altitude 5000-4000 m of the D-range. The K-basin has an average 15 km width and 50 km lateral extent. The basin is filled dominantly by debris flow fans derived from the southern flank of the D-range. Three levels of geomorphic surfaces are recognized in the Kangra basin fan. The K-basin fill is composed of post-Siwalik unconsolidated fan sediments. In the proximal part, the fan sediments are dominantly debris and hyper concentrated flows largely comprising of angular to subangular boulders and pebbles with out-size, 10-15 m, diameter boulders of Dhauladhar granite. In the medial and distal parts, subordinate fluvial deposits are associated with the debris flows.

In the Siwalik range south of the Kangra fan of the K-basin, strath terraces are developed along the

Fig. 49 : Out-size Dhauladhar granite boulders in the debris flow in the Kangra intermontane basin suggest catastrophic flood resulting as a consequence of deglaciation in the Dhauladhar range.

Banganga river. The Banganga river, called the Baner river in its upper reaches north of Kangra, flows southwest from the southern slope of the Dhauladhar range and drains into the Pong dam reservoir erected across the Beas river. The river incises the Kangra fan sediments of the K-basin in northern part and the Siwalik range strata in southern part. South of K-basin in the Siwalik range, the river incises 40-88 m of Siwalik bedrock overlain by fluvial gravel cover 5-20 m thick with well developed strath terraces (Figs. 50 and 51). The strath terraces gravel cover along the Banganga river contain subrounded to rounded boulders of Dhauladhar granite in addition to other clast lithologies. The bed-rock incision of the strath terrace is considered as representing bed-rock uplift. Among the four levels of strath terrace surfaces, T2, T3 and T4 give OSL ages range between 76 ka and 17 ka, respectively with mean uplift (bed rock incision) rates 2.34 mm/yr (Fig. 52). The strath terraces lying over the hanging wall of the JT were uplifted as result of southward thrust motion. The JT is characterized by a partially eroded frontal anticline in the Siwalik strata and a complementary broad synform of K-basin, mapped as Lambagaon syncline. The K- basin filled by eroded flux from the southern flank of the D-range is developed over the hanging wall of the JT post-dating the formation of

Fig. 50 : Redish-orange paleosole horizon within the paraglacial debris flow represent an interstadial warm wet climate during last glacial cycle in the Kangra basin.

Fig. 51 : Feldspar laths, 3 mm to 3 cm across, embedded in the sand matrix derived from disintegration of Dhauladhar granite exposed at an altitude 2300 m, suggest paraglacial condition. Locality- Joth, Chamba, H.P.

Fig. 52 : Clast supported, poorly sorted, angular to sub rounded clasts of granite in debris flow deposit. Locality- Saru, Chamba.

Siwalik foreland basin.

Chamba region

The Chamba area lies on the northern side of the Dhauladhar range. The river Ravi drains the area. The river flows largely northwest from its origin along a narrow valley and takes a sharp east-west course in some segments. In some places the river valley is abnormally wide and the width of the river valley is about 2 km wide as seen in the Gehra, Chamba, Kiyani, Rajnagar, where the Quaternary deposits are accumulated in the form of terraces and the fan deposits. Four levels of terraces are preserved along the Ravi river in the Chamba region. The terraces contain the signatures of the climatic as well as the tectonic activities. Three terraces are the valley fill terraces and one is the strath terrace. The terraces T1, T2, T3 are distributed all along the river valley and the T4 is preserved at some places. Height of these terraces above the river beds are 10, 54, 89 and 188 m from the present day river bed respectively. Compositionally all the terraces contain pebbles to boulders sized clasts of granite, quartzite, sandstone and volcanic, with different amount in different terraces. The volcanic clasts occur after the junction between the Ravi and the Saho river. It is the Saho river that brought the volcanic clasts from its catchments area where volcanic rocks are exposed. Out-size clasts, 3-5 m across length, are observed along the tributaries coming from the granitic terrain and joining the Ravi river. The out-size clasts are a part of the fan deposits. The feeder channels of some fans are coming from the elevation of 2600 m or above. The fans on the Ravi river left bank are derived from the southern flank of the Dhauladhar range. Their framework and depositional features suggest the debris flow paraglacial deposits. Of the terraces, the youngest F1 terrace is the strath terrace. It is 10 m above the river bed overlain by 1 m of fluvial gravel cover which gives an OSL age of 10$\pm$1 ka. The incision rate of this terrace is 1 mm/yr. The abandonment ages of the valley-fill-cut terraces T2, T3, T4 are 17 ka, 30 ka, 50 ka respectively. The estimated incision rates of T4, T3, and T2 valley fill terraces are 3.76 mm/y, 2.96 mm/y, and 3.17 mm/y respectively. These higher incision rates are attributed due to greater discharge with increased erosive power and down-cutting of the valley-fill terraces.

Project

Establishment of Centre for Glaciology

(Director, WIHG)

Centre for Glaciology is actively involved in the development of flagship research station, infrastructure and strengthening the trained manpower. A field excursion has been made for in Gangotri Glacier system, Garhwal Himalaya in October 2012, to select two glaciers under this programme for long term as well as short term monitoring. However, presently as a

SPONSORED PROJECTS

measure long term monitoring, two glaciers are being monitored, the Dokriani in Bhagirathi river basin and the Chorabari in Alaknanda river basin (upper Ganga basin). The hydro-meteorological, glacial geomorphological, glacier mass change and snow/ice and melt water isotope studies were carried out during the study period to achieve the objectives enumerated in the project. The data have been collected as per international standards. The data were computed, analysed and the results obtained during the study period are summarized as follows:

Hydrological studies

The velocity-area method was used to estimate snow/ice and glacier melt water discharge of Chorabari and Dokriani glaciers for the entire ablation season of 2012. The measurements were carried out manually using a staff gauge for water levels and float for velocity measurements. Samples of suspended sediment were collected from gauging site twice a day at Indian standard time (8:00 and 17:00). The discharge shows increasing trend from June onwards and maximum discharge found in the month of August. The mean monthly discharge observed at Chorabari during study period 2012 for different months i.e. June, July, August and September are 3.9, 7.2, 8.5 and 2.9 m^3/s respectively.

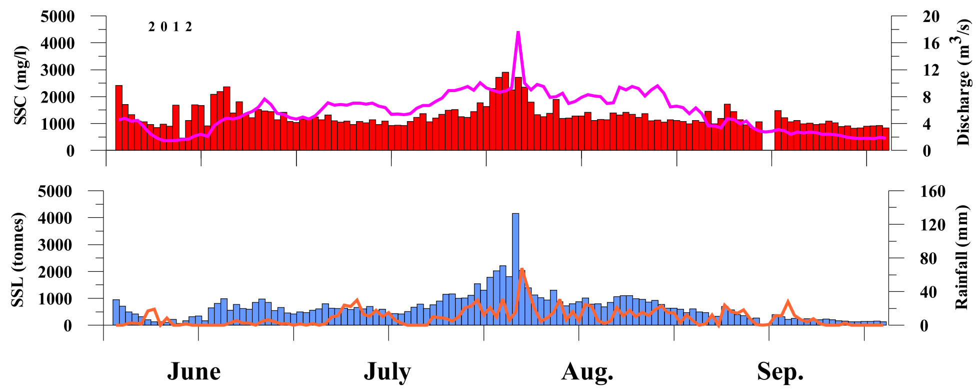

Fig. 53 : Mean monthly suspended concentration and Mean monthly total suspended loads of Chorabari glacier 2012

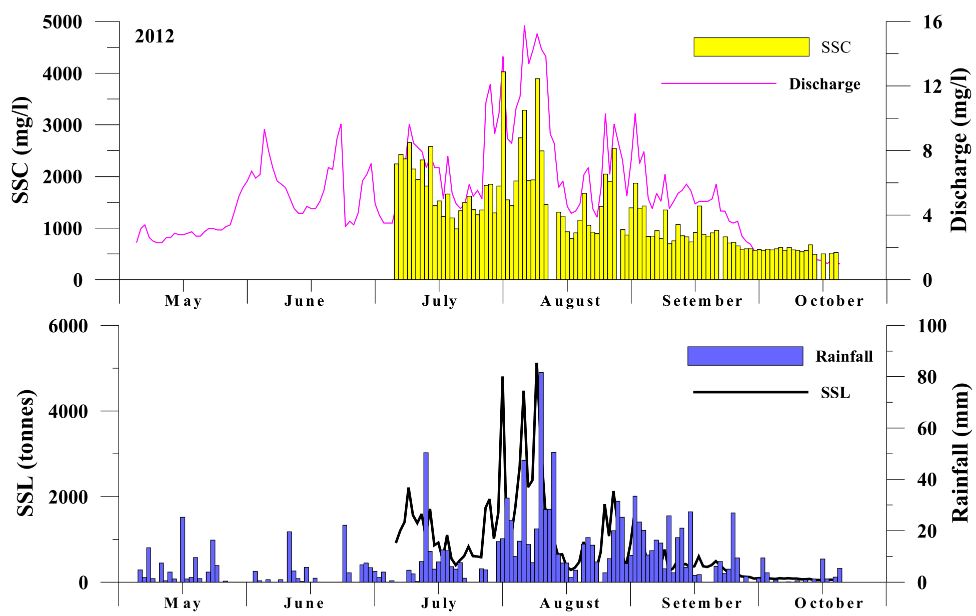

Fig. 54 : Mean monthly suspended concentration and mean monthly total suspended loads of Dokriani glacier 2012

Similarly, the estimated values during the same period for Dokriani glacier were 5.3, 7.9, 2.0 and 1.2 m^3/s. The suspended sediment concentration in the observed discharge was comparatively higher than the last year. Further, the large variation in discharge and suspended sediments was observed over the entire melt season.

Mean monthly suspended concentration during the study period (2012) i.e., June, July, August and September was 1383, 1285, 1433 and 1068 mg/l, respectively for the Chorabari glacier and 1891, 1465, 733 and 560 mg/l at the Dokriani glacier. Mean monthly total suspended loads for same months was 150, 257, 342, and 78 × 10^2 tonnes respectively. Similarly, suspended load estimated at Dokriani glacier for the months of July, August, and September was 1134, 274 and 68 tonnes respectively. The total discharge volume and sediment load estimated for the Chorabari glacier for ablation period 2012 are 60 cumecs and 827 × 10^2 tonnes respectively. The total discharge volume and sediment load estimated for the Dokriani glacier for ablation period 2012 is 30 cumecs during the months July-September. The distribution of daily discharge and suspended sediment concentration and load are shown in figures 53 and 54 for Chorabari and Dokriani respectively.

Meteorological observations at Chorabari and Dokriani glaciers

A network of three sets of Automatic Weather Stations (AWS) (Campbell Scientific) in each of the two glaciers, the Dokriani and the Chorabari Glaciers at three different elevations of approx. 4300 m asl (Glacier camp), 3800 m asl (Base camp) and 2700 m asl (lower valley) were used to collect various meteorological parameters viz. air temperature, wind speed & direction, relative humidity, vapour pressure, sun duration, net radiation, albedo, precipitation and snow surface temperature at hourly basis for round the year. Due to the harsh weather conditions, high wind and heavy snow fall in winter period, some of the sensor's wire broken and also some sensors and battery cabin were buried by the fresh snow which lead to discontinuity in the proper data recording. The maximum-minimum temperature, wind speed & direction, relative humidity, sun duration, rainfall data collected from six AWS

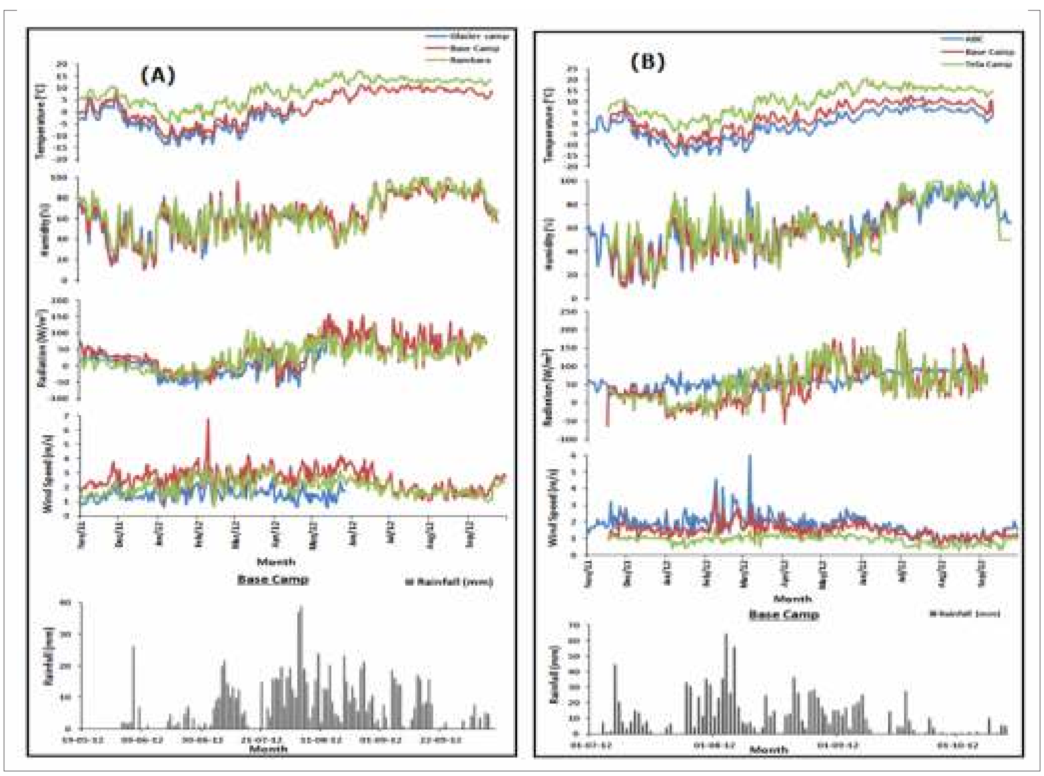

Fig. 55 : Meteorological variables recorded at six observatories at Chorabari (A) and Dokriani glaciers (B) during the period Nov. 2011 - Sep. 2012.

observatories (three from each glacier basin) at different altitudes in both glacier basins are shown in figure 55.

Isotopic Signatures of Winter Precipitation over Dokriani Glacier, Garhwal Himalaya

The study of oxygen and hydrogen isotopic composition of water is a power tool to trace the origin and movement of water vapour throughout the hydrological cycle. A major contribution to the total stream flow of Himalayan rivers during summer is delivered from the melting of glaciers. During the study period we have collected about 2000 samples of melt water (daily), precipitation (solid/liquid) and ice from the different locations over the glacier surface for isotopic analysis. At present only 58 samples have been processed (remaining are under processes) for stable isotopes to understand runoff generation processes during summer runoff. For the analysis of winter snowfall events (November-March) the sample were also collected from the snout of Dokriani Glacier. The collected samples were analysed by Stable Isotope Ratio Mass Spectrometer (IRMS) (Thermo Scientific limited delta V-plus) at the stable isotope laboratory, WIHG, Dehradun. The analysis part of the collected samples is still under process.

Project

Earthquake hazard and risk reduction on the Indian subcontinent (RRISC) - towards an earthquake-safer environment

(Vikram Gupta, Naresh Kumar, Gautam Rawat and PKR Gautam)

This is a joint collaborative project involving institutions like NORSAR 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. Under the ambit of this project, the Wadia Institute of Himalayan Geology had planned to study earthquake risk and loss assessment in the hilly areas, particularly in Mussoorie and Nainital townships (Uttarakhand), along with seismic hazard potential between Kangra and Chamba (Himachal Pradesh).

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 have been installed this year. The recording of the earthquake data is in continuous mode at sampling of 100 SPS. The recorded data of earthquake events (M>4.0) are from the local, regional and tele-seismic distances. In addition, the preparation of earthquake data base of the past events covering a period of past century of the northwestern Himalayan region is in progress. It includes the compiled information from existing earthquake catalogs, extraction of data from websites (e.g. USGS and IMD) and retrieval of information from the publications. By using this data, one can understand the seismic history of the area, and provide a background level for estimating hazard potential for the region.

Further, in order to understand the geotechnical characteristics of the soil developed on the slopes, field work has been carried out in Mussoorie and Nainital areas. A number of slope profiles have been selected for

RESEARCH PUBLICATIONS

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Vincent, C., Ramanathan, A., Wagnon, P., Dobhal, D.P. Linda, A., Berthier, E., Sharma, P., Arnaud, Y., Azam, M.F., Jose, P.G. and Gardelle, J. 2013: Balanced conditions or slight mass gain of glaciers in the Lahaul and Spiti region (northern India, Himalaya) during the nineties preceded recent mass loss. The Cryosphere, (In Press).

Wasson, R.J., Chauhan, M.S., Misra, C., Jaiswal, M., Singhvi, AK. and Srivastava, P. 2013: Erosion of River Terraces as a Component of Large Catchment Sediment Budgets: A pilot study from the Gangetic Plain. Journal of Asian Earth Sciences (In press).

Books/Chapters/Journals edited/published

Singhvi, A.K., Bhatt, N., Glennie, K. and Srivastava, P. 2012: Climate Change in India, Tibet, Arabia and the Middle East during the Quaternary: the chronostratigraphic record. In: Metcalfe, Sarah and Nash David (Eds.), Quaternary environmental change in the Tropics. John Wiley & Sons. ISBB: 9781405182966, pp.151-206.

Sharma, Rajesh and Srivastava, Pankaj K. : Hydrothermal Fluids of Magmatic Origin. In: Kumar, Santosh and Singh, R.N. (eds.), Modelling of Magmatic and Allied Processes. Springer-Verlag (In press).

Technical Reports

Bartarya, S.K. and Gupta, Vikram 2013: Mass movement activities affecting Vasant Vihar Colony and Sports Stadium in Gopeshwar township, district Chamoli, Uttarakhand, 24p.

Srivastava, P., Jayangondaperumal, R. and Juyal, N. 2012: Report on the "Training workshop on the Quaternary setup of arid NW Himalaya: main focus on ladakh-2012, organized at Leh from 18th August to 6th Sep, 2012, submitted to DST, New Delhi.

Kumar, K. and Srivastava, P. 2012: Institutional report of Wadia Institute of Himalayan Geology. Proceedings of Indian National Science Academy, 78p.

Negi, P.S. 2012: Report on proposal to declare Gaumukh-Gangotri-Haridwar corridor of Ganga River as a UNESCO World heritage site. Submitted to the Director, WIHG for onwards communication to the Ganga Action Parivar, Rishikesh, Uttarakhand, 2p.

Popular Article

Sharma, Rajesh. 2012. Geothermal Energy. Akshay Urja Ministry of New and Renewable Energy,

SEMINAR/SYMPOSIA/WORKSHOP ORGANISED

Training workshop on Quaternary setup of arid NW Himalaya: main focus on Ladakh, August 18 to September 6, 2012

Wadia Institute of Himalayan Geology (WIHG), Dehradun organized a *"Training workshop on Quaternary setup of arid NW Himalaya: main focus on Ladakh"* in Leh during 18th August to 6th September, 2012. Seventeen researchers and young scientists from different Universities and Institutes participated in the program. The workshop was inaugurated on 20th August 2012 at DC office, Leh by Prof. Ashok K. Singhvi, PRL Ahmedabad in the presence of Prof. Anil K. Gupta, Director, WIHG, Dehradun and Mr. Tsering Angchuk, DC, Leh. Dr. Umesh Sharma, Scientist, DST, New Delhi also graced the occasion. The mentors for this program were Drs. R.K. Pant and Navin Juyal from PRL, Ahmedabad; Drs. V.C. Thakur, Rohtash Kumar, Pradeep Srivastava and R.J. Perumal from WIHG, Dehradun; and Dr. Binita Phartiyal from BSIP, Lucknow.

Participants and mentors of the Workshop at Mughlib camp

The major objective of this training program was to introduce the young researchers to the Quaternary setup of arid NW Himalaya and to provide a new impetus to geoscientific work in the region. It is devoted to identify various lithofacies in the fluvio-aeolian setup along Indus River, and estimation of discharge from the imbrication data of the pebbles and boulders. Glacial geomorphology was specifically identified, and mapping of moraines and their importance in paleo-glaciological research was demonstrated on Khardung valley glacier. Traverses were also made to study the expressions of Karakoram Fault near Khalsar. Students were exposed to various features related to movements along strike-slip faults. Also, various fluvio-lacustrine, sand dunes and relict moraines were studied in the Nubra and Shyok valleys.

Meeting of Indo-Norwegian Bilateral Project on Geo-thermal Energy, August 7-9, 2012

The Institute during August 7-9, 2012, organized a kick off meeting of Indo-Norwegian Bilateral Project on Geo-thermal Energy at its premises to explore the possibilities of exploiting geothermal energy for power generation in the Himalaya. The meeting was attended by Drs. Roger Olsson, Project Coordinator and Rajinder K. Bhasin, NGI, Norway; Dr. Jiri Muller, Norwegian Energy Research Institute, Norway; Prof. A.K. Gupta, Director, WIHG, Dehra Dun, Dr. Nachiketa Das, Ravensaw University, Cuttack, Dr. Bhoop Singh, DST, New Delhi, Prof. Naval Kishore, Panjab University, Chandigarh, Dr. Mani Ram Saharan, NGF, Dehra Dun, Dr R.S. Banshtu, NIT, Hamirpur; and Drs. S.K. Bartarya, Santosh Rai and Gautam Rawat

Indo-Norwegian bilateral team on Geothermal energy studies

from WIHG, Dehra Dun, The focus of the meeting is to choose a test-site for the Project, and three possible places have been identified viz. Puga/Chummathang (J&K), Manikaran (H.P.) and Tapoban (Uttarakhand) located in the NW Himalaya.

National Conference on Green Earth with focus on the Himalaya, October 18 - 20, 2012

National conference on 'Green Earth with Focus on the Himalaya' was jointly organized by the Wadia Institute

Major General B.C. Khanduri, Prof. Anil K. Gupta and Dr. V.C. Tewari on the dais during the National Conference on Green Earth

of Himalayan Geology (WIHG), Dehra Dun and Indian Geological Congress (IGC), Roorkee during October 18-19, 2013 in the Wadia Institute of Himalayan Geology, Dehra Dun. It was inaugurated by the former Chief Minister of Uttarkhand Major General B.C. Khanduri. Prof. Anil K. Gupta, Director, WIHG presented a report on the scientific research and developmental activities of the Institute, and also explained the rise of the Himalaya and its link with the Indian summer monsoon that largely control the climate and agriculture of the South Asia. Prof. O.P. Varma, Executive President of IGC enlightened the audience about IGC and its services to the nation and geosciences, and Dr.V.C. Tewari, the convener of the Conference explained the main objectives of the Conference.

The conference discussed various aspects of protecting the Green Earth, climate change Indian summer monsoon, melting of Himalayan glaciers, predicting disaster scenario, early warning system etc. There was also some focus on major societal issues like pollution control, hydro power versus nuclear power/solar energy for Uttarakhand, mining of minerals, and mineral materials in the Himalayan region and the Ganga, a cause of concern.

In all eighty papers were presented including key note addresses and around 20 posters were presented under five themes, namely, (i) Green Earth destination to the human happiness, (ii) Climate Change, glaciers and the Himalaya, (iii) Natural Hazards and the environment, (iv) Environmental degradation and mining, and (v) Environmental management and protection. IGC had also given awards to the best posters. The valedictory session was chaired by Shri R. Rath, Director, Oil India Limited and following recommendations were made during panel discussion:

- The conference recommended total ban on production and use of polythene bags.
- Preparation of detailed inventory of mineral resources of the Himalayan region.
- Himalayan region has enormous potential of hydrocarbons, and suggested for their intensified exploration activities.
- Himalaya region being an ecofragile zone, preparation of a comprehensive new environmental plan is suggested.
- To give top priority for the sustainable development of the Uttarakhand state, and the environmental issues of the Uttarakhand state like melting glaciers, river pollution, forest fire, natural disasters (landslides, landslips, earthquakes, flash floods, cloudbursts).

78th Annual Meeting of the Indian Academy of Sciences, Bangalore, November 1-4, 2012

Wadia Institute of Himalayan Geology organized 78th Annual Meeting of the Indian Academy of Sciences (IASc), Bangalore at its premises during November 1-4, 2012. Prof. Anil K Gupta, Director, WIHG gave the

Prof. Ajay Sood, the President of the Academy along with other dignitaries on the dais inaugural address, and Prof. Ajay Sood, the President of the Academy had inaugurated the Meeting and gave a popular talk on *'Driven Matter'*. Over 150 Fellows and Associates of the Academy participated in the Meeting. Thirty three scientific presentations were made by distinguished Fellows and Associates of the Academy on over a wide range of scientific topics. Fifty teachers who have also participated in the Meeting got the opportunity to meet and interact with Fellows. The Meeting also included two symposia on topics like *'Science of the Himalaya'* and *'Computing legacy of Alan Turing'*. Apart from it, two public lectures were delivered by Dr. Mohan Agashe on *'Cinema for Health'* and Dr. Shyam Saran on *'The challenges of climate change and India's strategy in multilateral negotiations'*. Drs. Rajesh Sharma, Kishor Kumar and

AWARDS AND HONOURS

- Dr. Pradeep Srivastava was awarded National Geoscience Award - 2011 by Ministry of Mines, Govt. of India.
- Dr. Kaushik Sen has been conferred with 'K Naha Award' by the Geological Society of India, Bangalore.
- Drs. Ruchika Sharma, Vikram Gupta, B.R. Arora and Koushik Sen were awarded the Institute 'Best Paper Award' for the year 2011-2012 for their paper published in Tectonophysics. Drs. Ajay Paul and M.L. Sharma have also received the Institute 'Best Paper Award' for the year 2011-2012 for their paper published in Journal Asian Earth Science.
- Dr. Sushil Kumar received the best poster award in the National Conference on 'Green Earth with focus on the Himalaya', held in the WIHG during October 18-20, 2012. Sh. Bahnu Partap received the second prize, and Sh. Kapil Kesarwani and Sandeep Chabak received third prize.

VISITS ABROAD

- Drs. B.K. Mukherjee, Koushik Sen and Sudipta Sarkar visited Vienna, Austria to participate in the European Geosciences Union General Assembly meet during April 22-24, 2012.
- Shri Akshay Verma visited Montreal, Canada to participate in the Conference on the "International Polar Year - 2012" during April 22-28, 2012.
- Shri Bhanu Pratap visited Kathmandu, Nepal, to attend a training programme on Glacier Mass Balance including mountaineering safety and Mass Balance measurement during 26th April to 13th May 2012.
- Dr. Kishor Kumar visited Brussels, Belgium for a discussion meeting and comparative study of Early Eocene mammal faunas of India and Europe during May 19-28, 2012.
- Dr. S.K. Bartarya visited Bangkok, Thailand for training on Ion Chromatography during June 18-23, 2012.
- Dr. D.P. Dobhal visited Mississauga, Toronto, Canada to attend training on Ground Penetration Radar (GPR) during July 18-21, 2012.
- Dr. Negi, P.S. visited Montclair State University, New Jersey, USA to participate and present a paper in the International Conference on 'Sustainable Development' during 31st July to 2nd August 2012.
- Drs. Sushil Kumar, S.C. Vaideswaran and Ansuya Bhandari visited Singapore to participate and present papers in the AOGS-AGU (WPGM) Joint Assembly during August 11-17, 2012. Dr. S.C. Vaideswaran also further extended her stay till August 26, 2012 for discussion with the Tectonics Group Leader, EOS-NTU.
- Drs. V.C. Tewari and P.K. Mukherjee visited Brisbane, Australia to participate in the 34th International Geological Congress during August 6-12, 2012.
- Dr. Kishor Kumar visited Brussels Belgium to attend the '4th International Geologica Belgica Meeting - 2012' during September 9-17, 2012.
- Dr. Vikram Gupta visited National Center for Research on Earthquake Engineering, Taipei, Taiwan to attend the International Training Programme on 'Seismic Design and Structure' during 29th October to 3rd November 2012.
- Dr. V.C. Tewari visited Kathmandu, Nepal to participate and present a paper in the 27th Himalayan Karakoram Tibet (HKT) Workshop during November 28-30, 2012.
- Dr. Naresh Kumar visited Kathmandu, Nepal to attend a workshop on the “Quantification of Seismic Hazards in the Indo-Asian Collision Zone” during November 15-22, 2012.
- Prof. Anil K. Gupta visited Hobart, Tasmania to attend WG1 4th Lead authors meeting of the AR5 as Review Editor during January 14-18, 2013.
- Dr. S.K. Bartarya visited Reykjavik, Iceland to attend International Conference on 'Geothermal Energy' and Oslo, Norway for discussion with regard to Indo-Norwegian project on 'Geothermal Energy' during March 3-10, 2013.

Ph.D. THESES

Name of Student	Supervisor	Title of the Theses	University	Awarded/ Submitted
Sh. Yogesh Ray	Dr. Pradeep Srivastava (WIHG) Dr. Y.P. Sundriyal (HNBGU)	Late Quaternary aggradation and incision phases in upper reach of Ganga River system: implications to climate-tectonic Interaction	H.N.B. Garhwal University, Srinagar (Uttarakhand)	Awarded
Sh. Debaprasad Sahoo	Dr. V.C. Thakur (WIHG) Dr. Y.P. Sundriyal (HNBGU)	Neotectonic-active tectonics of Frontal Siwaliks range and Soan Dun in Himachal Pradesh, NW Himalaya	H.N.B. Garhwal University, Srinagar (Uttarakhand)	Awarded
Ms. Ruchika Sharma	Dr. Vikram Gupta (WIHG) Dr. Y.P. Sundriyal (HNBGU)	An integrated study of physical, mechanical and acoustic properties of rocks of the Bhagirathi and Alaknanda valleys and their inter-relationships	H.N.B. Garhwal University, Srinagar (Uttarakhand)	Awarded
Ms. Shivani Pandey	Dr. S.K. Parcha (WIHG) Prof. Pankaj K Srivastava (Jammu Uni., Jammu)	Integrated stratigraphy and depositional history of the Cambrian succession in the Parahio valley of Spiti Basin, Tethys Himalaya	Jammu University, Jammu (J & K)	Submitted
Ms. Poonam Jalal	Dr. S.K. Ghosh (WIHG) Dr. Y.P. Sundriyal (HNBGU)	Source-sink relationship of Neogene sandstone from Ram - Ganga sub basin and its correlation with the other sub basins of Himalayan Foreland	H.N.B. Garhwal University, Srinagar (Uttarakhand)	Submitted
Ms. S. Vyshnavi	Dr. R. Islam (WIHG) Dr. Y.P. Sundriyal (HNBGU)	Weathering history of granitic and basaltic rocks in parts of Garhwal Himalaya	H.N.B. Garhwal University, Srinagar (Uttarakhand)	Submitted
Ms. Kavita Tripathi	Dr. A.K. Dubey (WIHG) Prof. P.D. Pant (Kumaun Uni., Nainital)	Field and anisotropy of magnetic susceptibility studies around the frontal and oblique fault ramp of the Tethyan fault in Satluj and Bhagirathi valleys, Western Himalaya	Kumaun University, Nainital (Uttarakhand)	Submitted

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

Open Science & Policy seminar on "Climate change and adaptation" at India Habitat Center New Delhi, on April 04, 2012

Participant: S.K. Bartarya

Workshop for earthquake precursory research at ISRO, Indian Institute of Remote Sensing on April 24, 2012

Participant: S. Rajesh

Third International Geo-Hazards Research symposium, New Tehri, Uttarakhand, June 10-14, 2012

Participants: Naresh Kumar and S.C. Vaideswaran

Field Training Course in Glaciology at Manali and at Hamatah Glacier, Himachal Pradesh during 6th August to 5th September 2012

Participants: Rakesh Bhambri, Indira Karakoti, Amit Kumar, Akshaya Verma and Kapil Kesarwani

Meeting of Indo Norwegian Bilateral Project on Geo-thermal Energy at WIHG, Dehra Dun during August 7 - 9, 2012

Participant: S.K. Bartarya

Brain-storming workshop between WIHG and NGRI on "Structure of the Indian Lithoshpere along the Satluj valley transect in NW Himalaya: Geodynamic Implications (SHIVA) at WIHG Dehra Dun during August 27-29, 2012

Participants: Anil K. Gupta, Keser Singh, S.K. Bartarya, H.K. Sachan, Sushil Kumar, Ajay Paul, Naresh Kumar, Gautam Rawat, Devajit Hazarika, P.K.R. Gautam and Santosh K. Rai

Meeting on "Gangotri Glacier" at Snow and Avalanche Study Establishment (SASE), Chandigarh during September 14-15, 2012

Participants: Deepak Srivastava and D.P. Dobhal

Tenth NIAS-DST Programme on "Multidisciplinary Perspectives on Science, Technology and Society" at the National Institute of Advanced Studies, Bangalore during 24th September to 5th October 2012

Participant: G. Philip

National Seminar on Green Earth with focus on Himalaya at WIHG held during October 18-19, 2012

Participants: V.C. Tewari, N.S. Siddaiah, Meera Tiwari, G. Philip, B.N. Tiwari, T.N. Jowhar, Sushil Kumar, D.P. Dobhal, Vikram Gupta, Ajay Paul, P.S. Negi, Kapesa Lokho, Raj K. Singh, Jayendera Singh, Sameer K. Tiwari, S.K. Bartarya, *Santosh K. Rai* and Anil K. Gupta.

78th meeting of Indian Academy of Science, Bangalore at WIHG during November 2-4, 2012

Participants: Rajesh Sharma, Kishor Kumar, G, Philip, R. Islam, Keser Singh and S.K. Parcha

DST sponsored programme on 'Integrated Scientific Project Management' held at COD, Hyderabad November 19-23, 2012

Participant: D. Rameshwar Rao

Training on Climate Change and Carbon Mitigation at FRI, Dehra Dun during November 19-13, 2012

Participant: P.S. Negi

National Workshop on Engineering Geophysics for Civil Engineering and Geo-Hazards (EGCEG) at CSIR-Central Building Research Institute, Roorkee during November 22-23, 2012

Participant: Ajay Paul

International conference on the CO_2 Injection for EOR & Geological Sequestration at CSIR-NGRI, Hyderabad during November 26-28, 2012

Participant: Santosh K. Rai

Seminar of the Federation of Indian Chambers of Commerce and Industries (FICCI) at Indian Institute of Remote Sensing, Dehra Dun, November 30, 2012

Participant: Rajesh Sharma

1st meeting of Programme Advisory Committee for Himalayan Glaciology at Wadia Institute of Himalayan Geology, Dehra Dun during December 6 - 8, 2012

Participants: D.P. Dobhal and Deepak Srivastava

Conference of working group on the Evolution of Water within the Ganga River Basin, Natural vs. Anthropogenic Contributions: Implications for Future Watershed/Marine Management, Policy, and Ecosystem Health at Bhubneshwar during December 17-19, 2012

Participants: Anil K. Gupta, H.K. Sachan and Santosh K. Rai

2nd International Conference on Soft computing for Problem solving (SocPros 2012) at J.K. Lakshmipat University, Jaipur during December 28-30, 2012

Participant: T.N. Jowhar

100th Indian Science Congress at Calcutta University, Kolkata during January 3-7, 2013

Participant: T.N. Jowhar

Uttarakhand Teacher Science Congress at Rajiv Gandhi Navodaya Vidyalaya, Dehra Dun during January 14 - 15, 2013.

Participant: P.S. Negi

Indian Integrated Ocean Drilling Program (IODP) Participants Meet held at National Centre of Antarctica and Ocean Research Goa on January 14-15, 2013.

Participant: Raj Kumar Singh

Training programme on "Downscaling and analysing the meteorological data for use in Glacier modeling" at Indian Institute of Technology, New Delhi during February 4-16, 2013

Participants: Indira Karakoti, Amit Kumar and Kapil Kesarwani

DST sponsored programme on 'Future challenges to Society with Thematic of Resources and Development' at NIAS, Bangalore during February. 11-15, 2013

Participant: Meera Tiwari

4th PAGES Open Science Meeting 'The Past: A Compass for Future Earth' in Goa during February 13-16, 2013

Participants: J. Singh and N.K. Meena

Software training in GPS data processing at Indian Institute of Geomagnetism, Mumbai during 20th February to 5th March 2013.

Participant: Rajesh, S.

National Conference on Bio-Meterological Disaster, at Forest Research Institute, Dehra Dun during February 23, 2013.

Participant: P.S. Negi

Advance Techno-Management Programme for Scientist 'C' and 'D' at the Administrative Staff College of India, Hyderabad, from 25th February to 29th March 2013

Participant: A.K. Singh

Training course on Glacier studies, Climate change and Remote Sensing at Indian Institute of Science, Bengaluru during March 4-15, 2013

Participants: Kapil Kesarwani and Tanuj Shukla

National Seminar on emerging issues and challenges in Petrology and Environmental Geology at AMU, Aligarh during March 5-7, 2013

Participant: R. Islam

Meeting between WIHG and NGRI with regard to project initiative on "Structure of the Indian Lithoshpere along the Satluj valley transect in NW Himalaya: Geodynamic Implications (SHIVA)" at NGRI, Hyderabad on March 13, 2013.

Participants: Anil K. Gupta, Keser Singh, S.K. Bartarya, H.K. Sachan, Sushil Kumar, Ajay Paul, Naresh Kumar, Gautam Rawat, P.K.R. Gauatm and Santosh K. Rai

Meeting on "Climate Change Programme" at DST, New Delhi on March 14, 2013.

Participants: D.P. Dobhal and Santosh K. Rai

LECTURES BY INSTITUTE SCIENTISTS

Name of Scientist	Venue	Date	Topic
Dr. Rohtash Kumar	GSI Field Training Camp-Saketi, Kala Amb	20.04.2012	Lithostratigraphy and sedimentation history of Siwaliks
Dr. G. Philip	GSI Field Training Camp-Saketi, Kala Amb	20.04. 2012	Neotectonic activity in the Frontal belt of northwestern Himalaya
Dr. Rajesh Sharma	ASI, Dehra Dun	07.05.2012	Laser Raman Spectroscopy and its use in Archaeology
Dr. N. Suresh	Archaeological Survey of India, Dehra Dun	08.05.2012	Luminescence dating
Dr. Ajay Paul	WIHG, Dehra Dun	11.05.2012	Seismological Investigations and Seismicity Monitoring of Central Seismic Gap (CSG) in NW Himalaya
Dr. N. Suresh	WIHG, Dehra Dun	18.05.2012	Evolution of Late Quaternary deposits in the Soan Dun, NW Sub-Himalaya
Dr. K. Luirei	WIHG, Dehra Dun	08.06.2012	Tectonic geomorphology of the frontal part of southeastern Kumaun Sub-Himalaya
Dr. Vikram Gupta	Uttarakhand Academy of Administration, Nainital	22.06.2012	Landslides in Highways of Uttarakhand - Char Dham Yatra route
Dr. S.S. Bhakuni	WIHG, Dehra Dun	06.07.2012	Neotectonic activities along leading edge of Himalaya: a field-based study
Dr. Naresh Kumar	Institute of Seismological Research, Gandhinagar, Gujarat	27.07.2012	Earthquake precursory research based on MPGO, Ghuttu data
Dr. S.C. Vaideswaran	Directorate of Cold Water Fisheries Research, Bhimtal	04.08.2012	Hydropower Dams in Himalayan Rivers with special emphasis on the Tehri Dam, India
Dr.P.K. Mukherjee	ASI, Dehra Dun	07.08.2012	(i) Introduction to Rocks and Minerals (ii) Weathering of Building stones
Dr. S.K. Bartarya	WIHG, Dehra Dun	08.08.2012	Geothermal Springs in Himalaya: an overview and capabilities of WIHG
Dr. J. Singh	WIHG, Dehra Dun	30.08.2012	Tree ring based climate records from the western Himalaya, India
Dr. N. Suresh	ASI, Dehra Dun	06.09.2012	Luminescence dating
Dr. D.P. Dobhal	Doon Club, Dehra Dun	09.09.2012	Present and Future States of Himalayan Glaciers: Uttarakhand Perspective
Dr. P.S. Negi	WIHG, Dehra Dun	21.09.2012	Himalayan Bio-diversity, its ecological and socio- economic importance
Dr. Sushil Kumar	WIHG, Dehra Dun	21.09.2012	Japan me aya thoku bhukamp' (talk in Hindi).
Prof. Anil K. Gupta	BHU, Varanasi	06.10.2012	Abrupt changes in the Indian Summer Monsoon during the Neogene and Quaternary (K.K. Mathur Memoral Lecture)

Prof. Anil K. Gupta	National Hydrographic Office, Dehra Dun	12.10.2012	Ocean circulation and Global climate (XXXII INCA International Congress Lecture)
Prof. Anil K. Gupta	WIHG, Dehra Dun	18.10.2012	Abrupt changes in the Indian Summer Monsoon during the Late Quaternary (Green Earth Conference)
Dr. Vikram Gupta	WIHG, Dehra Dun	18.10.2012	Landslides as a primary and secondary hazards in the Himalaya (Green Earth Conference)
Dr. B.N. Tiwari	WIHG, Dehra Dun	26.10.2012	Oxygen in the atmosphere with geological perspective: from beginning to present (talk in Hindi)
Dr. R.J.G. Perumal	Garhwal University, Srinagar,	01.11.2012	(i) Seismic Hazard Assessment: An earthquake geological approach (ii) Lab and Field Mapping using Remote Sensing products, mapping software and hand held GPS
Dr. R.J.G. Perumal	Garhwal University, Srinagar	02.11.2012	Exogenous and Endogenous Process: Quantification
Dr. D.P. Dobhal	ICFRE, Dehra Dun	22.11.2012	Climate change impact on glaciers - ob servation and facts
Dr. P.S. Negi	Virbhadhra, Rishikesh	09.12.2012	Climate Change & Sustainable Development: an Himalayan perspective
Dr. Pradeep Srivastava	HNB Garhwal University, Srinagar	16.12.2012	Continental drift, plate tectonics and build up of Himalaya
Dr. Raj Kumar Singh	WIHG, Dehradun	28.12.2012	Arsenic pollution in Ground Water (talk in Hindi)
Prof. Anil K. Gupta	Panjab University, Chandigarh	15.03.2013	Indian Summer Monsoon as seen through marine sediments of the Arabian sea during the Quaternary (M.R. Sahni Memorial Lecure)
Dr. V.C. Tewari	Indian Institute of Technology, Roorkee	22.03.2013	Geomicrobiology and Astrobiology : Two emerging biosciences in India and their role in Origins of Life
Dr. Pradeep Srivastava	WIHG, Dehra Dun	22.03.2013	Late Pleistocene-Holocene morpho-sedimentary architecture, Spiti River, arid higher Himalaya (talk in Hindi)
Dr. A. K. Singh	Administrative Staff College of India, Hyderabad	25.03.2013	Geodynamic Evolution of the Himalaya

TECHNICAL SERVICES

Analytical Services

The state of art of instruments installed in the central facility laboratories of the Institute were employed to generate analytical data of very high standard. The users of these facilities are the Scientists and Scholars from the Institute, besides researchers from different universities, IITs, Government as well as Private Organizations from various parts of our country. A total number of samples analyzed using XRF, ICP-MS, SEM, XRD and Ion-Chromotography are provided in the table below. The down time for all the instruments was zero during this period.

Lab. / Technique	Samples analysed		
	WIHG Users	Outside Users	Total
XRF	443	403	846
ICP-MS	1113	412	1525
SEM-EDX	216	200	416
XRD	231	142	373
Ion-Chromotography	580	32	612

Photography Section

During the year 2012-2013 around 6500 images were clicked using digital cameras to cover the various functions organized in the Institute from time to time, including Foundation Day, Founders Day, National Science Day, National Technology Day, New Year's Day, Seminars/Symposia, and superannuation parties of the Institute staff etc. Apart from this, around 800 snaps were clicked for rock and fossil specimens. The colour printing of around 300 digital images was arranged from the market. No new cameras were purchased during the reporting year as a great 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 a pool as and when they require it.

Drawing Section

The Drawing Section caters to the cartographic needs of the Scientists of the Institute including various sponsored projects. During 2012-13, the section has provided six geological/structural maps/ geomorphological maps for the Scientists and Research Scholars of the Institute, besides the tracing of twenty seven aerial photo maps and nine geological columns. The section has also prepared name labels, thematic captions and annotations during different activities and functions of the Institute including writing work on the photo identity cards of the employees of the Institute.

Sample Processing Lab.

The sample processing laboratory provided thin/microprobe/polished sections to the requirements of the Institute Scientists and Research Scholars. During the reporting year, the laboratory provided 1019 thin and polished sections to various users for carrying out microscopic, fluid inclusion and EPMA studies. 950 rock samples have also been powdered in the laboratory for carrying out major, trace and REE analysis by ICPMS, XRF and XRD methods.

S.P. NAUTIYAL MUSEUM

The museum of the Institute is the educative section, and continues to remain as a center of attraction for the visitors. The Geological Clock displayed outside the museum remained the main point of attraction for those who visit museum. The visitors of the museum include a large number of student's from universities, schools and Institutes from different parts of the country, students and Scientists from overseas, and also it is an attraction for the general public. The Institute provides guided tours by Scientists and Research Scholars for large groups of school/university students who visit the museum. During the year more than 3,000 people visited the museum from different part of the country. A large number of visitors from abroad, like from Japan, Russia, France, U.K, USA, Vienna, Australia and Canada also visited the museum

The museum observed open day during National Technology Day (May 11, 2012), Foundation Day (June 29, 2012), Founder's Day (October 23, 2013) and National Science Day (February 28, 2013). Like previous year, a large numbers of students and general public visited the museum on these occasions. Science quiz and Hindi essay competitions were organized on the eve of science week calibrations (February 22-28, 2013). Around 40 students participated in the science quiz and around 50 students participated in the Hindi essay competition from various schools of Dehra Dun and the surrounding areas. As a part of encouragement to the students, prizes were distributed to the students who stood first, second and third, along with some consolation prizes.

LIBRARY

The Institute Library has its own reputation of being one of the best libraries of Earth Sciences. It has an unique collection of more than 35,500 books, monographs, journals and seminar/conference proceedings on geology, geophysics and mountain building processes with special reference to Himalayan Geology. Library subscribes to 44 National and 86 International titles of scientific journals of repute in the field of Earth Sciences. The Library is computerized since 1991, and all the operations viz. acquisition, catalog, circulations and journals subscriptions are computerized. The Library has the small hub of computers for accessing the e-books and e-journals and Internet browsing, and the other e-resources available through the National Knowledge Resource Consortium *(NKRC)*.

The Library is also member of NKRC of CSIR and DST Libraries. Through NKRC the library had online full text access to the resources of 18 major publishers up to December 2012. Presently the library has full text online access to more than 300 titles of journals pertaining to various disciplines of thrust areas of the Institute. The Library has also subscribed to Elsevier's Earth & Planetary Science subject collection consisting of 115 titles on Science Direct platform from volume 1 to the current issue. The DST has provided funds to the Institute to support its libraries for access to several resources.

The back volumes of most of the journals are available in print, starting from 1977 onwards except those titles which Library started subscribing later. The titles subscribed from Wiley and Elsevier are available online from first volume to the current issue.

A total number of 130 books are purchased during the period of this report. All these books have been classified, catalogued and their bibliographic information has been updated into computerized database for on-line searching and circulation purpose.

An *Institutional Repository* of WIHG research is developed using Open Source Software (OSS) DSpace for organizing and disseminating the research output of the Institute in digital format. It consists of full text of publications of WIHG Scientists. The reprints of the scientists' publication beginning from the inception of the Institute are collected and digitized by the library staff for creating searchable PDF files for the users. The publications of the late Prof. D.N. Wadia has been digitized and already incorporated into it. The development of digital collection of some old and rare documents for incorporating into the Institutional Repository is under progress. The repository presently consists of 1345 digital documents and it is accessible on the intranet (LAN) of the Institute.

WIHG Library

PUBLICATION & DOCUMENTATION

The Publication & Documentation section during this year brought out the publications of (i) 'Himalayan Geology' volumes 33(2) and 34(1), (ii) 'Annual Report' of the Institute for the year 2011-12 in Hindi and English, (iii) Hindi magazine 'Ashmika' volume 18, and (iv) newsletter 'Bhugarbh Vani' volumes 2(1), 2(2), 2(3) and 2(4). Apart from this, works pertaining to printing of publicity/seminar brochures, circulars, invitation cards, certificates, greeting cards, ACR forms, visitor pass books, telephone directory, leave record cards 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 & stock account of publications. The section also provides the technical service 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. The Impact Factor for the year 2011 was 0.49 (source: Thomson Reutors). Under the Life Time Subscriber Scheme (LTSS) Membership for Himalayan Geology (journal), 20 new members got registered; bring the total registered number to 371.

CELEBRATIONS

National Technology Day

The 14th 'National Technology Day' was observed on May 11, 2012. The day has been observed as open day wherein the museum and other laboratories were kept open for the school and college children, and for other general public. On the occasion, two lectures were delivered, one by Prof. C. N. R. Rao, Scientific Advisor to the Prime Minister of India and National Research Professor on *'Three lessons of Chemistry for the School*

Prof. C. N. R. Rao delivering the Technology Day Lecture and having group photo with school children on the eve of 'National Technology Day'

Children'; and the other by Prof. Linus Pauling, Research Professor and Honorary President JNCASR, Bangalore on *'2011-Celebration of Science'*. A large number of students from different schools, colleges, general public, Institute staff and invited guests from other Institutions attended the talks.

Foundation Day

The 44th 'Foundation Day' of the Institute was celebrated on June 29, 2012. The Chief Guest on the occasion, Padma Shri Prof. Aditya N Purohit gave the Foundation Day Lecture on *'The Changing World during 21st Century - New Paradigm for Development'*. The Chief Guest also distributed awards to the best research papers published by the Institute Scientist(s) as well as the best worker award in various categories of the Institute.

The award winners include Sh. Pankaj Chauhan (Technical Assistant), Sh. Surender Singh (Bearer), Sh. Chander Sekhar (Sr. Tech. Officer), Sh. N.K. Juyal (Jr. Tech. Officer), Sh. Satish Prasad Bahuguna (Sr. Lab.

Padma Shri Prof. A. N. Purohit delivering the 'Foundation Day Lecture'

Assistant), Sh. Sekhranandan (Section Cutter), Sh. Girish Chander (Guest House Attendant cum Cook), Sh. Ravi Lal (Field cum Lab. Attendant), Sh. Tirath Raj (Sr. Lab. Assistant), Sh. B.B. Panthri (Field Attendant), Sh. A.S. Negi (Assistant), Sh. S.K. Chettri (U.D.C.), Sh. Ajit Kumar Gupta (Sr. Lab. Assistant), Sh. Hari Singh Chauhan (Field cum Lab. Attendant), Sh. R.S. Negi (Field Attendant), Sh. M.S. Rawat (Field Attendant), Sh. Satya Parkash (Section Cutter), Sh. Santu Das (Section Cutter), Sh. M.C. Sharma (Assistant), Sh. Jeevan Lal (Bearer), Dr. Jitender Bhat (Sr. Tech. Assistant), Smt. Neelam Chabak (U.D.C.), Sh. Rahul Sharma (L.D.C.), Sh. O.P. Anand (Office Supett.), Sh. R.S. Yadav (Driver) and Sh. S.S. Bhandari (Sr. Tech. Assistant) for the good work carried out by them during the year 2012-13.

Founder's Day

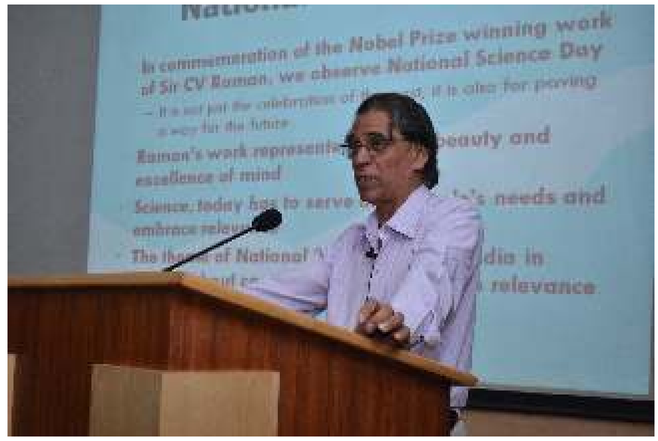
The Institute celebrated its 'Founders Day' on October 23, 2012. Prof. U.R. Rao, Former Chairman of Space Commission and Space was the Chief Guest on the occasion. He delivered the 'Founders Day Lecture' on the topic the *'Exciting Challenges in Space'*. The lecture was attended by large number of students and staff of the Institute. Prof. Rao also visited various laboratories and interacted with the Institute Scientists.

Prof. U.R. Rao and Anil K Gupta on the dais during the 'Founder's Day Celebrations'

National Science Day

The National Science Day is organized as a week long activity in the Institute. Dr. T. Ramasami, Secretary, Department of Science and Technology delivered the 'National Science Day' lecture on the topic *'Social Contract of Science towards Food Security'*. The lecture was attended by large number of students, staff members and other dignitaries from various Institutes.

The National Science Day, February 28, 2013 is observed as open day, and laboratories and museum were kept open for public. In total, sixty educational instuitions with more than 3,000 school children and large numbers of college students and public visited the Institute museum and laboratories. Various exhibits on the Himalayan glaciers, Earthquakes, Landslides, Origin of life, Volcanoes, Rocks, Minerals, etc were displayed in the museum and a team of researchers explained the students and other visitors about the exhibits. Likewise, the students and visitors who went around various laboratories were explained the functioning of the instruments.



Dr T. Ramasami, Secretary, DST delivering the 'National Science Day' Lecture

Prof. Anil K Gaur of G. B. Pant University of Agriculture & Technology, Pantnagar had also delivered a talk on '*Genetically modified Crops and Food Security*', which was attended by a large number of students and the staff of the Institute. Various other activities have been organized during this week, for example, Science Quiz and Hindi Essay competitions for the school children from Dehradun, Hindi and English slogan competition for Scientists, staff and Research Scholars of the Institute. Prizes were also distributed to the winners of the Science Quiz, Hindi Essay and Slogan competitions.

J.B. Auden Memorial Lecture

Under the lecture series organized by the Institute, this year on March 18, 2013, the 'J.B. Auden Memorial Lecture' was delivered by Prof. Mrinal K. Sen, Director, National Geophysical Research Institute, Hyderabad.

Prof. Mrinal K. Sen, Director, NGRI delivering the 'J.B. Auden Memorial Lecture'

He gave a talk on *'Geophysical Investigation of Impact Craters'*. The lecture was attended by the staff members of the Institute and also by other invited dignitaries.

Science Outreach Programme

In order to decipher the knowledge among the students and awareness among the people about natural disaster like Earthquakes, Land slide, Flashflood etc. the Wadia Institute of Himalayan Geology under the Science Outreach Programme participated in the following exhibitions and programmes :

- "Pride of India" ISC Expo - 2013 organized by the Department of Science & Technology, New Delhi form January 3-7, 2012 at Kolkata
- Basant Mela - 2013 organized by Indo-Tibetan Border Police
- Vasant Utsav - 2013 held at Rajbhavan, Dehra Dun from March 23-24, 2013

DISTINGUISHED VISITORS TO THE INSTITUTE

- Dr. Olafur Ragnar Grimsson, His Excelency, The President of Iceland
- Shri S. Jaipal Reddy, Hon'able Minister for Science & Technology and Earth Sciences, Govt. of India
- Gudmundur Eirisson, Ambassador of Iceland to India
- Ornolfur Thorsson, Secretary General, Office of President, Iceland
- Prof. C.N.R. Rao, Scientific Advisor to the Prime Minister of India
- Dr. T. Ramasami, Secretary DST, Govt. of India, New Delhi
- Professor U.R. Rao, Former Chairman, Space Commission and Space, Bangalore
- Padmashri Prof. A.N. Purohit, Ex DG, CSIR
- Dr. V.K. Bahuguna, DG, Forest Research Institute, Dehra Dun
- Dr. Mrinal K Sen, Director, NGRI, Hyderabad
- Prof. Sridhar Anandakrishnan, Pennsylvania State University, USA
- Prof. Jean Louise Mugneir, (ISTerre, Universite de Savoie, France)
- Prof. A.K. Sood, Indian Institute of Science, Bangalore (President, IASc)
- Professor Anil K. Gaur, GB Pant University of Agriculture & Technology, Pantnagar
- Prof. S. Krishnaswami and Dr. Vinay Rai, PRL, Ahmadabad
- Prof. Somdatta Sinha, Indian Institute of Science Education and Research (IISER), Mohali

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.

As a part of Hindi training courses organized by Central Hindi Training Institute, New Delhi, Dr. Sudipta Sarkar has successfully completed the Praveen course and Mr. M. Prakasam completed the Probodh and Praveen courses with distinction. Also, Dr. D. Hazarika has been honoured by the Institute for passing the Hindi Praveen course (in the year 2011) with distinction. Dr. S.K. Rai participated in the Hindi sangosthi held at IRDE, Dehradun during February 7-8, 2013.

Hindi pakhwara was celebrated in the Institute from September 14-28, 2012, during which essay competition and debate for school children and Institute employees was organized. Hindi Pakhwara was inaugurated by Shri Subhash Kumar, Chairman, Revenue Board. A *nara* competition and Swarachit Kavita Path was also organized for Institute employees On this occasion Prof. V.K. Gairola, Ex-Head, Geology Department, B.H.U., Prof. Ruchi Badola from Wild Life Institute, Dehra Dun, Prof. V.K.S. Dave, Ex-Head, Earth Sciences Department IIT Roorkee, Dr Rajesh Tewari, a renowned Opthalmologist at Dehra Dun and Prof. Rupesh Pant from J.N.U., New Delhi delivered invited talks on various topics of public interest. A Hindi Kavya Goshthi was also organized during the Hindi Pakhwara in which renowned National kavies were invited for Kavita Path.

On the 44th Foundation Day of the Institute i.e., on June 29, 2012, the Hindi Magazine *'Ashmika'* volume 18 was released. The Annual Report of the Institute for the year 2011-12 was published in bilingual form (Hindi and English).

The Library has also got good collection of Hindi books for promotion of Hindi among the Institute's staff. This section consists of 2538 books by eminent authors on wide range of subjects. During the reporting period **a** total number of 87 books were added to the Hindi books collection.

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 employees' 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 which provides 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 2012-13.

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, 2012-13.

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 2011-12.

The details of information on the RTI cases during the year 2012-13 are as under:-

Details	Opening balance as on 01.04.2012	Received during the year 2012-2013	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	18	Nil	Nil	18
First appeals	Nil	6	Nil	6	Nil

No application or appeal under the Right to Information Act, 2005 was carried forward to the next financial year 2013-14.

8. Sanctioned Staff strength (category wise)

Group/ Category	Scientific	Technical	Administrative	Ancillary	Total
A	63	-	2	-	65
B	-	2	6	-	8
C	-	37	30	14	81
D	-	28	-	26	54
				Total	208

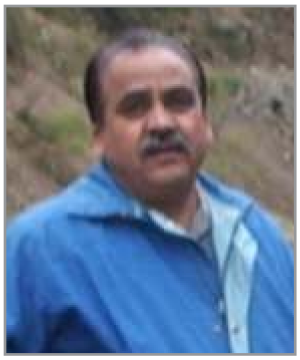
9. Sanctioned and released budget grant for the year 2011-2012

Plan	:	Rs. 1,946.00 lakhs
Non-Plan	:	Rs. 54.00 lakhs
Total	:	Rs. 2,000.00 lakhs

OBITUARY

KISHOR KUMAR PUROHIT

(1954 - 2012)



Dr. Kishor Kumar Purohit had an untimely death at an age of 57 years. He had a massive stroke at his residence in Vivek Vihar, Dehradun on the night of November 1, 2012. Dr. Purohit was born in Garhwal on July 2, 1954. He did his schooling from Sainik School, Ghorakhal near Nainital. As a student he had keen interest in sports and games and was a school champion in boxing and represented his school in table tennis, cricket and volley ball. After completing his M.Sc. (Hons) in Applied Geology from Delhi University, he joined Wadia Institute in 1979 as a Research Scholar, and he was subsequently elevated to Senior Research Assistant (SRA). He earned his Ph.D. degree in 1986 under the stewardship of Dr. V.C. Thakur, and in the same year he was inducted as Scientist 'B' in Geochemistry and Petrology group of WIHG. He was holding the post of Scientist 'F' at the time of his death.

His career in Wadia Institute spanned for more than 32 years during which he demonstrated his scientific proficiency through regular publications in national and international journals. He had more than 35 publications to his credit. His research interests were broad and extended from structure and tectonics, magmatic rocks of the Lesser and Higher Himalaya to environmental and exploration geochemistry. However, the main area of his liking was Geochemical mapping of different parts of Doon valley, Garhwal and Kumaun Himalaya, Pinjore-Una Dun, and preparation of reference materials from the Himalaya. It was his visionary and persistence for development of geochemical standards from Himalayan orogenic belt. Because of his vision, today WIHG has earned a place in the world map of reference geostandards producer with three standards (DG-H, MB-H and AM-H) now included in the elite list of reference materials.

His administrative and technical management skills are so much so that he became indispensable for the Institute. Dr. Purohit had a very sharp memory and was straight forward in approach and always wanted to do his work in his own way. Being very simple and easily approachable, he was able to solve problems of many persons of the Institute. He held a very important responsibility as Technical Secretary to Director, and served nearly all the Directors of the Institute till his death. He was mostly engaged in work pertaining to planning and coordination of various research activities of the Institute and contributed in a big way in the development of this Institute. Even the preceding evening of his death, he stayed back in the office late in the evening till 7.00 PM serving his duties.

He was scared of loneliness and always preferred to live in a joint family and shouldered the family responsibilities with the strength of togetherness. He was an active, soft spoken, humble and affectionate person. His death is an unbearable loss not only to his family, but to our Institute and the entire geological community. Dr. Purohit is survived by his wife, Ms. Prabha.

STAFF OF THE INSTITUTE AS ON 01.04.2013

Scientific Staff

1.	Prof. Anil K. Gupta	Director
2.	Dr. A.K. Dubey	Scientist 'G' (Retired on 31.10.2012)
3.	Dr. V.C. Tewari	Scientist 'G'
4.	Dr. Rohtash Kumar	Scientist 'G'
5.	Dr. V.M. Choubey	Scientist 'G'
6.	Dr. P.P. Khanna	Scientist 'G'
7.	Dr. R.S. Rawat	Scientist 'F' (Retired on 31.03.2013)
8.	Dr. B.K. Choudhuri	Scientist 'F'
9.	Dr. (Mrs) Meera Tiwari	Scientist 'F'
10.	Dr. S.K. Ghosh	Scientist 'F'
11.	Dr. D.K. Misra	Scientist 'F'
12.	Dr. N.K. Saini	Scientist 'F'
13.	Dr. K.K. Purohit	Scientist 'F' (Expired on 02.11.2012)
14.	Dr. Kishor Kumar	Scientist 'F'
15.	Dr. N. Siva Siddaiah	Scientist 'F'
16.	Dr. Rajesh Sharma	Scientist 'F'
17.	Dr. G. Philip	Scientist 'F'
18.	Dr. Rafikul Islam	Scientist 'F'
19.	Dr. B.N. Tiwari	Scientist 'F'
20.	Dr. D. Rameshwar Rao	Scientist 'F'
21.	Dr. Keser Singh	Scientist 'F'
22.	Dr. P.K. Mukherjee	Scientist 'F'
23.	Dr. S.K. Bartarya	Scientist 'F'
24.	Dr. S.K. Paul	Scientist 'F'
25.	Dr. T.N. Jowhar	Scientist 'F'
26.	Dr. S.K. Parcha	Scientist 'E'
27.	Dr. H.K. Sachan	Scientist 'E'
28.	Dr. Sushil Kumar	Scientist 'E'
29.	Dr. A.K. Mahajan	Scientist 'D'
30.	Dr. D.P. Dobhal	Scientist 'D'
31.	Dr. Vikram Gupta	Scientist 'D'
32.	Dr. Suresh N.	Scientist 'D'
33.	Dr. Pradeep Srivastava	Scientist 'D'
34.	Shri V. Sriram	Scientist 'D'
35.	Dr. Ajay Paul	Scientist 'D'
36.	Dr. S.S. Bhakuni	Scientist 'D'
37.	Shri B.S. Rawat	Scientist 'C'
38.	Dr. A.K. Mundepi	Scientist 'C'
39.	Dr. P.S. Negi	Scientist 'C'
40.	Dr. A.K.L. Asthana	Scientist 'C'
41.	Dr. (Mrs) Kapesa Lokho	Scientist 'C'
42.	Dr. R.Jayangondaperumal	Scientist 'C'
43.	Dr. A.K. Singh	Scientist 'C'
44.	Dr. R.K. Sehgal	Scientist 'C'
45.	Dr. Jayendra Singh	Scientist 'C'
46.	Dr. B.P. Sharma	Scientist 'C' (Retired on 31.03.2013)
47.	Dr. Khayingshing Luirei	Scientist 'C'
48.	Dr. Rajesh S.	Scientist 'C'
49.	Dr. Gautam Rawat	Scientist 'C'
50.	Dr. B.K. Mukherjee	Scientist 'B'
51.	Dr. Naresh Kumar	Scientist 'B'
52.	Dr.(Mrs) Swapnamita	Scientist 'B'
53.	Dr. Santosh K. Rai	Scientist 'B'
54.	Dr. Devajit Hazarika	Scientist 'B'
55.	Dr. N.K. Meena	Scientist 'B'
56.	Dr. Dilip Kumar Yadav	Scientist 'B'
57.	Dr. P.K.R. Gautam	Scientist 'B'
58.	Dr. Koushik Sen	Scientist 'B'
59.	Dr. S.S. Thakur	Scientist 'B'
60.	Dr. Sudipta Sarkar	Scientist 'B'
61.	Dr. Prakasam M.	Scientist 'B'
62.	Dr. Raj Kumar Singh	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 S.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 Rakesh Kumar	Tech. Officer, Gr.III(4)
9.	Shri Ravindra Singh	Tech. Officer, Gr.III(4)
10.	Shri H.C. Pandey	Tech. Officer, Gr.III(4)
11.	Shri S.C. Kothiyal	Tech. Officer, Gr.III(4)
12.	Shri N.K. Juyal	Jr. Tech. Officer, Gr.III(3)
13.	Shri T.K. Ahuja	Jr. Tech. Officer, Gr.III(3)
14.	Shri C.B. Sharma	Assistant 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.	Mrs Sarita Gautam	Tech. Assistant, Gr.III(1)
21.	Shri V.K. Kala	Draftsman, Gr.II(5)
22.	Shri Navneet Kumar	Draftsman, Gr.II(5)
23.	Shri B.B. Saran	Draftsman, Gr.II(5)
24.	Shri Shekhranandan	Section Cutter, Gr.II(5)
25.	Shri Pushkar Singh	Section Cutter, Gr.II(5) (Voluntary retired on 31.10.2012 F/N)
26.	Shri Satya Prakash	Section Cutter, Gr.II(5) (Expired on 06.11.2012)
27.	Shri Nand Ram	Elect.cum-Pump.Optr.Gr., II(5)
28.	Shri Santu Das	Section Cutter, Gr.II(3)
29.	Shri Puneet Kumar	Section Cutter, Gr.II(1)
30.	Shri Lokeshwar Vashistha	S.L.T., Gr.II(3)
31.	Dr. S.K. Chabak	S.L.T., Gr.II(3)
32.	Shri R.M. Sharma	S.L.T., Gr.II(3)
33.	Shri C.P. Dabral	S.L.T., Gr.II(3)
34.	Shri Satish Pd.Bahuguna	Sr.Lab. Assistant, Gr.II(5)

35. Shri S.K. Thapliyal	Sr. Lab. Assistant, Gr.II(5)
36. Shri Shiv Pd. Bahuguna	Sr. Lab. Assistant, Gr.II(5)
37. Shri Sashidhar Pd.Balodi	Sr. Lab. Assistant, Gr.II(5)
38. Shri Rajendra Prakash	Sr. Lab. Assistant, Gr.II(5)
39. Shri A.K. Gupta	Sr. Lab. Assistant, Gr.II(5)
40. Shri Tirath Raj	Sr.Lab.Asstt.(Photo.), Gr.II(5)
41. Shri Balram Singh	Sr.Elect.cum Pump Opt., Gr.II(5)
42. Shri Pratap Singh	F.C.L.A., Gr.I(4)
43. Shri Ram Kishor	F.C.L.A., Gr.I(4)
44. Shri Ansuya Prasad	F.C.L.A., Gr.I(4)
45. Shri Puran Singh	F.C.L.A., Gr.I(4) (Retired on 30.04.2012)
46. Shri Ram Khilawan	F.C.L.A., Gr.I(4)
47. Shri Madhu Sudan	F.C.L.A., Gr.I(4)
48. Shri Hari Singh Chauhan	F.C.L.A., Gr.I(4)
49. Shri Ravi Lal	F.C.L.A., Gr.I(3)
50. Shri Preetam Singh	F.C.L.A., Gr.I(3)
51. Shri Vivekanand Khanduri	F.C.L.A., Gr.I(1) (Missing since 2.06.2011)
52. Shri Sanjeev Kumar	F.C.L.A., Gr.I(1)
53. Shri Nain Das	Lab. Assistant, Gr.I(1)
54. Shri Rahul Lodh	Lab. Assistant, Gr.I(1)
54. Mrs.Rama Pant	Field Attendant, Gr.I(3)
55. Shri R.S.Negi	Field Attendant, Gr.I(3)
56. Shri Ramesh Chandra	Field Attendant, Gr.I(3)
57. Shri Khusi Ram	Field Attendant, Gr.I(3)
58. Shri Tikam Singh	Field Attendant, Gr.I(3)
59. Shri Bharosa Nand	Field Attendant, Gr.I(3)
60. Shri B.B. Panthri	Field Attendant, Gr.I(3)
61. 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 M.K. Biswas	Store and Purchase Officer
4. Shri Tapan Banerjee	Sr. Personal Assistant
5. Mrs. Manju Pant	Asstt. Fin. & Acc. Officer
6. Shri B.K. Juyal	Accountant
7. Mrs. Shamlata Kaushik	Assistant (Hindi)
8. Shri O.P. Anand	Office Supett.
9. Shri Hukam Singh	Assistant
10. Shri D.P. Chaudary	Stenographer, Grade-II
11. Shri P.P. Dhasmana	Stenographer, Grade-II
12. Smt. Rajvinder K. Nagpal	Stenographer, Grade-III
13. Shri S.S. Bisht	Assistant
14. Mrs. Sharda Sehgal	Assistant
15. Shri M.C. Sharma	Assistant
16. Shri A.S. Negi	Assistant
17. Shri S.K. Chhettri	U.D.C.
18. Shri Vinod Singh Rawat	U.D.C.
19. Shri S.K. Srivastava	U.D.C.
20. Mrs. Prabha Kharbanda	U.D.C.
21. Shri R.C. Arya	U.D.C.
22. Mrs. Kalpana Chandel	U.D.C.
23. Mrs. Anita Chaudhary	U.D.C.
24. Shri Shiv Singh Negi	U.D.C.
25. Mrs. Neelam Chabak	U.D.C.
26. Mrs. Seema Juyal	U.D.C.
27. Mrs. Suman Nanda	U.D.C.
28. Shri Rahul Sharma	L.D.C.
29. Shri Kulwant S. Manral	L.D.C.
30. Shri Vijai Ram Bhatt	L.D.C.
31. Shri Rajeev Yadav	L.D.C. (Contractual)
32. Shri Neeraj Bhatt	L.D.C. (Contractual)

Ancilary Staff

1. Shri Dewan Singh	Driver (Voluntary retired on 01.04.2013 F/N)
2. Shri Sohan Singh	Driver
3. Shri Ganga Ram	Driver (Retired on 30.09.2012)
4. Shri Naresh Kumar	Driver (Voluntary retired on 01.02.2013 F/N)
5. Shri Shyam Singh	Driver
6. Shri R.S. Yadav	Driver (Retired on 31.07.2012)
7. Shri Surjan Singh	Driver
8. Shri Reza Uddin Chaudhary	Driver (Contractual)
9. Shri Rajesh Yadav	Driver (Contractual)
10. Shri Bhupendra Kumar	Driver (Contractual)
11. Shri Girish Chander Singh	Guest House Attdt. cum Cook
12. Sh. Dinesh Parsad Saklani	Guest House Attdt. cum Cook
13. Mrs. Kamla Devi	Bearer
14. Mrs. Deveshawari Rawat	Bearer
15. Shri S.K. Gupta	Bearer
16. Shri Chait Ram	Bearer
17. Mrs. Omwati	Bearer
18. Shri Jeevan Lal	Bearer
19. Shri Surendra Singh	Bearer
20. Shri Preetam Singh	Bearer
21. Shri Ramesh C. Rana	Bearer (Contractual)
22. Shri Rudra Chettri	Bearer (Contractual)
23. Shri Harish Verma	Bearer (Contractual)
24. Shri Uttam Singh	Bearer (Contractual)
25. Shri Har Prasad	Chowkidar (Retired on 28.02.2013)
26. Shri Mahendra Singh	Chowkidar
27. Shri Rohlu Ram	Chowkidar
28. Shri H.S. Manral	Chowkidar
29. Shri G.D. Sharma	Chowkidar
30. Shri Laxman S. Bhandari	Chowkidar (Contractual)
31. Shri Pradeep Kumar	Chowkidar (Contractual)
32. Shri Kalidas	Chowkidar (Contractual)
33. Shri Ummed Singh	Chowkidar (Contractual)
34. Shri Sang Bam Kach	Chowkidar (Contractual)
35. Shri Ashok Kumar	Mali
36. Shri Satya Narayan	Mali
37. Shri Ramesh	Safaiwala
38. Shri Hari Kishan	Safaiwala
39. Smt. Sang Bam Namo	Part-time Safaiwala (Contractual)

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 'F' 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 'F' 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, A.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
Email : 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, 2013 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.

SINGHAL & ASSOCIATES DEHRADUN CHARTERED ACCOUNTANTS

AUDITOR'S REPORT

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, 2013;
b) in the case of the Income and Expenditure Account of the deficit 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 DEHRADUN

CA VIPUL KUMAR SINGHAL
PARTNER

FRN: 013108C
M.NO: 405071

Date: 16th Aug, 2013
Place: Dehradun

Annexure - 1 to the Main Audit Report

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 basis.
2	During the Financial Year 2012 -13 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 are noted.
4	The financial statements of the institute and the projects sponsored by the other agencies and the CPF, GPF and the new pension scheme are not consolidated as per Accounting Standard 21 "Consolidation of financial Statement" as issued by the Institute of Chartered Accountants of India. The CPF and 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 Year 2012-13 is in process upto the date of Audit.	The suggestion on the observation of the audit has been noted for compliance.
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, 2013. 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 audit have been noted for compliance.

AUDITOR'S REPORT

7	The Institute has not bifurcated the advances indicating the period of outstanding given to staff and Parties. The Party Debtors amounting to Rs. 1,26,921/- and Staff Debtors amounting to Rs 21,512/- 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 11,634.00 has been shown as credit balance in Party debtors which should be taken to receipts after following nodal procedure.	Best efforts are being made to settle the old outstanding advances against staff and parties. However, for the exceptional cases the proposal for writing off of outstanding advances will be submitted to the competent authority for approval.
8	Earmarked funds have the debit balance in following activities: Training Workshop Prog-Ladakh- Rs. 2,19,905.00 Annual Convention (IGU 2009) - Rs. 41,275.00 ULF/VLF Equipments - Rs. 1,57,881.00 4th TPE Workshop - Rs. 1,00,000.00 The above 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, programmes etc., for which fund is provided by the other granting agency is received occasionally in advance otherwise generally after completion of the activity. For successful organization of the activity required expenditure is met from institute grant on refundable basis. Most of the amounts are reimbursed in time, but the reported advances could not be settled before the closure of financial year. Hence remained outstanding and will be settled during 2013-14.
9	During the Financial Year 2012-13 the expenditure planned and incurred in Non Plan has been regrouped as Plan expenditure as per the instructions from DST vide their letter no: AI/Grant/1003/2012 dated 31.01.2013.	Salary and allowances of the administrative staff were booked under Non-Plan head and as per the instruction from DST vide their letter No. AI/Grant/003/2012 dated 31.1.2013, all the Non-Plan expenditure have been regrouped and booked under Plan head from the current financial year.
10	Transactions in Consultancy activity has been merged into the Financial Statements of the Institute. Previous year figures have been incorporated to give effect of the same.	In view of the practical requirement and as per the suggestion from the audit, the transaction have been merged into the Institute account.

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(Prof. ANIL K. GUPTA)
Director

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRADUN

BALANCE SHEET
(AS AT 31ST MARCH 2013)

(Amt in Rs...)

PARTICULARS	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
LIABILITIES			
Corpus/ Capital Fund	1	39,13,75,619	43,60,83,683
Reserves and Surplus	2	-	-
Earmaked/ Endowment Fund	3	11,57,844	12,75,154
Secured Loans & Borrowings	4	-	-
Unsecured Loans & Borrowings	5	-	-
Deferred Credit Liabilities	6	-	-
Current Liabilities & Provisions	7	74,02,614	30,94,739
TOTAL		**39,99,36,077**	**44,04,53,576**
ASSETS			
Fixed Assets	8	35,34,73,204	31,32,36,769
Investments from Earmaked/ Endowment Funds	9	34,017	31,422
Investment- Others	10	-	-
Current Assets, Loans & Advances	11	4,64,28,856	12,71,85,385
TOTAL		**39,99,36,077**	**44,04,53,576**
Significant Accounting Policies	37		
Contingent Liabilities and Notes on Account:	38		

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

FOR VIPUL SINGHAL & ASSOCIATES
CHARTERED ACCOUNTANTS

VIPUL SINGHAL & ASSOCIATES DEHRADUN CHARTERED ACCOUNTANTS

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

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF. ANIL K. GUPTA)
Director

Date : 16th August, 2013
Place : Dehradun

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2013

SCHEDULE 1 : CORPUS/CAPITAL FUND

(Amt in Rs…)

PARTICULARS	SCH	RECURRING FUND	NON-RECURRING FUND	CURRENT YEAR	PREVIOUS YEAR
Opening Balance		**37,89,903**	**43,22,93,780**	**43,60,83,683**	**43,70,86,304**
Less: Capital Assets written off during the year	8	-	-	-	-
Add: Contribution towards Corpus / Capital Fund	13	-	-	-	-
Add: Transferred from WIHG Project		-	-	-	1,06,18,178
Add: Surplus/(Deficits) as per Income & Expenditure A/c		(4,47,08,064)	-	**(4,47,08,064)**	(1,16,20,799)
Add: Depreciation Reversed		-	-	-	-
BALANCE AS AT YEAR END		**(4,09,18,161)**	**43,22,93,780**	**39,13,75,619**	**43,60,83,683**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF. ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES
DEHRADUN
CHARTERED ACCOUNTANTS

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRADUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2013

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

VIPUL SINGHAL & ASSOCIATES CHARTERED ACCOUNTANTS DEHRADUN

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2013

SCHEDULE 3 : EAR MARKED / ENDOWMENT FUND

(Amt in Rs…)

PARTICULARS	FUND WISE BREAK UP					TOTAL	
	TRAINING WORKSHOP PROG. LADDAKI	PR.MISHRA AWARD FUND	WOMEN COMPONENT	ANNUAL CONVENTION (I.G.U 2009)	RTF DCS FELLOWSHIP	CURRENT YEAR	PREVIOUS YEAR
a) Opening Balance of the Fund	-	31,422	5,00,000	(41,275)	-	4,90,147	5,13,320
b) Additions to the fund							
I) Donation / Grant	20,00,000	-	-	-	2,70,000	22,70,000	21,79,000
ii) Income from investments made on account of fund	-	2,595	-	-	-	2,595	2,398
iii) Other additions (Specify)							
Registration	-	-	-	-	-	-	-
TOTAL	20,00,000	34,017	5,00,000	(41,275)	2,70,000	27,62,742	26,94,718.00
c) Utilisation / Expenditure towards objectives of Fund							
I) Capital Expenditure							
- Fixed Assets (Equipments)	-	-	-	-	-	-	-
ii) Revenue Expenditure							
a) Salaries / Wages/ Allowances/honorarium	-	-	-	-	-	-	1,29,756
b) Rent / Contingencies/TA-DA/Advertisement	11,49,905	-	-	-	-	11,49,905	2,56,523
c) Other Administrative Expenses:							
- Advances to project fellows	-	-	-	-	-	-	15,79,000
d) Excess fund Transferred	-	-	-	-	-	-	
e) lodging and boarding	10,70,000	-	-	-	-	10,70,000	
f) Registration	-	-	-	-	-	-	
iii) Grant refunded	-	-	-	-	-	-	2,39,292
iv)Transfer To WIHG	-	-	-	-	-	-	-
TOTAL	22,19,905	-	-	-	-	22,19,905	22,04,571
Balance Carried Forward	(2,19,905)	34,017	5,00,000	(41,275)	2,70,000	5,42,837	4,90,147

SINGHAL & ASSOCIATES • VIPIN • CHARTERED ACCOUNTANTS • DEHRADUN

Contd.2

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN
SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2013

SCHEDULE 3 : EAR MARKED / ENDOWMENT FUND

(Amt in Rs…)

PARTICULARS	NATIONAL FIELD WORKSHOP	TSUNAMI EQUIPMENT	PMB MEETING 2,009.00	ULF/VLF EQUIPMENTS	4TH TPE WORKSHOP	TOTAL CURRENT YEAR	TOTAL PREVIOUS YEAR
Balance Brought forward						5,42,837	4,90,147
a) Opening Balance of the Fund	70,000	8,30,633	42,255	(1,57,881)	-	7,85,007	9,33,215
b) Additions to the fund							
I) Donation / Grant	-	-	-	-		-	-
ii) Income from investments made on account of fund	-	-	-	-		-	-
iii) Other additions (Specify)	-	-	-	-		-	-
TOTAL	70,000	8,30,633	42,255	(1,57,881)	-	7,85,007	9,33,215
c) Utilisation / Expenditure towards							
Objectives of Fund							
I) Capital Expenditure							
- Fixed Assets (Equipments)	-	-	-	-		-	-
ii) Revenue Expenditure							
a) Salaries / Wages/ Allowances	-	-	-	-		-	-
b) Rent / Contingencies/TA-DA	-	-	-	-		-	-
c) Other Administrative Expenses:	-	-	-	-		-	-
- Advances to project fellows	-	-	-	-	1,00,000.00	1,00,000.00	-
d) Excess fund Transferred	-	-	-	-		-	-
e) Lodging & boarding	-	-	-	-		-	-
iii) Grant refunded/transferred	70,000	-	-	-		70,000.00	1,48,208
iv)Transfer To WIHG	-	-	-	-		-	-
TOTAL	70,000	-	-	-	1,00,000.00	1,70,000	1,48,208
Balance	-	8,30,633	42,255	(1,57,881)	(1,00,000)	6,15,007	7,85,007
GRAND TOTAL						11,57,844	12,75,154

VIPUL SINGHAL & ASSOCIATES DEHRADUN CHARTERED ACCOUNTANTS

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF. ANIL K. GUPTA)
Director

AUDITOR'S REPORT

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2013

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

VIPUL SINGHAL & ASSOCIATES CHARTERED ACCOUNTANTS DEHRADUN

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2013

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

VIPUL SINGHAL & ASSOCIATES DEHRADUN CHARTERED ACCOUNTANTS

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2013

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')	19,58,217	15,000
	3	Securities from Suppliers (As per Annexure '17')	39,01,320	25,46,935
	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	3,381	2,357
		Consultancy Activity	12,83,941	2,65,858
		PLI	120	120
		Expenses payable	-	-
		(As per Annexure '16')	2,55,635	2,64,469
		TOTAL (A)	**74,02,614**	**30,94,739**
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)	**74,02,614**	**30,94,739**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES · CHARTERED ACCOUNTANTS · DEHRADUN

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2013

SCHEDULE 8 : FIXED ASSETS

(Amt in Rs....)

	PARTICULARS	GROSS BLOCK: COST AS ON BEGINING OF THE YEAR	GROSS BLOCK: ADDITION DURING THE YEAR	GROSS BLOCK: DED./WRITT. OFF / TRFD. DURING THE YR.	GROSS BLOCK: COST AT THE END OF THE YEAR	DEPRECIATION: OPENING BALANCE	DEPRECIATION: OPENING BAL. TFD FROM PROJECT	DEPRECIATION: DEP DURING THE YEAR	DEPRECIATION: DED./WRITT. OFF / TRFD DURING THE YR.	DEPRECIATION: TOTAL	NET BLOCK: CURRENT YEAR	NET BLOCK: 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)	1,27,43,996	-		1,27,43,996	66,48,583		6,09,541		72,58,124	54,85,872	60,95,413	10%
	b) On Leasehold Land	-			-	-				-	-	-	10%
	c) Guest House cum Hostel/ Staff Quarter	1,00,93,765	-		1,00,93,765	52,53,639		4,84,013		57,37,652	43,56,113	48,40,126	10%
	d) Store Building	96,15,648	-		96,15,648	45,02,492		5,11,316		50,13,808	46,01,840	51,13,156	10%
	e) New Lab Complex(IVth Block)	85,11,316	-		85,11,316	44,40,380		4,07,094		48,47,474	36,63,842	40,70,936	10%
	f) Boundary wall (Dharamshala)	6,41,905	-		6,41,905	3,15,501		32,640		3,48,141	2,93,764	3,26,404	10%
	g) Staff Quarters Type III & IV - Phase I	1,18,48,397	-		1,18,48,397	40,74,664		7,77,373		48,52,037	69,96,360	77,73,733	10%
	h) Staff Quarters Type III & IV - Phase II	1,82,31,591			1,82,31,591	18,23,159		16,40,843		34,64,002	1,47,67,589	1,64,08,432	10%
	i) Mass Renovation of WIHG Building	-	2,69,84,584	-	2,69,84,584	-		26,98,458		26,98,458	2,42,86,126	-	10%
	j) Bank Building	17,96,289	-		17,96,289	6,17,744		1,17,855		7,35,599	10,60,690	11,78,545	10%
	k) Road & Cabling	6,13,781	-		6,13,781	2,11,079		40,270		2,51,349	3,62,432	4,02,702	10%
	l) Directors Residence	64,87,581			64,87,581	6,48,758		5,83,882		12,32,640	52,54,941	58,38,823	10%
3	**Plant, Machinery & Equipment**	36,36,18,330	5,99,40,015	13,990	42,35,44,355	19,38,32,421		3,44,56,790	3,882	22,82,85,329	19,52,59,026	16,97,85,909	15%
4	**Vehicles**	40,52,180		8,69,831	31,82,349	16,92,924		2,23,414	5,90,983	13,25,355	18,56,994	23,59,256	15%
5	**Furniture & Fixtures**	1,13,88,959	5,69,686		1,19,58,645	51,60,141		6,79,850		58,39,991	61,18,654	62,28,818	10%
6	**Office Equipments**	64,08,247	46,500		64,54,747	33,60,459		4,64,143		38,24,602	26,30,145	30,47,788	15%
7	**Field Equipments- WIHG**	16,66,858	-		16,66,858	8,74,128		1,18,910		9,93,038	6,73,820	7,92,730	15%
	- Consultancy Activity	18,044	-		18,044	12,260		868		13,128	4,916	5,784	15%
8	**Library Books**												
	a) Indegenous Books	9,62,62,154	85,74,657	1,412	10,48,35,399	5,06,06,338		81,34,359	506	5,87,40,191	4,60,95,208	4,56,55,816	15%
9	**Tube Well & Water Supplies**	2,08,974	-		2,08,974	1,41,981		10,049		1,52,030	56,944	66,993	15%
10	**Computer & printers**	13,88,173	37,14,739	85,342	50,17,570	8,32,904	-	25,10,800	63,429	32,80,275	17,37,295	5,55,269	60%
		56,64,22,968	**9,98,30,181**	**8,85,233**	**66,52,82,574**	**28,50,49,555**	-	**5,45,02,468**	**6,58,800**	**33,88,93,223**	**32,63,89,351**	**28,13,73,413**	
	Equipments (Project) (As per Annexure '18')	8,75,51,071	-		8,75,51,071	5,56,87,715	-	47,79,503		6,04,67,218	2,70,83,853	3,18,63,356	15%
	TOTAL OF CURRENT YEAR	**65,39,74,039**	**9,98,30,181**	**8,85,233**	**75,28,33,645**	**34,07,37,270**	-	**5,92,81,971**	**6,58,800**	**39,93,60,441**	**35,34,73,204**	**31,32,36,769**	
	TOTAL OF PREVIOUS YEAR	**59,34,85,661**	**6,04,88,793**	**415**	**65,39,74,039**	**27,89,47,257**	**97,32,881**	**5,20,57,132**	-	**34,07,26,030**	**31,32,36,769**	**31,45,38,404**	

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

VIPUL SINGHAL & ASSOCIATES
DEHRADUN
CHARTERED ACCOUNTANTS

(PROF ANIL K GUPTA)
Director

AUDITOR'S REPORT

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2013

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	34,017	31,422
	TOTAL	**34,017**	**31,422**

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	-	-

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF. ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES
DEHRADUN
CHARTERED ACCOUNTANTS

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2013

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')	4,88,702	5,13,405
Sundry Debtors (As per Annexure '3')	6,07,744	9,89,211
Cash Balance in Hand	5,347	13,479
Imprest Money - WIGH (As per Annexure '4')	58,500	43,500
Bank Balance		
a) With Scheduled Bank		
- On Saving Account(UBI S/A No. 518602170033001)	80,10,033	7,85,09,223
- On Saving Account(SBI) A/c No. 10022411762	45,450	90,774
- On Deposit Account (L/C Margin Money)	27,00,000	2,43,35,000
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	23,95,418.00	25,80,426
FDR	2,74,47,254.00	1,55,98,010
Post Office Saving Accounts	-	-
TDS	8,39,332.00	8,31,808
TOTAL (A)	**4,25,97,780**	**12,35,04,836**

VIPUL SINGHAL & ASSOCIATES
DEHRADUN
CHARTERED ACCOUNTANTS

AUDITOR'S REPORT

AUDITOR'S REPORT

SCHEDULE 11 : CURRENT ASSETS, LOANS & ADVANCES

(Amt in Rs…)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
LOANS & ADVANCES (B)		
Loans		
a) Staff (As per Annexure '5')	31,09,268	29,58,741
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	-	-
c) On Loans & Advances	-	-
d) Others	-	-
(Including Projects/ Cheques/ Drafts & Imprests)		
Claims Receivable	-	-
Security Deposit (As per Annexure '12')	7,21,808	7,21,808
TOTAL (B)	**38,31,076**	**36,80,549**
TOTAL (A + B)	**4,64,28,856**	**12,71,85,385**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES
DEHRADUN
CHARTERED ACCOUNTANTS

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRADUN

INCOME & EXPENDITURE ACCOUNT
FOR THE PERIOD ENDED 31ST MARCH 2013

(Amt in Rs…)

S.NO.	PARTICULARS	SCH.	CURRENT YEAR	PREVIOUS YEAR
A	**INCOME**			
	Income from sales/ services	12	-	-
	Grants/ Subsidies	13	20,00,00,000	22,96,03,000
	Fees/Subscription	14	23,370	38,000
	Income from Investments	15	7,89,354	8,63,654
	Income from Royalty, Publication etc.	16	59,523	48,883
	Interest earned	17	1,07,74,589	39,58,973
	Other Income	18	73,49,558	78,55,634
	Increase/ Decrease in Stock (Goods & WIP)	19	-	-
	TOTAL (A)		**21,89,96,394**	**24,23,68,144**
B	**EXPENDITURE**			
	Establishment Expenses	20	16,39,92,520	15,56,41,078
	Other Research & Administrative Expenses	21	4,03,22,588	4,27,23,038
	Expenditure on Grant/ Subsidies etc.	22	-	-
	Interest/ Bank Charges	23	466	2,010
	Depreciation Account	8	5,92,81,971	5,20,57,132
	Increase/ Decrease in stock of Finished goods, WIP& Stock of Publication	A-2	24,703	1,18,841
	Loss on sale of Assets	A-19	82,210	-
	TOTAL (B)		**26,37,04,458**	**25,05,42,099**
	Surplus/ (Deficit) being excess of Income over Expenditure (A - B)		(4,47,08,064)	(81,73,955)
	Transfer to Special Reserve (Specify each)		-	-
	Transfer to / from General Reserve		-	-
	BALANCE BEING SURPLUS /(DEFICIT) CARRIED TO CORPUS FUND		**(4,47,08,064)**	**(81,73,955)**

AUDITOR'S REPORT

"As per our separate report of even date"

FOR VIPUL SINGHAL & ASSSOCIATES
CHARTERED ACCOUNTANTS

VIPUL SINGHAL & ASSOCIATES DEHRADUN CHARTERED ACCOUNTANTS

(CA VIPUL KUMAR SINGHAL)
PARTNER, FCA

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

Date: 16th August, 2013
Place: Dehradun

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING ON 31ST MARCH 2013

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**	9,98,30,181	9,47,69,819	54,00,000	20,00,00,000	22,96,03,000
2 **State Government**	-	-	-	-	-
3 **Government Agencies**	-	-	-	-	-
4 **Institutions / Welfare Bodies**	-	-	-	-	-
5 **International Organisation**	-	-	-	-	-
6 **Others (Specify)**	-	-	-	-	-
				-	
TOTAL	**9,98,30,181**	**9,47,69,819**	**54,00,000**	**20,00,00,000**	**22,96,03,000**

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

VIPUL SINGHAL & ASSOCIATES CHARTERED ACCOUNTANTS DEHRADUN

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING ON 31ST MARCH 2013

SCHEDULE 14 : FEES/ SUBSCRIPTION

(Amt in Rs...)

	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	**Entrance Fees**	-	-
2	**Annual Fees/ Subsription**	23,370	38,000
	(WIHG Lib.)	-	-
3	**Seminar/ Programme Fees**	-	-
4	**Others(Specify)**	-	-
	TOTAL	**23,370**	**38,000**

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**	7,89,354	8,63,654
4		**Others (Specify)**	-	-
		TOTAL	**7,89,354**	**8,63,654**

SCHEDULE: 16 INCOME FROM ROYALTY, PUBLICATION ETC.

(Amt in Rs...)

	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	**Income from Royalty**	-	
2	**Income From Publication**	59,523	48,883
	(WIHG Volumes)	-	
3	**Others (Specify)**	-	-
4	**Gratis to Life Members**	-	-
	TOTAL	**59,523**	**48,883**

(HARISH CHANDRA) Finance & Accounts Officer	WIPUL SINGHAL & ASSOCIATES CHARTERED ACCOUNTANTS DEHRADUN	**(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 2013

SCHEDULE: 17 INTEREST EARNED

(Amt in Rs…)

	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	**In Term Deposit :**		
	a) With Scheduled Bank	15,06,139	-
	b) With Non-Scheduled Bank	-	-
	c) With Institution	-	-
	d) Others	-	-
2	**On Saving Account :**	-	-
		-	-
	a) With Scheduled Bank	17,04,414	29,31,950
	b) With Non-Scheduled Bank	-	-
	c) Post Office Saving Account	-	-
	d) Others	-	-
		-	-
3	**On Loans :**	-	-
		-	-
	a) Employees/ Staff :	-	-
	-HBA	7,33,808	6,39,944
	-Conveyance Advance	67,438	2,53,678
	-Computer Advance	35,746	56,331
	b) -Others	46	5,026
4	**Interest on Debtor & Other Receivable**	-	-
5	**Interest - Consultancy Activity**	67,26,998	72,044
	TOTAL	**1,07,74,589**	**39,58,973**

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

VIPUL SINGHAL & ASSOCIATES CHARTERED ACCOUNTANTS DEHRADUN

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING ON 31ST MARCH 2013

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**	8,10,000	4,57,000
3		**Fees for Miscellaneous Services**		
		(As per Annexure'13')	7,85,486	5,59,485
4		**Miscellaneous Income**		
		(As per Annexure '14')	55,97,538	66,98,400
5		**Leave Salary & Pension Contribution**	-	1,09,052
6		**Tender Form Fee**	51,732	31,697
7		**Others (Liquidated Damage)**	1,04,802	-
		GRAND TOTAL	73,49,558	78,55,634

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)		-

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES
CHARTERED ACCOUNTANTS
DEHRADUN

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT

SCHEDULE-20 ESTABLISHMENT EXPI

(Amt in Rs...)

	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
A.	Salary , Wages & Fellowship	6,05,89,287	5,91,49,951
	Visiting/research fellowship	46,29,038	37,97,668
B.	Allowances, Bonus & Honorarium		
	1. Allowances	5,45,40,887	4,42,85,425
	2. Bonus	4,28,826	3,51,997
	3. Honorarium	1,51,800	3,59,750
C.	Contribution to CPF	2,05,318	2,09,676
D.	Contribution to NPS	14,03,580	12,13,724
E.	Staff Welfare Expenses	-	-
F.	1.Expenses on Employees	-	-
	2.Retirement & Terminal Benefits	1,87,32,876	2,10,12,155
	3.TA on Retirement	1,85,105	1,40,055
G.	1.Leave Travel Concession	15,46,351	15,69,021
	2.Leave encashment on LTC	8,81,178	5,02,400
H.	Leave Salary & Pension Contribution	1,69,54,371	1,77,81,975
I.	1.Others (Medical Reimbursement)	36,14,584	51,56,395
	2.(Training Programme)- In India	1,12,607	1,01,891
	3.(Training Programme)- Abroad	16,712	8,995
	TOTAL	16,39,92,520	15,56,41,078

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES
CHARTERED ACCOUNTANTS
DEHRADUN

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULES FORMING PART OF INCOME & EXPENDITURE ACCOUNT
FOR THE YEAR ENDING ON 31ST MARCH 2013

SCHEDULE 21 : OTHER RESEARCH & ADMINISTRATIVE EXPENSES

(Amt in Rs…)

		PLAN	NON PLAN	CURRENT YEAR	PREVIOUS YEAR
a.	Purchases	-	-	-	-
b.	Analytical & Dating charges	4,62,261	-	4,62,261	3,20,565
c.	Cartage & Carriage Inward	-	-	-	-
d.	Electricity, Power & Water Charges	47,61,470	-	47,61,470	32,48,937
e.	Insurance for Vehicle	91,888	-	91,888	91,565
f.	Repair & Maintenance			-	-
	1. Building & Garden	16,67,946	-	16,67,946	1,06,97,733
	2. Equipment & Others	37,28,747	-	37,28,747	37,68,863
g.	Excise Duty	-	-	-	-
h.	Rent, Taxes,Rate Contract & Service Charges	56,88,022	56,000	57,44,022	45,80,671
i.	Vehicle Running & Maintenance	5,76,224	-	5,76,224	6,91,064
j.	Postage, Telephone	-	8,73,737	8,73,737	4,44,961
k.	Subscription exps., Internet & bandwidth Charges	7,93,415	-	7,93,415	4,21,562
l.	Printing & Stationery	-	7,40,509	7,40,509	8,72,304
m.	Travelling & Conveyance exp./Field tour expedition	37,48,599	9,84,946	47,33,545	46,56,510
n.	Exps. On Seminar/Workshop ("As per Annexure 15")	40,11,049	-	40,11,049	24,23,262
o.	Guest House Expense	1,57,504	-	1,57,504	1,67,171
p.	TA/DA to GB/Committee members	7,57,369	7,74,003	15,31,372	7,57,038
q.	Auditor's Remuneration	-	7,865	7,865	10,412
r.	Hospitality Exps.	-	58,225	58,225	36,256
s.	Professional Charges/Legal Exps.	1,93,214		1,93,214	3,52,727
t.	Provision for Bad & Doubtful Debts/			-	-
	Advances	-	-	-	-
u.	Capital/Fixed Assets written off/Loss	-	-	-	-
v.	Festival, Fair & Exhibition	-	4,64,561	4,64,561	3,09,646
w.	Freight & Forwarding Exps.	-	-	-	-
x.	Distribution Exps.	-	-	-	-
y.	Advertisement & Publicity	-	12,58,184	12,58,184	8,77,622
z.	Leveries	-	-	-	-
a(i)	Others (Specify)			-	-
	1. Foundation Day	-	1,39,321	1,39,321	78,511
	2. Contingency	9,96,734	-	9,96,734	5,97,597
	3. Chemical Glassware & Photo Goods	18,09,639	-	18,09,639	34,82,443
	4. Royalty	144	-	144	324
	5. Publication	2,32,892	-	2,32,892	99,790
	6. Membership Fees for Earth Science Societies	2,000	-	2,000	6,000
	7.Computer Stationery/Peripherals	12,39,005	-	12,39,005	5,76,639
	8.Reprints & Research paper	18,137	-	18,137	34,361
	9.NSDL Service A/C	2,854	-	2,854	2,188
	10. Renovation, modification & oiling	21,62,890	-	21,62,890	
	11. Insurance of Field Party	74,764	-	74,764	
	12. Membership of Scientific Journals	6,000	-	6,000	
	13. Anti Termite treatment	2,38,546	-	2,38,546	
	14. Consultancy Activity Expenses	15,43,924		15,43,924	31,16,316
	TOTAL	**3,49,65,237**	**53,57,351**	**4,03,22,588**	**4,27,23,038**

(HARISH CHANDRA)
Finance & Accounts Officer

VIPUL SINGHAL & ASSOCIATES
CHARTERED ACCOUNTANTS
DEHRADUN

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

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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 2012

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**	-	466	466	2,010
d.	**Others**	-	-		-
	TOTAL	-	**466**	**466**	**2,010**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES
CHARTERED ACCOUNTANTS
DEHRADUN

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

RECEIPTS & PAYMENTS ACCOUNT
(FOR THE YEAR ENDED 31st MARCH 2013)

(Amt in Rs…)

PARTICULARS	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
RECEIPTS			
Opening Balance	24	9,68,35,412	8,43,54,825
Grants - in - Aids	26	20,00,00,000	22,96,03,000
Grants - in - Aids/Other Receipts (Ear Marked)	27	3,39,72,595	19,65,279
Loan & Advances	28	8,79,71,813	7,07,49,064
Loan & Advances (Ear Marked)	31	14,69,000	-
Fees/Subscription	14	23,370	38,000
Income from Investments	15	7,89,354	8,63,654
Income from Royalty, Publication etc.	16	59,523	48,883
Interest earned	17	1,07,74,589	39,58,973
Other Income	18	73,49,558	78,55,634
Investment (L/C Margin Money)	34	2,43,35,000	3,03,00,000
		46,35,80,214	**42,97,37,312**
PAYMENTS			
Establishment Expenses	20	16,39,92,520	15,56,41,078
Other Administrative Expenses	21	4,03,22,588	4,27,23,038
Expenditure on Grant/Subsidies Etc.	22	-	-
Interest/ Bank Charges	23	466	2,010
Loans & Advances	29	8,34,40,522	6,79,24,397
Loans & Advances (Ear Marked)	32	15,71,595	15,79,000
Investment (L/C Margin Money)	35	27,00,000	2,43,35,000
Fixed Assets	36	9,96,00,616	4,01,37,319
Ear Marked Fund Expenses	33	22,19,905	3,86,279
Grant - in - Aid (Ear Marked) Refunded	30	3,17,70,000	1,73,779
Closing Balance	25	3,79,62,002	9,68,35,412
		46,35,80,214	**42,97,37,312**

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

FOR VIPUL SINGHAL & ASSOCIATES
CHARTERED ACCOUNTANTS

VIPUL SINGHAL & ASSOCIATES CHARTERED ACCOUNTANTS DEHRADUN

(CA VIPUL KUMAR SINGHAL)
PARTNER, FCA

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF. ANIL K. GUPTA)
Director

Date : 16th August, 2013
Place: Dehradun

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF RECEIPT & PAYMENT AS ON 31ST MARCH 2013

SCHEDULE - 24 : OPENING BALANCE

(Amount in Rs...)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
Cash in Hand	13,479	34,548
Cash at Bank : Saving A/c UBI 518602170033001	7,85,09,223	6,96,73,284
Saving A/c SBI 10022411762	90,774	60,826
Imprest Money	43,500	38,500
Consultancy Activity		
Cash at Bank A/c No 563	25,80,426	19,49,657
FDR	1,55,98,010	1,25,98,010
TOTAL	**9,68,35,412**	**8,43,54,825**

SCHEDULE - 25 : CLOSING BALANCE

(Amt 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	7,85,09,223
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	2,74,47,254	1,55,98,010
TOTAL	**3,79,62,002**	**9,68,35,412**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES
DEHRADUN
CHARTERED ACCOUNTANTS

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF RECEIPT & PAYMENT AS ON 31ST MARCH 2013

SCHEDULE : 26 GRANT IN AID RELEASED BY DST FOR THE YEAR 2012-13

(Amt in Rs…)

S.NO	SANCTION NO. CURRENT YEAR	DATED	PLAN	NON-PLAN
1	AI/WIHG//003/2012/NP	19.09.2012		54,00,000
2	AI/WIHG//003/2012/2	08.05.2012	2,77,00,000	
3	AI/WIHG//003/2012/3	19.07.2012	5,51,50,000	
4	AI/WIHG//003/2012/4	19.07.2012	30,00,000	
5	AI/WIHG//003/2012/5	19.07.2012	20,70,000	
6	AI/WIHG//003/2012/6	19.09.2012	2,30,000	
7	AI/WIHG//003/2012/7	19.09.2012	4,14,00,000	
8	AI/WIHG//003/2012/8	19.09.2012	1,74,00,000	
9	AI/WIHG//003/2012/9	24.12.2012	60,00,000	
10	AI/WIHG//003/2012/10	24.12.2012	2,89,50,000	
11	AI/WIHG//003/2012/12	24.12.2012	95,00,000	
12	AI/WIHG//003/2012/14	25.03.2013	32,00,000	
	TOTAL		19,46,00,000	54,00,000
	GRAND TOTAL			20,00,00,000
	PREVIOUS YEAR			22,96,03,000

SCHEDULE : 27 GRANT - IN - AID/OTHER RECEIPTS (EAR MARKED) AS ON 31ST MARCH 2013

(Amt in Rs…)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	NGF Project	3,11,00,000	-
2	Indo- Iceland Workshop-2011	-	3,86,279
3	Boyscast Fellowship (AKS)	-	15,79,000
4	IAS Bangalore	5,00,000	-
5	UKS - S&T, Vasant Vihar, Dehradun	25,000	-
6	UGC -RC	75,000	-
7	RES. Training Fellow	2,70,000	-
8	Training Workshop Programme (NW Himalaya)	20,00,000	-
9	Prof Mishra Award Fund	2,595	
	Total	3,39,72,595	19,65,279

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES
DEHRADUN
CHARTERED ACCOUNTANTS

AUDITOR'S REPORT

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WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF RECEIPT & PAYMENT AS ON 31ST MARCH 2013

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

(Amt in Rs...)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
Expenses Payable	1,759	6,600
Income Tax	1,03,11,707	1,03,97,686
GPF	2,19,07,900	2,17,15,073
Festival Advance	1,42,950	1,45,200
Conveyance Advance	2,38,211	2,75,098
Computer Advance	2,29,112	2,51,161
Sundry Debtors (Party)	1,60,58,318	74,28,613
Sundry Debtors (Staff)	1,02,32,559	98,63,319
House Building Advance	3,20,191	3,94,608
Security Payable	29,00,099	9,01,323
Subs. Of NPS	14,18,329	-
Group Insurance	2,29,441	6,71,975
PLI	5,251	7,350
Uttarakhand Trade Tax	18,72,351	1,83,733
C.P.F	7,39,513	7,28,416
Co-Operative Society	1,05,59,574	93,72,555
Refund of HBA	60,000	10,51,390
CPF Loan	37,500	12,500
GPF Loan	10,30,715	7,88,408
LIC Premium	26,35,533	26,58,633
HDFC (Dehradun)	12,95,935	17,39,709
Warm Clothing Advance	9,000	14,175
Income Tax (Contractor/ Party)	9,66,359	4,33,156
Service Tax	6,153	3,090
Other Recovery (HBA-AKG)	-	60,000
M.C ON NPS	14,18,067	10,51,079
M.C ON CPF	2,05,672	2,09,676
A.C.W.F New Delhi	6,000	6,000
Sundry Debtors(CSIR Grant)	-	1,95,093
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	11,83,386	1,83,445
TOTAL	**8,79,71,813**	**7,07,49,064**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

SINGHAL & ASSOCIATES
DEHRADUN
CHARTERED ACCOUNTANTS

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF RECEIPT & PAYMENT AS ON 31ST MARCH 2013

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

(Amt in Rs…)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
Expenses Payable	10,593	78,263
Security Payable	15,45,714	6,23,021
House Building Advance	-	40
Sundry Debtors (Staff)	1,07,36,031	96,05,480
Sundry Debtors (Party)	1,56,76,851	58,76,528
Conveyance Advance	4,00,540	2,42,719
Computer Advance	-	60,000
Income Tax	1,03,11,707	1,03,97,686
G.P.F.	2,19,07,900	2,17,15,073
Festival Advance	1,69,050	1,39,350
Group Insurance	2,28,417	6,72,248
PLI	5,251	7,350
Uttarakhand Trade Tax	18,72,351	1,83,733
C.P.F	7,39,513	7,28,416
Co-Operative Society	1,05,59,574	93,72,555
Refund of HBA	-	10,51,390
CPF Loan	37,500	12,500
GPF Loan	10,30,715	7,88,408
Subs. of NPS	14,18,329	-
LIC Premium	26,35,533	26,58,633
HDFC (Dehradun)	12,95,935	17,39,709
Warm Clothing Advance	1,125	11,250
Income Tax (Contractor/ Party)	9,64,669	4,34,849
Service Tax	6,153	3,090
Other Recovery (HBA-AKG)	60,000	60,000
M.C ON NPS	14,18,067	10,51,079
M.C ON CPF	2,05,672	2,09,676
A.C.W.F New Delhi	6,000	6,000
Sundry Debtors(CSIR Grant)	-	1,95,093
Leave Salary Pension Contribution	7,011	-
Consultancy Activity	1,81,107	258
TDS Recoverable	9,214	
TOTAL	**8,34,40,522**	**6,79,24,397**

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

VIPUL SINGHAL & ASSOCIATES CHARTERED ACCOUNTANTS DEHRADUN

AUDITOR'S REPORT

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF RECEIPT & PAYMENT AS ON 31ST MARCH 2013

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

(Amt in Rs…)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
AOGS-2010	-	25,571
NGF Project	3,11,00,000	-
IAS Bangalore	5,00,000	-
Training Program on MAP	-	1,48,208
UKS - S&T, Vasant Vihar, Dehradun	25,000	-
UGC-RC	75,000	-
NFWSHPSI (Dr K Kumar)	70,000	-
TOTAL	**3,17,70,000**	**1,73,779**

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	-
TOTAL	**14,69,000**	**-**

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

(Amt in Rs…)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
BOYSCAST Fellowship (AKS)	-	15,79,000
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	
TOTAL	**15,71,595**	**15,79,000**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES CHARTERED ACCOUNTANTS DEHRADUN

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF RECEIPT & PAYMENT AS ON 31ST MARCH 2013

SCHEDULE - 33 : EAR MARKED FUND EXPENSES

(Amt in Rs...)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
Training Workshop Programme (NW Himalaya)	-	-
Training Workshop Programme (QSANWH Laddakh)	22,19,905	-
Indo- Iceland Workshop-2011	-	3,86,279
TOTAL	**22,19,905**	**3,86,279**

SCHEDULE - 34 : INVESTMENTS (RECEIPTS)

(Amt in Rs...)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
Letter of Credit/ Fixed deposit	2,43,35,000	3,03,00,000
TOTAL	**2,43,35,000**	**3,03,00,000**

SCHEDULE - 35 : INVESTMENTS (PAYMENTS)

(Amt in Rs...)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
Letter of Credit/ Fixed deposit	27,00,000	2,43,35,000
TOTAL	**27,00,000**	**2,43,35,000**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES CHARTERED ACCOUNTANTS DEHRADUN

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

SCHEDULE FORMING PART OF RECEIPT & PAYMENT AS ON 31ST MARCH 2013

SCHEDULE - 36 : FIXED ASSETS

(Amt in Rs…)

PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
Equipments :		
-WADIA	5,99,40,015	2,49,12,972
Field Equipment	-	-
Vehicle	-	20,02,594
Computer & Printers	37,14,739	13,88,173
Office Equipment	46,500	10,67,597
Building Construction	2,69,84,584	1,11,327
Books & Charts	85,74,657	95,75,144
Furniture & Fixture	5,69,686	10,79,927
TOTAL	**9,98,30,181**	**4,01,37,734**
Equipments :		
-PROJECTS	-	2,03,51,059
TOTAL	-	2,03,51,059
GRAND TOTAL	**9,98,30,181**	**6,04,88,793**
Add: (Profit)/Loss on asset		
- Vehicle	86,598	-
- Equipment Indeginious	(3,882)	-
- Library Books	(506)	415
Less :- Fixed Assets Written Off		
- Vehicle	8,69,831	-
- Library Books	1,412	-
- Equipment Indeginious	13,990	-
- Computer	85,342	-
Add: Depreciation Fund reversed		
- Vehicle	5,90,983	-
- Library Books	506	-
- Equipment Indeginious	3,882	-
- Computer	63,429	-
Projects	-	2,03,51,059
	9,96,00,616	**4,01,37,319**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES
DEHRADUN
CHARTERED ACCOUNTANTS

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WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE '1'
{ SUNDRY CREDITORS AS ON 31st MARCH 2013}

(Amt in Rs…)

S.NO.	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	C.D.S. Project (PB)	15,000	15,000
2	Dr. Kishore Kumar	-	-
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	
	Total	**19,58,217**	**15,000**

'ANNEXURE '2'
{ PUBLICATION AS ON 31st MARCH 2013 }

(Amt in Rs…)

S.NO.	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	**Opening Stock of Himalayan Geology Volume**	**5,13,405**	**6,32,246**
2	Less : Closing Stock of Himalayan Geology Volume	4,88,702	5,13,405
	Decrease In Stock	**24,703**	**1,18,841**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES
DEHRADUN
CHARTERED ACCOUNTANTS

AUDITOR'S REPORT

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WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRADUN

ANNEXURE '3'
{ PARTY DEBTORS AS ON 31st MARCH 2013 }

(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	2,07,637
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	BOC India Ltd. Faridabad	-	2,43,810
20	M/s Gatan House, Hyderabad	(376)	-
21	M/s Mahindra & Mahindra Ltd.	-	5,562
22	M/s Track Cargo, Delhi	1,17,458	4,16,915
23	M/s. Cameca, France	3,16,882	-
	TOTAL	**6,07,744**	**9,89,211**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA).
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES
DEHRADUN
CHARTERED ACCOUNTANTS

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE '4'
{ IMPREST MONEY AS ON 31ST MARCH 2013}

(Amt in Rs…)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Dr.A.K.Dubey	-	2,000
2	Dr.V.C. Tiwari	2,000	2,000
3	Dr. N. K. Saini	1,000	1,000
4	Shri Tapan Banerji	15,000	15,000
5	Shri O. P. Anand	500	500
6	Shri S. K. Parcha	9,000	4,000
7	Dr. N. Sivasidhya	2,000	2,000
8	VIC Imprest	1,000	1,000
9	Shri Manas Kumar Biswas	5,000	5,000
10	Shri Tajender Kumar Ahuja	2,000	2,000
11	Shri C. B.Sharma (JE)	2,000	2,000
12	Dr. B. K. Chowdhury	2,000	-
13	Dr. Kishore Kumar	7,000	7,000
14	Dr. H. K. Sachan	5,000	-
15	Shri Rambir Kaushik	5,000	-
	TOTAL	**58,500**	**43,500**

ANNEXURE '5'
{ STAFF ADVANCES AS ON 31ST MARCH 2013 }

(Amt in Rs…)

S.NO	PARTICULARS	ANNEXURE	CURRENT YEAR	PREVIOUS YEAR
1	Festival Advance	6	1,01,250	75,150
2	Conveyance Advance	7	6,47,338	4,85,009
3	House Building Advance	8	9,48,006	12,68,197
4	Computer Advance	9	6,29,904	8,59,016
5	Advance for Expenses (Staff Debtors)	10	7,66,708	2,63,236
6	Warm Clothing Advance	11	-	7,875
7	Consultancy Activity		16,062	258
	TOTAL		**31,09,268**	**29,58,741**

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

VIPUL SINGHAL & ASSOCIATES CHARTERED ACCOUNTANTS DEHRADUN

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

'ANNEXURE '6'
(FESTIVAL ADVANCE AS ON 31st MARCH 2013)

(Amt in Rs...)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Shri S. K. Chabak	1,875	2,250
2	Shri C. P. Dabral	1,875	2,250
3	Shri B. B. Panthari	1,875	1,950
4	Shri Lokeshwar Vashist	-	2,250
5	Smt. Rama Pant	1,875	2,250
6	Shri Ramesh Chand	1,875	2,250
7	Shri Nain Dass	2,625	2,250
8	Shri M. S. Rawat	-	2,250
9	Shri Khushi Ram	1,200	1,200
10	Shri Anand Singh Negi	1,875	-
11	Shri Har Prasad	-	1,800
12	Mrs. Deveshwari Rawat	-	2,250
13	Shri Madhu Sudan	2,625	2,250
14	Shri Vinod Singh Rawat	2,625	-
15	Shri Hari Krishan	3,750	1,800
16	Shri Ramesh	1,125	300
17	Shri Ram Khilawan	1,875	-
18	Shri Navneet Kumar	1,875	2,250
19	Shri Nand Ram	2,625	-
20	Shri Ganga Ram	-	1,200
21	Shri A. K. Gupta	2,625	-
22	Shri Shyam Singh	3,000	2,250
23	Shri S. K. Srivastava	2,625	-
24	Shri Shekhar Nand	1,200	1,200
25	Shri Pushkar Singh	-	2,250
26	Shri Satya Prakash	-	2,250
27	Shri Ram Kishore	2,625	-
28	Shri Pratap Singh	1,875	-
29	Shri Ansuya Prasad	2,625	1,200
30	Shri Shiv Prasad Bahuguna	2,625	1,800
31	Shri Shashidhar Prasad Balodi	2,625	2,250
32	Shri S. K. Thapliyal	1,200	1,200
33	Shri Satish P. Bahuguna	2,625	2,250
34	Shri Balram Singh	2,625	1,200
35	Shri Tirath Raj	1,875	1,800
36	Shri Sohan Singj	1,875	2,250
37	Shri Hari Singh Chauhan	1,875	-
38	Shri Rahul Sharma	2,625	-
39	Shri Kulwant Singh Manral	2,625	-
40	Shri Pankaj Chauhan	3,750	-
41	Mrs. Kalpana Chandel	3,000	2,250
42	Shri S. K. Gupta	1,875	1,200
43	Shri Surendra Singh	3,750	1,200
44	Shri S. C. Kothiyal	-	2,250
45	Shri Chait Ram	1,875	1,800
46	Mrs. Seema Juyal	2,250	-
47	Shri Santu Das	1,575	1,200
48	Mrs. Neelam Chabak	1,875	2,250
49	Shri Ravi Lal	-	1,200
50	Mrs. Suman Nanda	-	2,250
51	Shri Pretam Singh	4,950	1,200
52	Shri Bharat Singh Rana	1,875	2,250
53	Smt. Omwati	1,875	-
54	Shri Ram Khilawan	-	2,250
55	Shri Preetam Singh	1,875	1,200
	TOTAL	**1,01,250**	**75,150**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

VIPUL SINGHAL & ASSOCIATES CHARTERED ACCOUNTANTS DEHRADUN

(PROF ANIL K. GUPTA)
Director

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE '7'
{ CONVEYANCE ADVANCE AS ON 31ST MARCH 2013 }

(Amt in Rs...)

S.NO.	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Shri C. P. Dabral	15,020	20,156
2	Dr. A. K. Mahajan	8,979	14,127
3	Shri B. B. Panthari	-	3,412
4	Smt. Rama Pant	2,168	5,600
5	Shri Ramesh Chand	2,268	5,700
6	Shri Khushi Ram	1,982	5,414
7	Dr. P. P. Khanna	41,600	60,800
8	Dr. B. N. Tiwari	44,566	57,610
9	Smt. Manju Pant	60	4,164
10	Shri Vinod Singh Rawat	-	348
11	Shri Hari Kishan	-	3,412
12	Shri Ramesh	-	3,412
13	Shri Param Kirti Rao Gautam	26,000	-
14	Shri Ramesh Chand Arya	-	273
15	Shri Ansuya Prasad	-	3,412
16	Shri Balram Singh	34	3,982
17	Shri Samay Singh	1,38,805	-
18	Shri Surender Singh	-	3,412
19	Smt. Seema Juyal	-	3,412
20	Shri Surjan Singh	-	3,412
21	Shri Santu Dass	-	414
25	Smt. Suman Nanda	-	3,412
26	Shri Rakesh Kumar	9,937	14,053
27	Dr. D. P. Dobhal	-	11,160
28	Dr. Devajit Hazarika	9,884	15,020
29	Dr. A. K. L.Ashthana	93,250	1,46,650
30	Shri Chander Shekhar	1,30,000	-
31	Shri S. K. Gupta	11,165	14,585
32	Shri Madhu Sudan	24,852	30,000
33	Shri Navneet Kumar	19,541	23,657
34	Shri Shyam Singh	20,227	24,000
35	Shri Lokeshwar Vashist	24,000	-
36	Mrs. Prabha Kharbanda	23,000	-
	TOTAL	**6,47,338**	**4,85,009**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES CHARTERED ACCOUNTANTS DEHRADUN

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WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRADUN

ANNEXURE '8'

{ HOUSE BUILDING ADVANCE AS ON 31st MARCH 2013}

(Amt in Rs...)

S.NO.	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Dr. Mrs. Meera Tiwari	2,128	14,896
2	Dr. S.K. Ghosh	-	29,659
3	Dr Rajesh Sharma	1,55,856	2,02,608
4	Shri. Anand Singh Negi	38,140	52,480
5	Mrs. Rajvinder Nagpal	93,576	1,10,568
6	Shri. Ansuya Prasad	20,960	32,840
7	Dr. K.K. Purohit	-	7,660
8	Shri. Chander Shekher	22,660	47,164
9	Shri. D. Rameshwar Rao	10,740	21,024
10	Shri S.K Bartarya	-	38,480
11	Dr. George Philip	68,720	1,23,680
12	Shri Rakesh Kumar	1,65,980	1,86,020
13	Dr. A.K Singh	3,69,246	4,01,118
	TOTAL	**9,48,006**	**12,68,197**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES • CHARTERED ACCOUNTANTS • DEHRADUN

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRADUN

ANNEXURE ' 9'
[COMPUTER ADVANCE AS ON 31st MARCH 2013]

(Amt in Rs...)

S.NO.	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Shri S.K Chabak	20,600	23,000
2	Shri C P Dabral	16,000	18,400
3	Dr. A K Mahajan	33,499	37,471
4	Shri Lokeshwar Vashist	16,000	18,400
5	Shri B K Juyal	16,000	18,400
6	Shri Hukam Singh	16,000	18,400
7	Shri Vinod Singh Rawat	16,000	18,400
8	Shri Abhey Kumar Pandit	16,000	18,400
9	Shri Mms Rawat	1,752	6,888
10	Shri V K Kala	16,000	18,400
11	Shri. Navneet Kumar	12,000	18,000
12	Shri Naresh Kumar (Driver)	-	19,400
13	Shri Pushkar Singh	-	18,400
14	Shri Satya Prakash	-	2,800
15	Shri Ram Kishore	16,000	18,400
16	Shri Ramesh Chandra Arya	18,400	20,800
17	Shri Shiv Prasad Bahuguna	17,000	19,400
18	Shri Shashidhar Prasad Balodi	16,000	18,400
19	Shri Satish Prasad Bahuguna	16,000	18,400
20	Shri Rajender Prakash	13,800	17,400
21	Shri Tirth Raj	3,300	9,300
22	Shri S S Bisht	16,000	18,400
23	Shri S K Shrivastava	3,000	9,000
24	Mrs Prabha Kharbanda	18,400	20,800
25	Shri Ramesh Kumar Sehgal	16,000	18,400
26	Shri Chander Shekher	16,000	18,400
27	Shri S C Kothiyal	16,000	18,400
28	Shri Samay Singh	16,000	18,400
29	Shri Santu Dass	18,400	20,800
30	Mrs.Neelam Chabak	21,800	24,200
31	Dr Sushil Kumar	16,000	18,400
32	Shri Rakesh Kumar	17,000	19,400
33	Dr.A.K.Singh	12,653	20,657
34	Dr. Khyanshing Luirei	12,000	18,000
42	Dr. Ajay Paul	18,400	20,800
43	Shri Pankaj Chauhan	20,600	23,000
44	Shri A.K. Mundepi	-	12,000
45	Smt. Rama Pant	-	12,000
46	Shri Madhu Sudan	18,000	24,000
47	Shri Dewan Singh	-	13,000
48	Shri Ansuya Prasad	14,500	20,500
49	Mrs. Anita Chowdhary	13,000	19,000
50	Shri B.B. Saran	13,000	19,000
51	Shri Kaushik Sen	18,000	24,000
52	Shri Ramesh Chand	10,000	22,000
53	Shri Nain Dass	24,800	29,600
	TOTAL	**6,29,904**	**8,59,016**

VIPUL SINGHAL & ASSOCIATES CHARTERED ACCOUNTANTS DEHRADUN

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

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRADUN

ANNEXURE '10'
[STAFF DEBTORS AS ON 31st MARCH 2013]

(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	(1,485)	(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	19,436	14,926
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	3,052	590
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	1,146
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	3,000
19	Dr. Iqrar Ahmed	1,320	1,320
20	Sh. Kali Dass	1,773	(627)
21	Sh. P.S.Negi	-	2,529
22	Shri Bharat Singh Rawat	300	-
23	Dr.V.C.Tiwari	1,75,575	-
24	Shri Gautam Rawat	73,980	-
25	Mrs. Anita Chaudhary	-	20,000
26	Shri Bhupender Kumar	75	-
27	Dr. Swapnamita Chowdhury	90,000	-
28	Shri H.C.Pandey	1,26,900	-
29	Dr.B.K.Chowdhury	4,023	-
30	Shri D.P.Chowdhury	1,240	-
31	Shri Satish Prasad Bahuguna	19,400	-
32	Sh Laxman Singh Bhandari	2,400	2,400
33	Sh Chandan Bora	(500)	(500)
34	Shri Narendra Singh	77,244	-
35	Km Vatinaro Imsong	16,000	-
36	Shri P.S. Negi	2,649	-
37	Shro Ramesh Kumar Sehgal	-	49,000
38	SH. Rameshwar Roa	42,185	28,841
39	SH. H.K SACHAN	-	1,51,602
	GRAND TOTAL	**7,66,708**	**2,63,236**

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES
DEHRADUN
CHARTERED ACCOUNTANTS

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRADUN

ANNEXURE '11'
(WARM CLOTHING ADVANCE AS ON 31st MARCH 2013)

(Amt in Rs...)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Shri S. K Chabak	-	2,625
2	Smt. Rama Pant	-	2,625
3	Mrs. Neelam Chabak	-	2,625
	TOTAL	-	7,875

ANNEXURE '12'
{ SECURITY DEPOSIT AS ON 31ST MARCH 2013 }

(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)	4,28,348	4,28,348
2	M/s. Garhwal Jal Sansthan	460	460
3	M/s. Lal Brothers	9,000	9,000
4	M/s. Indian Oxygen Ltd.	52,000	52,000
5	M/s. Vallay Gas Service	500	500
6	M/s. BSNL (Security Against Telephones)	2,15,500	2,15,500
	TOTAL	7,21,808	7,21,808

ANNEXURE '13'
{ FEES FOR MISCELLENOUS SERVICES AS ON 31ST MARCH 2013 }

(Amt in Rs...)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Licence Fees	1,97,181	2,18,088
2	Transportation Charges	37,830	37,320
3	Electricity & Water Charges	5,50,475	3,04,077
	TOTAL	7,85,486	5,59,485

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES
CHARTERED ACCOUNTANTS
DEHRADUN

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WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE '14'
{ MISCELLANEOUS INCOME AS ON 31ST MARCH 2013}

(Amt in Rs…)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	Private trunkcalls	311	1,987
2	Application Form Fee	-	-
3	Other Receipts		
	a)Auction of vehicle	-	-
	b)Misc.	68,290	99,921
	c)Vehicle charges (Pvt. Purpose)	34,700	16,385
	d) Consultancy Receipts	54,88,063	64,91,854
4	Xerox Charges	5,994	478
5	Fee For Information Act-2005	180	100
6	Insurance Damage Claim	-	37,675
7	EMD Forfeited	-	50,000
	TOTAL	**55,97,538**	**66,98,400**

ANNEXURE '15'
{ EXPENSES ON SEMINAR/ WORKSHOPS AS ON 31ST MARCH 2013 }

(Amt in Rs…)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	**Seminar/Workshop/Conference**		
	a) Expenses on Conference in India	5,41,317	17,19,336
	b) Expenses on Conference held abroad	8,07,440	6,75,807
	c) Professor D.N. Wadia Lecture Series	49,819	1,780
	d) Expenses on IAS 2012 Meeting	26,12,473	-
	e) S.P Nautiyal Memorial Lecture	-	26,339
	TOTAL	**40,11,049**	**24,23,262**

(HARISH CHANDRA)
(Finance & Accounts Officer)

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES
DEHRADUN
CHARTERED ACCOUNTANTS

ANNEXURE '16'
{ EXPENSES PAYABLE AS ON 31ST MARCH 2013}

(Amt in Rs…)

S.NO	PARTICULARS	CURRENT YEAR	PREVIOUS YEAR
1	DR Trilochan Singh	2,50,000	2,50,000
2	UHPM Project	1,627	1,627
3	EPGPS (PB)	500	500
4	QCTLKH	1,008	1,008
5	FCRA Project	504	504
6	AKJ (FNA) Project	494	-
7	Ganga Basin	504	504
8	Smt Pushpa Barthwal	-	5,710
9	AFNAH-II (NSV) Project	-	500
10	Siachen Glacier	-	504
11	EREC (SKP) Project	504	504
12	GEO-SEDI Project	-	500
13	NEO- Tectonics (VCT)	-	504
14	IJCSP (GP) Project	-	500
15	ILTP- NEMFIS (VR) Project	494	1,000
16	HIMSCOPE Project	-	604
	TOTAL	**2,55,635**	**2,64,469**

(HARISH CHANDRA)
(Finance & Accounts Officer)

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES
CHARTERED ACCOUNTANTS
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ANNEXURE '17'
{ SECURITY PAYABLE AS ON 31ST MARCH 2013 }

(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	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. National Electricals	-	18,537
9	M/s Virender Elec.	2,100	2,100
10	Guardwell Security Services	50,000	50,000
11	M/s Radix Technologies	5,000	5,000
12	IR Tech Services N.Delhi	6,000	6,000
13	EICON Technology DDN	20,000	20,000
14	Pest Control India Ltd	50,066	1,202
15	Tej Technology Hybd	20,000	20,000
16	Polutn Equipt Cont Ndel	9,000	9,000
17	M/s. Cetac Technology	3,76,540	3,76,540
18	M/s. Chamoli Associates	-	6,52,722
19	Mahindra & Mahindra Ltd	1,813	1,813
20	M/s. Algade Sas	58,350	58,350
21	M/s. Rawat Sanitation	1,246	1,246
22	M/s. Mountarian Equipment	4,850	4,850
23	M/s. Dev Associates	70,000	70,000
24	M/s. Dec-N-Trap, N.Delhi	13,30,062	1,20,000
25	M/s. Bil Trading N Del	20,000	20,000
26	Indian Book House Ddn	2,000	2,000
27	SWJ Associates	3,091	3,091
28	M/s. Doon Light Asso. , DDun	2,44,185	1,29,232
29	M/S. Sun Construction, DDun	-	7,09,694
30	M/s. Sulaksh Inters. Delhi	11,64,039	1,00,000
31	Shri S.K. Goyal, Contractor	3,55,457	58,037
	TOTAL	**39,01,320**	**25,46,935**

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

VIPUL SINGHAL & ASSOCIATES • CHARTERED ACCOUNTANTS • DEHRADUN

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE 18'

(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.
	Projects												
1	GPS Equipment	1,30,83,695	-	-	1,30,83,695	88,89,363	-	6,29,150	-	95,18,513	35,65,182	**41,94,332**	15%
2	Neotectonic Project (S. Kumar)	3,14,552	-	-	3,14,552	2,13,714	-	15,126	-	2,28,840	85,712	**1,00,838**	15%
3	Neotectonic Project(VCT)	32,760	-	-	32,760	22,257	-	1,575	-	23,832	8,928	**10,503**	15%
4	CSIR Project(VCT)	40,000	-	-	40,000	27,177	-	1,923	-	29,100	10,900	**12,823**	15%
5	PAC(AP) Project(TS)	3,45,430	-	-	3,45,430	2,34,693	-	16,611	-	2,51,304	94,126	**1,10,737**	15%
6	SNWH Project (SKP)	16,150	-	-	16,150	10,973	-	777	-	11,750	4,400	**5,177**	15%
7	PILOT Project(JTG)	2,49,442	-	-	2,49,442	1,69,477	-	11,995	-	1,81,472	67,970	**79,965**	15%
8	SDB Project(SK)	5,05,504	-	-	5,05,504	3,43,451	-	24,308	-	3,67,759	1,37,745	**1,62,053**	15%
9	LSZ Project(NSV)	19,314	-	-	19,314	13,123	-	929	-	14,052	5,262	**6,191**	15%
10	DFSZ Project (HKS)	5,88,352	-	-	5,88,352	3,99,740	-	28,292	-	4,28,032	1,60,320	**1,88,612**	15%
11	HIA Project (AB)	33,878	-	-	33,878	23,018	-	1,629	-	24,647	9,231	**10,860**	15%
12	HRGH Project (NRP)	1,85,980	-	-	1,85,980	1,26,358	-	8,943	-	1,35,301	50,679	**59,622**	15%
13	ESS Project(SKP)	4,64,499	-	-	4,64,499	3,15,592	-	22,336	-	3,37,928	1,26,571	**1,48,907**	15%
14	SHA Project (AKM)	71,360	-	-	71,360	48,484	-	3,431	-	51,915	19,445	**22,876**	15%
15	EHA Project (TNB)	1,60,966	-	-	1,60,966	1,09,364	-	7,740	-	1,17,104	43,862	**51,602**	15%
	Balance Carried Forward	**1,61,11,882**	-	-	**1,61,11,882**	**1,09,46,784**	-	**7,74,765**	-	**1,17,21,549**	**43,90,333**	**51,65,098**	

VIPUL SINGHAL & ASSOCIATES CHARTERED ACCOUNTANTS DEHRADUN

Contd.2.

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE 18'

(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	1,61,11,882	-	-	1,61,11,882	1,09,46,784	-	7,74,765	-	1,17,21,549	43,90,333	51,65,098	
16	ILHDR Project (RK)	7,13,860	-	-	7,13,860	4,85,013	-	34,327	-	5,19,340	1,94,520	2,28,847	15%
17	SSTH Project	45,08,227	-	-	45,08,227	30,62,992	-	2,16,785	-	32,79,777	12,28,450	14,45,235	15%
18	RMGC Project (SJS)	16,03,022	-	-	16,03,022	10,89,258	-	77,065	-	11,66,323	4,36,699	5,13,764	15%
19	PTS Project (HR)	90,112	-	-	90,112	61,121	-	4,349	-	65,470	24,642	28,992	15%
20	CE Project (NSM)	56,421	-	-	56,421	38,334	-	2,713	-	41,047	15,374	18,087	15%
21	ESTG Project	1,01,611	-	-	1,01,611	69,036	-	4,886	-	73,922	27,689	32,575	15%
22	PBP MT Project (MT)	1,29,149	-	-	1,29,149	87,747	-	6,210	-	93,957	35,192	41,402	15%
23	EPGPS PRO (PB)	56,06,753	-	-	56,06,753	38,09,357	-	2,69,609	-	40,78,966	15,27,787	17,97,396	15%
24	LHZ SILROOT PROJECT (GP)	1,09,958	-	-	1,09,958	74,710	-	5,287	-	79,997	29,961	35,249	15%
25	UHPM PROJECT (HKS)	80,409	-	-	80,409	53,542	-	4,030	-	57,572	22,837	26,867	15%
26	BSS (KPJ) PROJECT	43,790	-	-	43,790	29,751	-	2,106	-	31,857	11,933	14,039	15%
27	FMD (AKD) PROJECT	1,88,392	-	-	1,88,392	1,27,998	-	9,059	-	1,37,057	51,335	60,394	15%
28	SSR-NCR PROJECT	96,57,406	-	-	96,57,406	65,61,463	-	4,64,391	-	70,25,854	26,31,552	30,95,943	15%
29	MGGS-NCS PROJECT	96,903	-	-	96,903	65,838	-	4,660	-	70,498	26,405	31,065	15%
30	EGLLT PROJECT (NSV)	7,03,060	-	-	7,03,060	4,77,675	-	33,808	-	5,11,483	1,91,577	2,25,385	15%
31	AFNAH-I PROJECT (NSV)	74,940	-	-	74,940	50,916	-	3,604	-	54,520	20,420	24,024	15%
32	RPL PROJECT (VG)	4,13,306	-	-	4,13,306	2,57,428	-	23,382	-	2,80,810	1,32,496	1,55,878	15%
33	ILTP (K)	25,350	-	-	25,350	15,789	-	1,434	-	17,223	8,127	9,561	15%
	Balance Carried Forward	4,03,14,551	-	-	4,03,14,551	2,73,64,752	-	19,42,470	-	2,93,07,222	1,10,07,329	1,29,49,800	

VIPUL SINGHAL & ASSOCIATES DEHRADUN CHARTERED ACCOUNTANTS

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE 18'

(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	**4,03,14,551**	-	-	**4,03,14,551**	**2,73,64,752**	-	**19,42,470**	-	**2,93,07,222**	**1,10,07,329**	**1,29,49,800**	
34	EGMS PRO. (PB)	8,45,448	-	-	8,45,448	5,74,417	-	40,655	-	6,15,072	2,30,376	**2,71,031**	15%
35	LHZ PRO.(GP)	60,315	-	-	60,315	40,979	-	2,900	-	43,879	16,436	**19,336**	15%
36	SEISMOCITY (TNB)	25,000	-	-	25,000	16,986	-	1,202	-	18,188	6,812	**8,014**	15%
37	CSIR (KNK)	2,08,237	-	-	2,08,237	1,41,481	-	10,013	-	1,51,494	56,743	**66,756**	15%
38	PBEKS (SKP)	1,66,478	-	-	1,66,478	1,13,109	-	8,005	-	1,21,114	45,364	**53,369**	15%
39	ONGC (RANGA RAO)	28,183	-	-	28,183	19,148	-	1,355	-	20,503	7,680	**9,035**	15%
40	CSIR (V-RAIVERMAN)	50,800	-	-	50,800	34,515	-	2,443	-	36,958	13,842	**16,285**	15%
41	PGC PROJECT (AKS)	69,591	-	-	69,591	46,912	-	3,402	-	50,314	19,277	**22,679**	15%
42	PBBD (VCT)	87,760	-	-	87,760	59,626	-	4,220	-	63,846	23,914	**28,134**	15%
43	MBGH (JTG)	24,41,537	-	-	24,41,537	16,58,837	-	1,17,405	-	17,76,242	6,65,295	**7,82,700**	15%
44	TOTAL STATION	24,14,225	-	-	24,14,225	16,40,280	-	1,16,092	-	17,56,372	6,57,853	**7,73,945**	15%
45	CDS (PB) PRO	41,52,662	-	-	41,52,662	28,21,413	-	1,99,687	-	30,21,100	11,31,562	**13,31,249**	15%
46	SEISMO GPS (PB) PRO	1,48,46,853	-	-	1,48,46,853	89,05,792	-	8,91,159	-	97,96,951	50,49,902	**59,41,061**	15%
47	DDBC (BS)	3,83,004	-	-	3,83,004	2,60,222	-	18,417	-	2,78,639	1,04,365	**1,22,782**	15%
48	SIACHIN GLR (HKS)	95,160	-	-	95,160	52,961	-	6,330	-	59,291	35,869	**42,199**	15%
49	EREC (SKP) PRO	10,10,208	-	-	10,10,208	6,10,677	-	59,930	-	6,70,607	3,39,601	**3,99,531**	15%
50	ECD(BR) PROJECT	1,03,26,133		-	1,03,26,133	57,16,462		6,91,451	-	64,07,913	39,18,220	46,09,671	15%
51	GANGA BASIN PROJECT	51,521		-	51,521	19,881		4,746	-	24,627	26,894	31,640	15%
	Balance Carried Forward	**7,75,77,666**	-	-	**7,75,77,666**	**5,00,98,450**	-	**41,21,882**	-	**5,42,20,332**	**2,33,57,334**	**2,74,79,215**	

VIPUL SINGHAL & ASSOCIATES • CHARTERED ACCOUNTANTS • DEHRADUN

Contd.4.

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE 18'

(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	7,75,77,666	-	-	7,75,77,666	5,00,98,450	-	41,21,882	-	5,42,20,332	2,33,57,334	2,74,79,215	
52 AFNAH II (NSV)	40,000		-	40,000	15,435		3,685	-	19,120	20,880	24,565	15%
53 ILTP- NEMFS(AKM)	42,453		-	42,453	20,293		3,324	-	23,617	18,836	22,160	15%
54 ECGHR (GP)	3,09,670		-	3,09,670	2,10,397		14,891	-	2,25,288	84,382	99,273	15%
55 MGIE(BRA)	51,17,709		-	51,17,709	31,87,567		2,89,521	-	34,77,088	16,40,621	19,30,142	15%
56 GEES (BKC)	44,63,573		-	44,63,573	21,55,573		3,46,200	-	25,01,773	19,61,800	23,08,000	15%
TOTAL	8,75,51,071	-	-	8,75,51,071	5,56,87,715	-	47,79,503	-	6,04,67,218	2,70,83,853	3,18,63,356	

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

VIPUL SINGHAL & ASSOCIATES DEHRADUN CHARTERED ACCOUNTANTS

(PROF. ANIL K. GUPTA)
Director

WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRA DUN

ANNEXURE '19'
{ PROFIT/LOSS ON SALE OF ASSET AS ON 31ST MARCH 2013 }

(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	1,412	-
Less: Accumulated Dep	8	506	-
Net Value		**906**	-
Less: Sold during the Year	18	1,412	-
(Profit)/Loss on sale	(B)	**(506)**	-
Equipment			
Gross Value	8	13,990	-
Less: Accumulated Dep	8	3,882	-
Net Value		**10,108**	-
Less: Sold during the Year	18	13,990	-
(Profit)/Loss on sale	(C)	**(3,882)**	-
Computers			
Gross Value	8	85,342	-
Less: Accumulated Dep	8	63,429	-
Net Value		**21,913**	-
Less: Sold during the Year	18	21,913	-
(Profit)/Loss on sale	(D)	-	-
Total (Profit)/Loss (A+B+C+D)		**82,210**	

(HARISH CHANDRA)
Finance & Accounts Officer

(DINESH CHANDRA)
Registrar

(PROF ANIL K. GUPTA)
Director

VIPUL SINGHAL & ASSOCIATES CHARTERED ACCOUNTANTS DEHRADUN

AUDITOR'S REPORT

WADIA INSTITUTE OF HIMALAYAN GEOLOGY,
33, GMS ROAD DEHRADUN

SCHEDULE FORMING PART OF ACCOUNTS FOR THE YEAR ENDED 31ST MARCH, 2013

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.

VIPUL SINGHAL & ASSOCIATES
DEHRADUN
CHARTERED ACCOUNTANTS

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 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 : 16th Aug, 2013
Place: Dehradun

VIPUL SINGHAL & ASSOCIATES • CHARTERED ACCOUNTANTS • DEHRADUN

WADIA INSTITUTE OF HIMALAYAN GEOLOGY,
33 GMS ROAD, DEHRADUN

SCHEDULE FORMING PART OF ACCOUNTS FOR THE YEAR ENDED 31ST MARCH, 2013

SCHEDULE – 38: CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS

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	27,00,000
	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

VIPUL SINGHAL & ASSOCIATES DEHRADUN CHARTERED ACCOUNTANTS

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. 2012-13 is as follows:

Remuneration to auditors		
i)	As Auditors	7865/-
	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) New Pension Scheme.
e) Consolidated financial statement of projects sponsored by other Agencies.
f) 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, 2013, Income and Expenditure Account and Receipt & Payment for the year ended on 31st March, 2013.

(Harish Chandra)
Finance & Accounts Officer

(Dinesh Chandra)
Registrar

(Prof. Anil K. Gupta)
Director

Date : 16th Aug, 2013
Place: Dehradun

VIPUL SINGHAL & ASSOCIATES CHARTERED ACCOUNTANTS DEHRADUN

Saraswati Press, D.Dun, M. : 9359211333