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President : **Prof. Arun Kumar**

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Geo Risk in Indian Sub-Continentare we Well Prepared?

President : Prof. Arun Kumar*

SECTION OF EARTH SYSTEM SCIENCES

I welcome you all to the beautiful city of *Singara* Chennai which is known for its rich cultural heritage, temple architecture and endowed with one of the longest beaches in the world-*Marina Beach*.

When a man of science accepts the position of honour in which I find myself this evening it is usually understood that he undertakes to engage a large public audience on some topic of general scientific interest. Considering the immediate need for Earth System Sciences in present context, I take this opportunity to discuss the Geo Risks and current status of mitigation in Indian Subcontinent.

Mother Earth can seem like an uncared parent. The impact of geohazards on our lives and economy is very important, and will never go away. Every year floods, tsunamis, severe storms, drought, wildfires, volcanoes, earthquakes, landslides and subsidence etc claim thousands of lives, injure thousands more, devastate homes and destroy livelihoods.

Taking this opportunity I would like to raise a few issues of georisks that I personally feel important to be highlighted.

1. How we have modified our landscape, the geosphere and the biosphere to trigger certain hazards and increasing societal vulnerability to them?

2. What technologies and methodologies are required to assess the vulnerability of people, places and spatial scales of hazards?

3. How does our current ability to monitor, predict and mitigate vary from one geohazard to another? And how to further improve these capabilities?

4. What are the constraints, that prevents our Central and State governments from using risk and vulnerability information to create policies and plans to reduce them?

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*Department of Earth Sciences, Manipur University, Imphal-795 003, Manipur

It is, now, a fact that due to the rapid growth of urbanisation on our planet earth, we have already modified 40-50% of our ice free land surface and utilise 54% of available fresh water. We have significantly accelerated the magnitude of flow of sediments than all natural processes operating on the earth. We have also fixed more atmospheric nitrogen than all the combined terrestrial sources (Martin Goldhaber, 2010). Our interventions and planetary scale changes induce extensive modifications to ecosystem that support life on the earth and pose a great challenge to all of us. The mitigation of impacts of planetary change goes beyond available input from many disciplines, and even far behind from the interdisciplinary science. There is further need for an integrated science in which issues are framed in entirely new ways that transcend discipline boundaries.

To address these question, we earth scientists, must elaborate the concept of georisk. It covers many diversified but interlinked areas of active research and practice, such as geohazards, safety of engineered structures, environmental risk, seismic risk, geostatistics, decision analyses, structural reliability, risk and vulnerability, hazard mapping, loss assessment, Geographical Information System (GIS) databases, remote sensing, and many other related disciplines. Uncertainties associated with geo-materials (soils, rocks, snow), geologic processes and anthropogenic actions can be estimated large and complex phenomenon. These uncertainties play an important role in the assessment of hazard and risk and in the management of risk. Quantification of the above uncertainties and to develop the sustainable risk management methodologies are the significant theoretical and practical challenges for us. It is the urgent need for decision-makers and stakeholders. We further require discussing about geo-hazards in managing georisks.

"Geo-hazard" is a term that includes geological hazards, like landslides and volcanoes and earthquakes and Hydro-meteorological hazards like floods, draught and cyclones etc. Any Earth process that poses risk to human life can be termed as geo-hazard, ranging in scope from local events (such as small rock falls) to global geological events that can pose a threat to the existence of our entire species, like major asteroid impacts and super-volcanic eruptions. Geohazards occur at different scales in time and space, affect our life and health as well as having a drastic impact on the sustainable development of society, especially, in developing countries, which are vulnerable due to their poverty. Even in developed countries, geohazards are pending danger to vulnerable life line and infrastructure such as water supply reservoir, pipe lines and power lines. The hazards can be classified as - hydrological, meteorological, tsunamis, volcanoes, seismic and geodetic (landslides) etc. The risk which is estimation of economic losses, as a consequence of hazard involves sustainability issues such as infrastructure (building vulnerability, robustness of infrastructure), and health (air quality, water quality, contaminated land). The

beginning of the 21st century has been marked by a significant number of natural disasters, namely, floods, storms, wildfires, earthquakes, landslides and tsunamis. These extreme natural events cause devastation resulting in loss of human life, large environmental damage, and partial or total loss of infrastructure. The signature of such events is that their probability decreases with magnitude, but the damage caused increases rapidly, and so does the cost of its mitigation. The recent catastrophic events (e.g. the Indian Ocean giant earthquake and devastating tsunami in 2004, earthquakes in Pakistan in 2005, China in 2008, Haiti in 2010) reminded us once again that there is a strong coupling between complex solid Earth, oceanic, and atmospheric processes. Now, I will mention about natural hazards in Indian subcontinent.

NATURAL HAZARDS IN INDIAN SUBCONTINENT

India is vulnerable to different natural hazards due to its proximity to geo-dynamically active locales and unique climatic pattern. Both these factors in different combinations lead to the occurrence of disasters resulting from natural hazards like floods, earthquakes, draught, cyclones and landslides in different parts of the country at frequent intervals. It is estimated that about 60% of landmass of the country is vulnerable to earthquakes; about 8% of total area is susceptible to cyclone; about 68% of the area is draught prone; 12% of area is susceptible to floods and approximately 15% of total area of the country is susceptible to landslides (Sharda 2008). The disaster situation in the country are further compounded by increased vulnerabilities related to rapidly growing population, unplanned urbanization and fast-paced industrialization, rapid development in high risk areas, environmental degradation and climate change.

It is observed that impact of natural disasters is felt more severely by people who are socio-economically weak because their habitats are located in vulnerable areas and not designed to withstand the impact. Therefore, the processes of poverty eradication and disaster management are intricately linked. In India, the incidence of earthquakes has increased, which is evidenced by the earthquakes of Latur, Uttarkashi, Bhuj and the mega earthquake in Indian Ocean that caused the mega Tsunami. In all these earthquakes, the damages of life and property have been very heavy mostly due to high population density and poor housing. One of the main reasons of the incidence of earthquake in Indian peninsular region is the result of tectonic movement of the Indian plate and collision with the Tibetan plate and the occurrence of the earthquakes along the fault lines and the sensitive zones. In India, the Himalayan region and the coastal zones are the most sensitive regions and are related with the tectonic movement. In the Himalayan region, the

earthquakes are causing landslides, meandering of rivers and resultant floods of the sub-Himalayan plains in Gangatic basin in Bihar and the Brahmputra basin in Assam. The 1986 flood on the Godavari River is the largest flood on record in the entire Indian subcontinent till date (Nageswara Rao, 2001).

EARTHQUAKE

Earthquake is considered to be one of most damaging natural.hazard. In the known history, millions of lives have been lost and the damage to property runs into thousands of billions of dollars. The Shanxi Province earthquake of China of 23rd January 1556 claimed about 830,000 human lives. In the recent past the Tangshan earthquake of July 27, 1976, also in China, claimed 242,000 human lives. The Kobe, Japan earthquake of 16th January 1995, although of only 7.2 magnitude, claimed 5,900 lives, and the economic losses are estimated to be in excess of US$ 150 billion US $. In our own country, the Himalayan region is known to be seismically the most active intra-continental region. During a short span of 53 years, there have been four great earthquakes exceeding magnitude 8, namely the Shillong earthquake of June 12, 1897; the Kangra earthquake of April 4, 1905; the Bihar-Nepal earthquake of January 15, 1934 and the Assam earthquake of August 15, 1950. The Kangra earthquake had claimed about 22,000 lives. It is estimated that if the Kangra earthquake repeats today, up to 280,000 lives will be lost if it occurs in the night, when everyone is sleeping inside homes (Gupta 2007). This is due to increase in the population and unplanned urbanisation. Equally important factor is the deterioration in the quality of the construction of the houses. Earlier, most of the houses were constructed with wood, which have now been changed to mud, stone and cement. Such constructions are most vulnerable to horizontal accelerations experienced during earthquakes and collapse like a house of cards. The estimate of loss of lives in the Kangra region in a way proved to be right during the recent Muzzafarabad earthquake of October 8, 2005 where about 88,000 lives were lost. The city of Muzzafarabad is located in an environment similar to Kangra and has similar population density and style of houses.

In India problem of the earthquakes is not limited to the Himalayan region alone. The Peninsular region has its own share of earthquakes. We had a devastating earthquake in Bhuj on January 26, 2001 which claimed about 20,000 lives and the financial losses were estimated to be about 50,000 Crores. A similar earthquake had occurred on June 16, 1819 in the same area known as the Kuchch earthquake, which created a scarp up to 6 m in height and running some 90 km in length. The recent Latur earthquake of September 30, 1993, although of M 6.2 only, claimed about 10,000 human lives, and is the deadliest stable continental region earthquake

till 1993. The huge number of human lives lost was due to high population density, poor construction of houses and the fact that the earthquake occurred early in the morning around 4 a.m. when everyone was asleep inside. The most significant site of earthquakes triggered by filling of artificial water reservoirs is at Koyna in west India. Here, earthquakes began to occur soon after the filling of the reservoir in 1962 and are still continuing. The largest triggered earthquake of magnitude 6.3 occurred on December 11, 1967. Over the years, about 20 earthquakes of M>_ 5 and several thousand smaller earthquakes have occurred at this unique site in a small area of some 20x30 sq. km. Ten significant earthquake rocked South Asia region during last hundred years are listed below :

Ten Strongest Earthquakes of South Asia since 1900

	Date	**Mw**	**Latitude**	**Longitude**	**Location**
1	26 December 2004	9.1	03.29	95.98	Sumatra-Andaman arc
2	15 August 1950	8.6	28.38	96.76	Chayu-Upper Assam
3	15 January 1934	8.1	27.55	87.09	Nepal-Bihar border
4	27 November 1945	8.0	25.15	63.48	Makran Coast, Pakistan
5	30 May 1935	7.8	28.87	66.40	Quetta, Balochistan
6	4 April 1905	7.8	33.00	76.00	Kangra, Himachal Pradesh
7	26 June 1941	7.7	12.40	92.50	Middle Andaman Island
8	26 January 2001	7.7	23.44	70.31	Bhuj, Gujarat
9	8 October 2005	7.6	34.43	73.53	Kashmir-Kohistan
10	29 February 1944	7.4	00.30	75.30	Near Maldive Islands

About 60% of India’s population has a potential of experiencing a damaging to a devastating earthquake. The extreme catastrophic nature of the earthquake is known for centuries due to resulted devastation in many of their occurrences. The abruptness along with apparent irregularity and infrequency of earthquake occurrences facilitate formation of a common perception that earthquakes are random and unpredictable phenomenon. The challenging questions remain pressing:

What happens during an earthquake?

How to size earthquake?

Why, where and when do earthquake occur?

The stock of situations on the outcome of the earthquake research in India is fairly good. Multi-disciplinary and multi-institutional research is undertaken by various research institutes/organisations, IITs and universities are excellent and at par with many developed countries. The Government of India through its various agencies also extends the financial support for the same. Under the aegis of Ministry of Home Affairs, National Disaster Management Agency (NDMA) is set up for disaster mitigation, capacity building, emergency preparedness and public awareness in our country. Various multi-institutional efforts are now being on earthquake forecast.

Earthquake forecast is one of the most cherished goals of seismologists. Efforts in this direction started about a century ago and peaked during 1970's when there was a cautious optimism that reliable earthquake forecast may be around the corner. Successful prediction of Blue Mountain earthquake near New York, and Heicheng earthquake in China added to this optimism. However, non-occurrence of Park Field earthquake in the specified time frame (1985 - 1993) of the official forecast of the U.S. Geological Survey led to disbelief. Similarly, the forecast made for the Tokai region in Japan did not yield positive results. An earthquake did occur in the Tokai region in 2003, but no definite precursors were observed.

Keeping in view the present scenario, the following specific long-term goals in areas of interdisciplinary research that offer exceptional opportunities to further the national effort in earthquake science, could be useful.

***Earthquake Precursory Research* :** It is clear that at present there is well established scientific technique available in the world over, which can give an earthquake forecast in terms of space time and size. Therefore, its necessary to develop different models, which may help in establishing a correlation between earthquake occurrence and specific geophysical observations. This is however, possible when we have comprehensive data base available with us.

A variety of earthquake precursors are known from the global monitoring programs but they seem to have poor prognostic value as the noted changes are not observed for all earthquakes and in different parameters or even for different earthquakes in the same region. It remains to be established how the range of seismological and non-seismological precursors relate to earthquake building processes and at what stage of earthquake preparatory cycle they appear and what are their characteristic space-time signatures? Earthquakes are thought to be associated with a broad range of EM phenomenon, from precursory to co-seismic and from luminous effect to ULF variations and long term changes in the electric properties of crustal rocks. The mechanism generating to these phenomenon are thought to be multiple, complex, complicated interactions, according to subject to intensive

research with diverse method of scientific enquiry. The strain building process in several regions of the world has shown perturbation in seismicity, crustal deformation, electrical conductivity, gravity-magnetic properties, water level and emanation of radon and helium gas. Considering that in case of an earthquake rupture certain precursory activities can be expected, search for precursory signals in many active seismic zones has continued. As a result of intensive monitoring, variety of precursory signals are reported which can be broadly classified into following categories: Seismological Precursors, Geomagnetic and Geoelectric Precursors, Atmospheric/ Ionospheric Precursors, Geodetic Precursors and Geochemical Precursors.

I would like to mention that in precursory research there has been considerable progress in India during last few years. Based on the observations of anomalous phenomena in different geophysical observations, a National programme on Earthquake Precursors has recently been launched by Govt. of India. The programme, basically aimed at generating long term geophysical data base in the areas, where the possibility of occurrence of M>6 is perceived high. In order to examine the precursory signals, Multi-Parameter Geophysical Observatories (MPGOs) are proposed to be set up at identified sites. In fact at two locations, one at Ghutu, NW Himalaya and another at Shillong such observatories are functional for last 3 years. Similar observatories are planned for PortBlair, Sikkim, IMR (Manipur), and other strategic locations in the country.

***Ground-Motion Prediction* :** Prediction of strong ground motions caused by earthquakes and the nonlinear responses of surface layers to these motions, including fault rupture, landslide, and liquefaction—with enough spatial and temporal detail to assess seismic risk accurately is equally important. The ground motion prediction also helps in a-seismic design of structures. In addition, this may provide a vital role in landuse planning and future developments in a particular city/area. Though, some of these studies are taken up by IITs and other academic institutions, but their full utility is still remains to be unexploited.

***Seismic Hazard Analysis* :** It incorporate time dependence into the framework of seismic hazard analysis in two ways: (1) by using rupture dynamics and wave propagation in realistic geological structures to predict strong-motion seismograms (time histories) for anticipated earthquakes, and (2) by using fault-system dynamics to forecast the time-dependent perturbations to average earthquake probabilities. In the absence of any forecast model accurate assessment of seismic hazard becomes very important. The building design code prepared and published by Bureau of Indian standards (BIS), though provide a general guideline for building of structures to with stand the earthquake forces, however, it is not considered to be sufficient

for local scenario. For example, as per the code, the entire Delhi lies in Seismic zone IV. However, the ground motion will not be uniform for the entire city due to local site conditions etc. Therefore, hazard assessment on large scale or microzonation, becomes important. Such efforts have also been initiated at National level through a multi-institutional and multi-disciplinary approach.

The basis of micro-zonation is to model the rupture mechanism at the source of an earthquake, valuate the propagation of waves through the earth to the top of bed rock, determine the effect of local soil profile and thus develop a hazard map indicating the vulnerability of the area to potential seismic hazard. The response of soil due to seismic hazards producing a significant amount of cumulative deformation or liquefaction has been one of the major concerns for geotechnical engineers working in seismically active regions. Liquefaction can occur in moderate to major earthquakes, which can cause severe damage to structures. Transformation of a granular material from solid state to liquid sate due to increased pore pressure and reduced effective stress is defined as liquefaction (Marcuson, 1978). When this happens, the sand grains lose its effective shear strength and will behave more like a fluid. The grain size distribution of soil, duration of earthquake, amplitude and frequency of shaking, distance from epicentre, location of water table, cohesion of the soil and permeability of the layer affects soil liquefaction. Liquefaction hazards are associated with saturated sandy and silty soils of low plasticity and density. Seismic microzonation may also help in designing buried lifelines such as tunnels, water and sewage lines, gas and oil lines, and power and communication lines.

Most of the damages of life and property could be minimised if the housing and other constructions in the built up environment are made on the earthquake resistant construction technology. Advance warning system which is available could be used for evacuation of the people in the earthquake sensitive zones. Lessons learnt from the past disaster and the scientific and technological capabilities already developed and applied in earthquake sensitive regions like Japan and other countries, the Government of India has now initiated to develop these capabilities in most of the sensitive regions. The National Disaster Management Agency and other disaster management groups have been created at the national and state levels in our country. The awareness and capacity building in the area of natural disasters is being implemented in the disaster sensitive regions.

Education and Outreach **:** Awareness is one of the most important components of any programme. Establishment of effective partnerships between earthquake scientists and other communities to reduce earthquake risk through research

implementation and public education is very essential. Himalayan School Earthquake Lab Programme (HIMSELP) and now North Eastern School Earthquake Programme (NESELP) programmes, which extend Himalayan and NE Region of the country, operated by Manipur University and Wadia Institute of Himalayan Geology are such instances. The basic aim of the programme is to impart the earthquake education to school students, inculcate the culture of measurement and create awareness amongst students and public at large. Under this programme, 100 schools were selected to set up low version of seismographs in Himalayan region. The programme is now extended in other important areas, namely western India.

LANDSLIDES

Landslides are one of the natural hazards that affect at least 15% of land area of our country exceeding 0.49 million km^2. Landslides of different types occur frequently in geodynamically active domains in Himalaya, North East India as also in stable domains in Western Ghats and Nilgiri Hills of Southern India (Sharda 2008). The Himlayan terrain, being geologically young and geodynamically active to triggering large number of earthquakes and intensive soil erosion, is highly prone to the landslide hazards. Over the decades, due to increase in populations as well as their properties in these terrains along the National and State Highways, the incidences of landslides have shown a disturbing and damaging trend of occurrences with higher damage to life and property. Large landslides occurred during last one and half decades (1990-2005) in our country are listed below :

Table 2 Major landslides in Indian subcontinents

Date	**Locality**	**Damage of property and death toll**
October 1990	Nilgris	36 people killed and several injured. Several buildings and communication network damaged
July 1991	Assam	300 people killed, road and buildings damaged, Millions of rupees
November 1992	Nilgiris	Road network and buildings damaged, Rs.5 million damage estimate
June 1993	Aizawal	4 persons were buried
July 1993	Itanagar	25 people buried alive 2 km road damaged
August 1993	Kalimpong, West Bengal	40 people killed, heavy loss of property

August 1993	Kohima, Nagaland	200 houses destroyed, 500 people died, about 5km road stretch was damaged
November 1993	Nilgris	40 people killed, property worth several lakhs damaged
January 1994	Kashmir	National Highway 1A severely damaged
June 1994	Varundh ghat, Konkan Coast	20 people killed, breaching of ghat road damaged to the extent of 1km. At several places
May 1995	Aizwal Mizoram	25 people killed road severely damaged
June 1995	Malori Jammu	6 persons killed, NH 1A damaged
September 1995	Kullu, HP	22 persons killed and several injured about 1 km road Destroyed
14, August 1998	Okhimath	69 people killed
18, August 1998	Malpa,Kali river	205 people killed road network to Mansarovar disrupted
August 2003	Uttarkashi	Heavy loss of infrastructures
July 2004	Joshimath-Badrinath	Heavy landslides hit Lambagarh areawashed away nearly 300 meter long road between Joshimath and Badrinath, 17
August 03, 2004	Tehri dam project	Occurrence of Landslide at 9 killed
July 10, 2004	Senapati, Manipur	Mudflow along NH-39 , 1 killed Many building and houses destroyed

(Modified from : saarc-sdmc.nic.in/pdf/landslide.pdf)

Of the many common concerns in the area of geo-hazard management, Landslide Risk Management deserves to be placed on the priority agenda because we can prevent and predict landslides thereby averting landslide unlike earthquake and tsunami disasters. A number of knowledge institutions are working at sub critical levels without cohesion, and there is a huge potential that can be tapped through a well coordinated effort. We urgently need inspiring examples of landslide mitigation and management and quality and trained human resource to match the felt needs. The R&D base needs to be expanded to transform mono-discipline approach to a truly multidisciplinary approach and high quality knowledge products, training manuals and education materials ought to be made available to meet the projected needs of the educational institutions, all set to launch degree and diploma courses in disaster management.

South Asia looks up to India for direction and leadership in this area because no other country is so directly exposed to such a bewildering variety of landslide problems as India is. For achieving that position we do not have to build our capacities to manage landslide risks from the scratch because we have already made some beginning. It is, however, time for us to open up and think and act together so that our country can set reactive and quick fix approach and leapfrog into the world of new knowledge on landslides, as also make informed choices of technologies best suited to their respective situations.

In India, landslide studies are conducted by a number of institutions, research and academic. However, there is a need for better coordination among various research groups so that a focussed thrust can be provided to some critical aspects of landslide studies, for example geotechnical characterisation, soil mechanics and landuse zonation. The Department of Science & Technology has initiated a coordinated programme on the Study of Landslides which is being carried out in a multi-institutional mode.

Current Status on landslides hazards

Landslide Hazard Mapping, Vulnerability and Risk analyses are other areas which deserve to be placed high on our agenda. In 2005, an Atlas of Landslide Hazards Zonation and Mitigations for NE India has been prepared, in which all major highways of the region has been included. There are number of Ph.D. theses that are awarded in various landslides case studies of individual landslides in Manipur as well as other parts of NE Region (Dolendro 2007, Okendro 2007). Attempts are also made to study the landslides of Garhwal Himalaya (Bhoop Singh 2005). The overall status of landslide hazards and their mitigative measures in India is given below :

- Development of methodology for zonation mapping, Lanslide Hazard Evaluation Factor (LHEF) ratings for zonation, capacity building and mapping of select areas
- Landslide Safe Intelligent Route Finder (LASIRF)
- Studies for early warning and monitoring – instrumentation and monitoring of rock slopes, active deformation measurements using 3D Deformeter, development of inexpensive automatic weather station (< $ 500)
- Network of institutions for landslides hazards

  (WIHG, IITS, CBRI, Universities, SOI, GSI)
- To establishment of National Geotechnical Facility (NGF)

There are specialised Landslide Monitoring Techniques which have been now initiated in India:

1. Geodetic : Global Positioning System (GPS), Geographical Information System (GIS)

2. Microseismic – provide data for determining seismic wave Velocities

3. Acoustic Emission – NANOSEISMIC

4. Synthetic Aperture Radar (SAR) Interferometry – use of corner reflectors

6. Ground Penetration Rader (GPR)

7. Early Warning System

EARLY WARNING SYSTEMS FOR LANDSLIDE HAZARDS :

There is a need to evolve an early warning system for landslides. Early warning systems elsewhere in the world have been developed by the real-time monitoring of landslides. This includes the continuous monitoring of movements, development of stresses, and pore pressures or hydrostatic pressures, and the transmission of this instrument generated data through a telemetric system at regular time intervals. At the initiation of an event, radio signals are transmitted and alarm signals are sent to the relevant authority regarding the impending danger and probable time of occurrence of a landslide. However, awareness generation and the involvement of local communities is a vital component of an early warning system, to ensure its success. Thus, in certain cases, the local communities, if properly trained and adequately motivated, can observe the movement indicators on the hill slopes and issue the necessary warnings.

Real-time monitoring may be undertaken for the development of an early warning system in the case of a few devastating, large dimension and recurring types of slides or rock falls which are very difficult to stabilise and pose a high risk. Since the ultimate goal is to find a permanent solution, the development of an early warning system is not the ultimate answer to this natural hazard, but only a part of the effort to mitigate its impact. The experience gained from this type of exercise will be immensely helpful for studying other landslides. Efforts have been made in India for developing the early warning system for landslide. One is sensor based technology, which is buried in the ground and other is the installation of instruments in the bore

hole (piezometers, extensometers and inclinometers and 3 D fault deformeters) for predicting the landslide failure.

1. Early Warning System for Rainfall Induced Landslides, Linga Slide, the Nilgiris

The EWS for rainfall induced landslide in Nilgiri hills has been developed in India. The site falls in very highly vulnerable zone in the Hazard Zonation map prepared through the major NRDMS funded project "Nilgiri Landslides Mitigation through Remote Sensing and GIS" (NILA). Various elements of landslide *viz*: Crown, logitudinal cracks, traverse cracks, traverse mounds, toes etc are well manifested indicating the active nature of the slide. Large number of buildings has been constructed on Linga Landslide. Toe is extending in the valley and hence stands prone for erosion. Site is located just on the Conoor – Ooty highway providing easy accessibility. It is one of the ideal sites for installing various instruments for monitoring. The detailed mapping of landslide provides successful installation of piezometers, inclinometers, extensometers and ground based inferometric observations. These instruments are connected through VSAT for online data recording and provide the early warning to the local people (Singh 2010; personal communication).

2. Wireless Landslide Detection System developed at Muner Kerala India

Scientists from the Amrita Vishwa Vidyapeetham have developed India's first wireless sensor network system for landslide detection. Scientists have deployed a number of wireless sensors in and around Antonyiar colony in Munnar where five people lost their lives in the landslide that occurred in July 2005. The sensors are buried a couple of metres into the soil and can measure the moisture content, pressure and vibration of the earth and several other geological parameters. Wireless sensors have already been used in Japan to predict the occurrence of shallow landslides. It is interesting that the major advantage is surprisingly its low cost. According to Uchimura and colleagues, who used such sensors for natural and artificial slopes, there are several problems that need to be solved before the effective early warning system can be developed. For example, their study showed that moisture content is not a reliable parameter, and it should be used together with inclinometers or extensometers.

3. Installtion of 3 D Fault Deformeter in Manipur, India

The fault deformeter is installed for the first time in India and found useful in deformation measurements along one of the Active tectonic regions (Indo-Myanmar subduction) of the world. It is in embryonic stage and we require monitoring of the deformeter for period of at least two more years. It is installed at Senapati since last three years, to monitor the Churachandpur Mao fault (CMF), which is strike slip fault and triggers creeping and microseismicity. Due to that, National Highway NH 39 which is the life line of Manipur connecting Nagaland is highly landslide prone region. The deformation data through the sensors of deformeter indicate triggering of slip surfaces, which ultimately causes various large landslides along the National Highway Attempts are made to evaluate the use of fault deformeter in predicting the slope failure in active deformation terrain in other seismically active terrain as well as landslide prone regions. The long term monitoring of the sub-surface deformations using the 3D fault deformeter will prove to be an important parameter for precursory studies as well as Early Warning System in landslide hazards.

TSUNAMI

It is worth to mention about the last Indian Ocean Mega Tsunami in our discussions on tsunami hazards in India. The Mega Earthquake of 26th December 2004 in Southeast Asia, the greatest earthquake in 40 years occurred on Sunday at 00:58:50 UTC (6:58:50 a.m. local time). The epicentre was at 3.298 N, 95.779 E about 150 kilometres off the west coast of northern Sumatra Island in Indonesia and its focal depth was very shallow (about 10km). The earthquake generated a disastrous tsunami that caused destruction in 11 countries bordering the Indian Ocean. The quake was widely felt in Sumatra, the Nicobar and Andaman Islands, Malaysia, Myanmar, Singapore, Thailand, Bangladesh and India. The region where the great earthquake occurred on 26 December 2004, marks the seismic boundary formed by the movement of the Indo-Australian plate as it collides with the Burma sub plate, which is part of the Eurasian plate. It appears that the two plates have separated many million years ago and that the Australian plate is rotating in a counter clockwise direction, putting stress in the southern segment of the India plate.

The tsunami waves caused considerable destruction and killed people more than 2,000 kilometres away, in the Seychelles and in Somalia. As of February 10, 2005, the global death toll was raised to 226,566 and continued to rise. The demographics in this part of the world are not very good. There are many remote islands in the Nicobar, Andaman, Maldives and off the African coasts, so there are many unreported deaths. (http: // www. drgeorgepc. Com /Tsunami 2004 Indonesia.html)

The large tsunami which struck nations that border the Indian Ocean was a complete surprise for the people living there, but not for the scientists who are aware of the tectonic interactions in the region. Many seismic networks recorded the massive earthquake, but there was no tide gauges or other wave sensors to provide confirmation as to whether a tsunami had been generated. There was no established communications network or organizational infrastructure to pass warning of any kind to the people at the coastlines. However, past tsunamis along Indian coasts were reported earlier in the literature (Verma 2007).

No Tsunami Warning System exists for the Indian Ocean as there is for the Pacific. Review of historical records would have revealed that a very destructive tsunami occurred in 1941, in the same area. This particular tsunami killed more than 5,000 people on the eastern coast of India, but it was mistaken for a "storm surge". Thousands more must have gotten killed elsewhere in the islands of the Bay of Bengal in 1941, but there has been no sufficient documentation. Unfortunately, no Regional Tsunami Warning System, Preparedness Program, or effective Communications Plan exist for this part of the world.

Later on recovery and rehabilitation implemented by the Government of India has been indeed exemplary. Rehabilitation work was based on the outcome of number of scientific surveys and studies in all the tsunami affected regions of Indian subcontinent. The tsunami damage assessment was done by using the Remote Sensing Techniques at Andaman and Nicobar Islands (Kumar 2006).

Early Warning System for Tsunami

It was realized that the Pacific Tsunami Warning System was not suitable for India. In this system Tsunami warnings are issued on the basis of occurrence of a large earthquake anywhere on the Pacific coast. In the Indian Ocean there are only two areas, 1) a stretch of some 4,000 km from Java-Sumatra to Andmans, and 2) an area of about 1000 km off the Makran coast in the Arabian Sea, which are

capable of generating tsunamigenic earthquakes. Unlike all the Pacific Ocean rim countries, which can contribute to forming a tsunami warning, in the Indian Ocean, countries located close to the two tsunamigenic areas can only contribute to generate tsunami warning. Such countries are mainly India, Sri Lanka, Thailand, Indonesia, Malaysia and Australia for the Java- Sumatra to Andaman zone, and Iran, Pakistan and India for the Makaran zone. Tsunamis in the Indian Ocean are not frequent, any system which is set up for tsunami warnings, would become dysfunctional due to fatigue.

After 2004 Indonesia-Andman Mega Tsunami, initiatives taken up by the Ministry of Earth Sciences (MoES) in implementing the Tsunami Warning System (costing about Rs. 125 Crores) are worth mentioning (Gupta 2007). The Early Warning System is taken care by the Indian Tsunami Early Warning Centre which is again a part of the Indian National Centre for Ocean Information Services (INCOIS), Hyderabad. This dual-use Early Warning System has been set up to cover the two known Tsunamigenic zones that affect Indian Ocean region. It is an end-to-end system that is scientifically and technically sound. It is comprehensive and covers the required observations, modeling, data communication, warning centre, capacity building.

FLOODS

Flooding is the only major natural hazard in India that occurs with an unfailing regularity. Some of the most unusual and unprecedented floods have been recorded on different rivers of the subcontinent in the most recent decades (Rakhecha, 2002; Herschy, 2002; Kale, 2003a; Dhar and Nandargi, 2004). The 2008 Bihar flood, which is one of the worst and disastrous floods in the history of the Indian state of Bihar, occurred due to a breach in the Kosi embankment near Indo-Nepal border on August 18, 2008. The river changed its course and inundated areas which hadn't experienced floods in last many decades. The flood affected over 2.3 million people in the northern part of Bihar. The 2010 Leh floods occurred on August 6, 2010 in Leh in the state of Jammu and Kashmir, India. At least 193 people died. Official reports suggested five foreign tourists were killed, and thousands were injured as heavy rains overnight caused flash floods and mudslides. Thousands more were rendered homeless according to government officials. 200 people were reported missing following the floods.

Recent literature on monsoon floods is dominated by (1) studies on the spatiotemporal aspects of floods (2) research focused on the impact of monsoon floods on the fluvial systems and (3) remote sensing and GIS-based research that has gained considerable momentum in the last few years. A few studies on the flood processes and the impact of climate change have also been undertaken. Over the review period, work has continued on mapping of the flood-prone areas in India. Several agencies, such as the Central Water Commission – CWC (Flood Atlas of India), the Building Materials and Technology Promotion Council – BMTPC (Vulnerability Atlas of India), and the National Atlas and Thematic Mapping Organization – NATMO (Natural Hazard Map of India), have been involved in the flood-hazard mapping. These and other studies indicate that the areas that are frequently vulnerable to flooding in the country are:

1. Sub-Himalayan region and the Ganga plains
2. Brahmaputra Valley
3. Punjab Plains
4. Mahanadi-Godavari-Krishna-Kaveri Delta Plains
5. Lower Narmada-Tapi-Mahi Valleys

In India, research on different aspects of monsoon floods reveals to be wide-ranging. Traditional classification and descriptive studies have been replaced by more systematic and quantitative studies of the floods and their impacts. This approach, together with the development in the fields of palaeo-flood hydrology, remote sensing, GIS and computer modelling is providing precise information for flood hazard management in India. Attempts are also being made to forecast the floods hazards through the early warning system.

EARLY WARNING SYSTEM FOR FLOOD HAZARD

Out of all the non-structural measures for Flood Management, flood-forecasting and warning is gaining sustained attention of the planners and accepted by the public. A nationwide flood forecasting and warning system covering major inter-state rivers has been established by the Central Water Commission (CWC). The system under CWC is often supplemented by the states that make arrangements for advance warning at other stations strategically important to them. The CWC also extends Flood Forecasting services to such stations at the request of the states

concerned. With reliable advance information/warning about impending floods, loss of life and property can be reduced to a considerable extent. People, cattle and valuable assets can be shifted in advance to safer places.

Real time hydrological data *viz.* gauge and discharge and meteorological data, *viz*. rainfall, are the basic requirements for the formulation of a flood forecast. Hydrological and hydro-meteorological data from over 945 stations in the 62 river sub-basins are daily collected, analysed and utilised for formulation of flood forecasts (NDMA 2008). The CWC provides communication facilities to the Flood Management Organisations in transmission of rainfall data of rain gauge stations located at the various CWC gauge and discharge stations. Transmission of data on a real-time basis from the hydrological and hydro-meteorological stations to the flood forecasting centres is a vital factor in the Flood Forecasting System. Landline communication *i.e.*, by telephone/telegram was the commonly used mode for data transmission in Flood Forecasting services till the beginning of the 1970s. The communication is mainly by VHF/HF wireless sets at the data observation/collection sites and at the Flood Forecasting centres. There are over 500 wireless stations of the CWC all over the country for communication of real-time data related to flood forecast.

INDIAN INITIATIVES ON POLAR STUDIES

Expedition to Antarctica :

The Antarctic Research Programme, which was initiated in 1981, has taken the shape of a major national programme that has a distinct multi-institutional and multi-disciplinary approach. So far 29 scientific expeditions have been launched on a regular basis. In addition, three expeditions to the Southern Oceans for carrying out research in the thrust areas of polar science including a Weddel Sea Expedition and Krill Expedition for assessment of Krill Resources in Antarctic waters, were also undertaken (http:// ncaor-arctic. ncaor. org:5050/ website/index.html). The Indian station Maitri situated in the Central Droning Maud land of east Antarctica has provided a platform to more than 1,500 personnel drawn from about 75 national laboratories, institutes, universities, survey and service organisations to conduct experiments in all major disciplines of polar sciences. This is an outstanding example of networking national facilities and expertise. Now, India has taken up more initiatives to send the expedition to the South Pole during November 2010.

Expedition to Arctic :

India already has a strong presence in the Antarctica for the past 27 years. However, despite the scientific and logistics expertise gained by the country over the years in Antarctica, a wide gap exists in our knowledge of the Arctic, hindering a much-needed bi-hemispherical approach to polar sciences. The Arctic Ocean and the surrounding regions are one of the most important areas that not only govern the earth's climate but have also faithfully recorded its past climatic history. The region is also an excellent harbinger of future change, because the signals or clues that signify climate change are much stronger in the Arctic than elsewhere on the planet. This region has always been significant to the Indian subcontinent due to probable teleconnection between the northern polar region and Indian monsoon intensity, which is critical for our agriculture output and economy.

Indian Scientific endeavours in the Arctic region commenced just about four years back in 2007 when a five-member team of scientists from India visited the International Arctic Research facilities at Ny-Ålesund, International Research facility in Sptilsbergen island of Norway. The four Arctic expeditions have been so far taken up by various research institutes and universities in India in which NCAOR, Goa; CCMB, Hyderabed; IITM, Pune, BSIP Lucknow, Geological survey of India and Manipur University are lead agencies. The success of these early footsteps led to the development of Science Plan of Indian activities in the Arctic region on focal areas of collaborative scientific research, sustained multi-institutional and multi-disciplinary scientific field studies by Indian scientists.

THE ROLE OF EARTH SCIENTISTS IN GEOHAZARDS

Living in an often turbulent and unpredictable public environment, Earth scientists can contribute to decision-making through a risk management framework designed to examine technical and social issues related to sustainability. This means :

1. Setting up monitoring systems to collect, assimilate and relate with archival data relevant to the determination of sustainability and risk, now and in the future

2. Identifying consequences by systematic cataloguing of hazards

3. Evaluating the certainties, uncertainties, and probabilities involved in calculating vulnerability and exposure of people to risk

4. Determining concerns by using risk assessment techniques for various potential future emergencies

5. Making calculations about potential future situations using appropriate computer models

6. Comparing the risks against pre-determined criteria to assess the need for further action

7. Communicating the results to those who need to know

8. Integrating knowledge and understanding from all relevant disciplines to enable society to review the sustainability and risks of proposed policies and plans.

CONCLUSIONS

It is not possible to prevent the occurrence of natural phenomenon entirely. However, we are able to gain a better understanding of the complex mechanism that cause the disaster and deliver their knowledge to disaster management agencies for necessary preventive measures to reduce loss of life and property. Science has contributed much to the understanding of natural hazards but, the natural hazards remains unpredictable. Scientific knowledge and technologies are not always available when and where they are needed. A new strategic international and interdisciplinary approach to science is necessary to exploit fully the existing knowledge and identify and address the geohazards. In practice, this requires addressing issues such as real-time monitoring and prediction, emergency preparedness, public education, post-disaster recovery, engineering, land use, and construction practices. Coordinated approaches involving scientists, engineers, policy makers, builders, investors, news media, educators, relief organizations, and the public are most essential. A close interaction between scientists and policy makers is expected in evolving more effective strategies for mitigation of the effects of natural hazards, need to be developed and deployed. We will make our planet safer, only when good science and policy making are effectively combined. This means that implementing risk management can be achieved only through interaction of theory and practice. Disaster risk reduction can be achieved only if all citizens participate in complying with the techno-legal regime, actively support the capacity building and public awareness campaigns and disseminate the need for carrying out mock drills in their neighbourhoods. The vision of a disaster-resilient India can be achieved only by spreading the culture of preparedness among all sections of the society.

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98th Indian Science Congress

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II

ABSTRACTS OF PLATINUM JUBILEE LECTURE

PLATINUM JUBILEE LECTURE

Structure and Deformation History of the Rocks of MCT Zone of Garhwal Higher Himalaya

H. B. Srivastava
Centre of Advanced Study in Geology
Banaras Hindu University, Varanasi-221 005

The Main Central thrust (MCT) is one of the major intra-continental thrust in the Himalayan Orogenic belt along which considerable amount of post-collision crustal shortening was accommodated. In Kumaun-Garhwal Himalaya, the MCT separates the medium to high-grade metamorphic rocks of the Higher Himalayan Crystalline Zone from the underlying sedimentary and low-grade metamorphic rocks belonging to the Lesser Himalayan Zone. Recent studies have revealed that MCT is not a plane, but a several kilometer thick crustal scale ductile shear zone of high strain and have been referred as Main Central Thrust Zone (MCT Zone). In Garhwal region, the MCT Zone forms a 10-12 km thick NNE-dipping shear zone. The MCT Zone is marked by Main Central Thrust in the south and Vaikrita Thrust in the north. Gneisses, schists, migmatites, amphibolites and metabasics constitute the lithological units of MCT Zone. The rocks of the MCT Zone show dip of about 40^{o} to 55^{o} NE to NNE and exhibit mylonitic fabrics both along the hanging wall and footwall. The linear fabrics, developed in the MCT Zone, represent the stretching lineation trending in N to NNE direction with low to moderate amount of plunge. These lineations are more strongly developed near the MCT plane. The rocks of the MCT Zone are characterized by different kinds of deformational fabrics.

The mesoscopic and microscopic fabrics of the MCT Zone have been grouped, into (i) early structures, (ii) structures developed during progressive ductile shearing and (iii) late stage structures. The Early structures are pre-ductile shearing (before thrusting) and display two generations of folds (F_1 and F_2). The F_1 isoclinal folds are gently plunging towards NNE direction with low to moderate amount of plunge and exhibit well-developed axial plane cleavage (S_2). During thrusting of crystalline rocks over quartzites of Garhwal Group, the rocks both the side of MCT have been affected by ductile shearing, but the degree of shearing varies considerably,

and have produced different kinds of shear zone structures. Different kinematic indicators such as sigmoidal foliations, δ-type and σ-type of rotated porphyroclasts, asymmetric recrystallized tails around feldspars, S-C structures, mesoscopic ductile and brittle ductile shear zones, suggest abundant evidence of top to SSW directed sense of shear. The deformational features characterised by the structures developed due to progressive ductile shearing are attributed to D_2 phase of deformation. Detailed analysis of mesoscopic shear zones reveal that sinistral shear zones exhibit a variation in its strike from NNE to ENE and dextral shear zones exhibit variation from NNW to WNW directions and form a conjugate pair. The bisectors of statistically preferred orientations of the two sets of the shears indicate that they generated due to NNE-SSW horizontal compression synchronous to the translation of MCT which took place during northward movement of Indian plate. Late structures includes brittle deformation i.e. faults and joints, developed at shallow depth, are attributed to D_3 deformation.

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III

ABSTRACTS OF YOUNG SCIENTIST AWARD PROGRAMME

YOUNG SCIENTIST AWARD LECTURE

An Investigation into the Stability of Slope Using Geomechanical Modellings

Vikram Vishal
Department of Earth Sciences,
Indian Institute of Technology Bombay,
Powai, Mumbai-400 076
Email : V.vishal@iitb.ac.in

Stability of slopes is always associated with the economics of mine. A change in a single degree of slope angle can change the mine economics up to 4%. It is also pertinent for the safety and stability as well as the productivity of the mines. Steeper slopes are always desired by the mine management as they are economical but at the same time are also prone to failure. Hence, a proper design of slope geometry which would be steep enough to be economical should be attained for long term stability with the scheduled production. Rajapur mines in Jharia coalfield, Dhanbad, India have vulnerable slopes due to complex geological features, improper mining methods and age old underground fire problems. Slope contains a number of defects like joints, fillings, fracture, etc. These geological discontinuities pose serious problems in the stability of slope. Yet, mining in these areas is inevitable due to the good quality and regular supply of coal.

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IV

ABSTRACTS OF SYMPOSIUM / INVITED LECTURES

PROCEEDINGS
OF THE

NINETY EIGHTH SESSION OF THE

INDIAN SCIENCE CONGRESS

CHENNAI, 2011

PART II : (Abstract of Symposium/Invited Lecture)

SECTION OF
EARTH SYSTEM SCIENCES

President : **Prof. Arun Kumar**

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SECTION OF EARTH SYSTEM SCIENCES

President : **Prof. Arun Kumar**

ALTERNATE ENERGY RESOURCES

1. Gas-Hydrates—India's Viable Major Energy Resource of Future

Kalachand Sain
National Geophysical Research Institute
(Council of Scientific & Industrial Research)
Uppal Road, Hyderabad-500 007
Email : kalachandsain@yahoo.com

Keywords *: Gas-hydrates, energy potential, identification and quantification, Indian offshore.*

Depletion of fossil fuels and escalating demand of energy impose to search for an alternate source of energy for sustainable growth and development. Gas-hydrates, crystalline form of methane and water (Fig.1a), seem to be a viable resource of future due to their huge potential more than two times the energy content of total fossil fuels. Gas-hydrates are formed in shallow sediments of outer continental margins and permafrost regions at high pressure and low temperature

when methane concentration exceeds the solubility limit. One volume of gas-hydrates releases about 164 volume of methane and 0.8 volume of fresh water (Fig.1b) at standard temperature and pressure (STP). Presence of gas-hydrates makes the sediments impervious and hence the hydrate-bearing sediments trap 'free-gas' underneath. Unlike natural gas, oil and minerals, they are not stable at STP. Parameters like bathymetry, seafloor temperature, total organic carbon (TOC) content, sedimentary thickness, rate of sedimentation, geothermal gradient indicate good prospects of gas-hydrates in both the Bay of Bengal and the Arabian Sea (Sain and Gupta, 2008).

A total volume of 1894 trillion m^3 of methane has been predicted in the form of gas-hydrates within the vast exclusive economic zone (EEZ) of India. This volume is more than 1500 times the country's current natural gas reserve. Even 1% recovery of gas-hydrates can meet our gigantic need of energy for a decade or so. Since methane is the cleanest among all hydrocarbon fuels, its use can cause less pollution to the atmosphere. Therefore, identification and evaluation of resource potential of gas-hydrates are very essential. Earth Sciences, in particular Geophysics, can provide much needed impetus for the exploration of this new treasure of energy. At NGRI, we have proposed several approaches based on seismic attributes, attenuation, amplitude versus offset (AVO) attributes for the identification, and seismic traveltime tomography, AVO modeling, full-waveform inversion, each coupled with rock-physics modeling for the quantification of gas-hydrates (Sain and Gupta, 2008; Sain and Ojha, 2008a). The most commonly used marker for the detection of gas-hydrates is an anomalous reflector, known as the bottom simulating reflector or BSR on seismic section (Fig.2). In fact, the BSR is a physical boundary between the hydrate-bearing sediments above and gas-bearing sediments below. Using the seafloor temperature, bathymetry and geothermal gradient data available till date, we have modified the gas-hydrates stability thickness map (Sain et al., 2010a) along the continental margin of India to fill the data gap and to add the stability thickness map for the Andaman region. Since the BSR is often associated with the base of gas-hydrates stability zone, the map (Fig.3) can help identify the BSR on seismic section. By analyzing available and newly acquired seismic data, we have recognized the BSR on seismic section in the Krishna-Godavari, Mahanadi and Andaman regions in the Bay of Bengal, and the Kerala-Konkan and Saurashtra region in the Arabian Sea. All these potential zones of gas-hydrates are marked in Fig.3.

We have computed various seismic attributes such as the reflection strength, blanking, and instantaneous frequency (Satyavani et al., 2008; Ojha and Sain, 2009) attenuation (Q^{-1}) (Sain et al., 2009; 2010b), which can be used to characterize the gas-hydrate- and free-gas-bearing sediments. We also show that the pockmarks at

seafloor or gas escape features in shallow sediments such as the faulting or gas-chimney (Umashankar and Sain, 2007) can offer indirect evidences for gas-hydrates. As the presence of gas-hydrates increases and underlying free-gas decreases the seismic velocity with respect to the velocity of the host sediments, the velocity anomaly can be used for quantification of gas-hydrates and free-gas. We have estimated the velocity anomaly across the BSR using the traveltime tomography (Ojha and Sain, 2009), AVO modeling (Ojha and Sain, 2007) and full-waveform inversion (Sain et al., 2000) and quantified the saturations of gas-hydrates and free-gas by employing the rock physics modeling (Ghosh and Sain, 2008; Ojha and Sain, 2008; Sain et al., 2010c; Ojha et al., 2010; Ghosh et al., 2010). To assess the estimation of gas-hydrates and free-gas, we have employed two different techniques to the same data set, and appraised 15.5% gas-hydrates and 4.5% free-gas from cooperative traveltime inversion followed by AVO modeling, and 13% gas-hydrates and 2.8% free-gas from AVO attributes (Sain and Ojha, 2008b). Using the AVO A-B crossplot coupled with the Biot-Gassmann Theory modified by Lee, we have assessed the saturations gas-hydrates and free-gas varying from 4.5% to 15%, and 2.0% to 3.5%, respectively at BSR (Fig.4) along the seismic line that has been shown in Fig.2. All these approaches with field examples will be presented in this paper.

At this moment, the technology for producing gas from gas-hydrates does not exist anywhere in the world. Before the technology appears, we need to prepare the map for potential zones of gas-hydrates occurrences along the Indian margin using various disciplines of Earth Sciences. The exploration program will also help understand the effect of gas-hydrates on sediments, providing guidelines for safe production. It is to be stated that besides the energy potential, gas-hydrates may play role in climate change and submarine geo-hazards, if they dissociate under certain circumstances.

2. The Prospects of 'Calcrete Type Uranium Deposits' in India

K. L. Shrivastava

Department of Geology,
J.N.V. University, Jodhpur-342 005

Keywords : *Calcrete, Uranium deposit, Carnotite, Malani Igneous Suite, Palaeochannel.*

The 'calcrete type uranium deposits' are relatively a new category of uranium deposits added after the discovery of Yeelirrie deposit in Australia (1972),

although receiving attention to it numerous similar uranium deposits have been located in the world yet possibly a number of potential areas remain to be investigated.

The uranium is expected to be present as mineral is typically carnotite ($K(UO_2)_2(VO_4)_2.3H_2O$) which is commonly cemented by secondary minerals including calcite, gypsum, dolomite, ferric oxide and halite. Uranium deposit in calcrete usually form in regions where deeply weathered, uranium rich granites occur in a semi-arid to arid climate. Examples from Western Australia occur in valley-fill sediments along palaeochannels (e.g. Yeelirrie) and in playa lake sediments (e.g. Lake Maitland). These overlie and are adjacent to Archaean granite and greenstone basement of the northern Yilgarn Craton that also provide a source of vanadium necessary to form carnotite. The slow moving and upward welling groundwater rich in leached uranium undergo changes allowing carnotite to get precipitate near surface yet below calcrete. The changes in groundwater includes sorption, uranyl complex dissociation, changes in redox state of constituent metals, evaporation, variation in CO_2 partial pressure, pH, mixing of groundwater and colloidal precipitation.

In India prospecting of calcrete type uranium deposit is initiated for the first time. Provenance rocks of the Malani Igneous Suite (MIS), namely granites and rhyolites, at south of Jodhpur city have been explored. Petrological and geochemical studies showing that high uranium and high potash is present in these rocks, while mafic components may contribute vanadium. Attempts are on using Remote Sensing to trace the concealed palaeochannels of river Lunavati (present Luni river- a tributary of lost river Saraswati), specially of low order. Ground Penetrating Radar (GPR), will be used to find thickness of calcrete and its contact with the basement at selective sites. Presence of nonpedogenic calcrete and present day semi-arid and arid climate are suitable for the evaporation of groundwater, subsurface, to produce the economic deposit. Hence, there is high degree of prospect potentiality for the calcrete type uranium deposits in India.

GEO EDUCATION

3. Geology Education—Newer Horizons NOvel Priorities

S. Acharya
Bhubaneswar

Geology, considered as a natural science, wandered around fieldwork in search of mineral for metal, right from ‘Iron Age’ it started focusing from earth

surface and developed to earth-system-science to consider earth as whole with different allied parameters. Barring the traditional subjects, it now encompasses oceanography, natural hazard management, tectonics (earthquake and vacanology), satellite imagery studies and ecosystem etc and thus its teaching has been a tall order. In all these, field work and mapping are naturally important. In contrast its teaching has, however, been scientific. Geology churns out money for the society from the 'wasting assets' of the earth and occur civilization banks upon metals, fuels, soil, rock, groundwater etc. Even tourism is controlled by scenic beauties, which is function of rocks and structures. Gems and polished rocks are erase since aeons. There is no quicker route to material progress except learning of applying the knowledge this subject well and so our country must wake up from its shoulder of non-improvement of geology education. When done early, a good geologist can for example grade wise map BIFS, trace desirable sand patches on a river bed for concentration, concrete thermal springs to tectonics and balneotherapy on trace groundwater in a granite country using aerial photos. This list can be made very long but let over youngsters be 'Jacks of all trades and master of some' in geology so that their confidence level goes higher.

4. Ge-(E)ducation : An Indian Scenario

V. K. Verma

Delhi

e-mail : profvk_verma@yahoo.com

Keywords : *Ge-(e)ducation, earth, object of protection, integrated growth, geological garden.*

Ge-(e)ducation in India began about eight decades ago with undergraduate teaching in Geograhy at Aligarh Muslim University, later followed by Geology and Geophysics respectively elsewhere. Since then the field has witnessed many developments. The term "Earth System Sciences" was first used in a paper "Earth System Sciences and Remote Sensing" by Francis Bretherton (1985) perhaps with an altruistic desire to integrate and mobilize scientific endeavors to articulate an intellectually coherent global strands structure.

The age of Enlightenment has decisively witnessed immense contributions by Geoscientists, harnessing natural wealth reservoir unfortunately inflicting injuries to the mother earth that nourishes us all needs protection.

For knowledge based civil society education roots as foundation and instrumental for accessing rightful information to

- ensure intellectual productivity for creating advance knowledge
- educate and train enlightened citizens and qualified specialists and
- induce economic growth as indicated by rate of return analysis.

New dimensions have been added to the higher education scenario on the emergence of Information and Communication Technology (ICT) since the dawn of our Independence significantly upgrading learning prospects that

- compelled straight jacket distinct discipline boundaries to abridge
- modified human experience landscape and
- immensely broadening research orientation too.

The convergence of communication and computer technology became a new powerful tool for

i) identifying knowledge gaps and

ii) natural resource development

warranting integrated growth approach and studies necessarily aimed at awareness and linkages for

i) wider development across discipline spectrum and education - service sector mutually benefiting.

ii) developing cost effective and return benefit geological gardens on the pattern of Botanical/Zoological gardens and

iii) formulating newer disciplines to meet emerging areas.

CLIMATE CHANGE SCENARIOS OF THE INDIAN COAST LINE AND THE IMPACT ON THE ANDAMAN AND LAKSHADWEEP GROUP OF ISLANDS

5. Safeguarding National Food Safeguarding National Food Security in an Era of Climate Change

M. S. Swaminathan
Member of Parliament (Rajya Sabha)
Chairman, M S Swaminathan Research Foundation
Third Cross Street, Taramani Institutional Area
Chennai-600 113

I. Threats to agriculture, food and water security and the loss of livelihoods will be the most serious consequences of climate change. Even a one degree Celsius rise in mean temperature will affect wheat yield in the heartland of the green revolution, because of a reduction in duration, and reduced grain weight. **Climate Refugees** comprising of fisher and coastal communities will become internally displaced persons, in the event of sea level rise. The situation will be particularly serious in States like Kerala and Goa and cities like Mumbai where a large percentage of the populations live very near the shoreline. Anticipatory research and development are essential to strengthen our coping capacity to meet such challenges. I will like to indicate briefly some of the steps which should be included under the proposed National Mission for Sustainable Agriculture.

II. **Climate Change and Agriculture: Factors to cope with:**

- Unfavorable changes in temperature.
- Unfavorable changes in precipitation.
- Snow Melt and floods.
- Higher carbon dioxide levels in the atmosphere.
- Sea level rise.

A. Temperature: Impact of a rise in mean temperature by 1 to 2 degree Celsius (Copenhagen Accord)

- Wheat yield is a gamble in temperature.

  Major consequence of 1 degree Celsius rise in mean temperature will be a reduction in the growing period in the case of wheat, and greater risk of vector borne diseases in crops like potato.

- Response measures should include **shifting the breeding strategy to per-day rather than per-crop productivity** in the case of wheat, and developing and spreading the True Potato Seed (TPS) methodology in the case of potato.
- Rice has a wide range of adaptation. Short duration varieties or hybrids together with efficient agronomic practices like SRI should be promoted. **Hybrid rice strains characterized by hybrid vigour in the development of the root system should be recommended.**
- In all crops, the problem of pests and diseases may become more serious. Plant protection measures should particularly be tailored to meet the threat to crops and farm animals arising from the outbreak of vector-borne diseases.

B. Unfavorable alterations in precipitation.

- Both drought and floods may become more serious. Building a sustainable water security system and spreading more crop and income per drop of water technologies should receive priority attention. Drought and high temperature tolerant crop varieties should be developed through Marker Assisted Selection, as well as genetic engineering. A good example is the work done at MSSRF, Chennai in transferring to crop plants genes for drought tolerance from *Prosopis Juliflora* and for salinity tolerance from *Avicennia Marina.*
- In the case of floods, post-flood agricultural rehabilitation measure as well as flood tolerant rice varieties with the submergence (Sub) tolerant genes should be developed. After flood waters recede, crops like yellow-flesh sweet potato (rich in Vitamin A) **Sathi maize** (short duration) and sunflower, as well as fodder crops can be introduced.
- To implement alternative cropping strategies based on different weather conditions, seed reserves should be built. Seed reserves are as important for crop security, as food grain reserves are for food security.
- **Drought and Flood Codes** indicating the scientific strategies needed for reducing to the extent possible the adverse impact of drought on agriculture should be developed based on computer simulation models**.** The codes should spell out in implementable terms alternative cropping strategies and contingency plans. Along with Drought and Flood Codes, a Good Weather Code should be developed for each agro-climatic region, in order to help in maximizing production during good monsoon season.

C. Meeting the challenge of sea level rise

The strategy should include the following components.

- Developing Mangrove and non-mangrove **bio-shields** to minimize the impact of coastal storms and sea water inundation.
- Promoting **Sea Water Farming** through agri-aqua farms.
- Promoting **Below Sea Level Farming**, as already practiced by farmers in the Kuttanad area of Kerala.
- Breeding salinity tolerant crop varieties for cultivation in coastal areas, based on genetic engineering techniques.
- Preparing contingency plans for the resettlement of climate refugees.

2010 marks the 80th anniversary of Gandhiji's Dandi March (Salt Satyagraha), which emphasized that sea water is a social resource. 97% of the global water is sea water. We should launch a dynamic programme in the area of sea water farming involving salt tolerant crop verities, agro-forestry and marine aquaculture.

D. Livestock

A Food and Fodder Security Pan should be developed to safeguard our Dairy, Poultry, Sheep and Wool and other animal based enterprises which are the ones coming to the rescue of families living in the desert and semi-arid areas. Fodder and Food Banks should be developed with the help of local self-help groups (SHGS).

III. Mitigation and Adaptation strategies

Mitigation efforts should include both carbon sequestration through green plants and building Soil Carbon Banks through **fertilizer trees,**which enhance soil nutrient status. Soil carbon enrichment will help to enhance fertilizer use efficiency and thereby help to reverse diminishing factor productivity. A Farm Pond to collect rain water, a biogas plant and a few fertilizer trees in each farm should be promoted in rainfed areas.

Adaptation Measures should include the steps already indicated. In addition, green house horticulture should be promoted to take advantage of higher carbon dioxide content in the atmosphere. Arid and semi-arid horticulture combined with animal husbandry, and agro-forestry systems of land use, will help to enhance both livelihood and nutrition security.

NIO and Climate Change

NIO is already studying phenomena like sea level rise and its likely impact. Now that integrated coastal zone management, involving concurrent attention to the seaward and larndward sides of the shoreline, has been accepted as a national policy NIO could spearhead a movement for safeguarding the ecological security of coastal areas and the livelihood security of coastal areas and the livelihood security of coastal communities. NIO could for this purpose establish Climate Risk Management Centres along the coast.

IV. Research and Development Infrastructure:

A. Research and Training Centres for Climate Risk Management.

According to ICAR, there are 15 major agro-climate zones and 128 mini-agro-climatic zones. We **should establish in each of the 128 zones, a Research and Training Centre for Climate Risk Management**. These can be virtual centres headed by an agricultural scientist with computer simulation capability. He/ she should prepare computer simulation models of alternative weather probabilities and suggest how to checkmate the adverse effect. Each of these Centres should have the following facilities to convert plan into action.

a) A village Resource Centre with Satellite Connectivity established with the help of ISRO.

b) A Meteorological Station, capable of facilitating farm decisions on the basis of integrated weather forecasts.

c) A **Seed Bank** containing seeds of the alternative crops to be sown, if the first crop fails due to drought or flood.

d) A **Fodder and Feed Bank** to cater to the needs of Farm Animals.

e) A **Grain Bank** should be established adjoining each Centre particularly with reference to underutilized crops like millets, *ragi* etc as well as *bajra*, jowar and maize.

B. Capacity Building : The Research and Training Centre for Climate Risk Management should train at least one woman and one male member of every Panchayat as **Climate Risk Managers**. They should be well versed in the art and science of climate risk management.

In each of the major agro-climate zones, there should be warehousing and safe storage facilities at least for a million tonnes of food grains. Such a decentralised network of Grain Banks will help to respond quickly to urgent needs.

6. Carbon Dioxide Decomposition by Plasma Route to Combat Global Warming

M. P. Srivastava

Department of Physics and Astrophysics,
University of Delhi,
Delhi-110 007

In the present invited talk, we have summarized some of the earlier attempts by plasma route for the decomposition of carbon dioxide. However, in most of the earlier attempts of plasma methods, carbon dioxide is decomposed into carbon monoxide which is highly poisonous and toxic and it is a major drawback in these attempts. In order to circumvent the drawback we have proposed a scheme for decomposition of carbon dioxide using an array of high voltage electrode systems with which it may be possiC ble to decompose carbon dioxide to its constituents from the exhaust of the chimney of thermal power station or vehicle exhaust. The reaction products in carbon dioxide decomposition will also help in potential utilization in metallurgy, organic catalysis and hydrogen production and also in restoring the natural carbon resources. It is believed that more carbon dioxide content in the atmosphere is the main cause for climate change and global warming which is a current burning issue of concern for all. The increase of carbon dioxide (CO_2) in the atmosphere will give rise to more absorption of solar radiation in day time and less emission from earth in the night time and can cause climatic and geographical changes which will destroy nature. Global warming which is generally known as the increase in the average temperature of earth is caused by increasing concentrations of greenhouse gases, which result from human activities such as the burning of fossil fuel, deforestation and other developmental activities. Global warming and its related changes will vary from region to region around the globe, though the nature of these regional variations is uncertain. Another major consequence due to increase in atmospheric carbon dioxide is ocean acidification. In order to combat this destruction of nature we have attempted decomposition of carbon dioxide by plasma methods so as to bring the carbon dioxide content down to 260 ppm in the atmosphere in contrast to carbon dioxide sequestration.

7. Indo-Burma Biodiversity Hotspot : Impact of Climate Change

R. K. Ranjan Singh

Director, UGC-ASC, Manipur University
Canchipur, Imphal-795 003

The Convention on Biological Diversity (CBD) defines biodiversity as variability among living organisms from all sources including terrestrial, and marine and other aquatic ecosystems; it includes not only diversity between species but also between and within ecosystems and genes. The present paper is an attempt to reflect certain amount of adverse impact of climate change on the conservation effort of the Indo-Burma Biodiversity Hotspot with a specific observation on the location of Manipur State. Indo-Burma Biodiversity Hotspot covers the moist tropical and sub-tropical forests which extend from northeast India (Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Barak Valley of south Assam) and southern China across the lowlands and isolated mountains of South- East Asia, as well as the Andaman and Nicobar islands.

8. Foraminiferal Approach to Reconstruct Past Rainfall Recrods : Significance in Climate Change Studies

Rajiv Nigam

National Institute of Oceanography
Dona Paula Goa-403004
nigam@nio.org

Due to its vital importance for the economy of many Asian countries including India, monsoon has always been a matter of concern. Recently, monsoon has become the focus of wider scientific community all over the world due to the apprehension that global warming may alter the pattern of monsoonal rainfall. It has necessitated the study of factors governing monsoon dynamics. Such studies have lead to the development of several models in a hope to achieve predictive capability. At the same time it is also felt that we need monsoon rainfall records for longer time, much beyond the instrumental records. Such studies are clubbed under “Paleomonsoon”, a term coined more than two decades back.

Reconstructing the past short and long term monsoon changes helps understand the factors that affect monsoon. Therefore, past monsoon records are generated from different parts of the world, by using various types of techniques. Out of the available set of techniques, those based on characteristics of marine microorganisms, especially foraminifera, from the oceanic regions are very helpful to reconstruct past monsoon changes.

In order to obtain knowledge about past changes in the rainfalls, foraminifera in marine sediments particularly from microenvironments off river mouths can be used. Studies on core samples off Karwar, west coast of India showed the clear signals of marked high rainfall around 4000 and 3500 years BP and reversal of rainfall condition since 3500 B.P. with a marked low at 2000 years BP. These findings gathered support from palynological investigations of the same core and foraminiferal studies off Oman, western Arabian Sea. In addition to this, a cyclicity of approximately 77 years in concentration of drought years was deciphered which is possibly regulated by Gleissberg cycle in the radius of the sun. Similar studies were conducted in areas off the central east coast of India and Myanmar coasts. Besides Gleissberg cycle, two more cycles of 200±50 years and 22±3 years were deciphered. These cycles show influence of Seuss Solar Cycle and Double Sunspot Cycle on monsoonal rainfalls.

Although foraminifera have acquired the position of a very important and a very essential tool for many studies aimed to tackle environmental issues of the past and the present. But there still exists a need and scope for further development of foraminiferal techniques. This has further necessitated the establishment of laboratory culture experiments on living foraminifera to addresses successfully the new type of problems cropping up with ‘Development without Sustainability’.

9. Impact of Climate Change on Natural Resources and Environment : Role of Space Technology

Ajai

Group Director, MPSG
Space Applications Center, ISRO
Ahmedabad–380 015

The world is progressing fast with tremendous economic and social expansion. The population of the world has grown from just over 2 billion people in 1930 to

almost 6 billion today, and is likely to reach 12 billion sometime in the next century. With rapid industrializations World's economic output is growing at a faster rate. The effects of increasing population and economic growth have reached the point where we have not only converted much of the land surface to our own ends, but also alter the chemistry of the air, and, to a degree yet unknown, the climate of the entire planet.

Thus, climate change forms one of the most important global environmental challenges, with implications for food production, water supply, health, energy, etc. It is essential to study the impacts of climate change and thereby suggest mitigation measures. Goal of space based global change observation, together with other observations and studies, is to provide a sound scientific basis for developing national and international policy relating to natural and human induced changes in the Earth system. The observational need encompasses broad categories such as atmospheric compositions; ocean surface topography and physicochemical status; precipitation; and land surface imaging.

Space based remote sensing data helps in mapping earth resources, monitoring their changes and deriving bio-geophysical parameters. All this information helps in identifying the indicators and agents of climate change. The space-based inputs can also be integrated with physical simulation models to predict the impact of climate change. It provides information related to three aspects i) the indicators of climate change ii) assessment of agents of climate change, such as greenhouse gases and aerosol, their sources and distribution pattern and iii) modeling the impact of climate change in various fields of natural resources that would be of help in planning towards adaptation measures and preparedness.

Studies have been carried out at ISRO towards mapping/detecting the indicators of climate change, monitoring the agents of climate change and understanding the impact of climate change, in national perspectives. Towards mapping and monitoring of climate change indicators, the studies include glacier retreat, changes in polar ice cover, timberline change and coral bleaching.

Inventory of Glaciers on 1 : 50,000 scale has been carried out for entire Indian Himalaya using IRS-LISS III/AWiFS data of 2004-07 time frame. The inventory shows that the total number of Gaciers in Indian Himalayas are 16627 and the total glaciated area is 40563 km^2. To study the impact of climate change, about 2500 glaciers, distributed in all the climatic zones of Himalaya have been monitored for a period of 40 years.

Studies have been carried out to monitor the shifting of timberline in Himalayan region.

Coastal zones are most vulnerable to the sea level rise (SLR) and the impact of climate change. Entire Indian coastal zone has been mapped using the high resolution LISS IV data of 2004-07 time frame. Models have been developed to study the impact of sea level rise on the coastal habitat/environment.

The phenomenon of coral bleaching as a consequence of rise in sea surface temperature has also been studied. The coral reefs have been mapped at eco-morphological levels for the entire Indian coast using IRS data.

Desertification is another important indicator of climate change. Desertification status mapping has been done for the entire country on 1:50,000 scale using IRS-AWiFS data. This will serve as a base for future monitoring.

10. Impressions of Glacio-Eustasy and Global Warming in the Shelf Sediments off Parts of Indian Coasts

B. M. Faruque

Ex – Director GSI, Zahir Land,
Tinkonia Bagicha,
Cuttack-753 001

The sea level studies supported by radiocarbon dates for the Last Glacial Cycle along the continental shelves of India and its hinterlands are very few. However, the relative sea level changes along the Indian coast have been documented by several workers and the details are available in the studies of Brückner (1989), Nair (1974), Hashimi et al (1995), Vora (1996), Banerjee & Sengupta (1992), Vaz (1994), and Faruque et al (2008) in shelf area. The sea bed sediments in the shelf do not follow the expected combination of granulometric properties of clastics and authigenic material typical of corresponding energy zones. The present study is to analyse the impact of glacio-eustasy on the shelf sediments off parts of Indian coasts and the influence of sea level fluctuations on onshore environment.

The offshore data are synthesized for a synoptic picture of the shelves along Indian shelves. A series of submarine ridge-like features exist along the shelf due to the development of coral-algal growths of lowered palaeo sea level The occurrences of anomalous sediments in the shelf – high energy sediments in the low energy deep sea environment of outer shelf and calcareous sand at 122m depth with coral debris calcareous sand, silica sand and shell fragments, ostracod and barnacles, characterising a high energy shallow water depositional environment were deposited during lowered sea level of Last Glacial Maxima. Global warming followed Last Glacial Maxima and a transgressive sea is evident in the marine terraces and beach ridges present in the inner and outer shelves off Quilon and Kasargod area. At least seven such linear features are seen at depths between 77.5m and 116m. Ooids, in the outer shelf off Andhra Pradesh, were also formed in shallow water marine environment which is now submerged below 100m depth. Wave cut notches and other wave-induced scour marks on the coastal promontories indicate Late Holocene sea level rise of about 1 to 2.75m above the present mean sea level along the Indian coasts. In the outer shelf zone off Andhra Pradesh the sediments are sandy and contain ooids of grey, off-white, white and sometimes black colour. Radiometric ages of the carbonate material from the offshore ridges indicate that the ridge at -122m depth was formed earliest at 13,820 yrs B.P., the beach ridge at -76m depth at 8600 yrs BP, the one at 63m depth at 8820 yrs BP. The progressive younging of the ridges from deepest ridge to the shallower ones is indicative that the ridges were formed during the transgressive phase after deglaciation had set in. In the onshore part past sea level stands are inferred from wave-cut notches, caves and terraces confined to rocky promontories. The younger beach ridges at 76m and 63m depth were the result of sea level stand stills caused by mesoglaciation, which occurred at two levels during early Holocene (Faruque et al 2008). There are stretches of sediment starved shelves in parts of east coast which combined with coastal processes have been reasons for erosion posing a threat to some of the rural and urban settlement in parts of Orissa. Coastal environment is a dynamic system. The developmental programmes sometimes interfere with the natural system and disturb the equilibrium.

GEOHAZARDS IN INDIAN CONTEXT : PREPAREDNESS AND REHABILITATION

11. Reservoir Triggered Seimicity at Koyna, India

Harsh Gupta
Panikkar Professor,
National Geophysical Research Institute,
Hyderabad-500 007

Artificial water reservoirs have triggered the occurrence of earthquakes at over 100 sites on Earth. Triggered earthquakes exceeding M 6 have occurred in the China, Zambia, Greece and India. Changes in the sub-surface pore fluid pressure regime and mechanical properties of the near-field zone are proposed to be the causative factors.

A classical Reservoir Triggered Seismicity (RTS) site is Koyna, West Coast of India. Triggered earthquakes have been occurring in Koyna since the impoundment in 1962, including the largest RTS event of M 6.3 on December 10, 1967; 22 M > 5 earthquakes, and several thousands smaller ones. RTS increases following the monsoon rains and almost every year we have one or more M ~ 4 earthquakes. RTS was intense in 2009 and the latest M 5.1 earthquake occurred on December 12, 2009. The shallow (mostly < 6 km) RTS is confined to a small area of 20 x 30 sq. km with no other seismic activity within 50 km of the Koyna Dam. The Koyna region was stressed close to critical before the impoundment of the Koyna Dam and the maximum credible earthquake for the region is M 6.8. It is estimated that more than one half of this energy has been released since impoundment and RTS will continue for many more years. The occurrence of M > 5 is governed by factors like rate of loading, highest water level reached, duration of retention of high water levels, and whether the previous water level maxima has been exceeded or not (Kaiser Effect). Nucleation precedes M ~ 4 earthquakes, and its real time monitoring has led to short term forecasts.

Currently, a drilling project in the area is in a first conceptual planning phase. A deep borehole would provide direct observational data on the composition, physical state and mechanical behavior of a major active fault zone at focal depths of RTS. It would also be possible to test and constrain RTS hypotheses, faulting and earthquake generation in an intra-plate seismic zone, and contribute to earthquake hazard reduction. Down-hole measurements complemented by observations on core and cuttings, analyses of fluid and gas samples, geophysical and geological site characterization studies including fault zone monitoring would help answer questions related to the genesis of RTS.

12. Online Monitoring of Natural Emission of Methane

Abhai Mansingh*

Electronic Material and Devices Laboratory
Department of Physics and Astrophysics
University of Delhi, DELHI-110 007

Methane is, color less odor less explosive, gas. After water vapor and carbon dioxide methane is the third most important greenhouse gas in the atmosphere. Natural wetland ecosystems are one of the main sources of methane. It is also released into the atmosphere from the Earth's crust through faults and fractured rocks. The main source is natural gas, both microbial and thermogenic, produced in hydrocarbon-prone sedimentary basins and injected into the atmosphere through macro-seeps (onshore and offshore mud volcanoes etc.) and micro seepage, an invisible but pervasive flux from the soil. Micro seepage of methane should be checked while making tunnels. The gas in a tunnel can originate in the strata being excavated, or it can migrate a considerable distance from adjacent strata (micro seep). Lack of proper ventilation will increase the methane concentration which may cause explosion and endanger life of workers. The concentration of gas from micro seepage is expected to be small and requires sensitive, part per million (ppm), monitoring devices. Agriculture and livestock associated with habitation around wetland may be responsible for the emission of hazardous gases such as H_2S (decay process in soil) and ammonia (decomposition of urea) along with methane. A versatile methane sensor should be (i) sensitive (part per million) for detecting gas from micro seepage and (ii) hazardous gases in wet land should not interfere in the identification of methane. It will be ideal if these hazardous gases H_2S and ammonia are also identified.

Metal-oxide Semiconductors (MOS) such as (SnO_2, ZnO_2 and WO_3 etc) thin film conductivity sensors, due to their easy manufacturing, low cost, small size and short response time, are preferred over conventional analytical instruments for online monitoring of gases. The major disadvantage, of (MOS) sensors, is cross sensitivity. This is over come by using an array of sensors and using a pattern instead of out put of a stand alone (single) sensor to identify a gas (electronic nose). We report the feasibility of sensors array fabricated by RF sputtered SnO_2 films doped with suitable catalyst for online monitoring. Pd doped SnO_2 film had high sensitivity (~ 10 ppm at 220C) for CH_4. Principal Component Analysis showed Array had good discrimination between target gases.

**Former Professor of Physics. Advisor : Project on Gas Sensors, Funded by Department of Information & Communication Technology, Government of India.*

13. How Well are We Prepared to Mitigate Earthquake Hazard in India?

R. K. Chadha
National Geophysical Research Institute
Hyderabad-500 007

The Indian subcontinent characterizes continent-continent collision boundary in the north viz., Himalaya, subduction zone tectonics in the east, i.e., the Indo-Burmese arc extending through Andaman and Nicobar Islands to the Sunda trench in the south and rifted/non-rifted interiors of the Indian plate i.e., the Indian Peninsular shield. All these tectonic units are sources of damaging earthquakes capable of causing loss to property and human lives. Few of the recent examples are the Bhuj earthquake of 2001, Jabalpur in 1997 and Latur in 1993, all occurring in the Indian shield region and claiming more than 30,000 lives, collectively. Similarly, in the Himalaya, Muzaffarabad earthquake in 2005, Chamoli in 1999 and Uttarkashi in 1991 caused heavy casualty and severe damage to property. The 2004 Sumatra earthquake in the Sunda trench ruptured a 1200 km long fault up to the north Andaman and played havoc by generating an unprecedented tsunami in the Indian Ocean which claimed thousands of lives in the south-Asian region. Thus, strategies for the assessment of seismic hazard and mitigation efforts in these regions of varied tectonics require suitable practical solutions.

Large earthquakes cause damage to buildings and other structures in near and far fields, claiming human lives and causing heavy economic losses. This has been very well exemplified by the recent Mw 7.7 Bhuj earthquake in 2001 where several multi-storied buildings in the Ahmedabad city, about 300 km from the epicenter of the earthquake, suffered either partial or total collapse. This phenomenon of far field damages to buildings has been reported, worldwide, notable being the 1985 Mexico earthquake, where the epicenter was 400 km offshore from the Mexico city, which suffered very heavy damage. This observation brings out the importance of local site conditions in either reducing or enhancing the earthquake hazard in a region. Damage to structures are caused due to several reasons, most important being, i) magnitude and depth of the earthquake, ii) nearness to the epicenter, iii) shaking, iv) design of the structure, v) local site conditions like thickness of the soil layer and vi) quality of construction. While the first three are beyond the human control, the damage due to the other three factors can be countered by a conscious human effort. Rapid urbanization with scant respect for enforcing seismic building codes in building design is a major reason for increased risk during an earthquake. Major cities located in the Indo-Gangetic plains are exposed to earthquake hazard due to its nearness to the seismically active Himalaya and also due to the presence

of thick alluvium which causes great amplification of seismic waves leading to damage to structures. In my talk I will discuss the results of our studies being carried out in the Indo-Gangetic plains to reduce earthquake hazard in the region and also touch upon the strategies being adopted to address this problem in our country.

14. National Earthquake Percursor Program : An Integrated Approach to Earthquake Precursory Research

Brijesh K. Bansal and Mithila Verma

Geosciences Division
Ministry of Earth Sciences, CGO complex, Lodhi Road
New Delhi

Seismic vulnerability of India is well known as it has witnessed several large/ major earthquakes in last one hundred years. The first seismic observatory came in to being in 1898-99, soon after the great Assam earthquake of 1897. Since then several observatories have been established to monitor the earthquake activity. However, the Killari earthquake of 1993 gave a boost to these efforts and a new era of digital seimometry started in India. Simultaneously, a national GPS programme was also launched to monitor the crustal deformation and estimate the strain build up in different parts of the country. Both these programs have so far contributed considerably in improving our understanding of the earthquake source processes and geodynamics. Taking clue from the major successes and recognizing that documentation and authentication of earthquake precursors remains key mode to earthquake prediction, a road map for a National Program on Earthquake Precursor has been drawn.

A variety of earthquake precursors are known from the global monitoring programs but they seem to have poor prognostic value as the noted changes are not observed for all earthquakes and in different parameters or even for different earthquakes in the same region. It remains to be established how the range of seismological and non-seismological precursors relate to earthquake building processes and at what stage of earthquake preparatory cycle they appear and what are their characteristic space-time signatures? The national program on earthquake precursor is aimed at to find answer to some of these key questions. The main objective of NPEP is to generate long-term, multi-parametric geophysical observations in seismically active areas, analysis and interpretation of these multi-parametric geophysical observations on a real-time basis and establish possible relationship

between various earthquake precursory phenomenon and the earthquake generation processes. Accordingly, state-of-the-art Multi-Parameter Geophysical Observatory (MPGO) in critically stresses zones of Himalaya and other seismic active belts have been established. The MPGO housing, various geophysical monitoring systems, including, magnetotelluric, overhauser magnetometer, tri-axial fluxgate magnetometer, ULF band search coil magnetometer, super conducting gravimeter, radon, water level recorders, Broad Band Seismometers (BBS) and GPS is well equipped to record precursory signals resulting from stress-induced changes in density, resistivity, magnetization, elastic failure, deformation and opening of micro-cracks during the earthquake preparatory cycles. The first such MPGO is established at Ghuttu, in Garhwal Himalaya and is operational since 2007. The two other such observatories have since become functional at Shillong, NE India and Bhuj, western India.

15. Influence of Subducting Bathymetric Features and Sedimetns on the Earthquake Occurrence and their Rupture Characteristics

V. K. Gahalaut

National Geophysical Research Institute, Hyderabad
Email : vkgahalaut@yahoo.com, vkgahalaut@ngri.res.in
http://www.freewebs.com/vkgahalaut/

Many factors influence the earthquake occurrence in the subduction zones. Important of them are, the relative plate convergence rate, age of subducting plate, geometry of the subduction zone, crustal structure, rupture zones of previous earthquakes and earthquake slip history, rheology and influence of stress interaction amongst the earthquakes. Most of the worldwide seismological work has focussed attention on these aspects. However, another feature which significantly influences earthquakes and their rupture characteristics is the bathymetry of the subducting oceanic plate. Relatively limited work has been done in this regard. This is partly because of lack of detailed bathymetry data and lack of knowledge about the rupture characteristics of earthquakes that occurred before the modern instrumental era of seismology. It has now been realised that the subduction of seamounts, aseismic ridges, fracture zones and other bathymetric features including sediments that lie on the subducting ocean floor, influences trench morphology, topography/ bathymetry of the overriding plate, seismicity rate along the arc margin and also the earthquakes, their rupture characteristics. In some cases, their subduction causes high coupling between the subducting and overriding plates leading to high friction whereas in some cases they cause low friction, but in both cases they may slow

down the rupture speed and may eventually terminate the rupture. In some cases they act as barrier while in other cases, as asperity. Their influence on the earthquake rupture depends on their shape, structure (both internal as well as external), sediment thickness of subduction channel, their buoyancy, and their strength. Ruptures of several great earthquakes have been found to be influenced by the seamount and ridge subduction. A few of them are 1946 Nankaido earthquake, 1965 Aleutian Alaska earthquake; 1996 Biak, Indonesia earthquake; 2001 Peru earthquake; 2004 Sumatra-Andaman and 2005 Nias earthquakes. In fact the rupture of the recent 2010 central Chile earthquake appears to be influenced by the ridge wherein the northern edge of the rupture is terminated at the subducting Juan Fernandez ridge. A few well established examples of subducted seamounts are the Muroto in Nankai accretionary wedge offshore southwest Japan, Mediterranean ridge, Mariana, Cascadia seamount, Sumatra arc, etc.

In the Sumatra-Andaman region, after the occurrence of 2004 Sumatra-Andaman and 2005 Nias earthquakes, several studies have been initiated. We have focussed more on the GPS measurements in the Andaman Nicobar region to understand the crustal deformation through earthquake and the earthquake occurrence processes. A few studies on the identification of subsurface structures and high resolution mapping of bathymetry have also been taken up in the Sumatra region. In all these studies, more emphasis has been given to understand the earthquake processes in a more classical way, and the studies focussing on the influence of bathymetry on the earthquake ruptures and earthquake occurrence processes are very limited. One of the most enigmatic features of the 2004 Sumatra–Andaman earthquake was the slow rupture speed and low slip on the northern part of the rupture under the Andaman region. We propose that the aseismic 90? E Ridge (NER) on the Indian Plate obliquely subducts under the Andaman frontal arc region. Though other possibilities also exist, we hypothesized that this ridge probably acted as a structural barrier in?uencing rupture characteristics of the earthquake. Here we present several features of the Andaman region that favour NER subduction under the region, which include (i) comparatively shallow bathymetry and trench depth, (ii) low seismicity, (iii) signi?cant variation in the azimuths of coseismic horizontal offsets due to the 2004 Sumatra–Andaman earthquake, (iv) lack of post-seismic afterslip on the coseismic rupture in the Andaman frontal arc region, (v) low P wave with only small decrease in S wave speed from tomographic studies, (vi) gravity anomalies on the Indian Plate indicating continuation of the ridge under the Andaman frontal arc and (vii) lack of back arc volcanoes in the Andaman region.

16. Contemporary Environment and Diffusion of Malaria in Konkan Division (M.S.) A Study in Geography of Health

[1] Kailash Choubey and [2]Suryawanshi Arvind Laxmanrao

[1] Deptt. of Gen of Applied Geography Dr. H.S. Gour, University
A Central University,
Sagar M.P.-470 003
[2]Nana Shab Y.N. Chavan Arts, Science college
Chalishgaon (M.S.)

Keywords *: Diffusion of Malaria - Konkan (M.S.).*

Malaria is the queen of diseases, disturbing the world population as well as economy. Malaria has been a problem in India for centuries. It is a major public health problem still today. According to WHO around 40 percent of the global population is at risk of malaria residing in S.E. Asia region. It is both a disease of poverty and cause of poverty, which is slowing economic growth by 1.3 percent per year. The country loses millions of rupees annually from direct and indirect cost of malaria but the human pain and suffering caused by malaria cannot be expressed in million terms.

The Anophelese mosquito primarily breeds in stagnant water pools, accumulated after monsoon showers. It also breeds in clean stagnant or stored water in man mode situation. The adult female Anophelese mosquito picks up the malaria parasite of the protoza, belonging to genus plasmodium from an infected host (human) and transmits into a human being. The parasite flourishes well in the RBCS of human by invading them.

Environmental factors like rainfall, temperature and humidity affect the abundance of breeding sites and physiology of the vectors the parasites and the human host, various factors like human activities and natural calamity like excessive rainfall, flood, drought and other disasters have great bearing on mosquitogenic conditions leading to increased potential for malaria transmission.

17. Late Quaternary Glaciation in the Central Indian Himalayan Region : An Overview

Rameshwar Bali

Centre of Advanced Study in Geology
University of Lucknow,
Lucknow

Detailed study of the snow clad Higher Himalayas show the presence of different sets of moraines and related glacial and glacio-fluvial deposits. Such deposits present along the entire length of the Himalaya have helped in establishing relative chronologies of Quaternary glaciation in the Himalaya. Earlier, due to the paucity of the dates, it was suggested and believed that the farthest extension of Himalayan glaciation, coincided with the Northern hemisphere Last Glacial Maxima (LGM). Detailed studies carried out by several international as well as the national groups through out the entire length of the orogen, aided with some dates, suggests that there has been significant variation in the nature of glaciation through out the Himalayan belt. The phases of glaciation as well as the extent of glaciation vary considerably from east to west. Chronologies worked out in the Garhwal and the Kumaun Himalaya suggest that the Central Indian Himalaya have evidences for the earliest record of extension (Phase I) at around 60 Ka in the Bhagirathi and the Pindar valley. This has been observed to have been the most extensive episode of glaciation in the Central Himalayan region. Well preserved recessional moraines especially in the Pindar valley suggest a major phase (Phase II) of glacial advancement at around 25 Ka. Well preserved recessional moraines of the mid-Holocene support the Third Phase of advancement. A number of crecentric moraines present with in the glacial trunk valley are indicative of the Fourth phase of advancement in response to the Little ice age. The studies also are indicative of a definite control of the south Asian monsoons on the phases of glaciation and deglaciation in the Central Himalayan region. Monitoring of the snout of some of the glaciers for more than a century also suggests, that the rate of recession of the Central Indian glaciers has come down considerably as compared to that observed earlier.

FOREIGN DELEGATES

18. Warnings Ahead of Volcanic and Earthquake Hazards and Recent Iceland Volcanic Eruptions

Ragnar Stefansson

Professor University of Akureyri,
Iceland
raha@simnet.is

The common denominator for the nucleation of earthquake and volcanic hazards is fluids which penetrate from bellow up into the brittle crust. In the case of the volcanic eruptions a significant content of this fluid is incompressible, and in areas of low confining pressures, like in rift zones, the magma rises in interplay with large strain changes to the surface, easily observable by earthquake and deformation monitoring. In strike-slip and thrust-fault zones compressible fluids gradually migrate upwards into the brittle crust in response to strain and fluid pressure at depth, to corrode old earthquake faults resulting in many cases to the nucleation of large earthquakes. These processes give very weak signals, but can be made observable with adequate geo-watching. Multinational earthquake prediction research started in the Iceland “Natural laboratory” shortly before 1990, in spite of growing pessimism at these times about the possibility to predict or make useful warnings ahead of large earthquakes. In spite of all this pessimism, good successes in Iceland to warn before volcanic eruptions suggested that it might also be possible to predict earthquakes. The path was taken to a physical approach to understand pre-earthquake processes. The basic tool for this was expected to be information carried by microearthquakes, i.e. earthquakes down to magnitude zero which occurred almost continuously in the strike slip zones. The first part of the prediction research was to build a seismic system, capable to retrieve and interpret information from so small earthquakes, in near real time. This together with other monitoring and modeling has shown that all earthquakes larger than magnitude 5 in Iceland are preceded by observable and understandable crustal processes. Studies of processes preceding eruptions now enjoy the benefit of the automatic seismic monitoring and evaluation system, the SIL-system that was developed to understand the tiny pre-earthquake processes. The

capacity for automatically detecting and evaluating the tiny pre-earthquake process is also useful to resolve and physically understand the almost continuous larger activity occurring shortly before eruptions.

The increased monitoring sensitivity and new understanding of crustal processes makes it possible to see a long lasting but weak crustal processes even tens of years before the a dangerous rupture. The method of the hazard prediction is thus to use these long term observable processes to find the place of a probable hazard and to predict its character. Monitoring the ongoing process and creating constitutive laws for it, assuming earth-realistic parameters for the crust and upper mantle, makes possible to extrapolate it to near future and close distances. This opens the possibility for many kinds of warnings, even useful warning about time of the occurrence of the hazard release. Hopefully long term warnings lead to increased sensitivity of monitoring at places where preparation process is discovered, both for enhancing understanding of the ongoing process as well as for preparing actions to mitigate risk when the hazard occurs. Short term extrapolation of the ongoing process will help in short term for more precise assessing of where, when, and how will it be.

Such an approach to hazard prediction will help to enhance general hazard assessments, which are mainly based on history, as well as “early warnings”, which up to now have been mainly based on risk mitigation actions which start after the hazard occurs. Any progress, even small, in earthquake prediction research will make possible to provide “early warnings” still earlier.

The approach to pre-hazard warnings (call it predictions) described here requires an effective geo-watching system, consisting of sensitive multidisciplinary monitoring and visualization, dynamic near real time modeling based on the heaping observations, and rule based procedures for manually delivering well constrained warnings. This may be considered such a huge and expensive system that it will never be realized in practice. But precisely as the SIL monitoring and evaluation system was possible because of progress in computer technology, the build up and operation of contiuous near-real time multidisciplinary geo-watching system will be possible with help of good science and computer technology.

19. Vertical Electric Fields inside Layer-type and Blob-type Echo structures of 3-m Field-aligned Irregularities in Mid-latitude Sporadic E Region

Professor Yen-Hsyang Chu,
Dean, Research and Development Office,
National Central University
Chung-Li, Taiwan-32001, R.O.C.(TAIWAN)
yhchu@jupiter.ss.ncu.edu.tw

It has long been known from interferometer measurement that spatial structures of echoing regions of 3-m field-aligned irregularities (FAIs) in Es region can be categorized into layer- and blob-types. The layer-type structure is characterized by wide extent in horizontal and narrow thickness in vertical directions, and the blob-type structure is in quasi-isotropic shape. A method is proposed to measure vertical electric fields inside these two type echo structures observed by the Chung-Li VHF radar. Results show that the vertical electric field of the layer-type structure is very different from that of the blob-type structure. The former is in average about 1-2 mV/m with a pointing direction in compliance with that predicted by neutral wind shear theory. However, the electric field inside the blob-type structure is very weak with irregular pointing direction. The mechanisms responsible for the formations of these two type echo structures are discussed in this presentation.

20. Long Term Observations of the Upper Atmosphere

Iain M Reid[1,2]
[1]School of Chemistry & Physics
University of Adelaide, Adelaide 5005, Australia
[2]ATRAD Pty Ltd
Adelaide, Australia

Although distant from the immediate region in which we live, the upper stratosphere (~50-80 km) and the mesosphere lower thermosphere region (the MLT-region between about 80 and 110 km) are important for life on earth. For example, these regions directly protect the surface from solar EUV and X-ray

emissions by absorbing them. At Adelaide, we have been observing these regions for several decades and have built up both an extensive baseline of observations and the best suite of instruments for making these observations in the southern hemisphere, and one of the best in the world. We have also developed new techniques for the measurement of turbulence, the measurement of momentum flux, the measurement of transport parameters and the use of MF radar detected meteors to measure winds in the region. We have also re-established the Differential Absorption Experiment (DAE) to measure electron densities in the MLT-region, and have extended the meteor radar technique.

We plan to integrate our observations of scalar quantities such as temperature, airglow intensity, neutral density and electron density, with measurements of vector quantities such as wind velocity, momentum flux and mass transport, to understand the physics of the region. This has previously been done for campaigns; for example in the *TOMEX* campaign at the Starfire Optical Range and in campaigns at the *Maui-MALT* site, but we now plan to do it on an on-going basis.

Intercomparison of MLT region temperatures derived from a variety of techniques indicate some surprising variations. Given our interest in monitoring this parameter and separating the natural variability and any instrumental effects from any anthropogenic changes, this is a key part of our research. Deriving temperatures from meteor trail diffusion detected with radars has become a popular technique because of the number of such radars available and its apparent simplicity. However, work at Adelaide has shown that the diffusion of the meteor trails is affected by the presence of meteoric smoke and dust. This parameter is the basis for estimating the temperature of the region, and so great care is needed in interpreting the results. They turn out to depend on the radar operating frequency, the strength of the meteor echo itself, latitude and time of year. We have made significant progress in understanding the technique and how it can be applied to estimate MLT region temperatures, but there is some way to go before it can be used to contribute reliable to temperature climatologies. Access to reliable temperatures as well as winds across the radar network would greatly contribute to our understanding of the interaction between Planetary, Tidal and Gravity Wave scale motions.

We are pursuing lidar development at Adelaide to provide an independent and accepted measure of the temperature in the MLT region. In the present development, we expect to get temperatures at heights up to 75 km. This is not ideal for comparison with the other optical techniques we operate which return

results around 90 km, but it is a first valuable step. It will also allow us to investigate upward propagation of waves from the stratosphere (the "radar gap" region) into the mesosphere.

In addition to this, the main goal of our current project, we have an additional aim of extending and further developing the strong research base related to the innovative use of co-located instrumentation and data analysis techniques to derive fundamental parameters related to the dynamics of the atmosphere.

In the context of this project, we note that :

1. No one technique covers the entire height range and so we use a suite of co-located instruments.
2. No one site provides significantly horizontally spatially separated observations to investigate the horizontal scales of the dynamics of the region and so we use our local and regional networks of observing sites
3. Global coverage is not possible from the ground and so we integrate our ground based observations with satellite observations to gain a perspective on the complete system.
4. There is a need to assimilate observations through modeling and we are beginning to do this

We are using all of these elements to investigate the *aeronomy* of the region.

In this paper, we will describe our work at Adelaide with an emphasis on recent results of airglow studies. This work presents 15 years of measurements of two nightglow emission intensities at our field site near Adelaide, and five years of measurements of OH (6,2) and O2 (0,1) rotational temperatures from the same site. It adds to a number of recent studies which have greatly improved our understanding of the global morphology of the MLT region nightglow. The close link between the underlying chemistry, dynamics and temperature structure of the MLT-region and the clear interdependence of the parameters make this a particularly important topic. We consider the seasonal variability of the 730 nm OH (8,3) and 558 nm OI nightglow emission intensity over a period covering one solar cycle and compare them with OH (6,2) and O2 (0,1) measurements from an imager located the same site and TIME-GCM model results, and with WINDII satellite instrument measurements of OI and OH intensity. These results form a baseline for future intercomparison with the other instruments at our field site, which provide measurements of winds and rotational temperatures and with satellite and model results. We do this as a first step to better understanding the aeronomy of the MLT region at a lower middle latitude site.

21. Variability and Transport of Ozone in the Tropical Stratosphere

Prof. Hassan Bencherif

Université de la Réunion, Laboratoire de l'Atmosphère et des Cyclones
UMR 8105 CNRS / Université de la Réunion / Météo-France

Stratospheric Ozone is mostly created by sunlight at tropical latitudes, and circulates through the Brewer-Dobson cell from the tropics to the Polar Regions. In fact, because of interaction between planetary waves and the mean-zonal flow, ozone can be transported away from the production region. Additionally, in the winter stratosphere, erosion of the dynamical barriers such as the polar-vortex and the subtropical barrier by planetary-wave breaking, which results in the formation of filaments (*laminae*), also contributes to ozone distribution and balance.

Moreover, the "Tropical Stratosphere" is a region where significant changes are expected to occur over the next decades. Dynamical activity is closely linked to the chemical composition including ozone and other trace gases distributions. Indeed, any chemical or/and dynamical change may have a significant effect on mass and energy transport, including stratosphere-troposphere exchanges, as well as tropic/mid-latitude exchanges.

The subtropical barriers and the tropical tropopause are dynamical barriers that control energy and composition of the Tropical Stratosphere. Those dynamical barriers represent transition regions that modulate transport and mass fluxes in the Tropical Stratosphere.

In fact, recent observations showed that in the southern subtropics dynamical processes such as isentropic exchanges in the tropical stratosphere through the southern subtropical barrier take place (Bencherif et al., 2003; Portafaix et al., 2003; Semane et al., 2006; Bencherif et al., 2007). These processes must play an important role in the transfer of energy, air masses and notably tracers like ozone between the tropics and the mid-latitudes.

The talk aims to focus on stratospheric ozone variability (in terms of concentration and total columns) at different latitudes in the southern hemisphere and will display a typical event of meridian isentropic transport between the stratospheric tropical reservoir and neighbouring regions.

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ABSTRACTS OF ORAL/POSTER PRESENTATION

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PART II : (Abstracts)

SECTION OF EARTH SYSTEM SCIENCES

President : **Prof. Arun Kumar**

CONTRIBUTED PAPER

1. Record of Paleoclimate Change from Himalayan Caves

V. C. Tewari

Professor and Head, Sedimentology Group
Wadia Institute of Himalayan Geology,
Dehradun- 248 001, Uttarakhand
E.mail : vtewari@wihg.res.in

Keywords : *Caves, Himalaya, Monsoon, Plaeoclimate , Speleothems, isotope, Cherrapunji, Meghalaya.*

Cave deposits are abundantly found in the Himalaya from NW to NE India, where calcium carbonate is precipitated as stalactites and stalagmites.. Himalayan cave deposits may provide important record of palaeoclimate and palaeomonsoon since they are not subjected to erosion and terrestrial deposits. Holocene palaeoclimatic and palaeomonsoonal studies from the tropical and monsoonal regions of Indian subcontinent and SE Asia have been attempted in recent years. Carbon and oxygen isotopic variations in speleothems (cave deposits) especially stalagmite growth

laminae is used for interpreting the amount of rainfall. Present paper highlights important speleothem deposits from NW to NE Himalaya. The sedimentological microfacies of the speleothems , radiaxial fabric of cave calcite and carbon and oxygen isotopic ratios of the stalactites and stalagmites has been discussed for palaeoenvironmental and palaeoclimatic interpretations. All these caves lie in the high monsoonal region therefore, it is quite significant to study the strength of Indian Summer Monsoon (ISM) and decadal scale seasonal variations. The Mawsmai cave lies in the Sohra (Cherrapunji) area of the Shillong Plateau, Meghalaya where highest annual rainfall is 11931.7 mm. It is the wettest place on planet earth.

2. An Insight into the Estimation of Pressure-Temperature in Rocks : Case Studies from Ladakh Batholith, Gangotri Granite and Almora Crystallines

T. N. Jowhar

Wadia Institute of Himalayan Geology, 33 GMS Road,
Dehra Dun 248001
E-mail : tnjowhar@wihg.res.in

Keywords *: P-T estimates, Geothermobarometry, Ladakh batholith, Gangotri granite, Almora crystallines, Himalaya.*

Reconstruction of the P-T-t path followed by crustal rocks during orogeny has assumed greater significance. In this talk fundamental theory and aspects for estimation of Pressure-Temperature and their importance in rocks will be outlined. Case studies of P-T estimates from Ladakh batholith, Gangotri granite and Almora crystallines are discussed. Use and applications of computer programs TWQ, WEBINVEQ and THERMOCALC for P-T calculations and construction of phase diagrams are outlined. TWQ is an interactive program for calculation of mineral-fluid equilibria. WEBINVEQ is an interactive scientific software for thermobarometric calculations on the World Wide Web. WEBINVEQ thermobarometry uses an approach that provides some advantages in analyzing and solving the inverse chemical equilibrium problem in metamorphic petrology. It is a generalization of classical thermobarometry, hence of interest to geologists

who are studying metamorphic rocks. The mathematical problem is the determination of the weighted non-linear least-squares solution to a set of polynomial functions in the unknown pressure (P), temperature (T) and a set of chemical potentials (μ).

THERMOCALC is a thermodynamic calculation software for solving mineral equilibria problems. It has two main components: the application itself, and the internally-consistent thermodynamic dataset it uses. The mineral equilibria problems that can be addressed with THERMOCALC include *inverse modeling* (geothermometry/barometry using average PT), and *forward modeling* (calculating phase diagrams for model systems). Quantitative phase diagrams involving solid solutions can be calculated, including P-T projections, compatibility diagrams, P-T, T-X and P-X pseudosections for specific bulk compositions. In the last decade, this approach has been successfully applied to solving the phase relations, P-T conditions and evolution histories of rocks in pelitic and the mafic systems. Some test runs are generated for demonstrating use of these computer programs along with P-T estimates done on the Dudatoli-Almora crystallines, Garhwal-Kumaun Lesser Himalaya in order to place quantitative constraints on the conditions attained during the regional metamorphism. It is interpreted that in Dudatoli-Almora Crystallines T varies from 500 to 650^0C and P from 600 to 800 Mpa. Spatial distribution of data indicates inverted metamorphism.

The Ladakh batholith is exposed along the 600 km long and 20 to 80 km wide NW-SE trending Ladakh range north of the Indus-Tsangpo Suture Zone. It was emplaced with in an unmetamorphosed thick pile of mafic and felsic volcanics, ultramafics and sediments of Upper Cretaceous-Eocene age (Dras Volcanics, Khardung Volcanics). The granites from the Ladakh batholith (60Ma phase) within the Leh-Khardung La and Sakti-Chang La sections (samples collected between altitude of 3600M and 5440M above mean sea level) have been estimated for pressure and temperature of crystallization employing the hornblende geobarometer and hornblende-plagioclase geothermometer. These studies reveals that :

(i) Pressure and temperature of crystallisation was 254 $\pm$ 67 Mpa and 695 $\pm$ 20^0C.

(ii) The granites from the Ladakh batholith solidified at a depth of 8.6 $\pm$ 2.3 km.

(iii) The Ladakh batholith has been unroofed of 8.6 $\pm$ 2.3 km in this region.

The Gangotri granite (23 ± 0.2 Ma) is one of the largest bodies of the High Himalayan Leucogranite belt (HHL) located in the Garhwal Himalaya. The Gangotri granite is situated structurally above the kyanite and sillimanite gneisses of the Vaikrita Group, which in turn overlies the north-dipping Main Central Thrust Zone of inverted metamorphic isograds. Compared to other High Himalayan leucogranites it is particularly rich in tourmaline. The Gangotri granite is composed of quartz + K-feldspar + plagioclase + tourmaline + muscovite ± biotite ± garnet ± beryl, with apatite as the most abundant accessory mineral. K-feldspar is microcline microperthite and shows typical cross-hatched twinning. Tourmaline contains inclusions of plagioclase, apatite and monazite. All the analysed tourmalines belong to Alkali Group and are Schorl. Application of two-feldspar geothermometer gives temperatures of subsolidus equilibration of 441-270^{0}C and plagioclase-muscovite gives temperature in the range of 448-339^{0}C.

3. Trends in Meteorological Parameters and Weather Events over Kolkata

H. R. Biswas

Regional Meteorological Centre, Kolkata

Keywords *: Kolkata, Trend, temperature, rainfall, extreme weather events.*

At present one of the most important global issue is climate perceived to be changing worldwide and its implication in global and regional scales. In the present study an attempt has been made to explore the trends of different meteorological parameters and weather events over Kolkata, an important Metro city over East India. About 100 years of meteorological observational data of Kolkata city has been used for the analysis in this study. The study indicated that both annual mean maximum and annual mean minimum temperature have shown significant positive trend over Kolkata. Total number of rainy days (Rainfall > 2.4 mm) during southwest monsoon season (June to September) and total seasonal rainfall of southwest monsoon season have shown no significant trend over the period (1901 – 2003). Also time series and trend analysis for extreme weather events viz., frequency of heavy rain days, severe thunderstorm events associated with squall, hail etc, occurrence of fog, Very cold and hot days have been studied in this paper.

4. Deciphering the Quaternary Climatic History of the Arctic Region : Palynological Implications

Ratan Kar* & P. S. Ranhotra

Birbal Sahni Institute of Palaeobotany,
53 University Road,
Lucknow-226007
*****E-mail : ratankar@yahoo.com

Keywords *: Quaternary, Arctic, Svalbard, Palynology, Palaeoclimate.*

The Quaternary Period, approximately 2.6 million years of the earth's recent past, is marked by abrupt climatic shifts having glacial and inter-glacial phases. The climate of the Holocene (~11500 years) has been even more variable. Polar Regions play a significant role in regulating the earth's temperature and are also more vulnerable to even subtle climatic changes as these are more powerfully expressed in these regions. At present, the Arctic is the most rapidly warming place on earth, which is reflected in the rapid melting of the Arctic ice cover, faster than anywhere else on the globe. Keeping in view the importance of climatic studies in the Arctic region, India has also recently commenced its Arctic endeavour and has established a permanent research station, Himadri, at Ny-Alesund, Svalbard. Among other disciplines, unraveling the Quaternary climatic history of the Arctic region is one of the major objectives of India's Arctic Mission.

Ny-Alesund in Svalbard, Norway (79^0 N), represents a typical high Arctic ecosystem. This area bears the imprints of Quaternary climatic oscillations in a copybook fashion, which are manifested by fiord environments, raised beaches and marine terraces and a variety of glacial and fluvio-glacial geomorphologic features. Studies have been initiated for high resolution climatic interpretations through multi-proxy palynological analysis supported by C^{14}/AMS and OSL dates. Subsurface sediments, collected through the digging of trial trenches from different geomorphic regimes around Ny-Alesund, are being analysed for palynological studies. Pollen of local herbaceous taxa, along with other organic matter are encountered in varying frequencies in the sediment profiles reflecting changes in the climatic conditions. Besides, pollen of extra-local tree taxa,

transported by wind and deposited to the site of study, from the Boreal forests on the main land are also common. To develop modern palynological analogues, a number of surface samples were collected from various locations of Ny-Alesund region and air-borne spores and pollen were also monitored. The palynological data generated in Ny-Alesund and the palaeoclimatic inferences therein are also being correlated with similar studies from the glaciated regions of the Higher Himalayas.

5. Catastrophic Landslides in Northwest Himalaya Global Warming Effect?

V. K. Sharma

Geological Survey of India,
Project:Landslide Hazard studies,
Lucknow

Keywords *: Landslide, Northwest Himalaya, global warming, water induced disasters.*

The combination of geographical, geological and climatic set up of Northwest Himalaya has made it one of the most disaster prone regions of the globe in terms of toll of human lives and economic losses. Annual monsoon rains frequently leave a trail of a large number of deaths, sufferings and destruction affecting millions of people in the region. Precipitation during July to September brings most of the annual rain in the region causes serious water induced disasters including landslides, debris flows and environmental degradation.

Continued collision tectonics, high seismicity, high relief expressions and high-energy regime, of the mountainous region of Northwest Himalaya possesses geo-environmental conditions congenial to major mass-wasting phenomenon and the terrain is replete with such incidences in past. Though, there are ample examples of damaging to catastrophic landslides in historical and pre-historical past in NW Himalaya, those occurred in 1867, 1880 and 1889 in Nainital basin and a natural rockfall in 1893 that blocked of Birahiganga in Garhwal near village Gohna creating a 3 km long lake have special significance. Several incidences of river blockades are known from Garhwal Himalaya such as those

in Dhauliganga (1956), Rishiganga (1967), Patalganga (1970) and Bhagirithi blockade (1978,1992).

In recent years, numbers of landslides of catastrophic dimension have occurred in the Northwestern Himalaya such as (i) Malpa landslide (1998) in Central crystalline of Higher Himalaya an unique example of rock fall-cum-avalanche is one of the worst of its kind which has, killed over 200 people including 60 pilgrims camping on their way to Kailash pilgrimage (ii) Okhimath landslides (1998) in the valleys of Madhyamaheshwar and Mandakini in Garhwal region consequent upon the incessant rains caused slope failures which spread over 20sq km killing 101 people. The affected area forms parts of Central Crystalline zone of Higher Himalaya. The area is largely occupied by the old glaciated materials.(iii) Debris flows (1997) on the left bank of the river Satluj near Nathpa Jhakri Project site, following a cloudburst left behind a trail of heavy destruction and loss of 21 lives. Seven tributaries of Sutlaj River channelized the massive debris flows. Parechu (2004), in upper reaches of Satluj River, created widespread threat due to the bursting of landslide dam (iv) Burakedar debris slides/flows(2001) resulted due to intense rainfall in upper reaches of Dharamganga, a tributary of Bhilangana river, inflicted a cumulative loss of 28 people (iv) Pithoragarh debris flows (2009) occurred in and around Jhekla, La and Rumidola villages initiated by intense rainfall resulted in death of 43 human and (v) Leh mudflows/debris flows(2010) at an elevation of over 3500m in cold desert conditions, was a unique example of landslide disaster in high altitude terrain killed 182 people besides a colossal loss of property.

All these examples illustrate the growing impact of the landslide hazard in the Himalayan terrain possibly linked to Global warming which is a growing threat to humanity as a whole. The world experienced a surface temperature rise of 0.6°C on average during the 20th century, and the average temperature by year 2100 is projected to go as high as 6.4°C relative to1990 if Green House Gases (GHG) emissions are not reduced (IPCC 2007). As a result of global warming, the pattern of monsoon precipitation has undergone phenomenal changes with decreasing rainy days and increasing high-intensity rain fall events as discussed above. The increase or change in rainfall pattern may manifest in increase in frequency and magnitude of water-induced disasters such as landslides, debris/mud flows, bank erosion and floods etc.

6. Holocene Climate and Glacial Extent within Gangotri Valley, Garhwal Himalaya

Parminder Singh Ranhotra
Birbal Sahni Institute of Palaeobotany,
53 University Road,
Lucknow-226 007
E-mail : ranhotra.p@gmail.com

Keywords *: Palynology, Palaeoclimate, Holocene, Glacial extent, Gangotri valley.*

Since few decades instrumental monitoring of few Himalayan glaciers show a continuous retreat of their snouts at various rates in response to present day warm and moist climate. But to understand the extent of glaciers during distant past the proxy data analyses from various geomorphological features left behind within the glaciated valleys is important.

The palynology based palaeoclimatic study was done from two locations (Tapoban and Bhojbasa) within the Gangotri valley, Garhwal Himalaya, Uttarakhand. Three subsurface sediment profiles, two (2.40 and 0.70 m deep) from Tapoban palaeolake (~4,300 mamsl) on left bank above the glacier snout, and one (1.30 m deep) from the top of Kame deposits (~4,000 mamsl) above the right lateral moraine at Bhojbasa (4 km downstream of glacier snout), were analysed for spores and pollen. The radiocarbon (^{14}C) dates from these three profiles covers almost entire Holocene. The palaeoclimatic reconstruction done has recognised cold phases between 9,200 and 8,100 cal yr BP, ~6,900 to 5,830 cal yr BP, ~3,200 and ~800 cal yr BP when the glacier might had been at stagnation or under advancing condition. Recovery of good amount of arboreal (tree) pollen viz. *Betula, Juniperus, Salix,* conifers, *Quercus, Alnus, Ulmus* etc., and non-arboreal spores-pollen (*Ephedra, Potamogeton*, Chenopodeaceae, Asteraceae, Cyperaceae, Ranunculaceae, Polygonaceae, ferns etc.) around 10,189 cal yr BP suggests that during early Holocene both the sites were ice free and marshy to shallow lacustrine depositional environment prevailed under warm-moist climate. As the two sites are at lateral margins within the Gangotri valley, it can be said that during Early Holocene the lateral margin of glacial ice remained lower than the altitudes of these sites i.e. ~4,300 mamsl at Tapoban and ~4,000 mamsl at Bhojbasa. During same time though the glacier snout was much downstream from Bhojbasa but it was under retreating condition with the shifting of tree line to higher elevations. Also the

glacier never elevated to these altitudes during entire Holocene despite few advancing episodes.

As along with the retreat of snout, the glaciers are also reducing laterally i.e. thinning of the ice mass, therefore, the correlation of the glacier thickness with its length and snout position in the present context is important in a way to understand the extent of the glaciers and their snouts during distant past.

7. Use of Geopatial Data for Desertification Status Mapping : A Case Study of Hanle Watershed in Cold Desert of Ladakh

P. S. Dhinwa

Space applications Centre (ISRO),
Ahmedabad
Email of Corresponding Author : dhinwa_ps@sac.isro.gov.in

Keywords : *Desertification, Comprehensive Classification System, Cold desert, Degree of Severity, Hanle watershed, Ladakh district.*

Desertification has been defined as a process of land degradation operating in dryland regions of the world triggered by the natural and anthropogenic factors. Land degradation has been one of the environmental problems and is of great concern in our country as well. Both cold and hot regions of our country are affected by the process of land degradation. Though an appreciable amount of work has been done in hot regions of the country to understand the processes of land degradation/desertification and evolve procedure for its mapping, the efforts in cold desert region have been negligible. Space Applications Centre, Ahmedabad has taken up a project to evolve and standardize a methodology for desertification status mapping in both cold and hot regions of the country. In Hanle watershed (1F4H1), the mean annual temperature is less than 8 degree Celsius and mean annual precipitation is less than 150 mm. This watershed lies in the rain-shadow zone of the Trans Himalayan Range of the Greater Himalayas and hence receives very scanty rainfall. Water erosion, mass movement, wind erosion, frost shattering and frost heaving are the significant desertification processes observed in this watershed. The desertification status map has been prepared by using the methodology, a comprehensive classification system and other benchmark indicators

of desertification. Hanle watershed covers an area of 1262 sq. km. The diurnal range of temperature is very large in this watershed. Geologically, this watershed is characterized by shale, slate, quartzite, and phyllites rock types and gemorphologically, it is a dissected piedmont zone situated along Hanle River. Water erosion is a predominant process in this watershed covering an area of 812.27 sq. km. which is 65.54 per cent of the total area of watershed followed by mass movement which occupies an area of 303.52 sq. km, which is 25.29 per cent of the total area of the watershed. No apparent degradation occupies 6.57 per cent of the area. Wind erosion covers 0.75 per cent, followed by frost shattering which covers 0.68 per cent which is further followed by frost heaving which covers an area of 0.48%.

8. Green Building

Santhosh Jayanthi and P. S. V. Manoj Surya

GMRIT, RAJAM

Keywords *: Green building*

Buildings and homes (or the "built environment") affects natural environment. Buildings, where people spend 90% of their time, adversely impact human health. Buildings also account for 40% of energy and 16% of the water used annually worldwide. Air quality inside buildings is 2 to 5 times worse than outside.

9. Chemostratigraphy of the Eocene-Oligocene Sediments Between Iroishemba and Khongshang, Manipur, India

R. A. S. Kushwaha and M. Chandra Singh

Department of Earth Sciences, Manipur University,
Imphal-795 003
E-mail : rs_kushwaha@rediffmail.com

Keywords *: Chemozone, Chemostratigraphy, Eocene, Oligocene.*

Early Eocene-Late Oligocene deposits belonging to Disang and Barail groups are well exposed between Iroishemba and Khongshang along NH-53. Disang and

Barail group of rocks in the area are dominantly represented shale and sandstones. Results of the major elements from nine representative shale samples collected from different locations are used for chemostratigrphic evaluation of the Disang and Barail groups of rocks. Based on the chemical fingerprint four chemo zones such as CE-1, CE-2, CO-1 and CO-2 have been recognized. Chemozone CE-1 and CE-2 represents to lower and upper Disangs respectively and chemozone CO-1 and CO-2 belong to lower and upper Barails respectively. Upper horizon of chemozone CE-2 and CO-1 are characterized by the relatively high concentration of Fe_2O_3, MgO, CaO, Na_2O and low value of K_2O/Na_2O and Al_2O_3 / ($CaO+Na_2O$) whereas lower horizons of both these chemzones are distinguished by the low concentration of Fe_2O_3, MgO, CaO, Na_2O and high concentration of K_2O and TiO_2 and high value K_2O/Na_2O and $Al_2O_3/(CaO+Na_2O)$. Lower horizon of chemozone CO-2 is characterized by the low concentration of CaO and MnO and high value of K_2O/Na_2O and $Al_2O_3/ (CaO+Na_2O)$.

In addition to major elements trace elements also shows anomalous value. Upper horizon of CE-2 chemozone is characterized by relatively high concentration of Cr, Ni and Co and low value of Cr/Ni and high value of Cr/Zn whereas the lower horizon of CO-1 chemozone is represented by the extremely low concentration of Cr, Ni and Co and low value of Cr/Zn high value of Cr/Ni. The upper horizon of CE-1 chemozone is characterized by relatively low concentration of Cu, Zn and rich in Co whereas it's lower horizon by relatively low concentration of Co and rich in Cu and Zn. The uppermost chemozone CO-2 is characterized by relatively high value of Zn and NI and low concentration Cr and Co.

The anomalous values in the concentration of major and trace elements coincides with the variations in the trace fossils and leaf impressions which may be considered as one of the parameter to decipher the boundary between Disang and Barail.

10. Eartquake Forecasting System

Rishab Bagani[1], Sayan Dey[1], Arka Das[2] and Arghya Ray[3]

[1]Second Year, Electronics and communication Engineering, SRM University
[2]Second Year, Mechanical Engineering, SRM University
[3]Second Year, Computer Sciences, SRM University

Keywords : *earthquake forecasting, highly stable system, cost efficient, reliable, Underground monitoring system.*

We use a hollow carbon-reinforced-steel sphere, fitted with 3 types of sensors, for measuring pressure temperature and magnetic flux. The sensors are connected to the main electronics section which consists of an ADC 0809 driven by a microcontroller. The digital output of the ADC is sent via coaxial cable coming out of the sphere from the underground platform to the over ground platform and the digital output is collected and sent via wireless communication system to a station with a computer to which the digital input can be sent via USB. During an earthquake any change in pressure, temperature and magnetic flux can be detected by the sensors and thus can be alerted of an upcoming earthquake.

11. Impact of Climate Change on Landslide Hazards in Parts of Kali River Catchments, Eastern Kumaun Himalaya

K. K. Agarwal, V. K. Sharma and Chandra Prakash

Centre of Advanced Study in Geology,
Lucknow University,
Lucknow-226 007

The Kali river valley,the easternmost extremity of Kumaun Himalaya form a prominent physiographic setting characterized by high relief conditions, proximity to Himalayan thrusts and faults and fragility of slope forming material. The Kali river catchments has prominent glaciers in its sub basins of Ramganga, Goriganga, Dhauliganga and Kuthiyankti rivers which are fed by glacial melt water in addition to seasonal rains. The catchment supports as many as 271 glaciers and majority of glaciers are more than one km in length with dominant northeast orientation. The Milam glacier is the largest glacier in the basin.

The Kali river catchment has witnessed a number of landslide events of frightening proportions in recent past. The landslide at Malpa (1998) along Kailash-Mansarovar pilgrim trek blocked parts of the road and killed over 200 people; the widespread landslides and bank erosion in Jhekla La and Rumidou La area in 2009 resulted death of 43 people and recent floods of August 2010 vanished many villages in the catchment. Besides, number of medium to large landslide events has been reported in the catchment on account of intense rainfall. Excessive infiltration and percolation into the slope increase the pore pressure and higher pore pressures decrease inter granular forces along an existing or potential slide surface, increasing

the probability of slope instability. The higher discharge in rivers probably associated with glacial melt coupled with heavy rains had resulted into number of landslips that damaged the roads and establishments. The decadal scenarios on the landslide hazard indicate progressive seasonal increase in the discharges in the rivers which facilitate bank erosion and landslides. Freezing and thawing situation in higher elevation induce many rock fall and rock avalanche. All these phenomenon probably point out to the change in microclimatic regime in the basin and increase vulnerability of the people to the hazard. Even though, these effects are probably the least and of smaller magnitude than those associated with late Pleistocene de-glaciation (15,000 to 10,000 years ago), yet threat to people and development in hilly terrain as a result of recent phenomenon of climatically associated deglaciation has immensely increased. In addition, changes in sediment and water supply induced by climatic warming and glacier retreat have altered channel and floodplain patterns of rivers draining high mountain ranges.

The Climatic changes leading to global warming during the last century has resulted in a significant loss of glacier ice from the upper reaches of the mountainous areas. The natural processes, caused by recent climatic warming, may also be associated with events of moraine-dam failures and increase in landslide activities in the kali river basin.

12. Hydrochemistry of Alluvial Aquifers of Kasganj Sub-Division in Parts of the Central Ganga Plain, U. P. India

Syed Zaheer Hasan

Scientist Group-IV (6)
Gujarat Energy Research and Management Institute,
203, IT Tower-1, Infocity, Airport Road,
Near Indroda Circle, Gandhinagar-382 009,
Gujarat
E-mail : zaheer@germi.res.in

Keywords : *Hydraulic structures, major ions, heavy metals, dugwells, tubewells, permissible limit.*

Covering 1175 sq. kms., the study area forms an important part of the central Ganga plain where, the Quaternary alluvium makes the existence of high potential

aquifers. 75 water samples were collected from dugwells and 4 from the deepest tubewells for the analyses of major ions. In addition, 40 water samples from the different hydraulic structures were collected to analyze heavy metals. The analytical results show that the groundwater is potable, moderately hard to very hard, alkaline in reaction and belongs to an alkali-bicarbonate type composition category. Concentration of cadmium and manganese is found slightly higher than the permissible limit. In general, the groundwater is found suitable for domestic, agricultural and industrial purposes with the recommendation that for drinking purpose, the deeper aquifers may be tapped.

13. Applications of Microfossils

P. K. Kathal

CAS in Geology, Dr. Harisingh Gour Central University,
Sagar-470 003
email : pkkathal@dhsgus.ac.in pkkathal@rediffmail.com

Keywords *: Microfossils, biostratigraphy, paleoecology, paleoenvironemnt, paleogeography.*

Microfossils comprise the remains of once living bacteria, protists, fungi, plants and animals and in some cases fragments of larger organisms preserved within rocks by natural agencies whose study essentially requires use of a microscope throughout. They have applications in aspects like dating of rocks, co-relation, higher resolution biostratigraphy, understanding past- and present environments and above all in the field of petroleum exploration owing to their great abundance in time and space, and their wide morphological variability. They also serve well in developing sequential and event stratigraphy of petroliferous basins.

Importance of microfossils lies in their smallness and abundance in most of the post Proterozoic sediments, from small samples and from cores of deep bore-holes. Their extensive variability, abundance and rapid evolution make them excellent biostratigraphic indicators. They provide valuable information on the history of life and how the environments have changed through time. The evolution of species gives us a powerful tool to characterize and correlate rock units.

Being susceptible to minute environmental changes microfossils are the best suited in the studies related to environment and ecology of present and past; and

being numerous they lend themselves to statistical analysis. Besides, their highly visible external morphology and complex architecture yields ecological information.

Widespread occurrence of some of microfossils groups in all the possible marine and paralic water bodies both, in time and space makes them oceanographically useful to demarcate movement of water masses; study paleoecology of organisms, pelogeography, paleoclimate of deposition of sediments; opening and closing of straits and land barrier; and coastal pollution.

14. Variability Among Erosion Conditions Under Small Watersheds, Uttarakhand Himalaya

Anita Pande

Associate Professor, Department of Geography,
Kumaun University,
Nainital-263 002

Keywords : *Erosion stage, geomorphic development, altitude, land cover/land use, equilibrium stage, inequilibrium stage, erosion integral (EI), hypsometric integral (HI), watershed, cultivated land, forest land, barren land.*

Uttarakhand Himalaya has undergone acute erosion condition on account of divergent land cover/land use environment along with sharp surface undulations owing to differential elevation. Present study is concentrated on the small watersheds of Uttarakhand Himalaya. The erosion environment of these studied watersheds has been evaluated under diverse elevation as well as land cover/land use environment. As far as erosion stage of watersheds is concerned, 78% watersheds are experiencing their equilibrium stage while only 22% watersheds have attained their inequilibrium stage of geomorphic development. Variability in erosion stage is noticed under different land use/land cover: Under cultivated land scenario: about 56% watersheds have undergone their equilibrium stage while about 44% are still experiencing their inequilibrium stage of geomorphic development. Under forest land scenario: about 67% watersheds have undergone their equilibrium stage while about 33% are still experiencing their inequilibrium stage of geomorphic development. Under barren land scenario: 100% watersheds of the study area are experiencing their inequilibrium stage of geomorphic development. The lowest altitudinal zone of each basin does not register area under erosion integral (EI) of watersheds. The

highest altitudinal zone of each watershed has minimum area of hypsometric integral (HI) of the watersheds. Santri Gad watershed registers nil area under <1200m zone of hypsometric integral (HI). The lowest altitudinal zone of the cultivated land of each watershed does not possess area under erosion integral (EI). The highest altitudinal zone of the cultivated land of each watershed has minimum area under hypsometric integral (HI). The lowest altitudinal zone of the barren land of each watershed does not possess area under erosion integral (EI). The highest altitudinal zone of barren land of each watershed has minimum area under hypsometric integral (HI) in Ghat, Kodiyari, Gaunap and Siya Gad while lowest and highest altitudinal zone in Begarh Gad watershed. The lowest altitudinal zone of forest land of each watershed does not possess area under erosion integral (EI). The highest altitudinal zone of the forest land of each watershed has minimum area under hypsometric integral (HI).

15. A Report on Ore Beneficiation Studies from Delwara West Block, Bhukia Gold Prospect, Banswara District, Rajasthan

M. Karunaker Reddy and R. L. Jat

Geological Survey of India
Jaipur-302 004
(Mail : mkreddy55@gmail.com)

Keywords *: Cyanidation, Delwara, Bhukia gold prospect, Banswara , Rajasthan.*

The cyanidation, gravity separation and floatation techniques on laboratory scale has been carried out with an objective to find economically viable beneficiation process on composite drill-core samples from Delwara West Block, Bhukia gold prospect, Banswara district, Rajasthan. The cyanidation was carried out under standard conditions on bottle rollers for 24hrs, 36hrs and followed by carbon in pulp (CIP) to extract the gold. The average gold recovery remained 46%. To over come low leaching of ores, higher dose of cyanide concentration was maintained and found the average recovery increased to 91%. Alternately to study the gravity recoverable gold, the ore was subjected to 3 inch Laboratory Knelson concentrator. Total recoveries of two size fractions exceed 70% and the ore is amenable for gravity recovery. To avoid higher cyanide consumption the ore is subjected to floatation, which is successful in concentrating gold and reducing the bulk sample.

The study endeavors the pros and cons of different ore beneficiation techniques used in the recovery gold associated with copper.

16. Petrography and Diagenetic Environment of Disang—Barail Transitional Sediments in Parts of Kohima Synclinorium, Nagaland

N. Pandey*, S. K. Srivastava, and Rokokhono Nakhro****

*****Department of Earth Science, Assam University,
Silchar-788 011
**Department of Geology, Nagaland University,
Kohima-797 002

The lithologic characteristics in parts of the Kohima Synclinorium is unique in that, it neither matches with the argillaceous Disang Group of rocks (Upper Cretaceous to Eocene) nor the arenaceous Barails (Oligocene); rather a perfect blend of the two lithologies. Except for a little variation in grain – size, the gross mineralogical composition of different litho-types remains almost same. The sandstone composition varies between quartz wacke & lithic greywacke, the principal framework constituents being quartz, rock fragments, feldspars and mica. Heavy minerals, on an average, constitute 1.2% of the total framework grains. The DBTS seems to have suffered both an early as well as late stage diagenetic changes. Devitrification of volcanic glass leading to development of chert like microcrystalline aggregates, growth of chalcedonic spherulites, and alteration of glass into silica and clay minerals further suggests continuance of diagenetic processes in a sealed environment.

17. Response of the Lower Atmosphere to the Total Solar Eclipse of January 15, 2010

S. Eswaraiah[1], M. Venkat Ratnam[2] and S. Vijaya Bhaskar Rao[1]

[1]Department of Physics,
Sri Venkateswara University, Tirupati
[2]National Atmospheric Research Laboratory (NARL),
Department of Space, Gadanki

Keywords *: MST Radar, Solar Eclipse January15, 2010, Gravity waves.*

High frequency gravity waves induced during a solar eclipse are studied using Indian MST Radar and GPS Radiosonde in TLS region over Gadanki (13.5^{o}N, 79.2^{o}E). We have noticed appreciable change in the wave activity on the eclipse day. The findings are briefly as follows: as eclipse creates gradients in temperature field due to water vapour cooling in lower atmosphere, which causes the large variations in background wind field, thus on 15th Jan the disturbance in fluctuation wind field is clearly observed during the maximum obscuration and a phase change after the cessation of eclipse is clearly noticed. Fourier analysis of wind field fluctuation on 15th Jan, shown that 2-4 hrs dominant period gravity waves are induced on 15th Jan and existed on next day also between 9-13 km, whereas on 14th and 16th Jan 20 min to 1hr periodicities are noticed at and around 14 km.

18. A Study of the Onset Date of North East Monsoon Over Southern Peninsular India

Charlotte[1] Gibies[2] and Suguna Yesodharan[1]

1 Cochin University of Science and Technology,
Kochi-682 022,
2Indian Institute of Tropical Meteorology, Pashan,
Pune-411 008

Keywords *: North East Monsoon, onset, zonal wind, area average, deviation, seasonal mean rainfall and coastal onset.*

A precise date of onset of northeast monsoon is calculated from the area average of rainfall and zonal wind obtained during the post monsoon season over the southern peninsular India. Verification and validation of the onset date of northeast monsoon rainfall is done by calculating the deviation from the date of NE monsoon onset over coastal Tamil Nadu determined by Raj (1992) for the years up to 1990 and that calculated by IMD for the years after 1990 up to 2003.

Date of area average onset, in this study, is defined as the first day on which the daily mean rainfall of north east monsoon (DRNM) amount greater than the climatological mean rainfall of north east monsoon (CRNM) and the area average

zonal wind is Easterly. The onset date using area average method is determined for years from 1960 to 2003. The daily data of rainfall and 850hPa zonal wind are utilised for this study. The onset date determined by this method is compared with date of onset of northeast monsoon at coastal Tamil Nadu determined by Raj (1992) for years up to 1990 and with IMD's onset announcement for years from 1991 to 2003.

Most of the years have the northeast monsoon onset on or before October 27. Only a few years have monsoon onset dates in November and they are 1974, 1984, 1988 and 1992. Nine years have exactly the same date for area average as well as coastal onset. Fifteen years fall within the limit of one day deviation. Thirty six years have the deviation within the limit of seven days. Only seven years, out of forty three years, have deviation beyond seven days. The years 1963, 1974 and 2000 have late area average onset date and 1969, 1976, 1981 and 1984 have early area average onset o rainfall. The years 1969 and 1976 give very strong northeast monsoon with the advantage of early onset date. These years have area average onset date 6th and 7th of October respectively, but it take 8 more days to onset rainfall over coastal Tamilnadu.

19. Signatures of MJO and Planetary Oscillations in the Troposphere and Stratosphere Region Using Cosmic Temperature Data

G. N. Madhavi[1], P. Kishore[2] and S.Vijaya Bhaskara Rao[1]

[1]Department of Physics, S. V. University,
Tirupati-517 502
[2]Research Scientist, Dept.of Earth System Science,
University of California, USA

Keywords *: COSMIC, Madden-Julian Oscillation (MJO), Temperature, Water vapour.*

In this paper we present the global temperature morphology using COSMIC data sets between 10 and 60 km and compared with different satellite and model/ reanalysis data sets. The Madden-Julian Oscillation (MJO), is one of the most dominant phenomena in the tropical region. We have noticed from the results that the eastward convective system affects not only the temperature and wind fields but also the humidity filed in the troposphere and lower stratosphere region. We

have investigated space-time variations of tropical upper tropospheric water vapor and cirrus clouds associated with the ISO, such as the MJO, using temperature (COSMIC), water vapor (AURA_MLS), winds (JRA-25), cloud structures (CALIPSO) and Outgoing long wave radiation (OLR).

20. Spatial and Temporal Variation of Groundwater Quality in Vamanapuram River Basin, South Kerala, India

Veena M. Nair and R. B. Binoj Kumar

Department of Geology,
University of Kerala, Thiruvananthapuram

Keywords *: Spatial and temporal variation, groundwater quality, Vamanapuram river basin.*

The earth is a multi-layered treasure trove of precious natural resources, including metals, minerals, oil etc. Of them all, groundwater is the life-line resource, indispensable not just for mankind, but also for the earth's flora and fauna. Due to its multiple benefits and the problems created by its immoderation, shortages and quality deterioration, water as a resource requires special attention. The importance of groundwater for the existence of human society cannot be overemphasized. Groundwater is a major source of drinking in both urban and rural areas. Demand for hygienic water increases continually in line with world population growth. Vamanapuram River Basin is taken as the present study area. The Vamanapuram watershed is spread over the districts of Thiruvananthapuram and Kollam of Kerala State. The total length of the main channel is 88 km and the total area of the river basin is 687 Km^2. The river basin shows varied conditions from the upper to the lower reaches in terms of natural as well as anthropogenic impacts.

To evaluate the groundwater quality 104 open well water samples were collected during both pre and post monsoon seasons. Samples were analyzed for different physico-chemical parameters such as pH, EC,TDS, salinity, Na^+, K^+, TH, Ca^{2+}, Mg^{2+}, Cl^-, NO_3^-, SO_4^{2-}, PO_4^{3-} and HCO_3^- following standard procedures. The acquired values were compared with BIS standards to recognize its aptness for domestic use. Thematic maps were prepared using Arc GIS. From the analytical data it was learnt that 88 and 92% of the samples in the pre and post monsoon

seasons respectively are outside the recommended limits of pH for human consumption. The concentration of all chemical parameters increases from inland towards coastal region in both the seasons. Concentration of Na, Ca, Mg and Cl during pre-monsoon exceeds BIS limit along coastal areas.TDS values along the coastal region of Anchuthengu shows a sporadic increase during pre-monsoon relative to post-monsoon. Nitrate and phosphate values show erratic increase (0-37 ppm) at few places indicating anthropogenic input in post monsoon where as the values are within limits in the pre-monsoon season. The places where soaring concentration of NO_3, SO_4^- and PO_4^{3-} during post monsoon can be attributed to anthropogenic sources, chiefly leakage from drainage pits especially along the coastal regions. Consumption of this open well water may lead to health problems such as stomach disorders and diarrhea. Hence espousal of an effectual water management tactics is an imperative need for this region.

21. Detection and Mapping of Gas Escape Features (Pockmarks) Employing Multibeam Echosounder Data and GIS—ACase Study from the Central Western Continental Margin of India

***Sumanta Dandapath and Bishwajit Chakraborty**

National Institute of Oceanography (CSIR),
Dona Paula,
Goa-403 004
*E-mail : sdandapath@gmail.com

Keywords : *Gas escape features, Seafloor geomorphology, Pockmarks, Multibeam. bathymetry, Backscatter, GIS, WCMI, Arabian Sea.*

Seafloor bathymetry and backscatter data from ~100 km2 area of central western continental margin of India (water depth 150 – 330 m) was collected onboard employing high frequency (95 kHz) multibeam sonar. Tens of circular to elongated pockmarks (gas escape feature with negative relief) was detected based on contour pattern (bathymetry) and variation of backscatter strength. These pockmarks are medium sized (avg. diameter: 120 m ±41, vertical relief: 0.7 – 5.0 m) and characterized by higher relief vs. diameter ratio (1:73 ±29) than usually observed worldwide. They are probably originated due to along fault migration and escaping of gas from the deeper sources, and later modified by combined effects of bottom currents and submarine slumping.

22. Alpha Radiations in Spring and Ground-Water of Shillong

D. Walia[2], A.Saxena[1], Y. Sharma[1], P. Wahlang[2] and D. Maibam[1]

[1] Department of Physics, [2] Department of Environmental Studies,
North Eastern Hill University, Shillong
Email : deveshwa@gmail.com

The main source of alpha radiations through water is due to the presence of radon/thoron. The radon (^{222}Rn) which is a daughter product of ^{226}Ra emanates through the litho types and moves along the porous and permeable zones after radon recoil. Radon atoms entering the pore space are transported by diffusion and advection until they decay or are released. Radon generated in rock and soil matrix diffuses through the underground geological strata into subsurface water. Due to the lithostatic pressure the radon remains soluble in water and emanates when underground water flows out on the surface. The worldwide average annual mean effective dose by radon in water is 0.45 $mSv.y^{-1}$. The Shillong agglomeration is part of the Shillong plateau, which is a composite cratonic block and has numerous tectonic elements providing conduits to the surface. Such conduit enhances the possibility of sub-surface radon to reach to the surface. Hence, the radon concentration in underground water is studied in this physiographically uneven, seismically sensitive and geodynamically restless block so as to determine the potential health hazard and linkages with the seismicity in the region.

The high radon concentration in drinking water may pose potential health risks to humans due to exposure through inhalation and ingestion; as radon decays into Polonium, which may stick to the inner walls of respiratory and/or digestive systems.

23. Morphodynamics of Delhi Region

Baleshwar Thakur

Former Professor of Geography,
University of Delhi, Delhi

The study deals with the evolution and structure of morphology of Delhi region in relation to their controlling processes comprising tri-junction of Aravalli

ridge, Yamuna floodplains and approaching deserts. The study region is located at the intersection of Punjab-Haryana Plain, Upper Ganga Plain and Rajasthan Plain. It aims to: (1) investigate the nature of seismicity and its impact on the region, (2) classify and analyze the morpho-units of the region, (3) analyze the morphometric characteristics and with reference to spatio-temporal characteristics of floods, (4) classify and identify characteristics of floodplains of the Yamuna river, and (e) study the impact of falling groundwater level in the State.

The study area comprises of Delhi State, parts of Bagpat tehsil, Ghaziabad tehsil, Sonepat, Rohtak, and Jhajjar tehsil, parts of Gurgaon, and Ballabhgarh tehsil, and parts of Faridabad district. Physically, part of the area is monotonous alluvial plain and another part is diverse and complex. The study uses variety of secondary data sources including Geological Map, Topographical Sheet, Satellite Imageries, Aerial Photos, Seismological Atlas, Central Ground Water Board, Central Water Commission, Indian Meteorological Department, Administrative Atlas of Delhi and Geological Survey of India. Both statistical and cartographic techniques are used to arrive at conclusions. The study reveals control of the lithology and structure of two physical units- the Aravalli hills to the west and the river Yamuna to the east. The region is highly vulnerable to disaster, especially floods, earthquake and lowering of groundwater level. The floodplains of the Yamuna river are classified into: Old floodplain, New floodplain and low-lying area; while the bedrock is classified into : Aravalli ridge, the Piedmont plains and undulating to level plains of the Aravalli alluvium.

24. 3D City Modelling and Its Application Using Lidar Technology

Sheena A. D.
M.E Geomatics (II yr. Student),
Anna University,
Chennai

Keywords *: 3D, City model, Visualization, Infrastructure, Disaster Management.*

In this growing phase of urbanization and industrialization there is an emergent need of proper city planning systems. **3D city models** are digital

representations of the Earth's surface and related objects belonging to urban areas. **3D city models** are real world representation useful in 3D visualization, planning the city in Infrastructure development, Information system for tourism, Intelligent transportation systems, Environmental aspects, Disaster Management, public rescue operations, real estate market, utility management, Military operations, Training of officers, Simulation of new buildings, Updating and keeping cadastral data, change detection and virtual reality. LiDAR data (Light Detection and Ranging) is a relatively new technology for obtaining the earth's surface objects. This data when combined with digital orthophotos can be used to create highly detailed Digital Surface Models (DSMs) and eventually Digital 3D City Models. Research in 3D GIS helps to analyse the real world and the related issues using high quality 3D simulations towards sustainable infrastructure.

25. Investigation of Natural Resources in and Around Thoothukudi District, Tamil Nadu, India Using Geo Spatial Technology

A. Sathiayseelan, P. Alaguraja, M. Rajesh, A. Thirunavuakkarasu. A, and M. Manivel

1. Department of Geology, Bharathidasan University, Tiruchirappalli-24
Corresponding author:sathya.seelan28@gmail.com

Natural resource are finite implies increasing population is putting tremendous pressure on the natural resource by intensive use of land and depletion and degradation of its natural resource such as mineral, water, fuel and energy, at much faster rate to meet the ever increasing demands. Resources degradation through erosion of valuable layer of the earth surface, changes in flow regimes of rivers and other phenomena are frequently worst events faced by the present day world. The prime aim of the study is to develop the Natural resource information system of Thoothukkudi district in the form of customization with user friendly.The main objective of the study is to generate the digital thematic maps of Thoothukkudi district using remote sensing. To generate and collect the natural resource information.The Study area of Thoothukkudi district is situated in the extreme south-eastern corner of Tamilnadu state and bounded on the north by the districts of Tirunelveli, Virudhunagar and Ramanathapuram, on the east and south-east by Gulf of Manner and on the west and South-west by the district of

Tirunelveli are shown in the Total area of this district is 4621 sq. kms. Its extent longitude $78^0$40’33’’E to$78^0$23’15’’E and latitude is $8^0$19’8’’N to $9^0$22’46’’N. The study area covering the topographic sheet no 58-H: 9,13,14,15, 58-K: 3, 4, 7, 8, 58-L: 1/ 2 / 3/ 5. The study area covers three revenue divisions, eight taluks, twelve blocks and 468 revenue villages. The survey of India topographic data of the Thoothukkudi district was wrapped with Landsat TM data. The image was registered with the help of ERDAS IMAGINE software version 8.7.then, geo referenced. Using Digital image processing techniques the classification option for classified the image and interpretation was done and prepared various thematic data bases. Then the maps is digitized using ARCGIS 9.3 version which gives shape files and saved in .mxd format. The other secondary data were used for generation of various spatial parameters. The development and assessment of geology, geomorphology, and natural resources need précised maps. We can query directly from maps and can display the results based on queries. Natural resource information system, It furnished the maps of resource information of areas are considered to display the outputs by clicking on the respective areas of the map. This research has produced digital maps, implement using ArcGIS. It creates for giving information about natural resource information according to the need of the user, the decision maker, who has a great part in the improvement of the natural resource information system of Thoothukkudi district with query based. This system also provides updating the resource data and decision support of the study area, so that any planning and developmental activities will be easier in future.

26. Present Day Crustal Deformation in Indo-Myanmar Region Determined by Global Positioning System (GPS)

Laishram Sunil Singh

Department of Earth Sciences, Manipur University,
Canchipur, Imphal, Manipur
E-mail : linus2k@gmail.com

Keywords *: GPS measurement, Plate deformation, Velocity, CMT, aseismic motion.*

Using a regional GPS data set (2004-2010) from Indo-Myanmar Region and spanning 7 years, we update the present-day crustal deformation between the

Indian and Myanmar plates. The velocity estimates with reference to Indian plate suggest that the sites located east of Imphal valley moving faster than those in the west. This suggest that the increase in velocity in eastward direction is sudden, rather being gradual. A gradual increase in velocity will indicate strain accumulation, whereas, the sudden increase, like a "jump" will indicate aseismic motion across the boundary. Thus we suggest that at present aseismic motion is occurring along this boundary.

27. Geomorphological Study of Bhatwari-Sainj Area District Uttarkashi, Garhwal Himalaya Uttarakhand

N. P. Naithani and Mala Bhatt

Deptt. of Geology
H.N.B. Garhwal University Campus Badshahithaul,
Tehri Garhwal-249 199
E-mail : naithaninp@rediffmail.com

Keywords : *Himalayan Geology, Main central thrust, Geomorphology, Lineaments, Hot springs Uttarkashi, Drainage pattern, Structure.*

The Investigated area lies in lesser and central Himalayan part of Garhwal Himalaya in Uttarkashi District. Geologically the rocks of lesser Himalaya separated from central Himalaya. by main central thrust which passes near Sainj i.e 20 km from Uttarkashi along Uttarkashi Gangotri highway. The rocks of lesser Himalaya represented by Garhwal group comprises of quartzites, epidiorites and talc chlorite schist etc while central Himalaya represented by central crystalline comprises of schists, gneisses and various type of migmatites. Attempt here been made to study various geomorphological features structures and lithotectonic setup which control the landforms. Attempt also been made to study the lineaments and hot springs of the area.

28. Morphometric Analysis of Sarabanga Basin for Sustainable Water Resource Management Salem District, Tamil Nadu, Indal, Using Remote sensing and GIS Techniques

P. Alaguraja , M. Rajesh, Subburaj and M. Manivel

1. Department of Geology, Bharathidasan University, Tiruchirappalli-24
2. Central Groundwater Water Board, Chennai

Corresponding author:alagugis@gmail.com

Water is a precious natural resource, without which there would be no life on Earth. We, ourselves, are composed of two-thirds water by body weight. Our everyday lives depend on the availability of inexpensive, clean water and safe ways to dispose of it after use. As a source of water, groundwater obtained from beneath the Earth's surface is often cheaper, more convenient and less vulnerable to pollution than surface water. The present study of investigation has set the following as it aim.To delineate drainage morphometric characteristic (Linear and Aerial) carried out from the SOI sheets.To study morphometric characteristic of concern sub-watershed. To integrate the thematic maps through the GIS software ArcGIS.Methodology adopted for achieving the above mentioned goal is summarized in. There are three major components in the study viz. a) Field data collection include geological mapping; b) Meteorological data collection from Public Work Division (PWD); c) Remote sensing study through Landsat ETM satellite imagery and SRTM data.The Landsat ETM and SRTM satellite image was geometrically rectified with respect to the Survey of India (SOI) topographical maps on 1; 50,000 scale using ERDAS IMAGINE 8.7 software. The drainage pattern was initially derived from SOI toposheets and later updated using linearly stretched False Colour Composite (FCC) of Landsat ETM satellite data. Some of the first order drainages were updated from satellite data. The drainage pattern for delineated sub-watersheds was exported in Arc GIS 9.3 software for morphometric analysis. *The parameters computed include stream length, bifurcation ratio, drainage density, stream frequency basin shape, form factor, circularity ratio and elongation ratio (strahler, 1964). The information about* area, perimeter, stream length and number of stream was obtained from the sub-watershed layer and basin length was

calculated from stream length. All these studies are integrated in GIS environment and morphometric investigation. Water resource is utmost important to the human life and their environment. In the view of and developmental of activities is form in the water source. The present study deal morphological studies of the Sarabanga upper watershed, Salem Districts in the sector. The rivers or basin or nadi is drain to concentrate for their extension of the development planning. The study area "Sarabanga upper basin" falls within River Sarabanga originates from the Shevaroys and flows in the northwestern and western parts of Salem district and joins with the Cauvery near Komarapalayam town. The area is bounded within latitudes $11^0$30'00''N - 12^0 00'00''N and Longitudes 77^0 50'00''E – $78^0$10'00''E. The area covered by Survey of India Topo maps No. 58I/1, 58I/2, 58E/10, 58E/11, 58E/13, 58E/14 of scale 1:50,000. The total aerial extent of the study area is 1215 Sq.km.Based on the morphometric anlaysis the subbasin can be easily managed in flood period, because the subbasins are in elongated forms. These are due to highly weathered and minimum structured disturbances. Except Muthunaickenpatty and part of Kadayampatty subbasin all other basin and having vegetative cover and settlements. More checkdams may be constructed to store the precipitated water, for the use of agriculture, settlement and for high yield of groundwater potentials even in dry area.

29. Study of Landscape Metrics Along Indo-Myanyar Ranges Using Multi-Temporal Satellite Imageries

R. K. Chingkhei

Department of Earth Sciences,
Manipur University, Imphal, Manipur, Pin-795003
Email : chingkhei@gmail.com

Keywords *: Landscape Metrics, Indo-Myanmar Ranges, Fragstat, GIS.*

The present study deals with the quantification of landscape structure and temporal changes along the Indo-Myanmar Ranges using the landscape metrics. Altogether five classes have been identified and corresponding landscape metrics have been generated from the satellite imageries of 1977, 1988, 1998 and 2008 at Patch, Class and Landscape level using Erdas Imagine and FRAGSTAT. Finally,

an overlay analysis of the landscape has been performed using 1977 and 2008 data to study the temporal changes among the classes for the last 30 years using ARCGIS software. The result indicates a decrease in the mixed dense forest and mixed moderately dense forest while there is an increasing trend in the non-forest, open forest and shifting cultivation.

30. Health Effects of Suspended Particulate Matter : A Case Study

Bindu. G
Senior Research Associate
Department of Atmospheric Sciences,
Cochin University of Sci.& Tech.,
Cochin-16

Keywords *: SPM- PM10- Health impact.*

Kochi is a metro city in Kerala and its ambient air quality is being deteriorated day by day. Rapid increase in the number of vehicles, unplanned urbanization, enhanced potential for industrialization and uncontrolled growth of construction activities have taken the problem to a threatening dimension. Of the criteria pollutants, Suspended Particulate Matter (SPM) is the recent focus of the world community as it penetrates the respiratory systems of human beings and cause many disorders. There are mainly two categories of particulate matter that causes health effects: PM10 is the group including size smaller than 10 μm and PM2.5 are particles smaller than 2.5μm. Evidences indicate that children's health is more vulnerable to air pollution problems due to the ongoing process of lung growth and development, incomplete metabolic systems, immature host defenses and higher rates of infection by respiratory pathogens. Furthermore activity patterns specific to children can lead to higher exposure to air pollutions and higher doses of pollutants reaching the lungs. The PM10 can pass through the natural protective mechanism of human respiratory system and plays an important role in genesis and augmentation of allergic disorders. The goal of this work is to undertake a study on the status of air pollution of Kochi covering a 500 square kilometer grid and the impacts of air pollution on health of children under 15 years. Health data from Public Health Centres (PHCs) are considered as the starting point for identifying

linkage between ambient air quality levels and chronic or acute health problems. We focused on the ARI (Acute Respiratory Illness) in children in the study area. In order to assess the air pollution status of the study area both primary and secondary data of SPM are collected. Secondary data is collected from Kerala State Pollution Control Board and primary data is collected from sensitive areas within the study area, using a handy Hi.Volume sampler. Both the data are analyzed for inference. There are certain grids which show more incidence of ARI, which is evidently related higher concentration of SPM.

31. GIS Assessment of Evapotranspiration of Small Watersheds in Manipur

Th. Nixon Singh
Department of Earth Sciences,
Manipur University Imphal 795003
nixonsingh@gmail.com

Keywords *: Evapotranspiration, Blaney-Criddle, Crop coefficient, Arc GIS.*

Soil map, land use map and time series of monthly temperature were used in ArcGIS with SCS Blaney-Criddle equation to estimate spatially distributed evapotranspiration for Waikhulok watershed. The crop coefficient (Kc) information has been added to the land use shape files and the spatial distribution information of Kc was obtained by converting the crop coefficient shape file into a grid theme. Grid data were obtained for each climatic parameter from point shape file using spatial extension. Using Map Calculator the evapotranspiration in each month is calculated and a series of grid themes are generated. Thus information of evapotranspiration is visually obtained.

32. The North-East School Earthquake Laboratory Programme (NESELP)

W. Arunkumar Singh
SRF, Seismological Observatory
Department of Earth Sciences
Manipur University, Imphal

Keywords *: NESELP, Earthquake, Digital Seismographs.*

The North-East School Earthquake Laboratory Programme (NESELP) is one of the important Mission Mode Project of Ministry of Earth Sciences, Government of India. The project emphasizes developing the measurement skills among school children and passing the knowledge through them to the community at large. The program has multifold objectives with indirect emphasis on earthquake recording, analysis and management of seismic stations at selected schools in earthquake prone areas. This program is implemented by Department of Earth Sciences, Manipur University.The main objectives are to provide a platform for interactive learning through scientific understanding of earthquakes for school children and teachers. The installation of Digital Seismographs (Single component and Triaxial) in schools of Northeast Region of India. This will help the students and teachers in attaining conceptual development in earthquake science. The data recorded by the schools can be used as an additional input for further research in the field of seismology in this seismologically active region.

33. Convectively Generated Gravity Wave Characteristics and Source Mechanisms During Thunderstorm and Squall-Line Events over Gadanki

Arunachalam. M. S and S. Vijaya Bhaskara Rao

Department of Physics,
Sri Venkateswara University, Tirupati-517 502

Keywords *: Gravity wave, convection, thunderstorm, squall-line.*

In the current study we have studied source mechanisms for the convectively generated short period gravity waves (CGWs) through continuous observation of MST Radar, ERA-Interim Reanalysis, NCEP OLR and MTSAT-1R TBB Datasets during convection events due to the passage of thunderstorm and squall-line over Gadanki during 27-30 September 2004. The vertical wavelengths calculated using winds and temperature and Brunt-Vaisala frequency from temperature profiles for the entire period reveals the thermal forcing mechanism. Short period GWs observed using wavelet analysis provides the evidence for mechanical oscillator mechanism. Periodicity of the waves generated during the three phases of convective systems viz., initial, mature and dissipative are found to be different.

34. Morphometric Analysis of Imphal River Basin

Sh. Ashalata Sharma

Email:asha.ichan@gmail.com
Department of Earth Sciences,
Manipur University
Canchipur-795003,
Manipur

Keywords *: Morphometric Analysis, Imphal River Basin, GIS.*

GIS and image processing techniques were adopted to identify the morphological features and to analyse their properties. The linear, aerial and relief aspects of the river basin were determined and computed. The results indicated that the drainage area is 339 $km^{2,}$ perimeter 110.4Km, basin length 38.99Km, form factor 0.22, circulatory ratio 0.35, drainage texture 10.290, constant of channel maintenance 0.35. The stream frequency, drainage density, Bifurcation ratio and length of overland flow are respectively 3.35km/ km^2, 2.84km/$km^{2,}$ 4.116 and 0.18Km. The drainage density and circularity ratio value indicate that the basin has a gentle slope, low rainfall, strongly elongated and highly permeable homogenous geologic materials

35. Effect of Humidity on Aerosol Optical Depth Over NE India : In Search of Source Identification

B. Choudhury, M. Devi[a] and A. K. Barbara

Department of Physics, Gauhati University,
Guwahati 781014 Assam
[a]E-mail : md555@sify.com

This paper addresses the problem on identifying sources of aerosol at NE part of India by measuring its optical property through Lidar at Gauhati University, relevant satellite data and meteorological variabilities from ground based and radiosonde operations over and near Guwahati. The analysis covers aerosol optical depth (AOD) and humidity for a macroscopic understanding between these two

parameters through satellite images of AOD at 550 nm from Moderate Resolution Imaging Spectroradiometer (MODIS), while for microscopic view of the association between aerosol and cloud LIDAR data of Gauhati University are used. The observations point to the fact that a strong seasonal variations on aerosol optical parameters do exist with maximum in vernal equinoxial months of February to April and minimum during Autumnal months. Thus the vernal months are taken as special cases of study for source identification of aerosol. It is seen from LIDAR that low lying rain bearing cloud can modify aerosol extinction by 30-40% and similarly satellite AOD shows that this parameter may also get modified by 50 to 60% for changes of humidity from the driest to wet condition prevailing during this season of the year. These associations are examined with wind direction and rain rate conditions obtained from IMD and TRMM to identify local and remote sources leading to apparent high influx of aerosol. The track of aerosol is thus taken as an input for identifying its sources at other seasons of the year.

36. Improved Hypocentral Locations Integrating the NESELP Phase Data

W. Shiritikumar Singh
Project Assistant
Seismological Observatory
Department of Earth Sciences
Manipur University, Imphal

Keywords *: Hypocentral Locations.*

Obtaining precise location of epicenters is vital to earthquake studies. During the last decade, earthquake detection capabilities have been significantly improved due to expansion and upgradation of seismological network in the Northeast India. It is now possible to record the events down to Magnitude 1.5 due to better detection capabilities. However the total numbers of seismographs installed in the NE India is not sufficient for precise location of the epicenters due to poor azimuthal coverage. The Ministry of Earth Sciences, Government of India has started a Observatory Programme viz North-East School Earthquake Programme (NESELP) under the Mission Mode Project. The aim of the project is to equip 60 representative schools in the Northeast India with low cost earthquake monitoring

systems to create newer capabilities in capturing and analyzing earthquake related information. In the present study few selected earthquakes are analysed integrating the NESELP phase data. As the azimuthal coverage is improved with additional phase data, the standard errors are highly reduced. The uncertainties in locating the hypocenters tuned down to RMS 0.02,; ERLT and ERLN 0.1 and ERZ to 0.5.

37. Crustal Deformation Monitoring of Mishmi Block, Arunachal Pradesh, Using Global Positioning System (GPS)

M. Devachandra Singh

Department of Earth Sciences, Manipur University,
Canchipur, Imphal, Manipur
e-mail : joydev55@gmail.com

Keywords *: Mishmi block, Himalayan ranges, GPS, velocity.*

The permanent GPS station at Anini, Mishmi block shows the Eastern Himlayan belt and Indo Myanmar Arc are linked with the presence of Mishmi suture. The ongoing deformation tectonics of both the belts is controlled by the presence of the Mishmi suture zone. The sharp twisting of the Himalayan ranges as they turn from a southeasterly to a southerly direction and descend rapidly to China and Myanmar. The Mishmi block moves at the rate of 20.1344 mm/yr and 42.18^0 N azimuths which seems to be quite different with the deformation rates of Himalayan belt.

38. Impact of Seasonal Landslides Along National Highway 39 of Manipur

Th. Dolendro Singh

dolenkhuman@gmail.com
Department of Earth Sciences,
Manipur University, Imphal, Manipur

Keywords *: Seasonal Landslides, Hazards, DEM, GIS, fault Deformeter.*

Landslide is one of the most frequently occurring natural hazards in Manipur which is a tectonically active area. The seasonal landslides are studied

along NH-39 to find out their impact and causes, though the landslides in this highway are usually shallow slips in nature and the volume of slip mass is not very large, the impact is quite serious due to frequent occurrences and is increasing as compared to the recent past. Several landslides had occurred in different parts of the State in 2010. In a similar way during July 2010, about nine landslides have been reported between Maram and Mao of NH-39, which block the Highway for few days.

39. Rock–magnetic Properties of Sediments from the Mandovi and Zuari Estuaries of Goa

R. Sivakumar*, Pratima M. Kessarkar, R. Shynu** and V. Purnachandra Rao****

*Presidency college (Autonomous) Chennai.
**National Institute of Oceanography,
Dona Paula-403 004, Goa.

Keywords : *Rock–Magnetic Properties, Sediments, Estuaries, Goa*

Environmental magnetism involves the application of rock and mineral magnetic techniques to situations in which the transport, deposition, or transformation of magnetic grains is influenced by environmental processes in the atmosphere, hydrosphere, and lithosphere. Environmental magnetism is capable of providing important data for studies of global environmental change, climatic processes, and the impact of humans on the environment, all of which are major research initiatives in the international scientific community. Thus an attempt has been made to study the rock magnetic properties of the estuarine sediments of the Mandovi and Zuari Rivers, Goa. Mining activities occur along the river points of the Mandovi and Zuari Rivers. Two-third of the mining activity is located in the Mandovi basin. Fe-Mn ores brought from the mines of Goa are transported to the shore, stored and heaped at these points of the rivers, and then loaded on to barges to load these ore deposits onto bigger ships in the offshore for export. These loading points are more along the Mandovi River than in the Zuari River. The influence of the export of Fe-Mn ore transport can be identified using rock-magnetic parameters of the sediments. The Mandovi River is ~75 km long with a drainage basin of ~1,895 km^2. The width of the river at the mouth (in the Bay) is ~4 km, and the

average depth is 5 m. The width of the main channel at its mouth is 3.2 km and gets progressively narrower (to 0.25 km) and shallower upstream. The River Zuari within the state of Goa is one of the dynamic tropical estuaries along the central west coast of India. It has been classified as tide-dominated coastal plain estuary. The rock magnetic studies were carried out for the sediment samples (10 each) collected along transect stations of the Mandovi and Zuari estuaries covering a distance of ~40 km from the river mouth. The rock magnetic properties of sediments from the Mandovi and Zuari estuaries of Goa thus indicate the relatively higher magnetic concentrations of Mandovi estuary sediment samples than that in Zuari estuary. The other magnetic concentration parameters $\div_{ARM}$ and SIRM also exhibit higher values in Mandovi than in Zuari estuary. Goethite is the main magnetic mineral in both the estuarine sediments.

40. Remote Sensing and Gis based Groundwater Prospects Study in Parts of Krishnawati River Basin, Southern Haryana

Anup Kumar and R. S. Hooda

Haryana Space Applications Centre
CCS Haryana Agricultural University Campus
Hisar-125004, Haryana
E-mail : anup0106@yahoo.com

Key words : *Remote Sensing, GIS, Krishnawati, Groundwater Prospects, Haryana*

Water is prime requirement for living being on earth. About 97% of the available water is saline and not suitable for direct use either in irrigation or in drinking purposes. In the present context of changing environmental conditions, climatic changes and other anthropogenic activities have put stress on the availability and quality of surface and groundwater water resources. In the arid to semi-arid parts of the world, the groundwater is the main source for all purposes and being under stress due to changes in climatic conditions, environmental factors and anthropogenic disturbances. The southern parts of Haryana have arid to semi-arid type of climate with water scarcity. The drainages are ephemeral and rainfall is the only source for recharging of groundwater. Krishnawati, Dohan and Sahibi are the major ephemeral rivers in the region. The Krishnawati River originates from the hills in Sikar district

of Rajasthan State. As the lower part of the river basin falls in the Haryana state and embankments have been made by the Rajasthan Government in upper parts of the basin, the middle and lower parts of the basin are facing the acute problem of groundwater declining in recent years. As the agriculture of the region is mainly depend on rainfall and groundwater, it is necessary to assess the groundwater potentiality and quality in the basin so that proper development, planning and management options can be taken for sustainable agriculture and drinking water in the basin. The study area Krishnawati river basin is located between the latitude $27^0$47'52" N to $28^0$17'14 N and longitude $75^0$59'09" E to $76^0$25'21" E. The basin falls in the Survey of India Toposheets No. 53D/ 3, 53D/4, 54A/1, 53D/7 and 53D/8 and covers 1075 sq. km. area. Geologically, the basin has rocks of Delhi Super group and Quaternary alluvium and blown sand. The utilities of satellite data and GIS techniques are well known. IRS P6 LISS III May 2006 satellite and ArcMap 9.3 GIS software have been used to study the groundwater prospects in the study area. Hydrogeomorphologically, the basin has alluvial plain, flood plain, palaeochannel, sand dunes, pediments, structural hills, denudational hills, residual hills and inselbergs. The alluvial plain, flood plain and palaeochannel have good to very good; pediments have moderate; sand dunes and hard rock units (structural, denudational, residual and inselberg) have poor groundwater prospects except the joints and fractures in the hard rocks. The study clearly depicts the groundwater potentiality in the basin which can strengthen by geophysical resistivity surveys. The study is highly useful in planning, development, management and sustainable development of groundwater resource in the basin.

41. Morphometric Analysis of Anaimaduvu sub-watershed in Salem District, Tamil Nadu using Remotesensing and Gis Approach

A. Panneer Selvam[1] S. Aruchamy[2]

1. Research scholar, 2. Professor-Department of Geography
Bharathidasan University
Tiruchirappalli-620 024 Tamil Nadu

Keywords : *Morphometric analysis, Drainage pattern Remote Sensing and GIS*

The present study is aimed to morphometric analysis of anaimaduvu river sub- watershed was carried out using remote sensing techniques. Detailed drainage map prepared from SOI toposheets scale on (1:50,000) and delineated using LANSAT and TM data. In this study all the drainage layers generated by using GIS (Arc GIS 9.3). The parameters worked out include Bifurcation ratio (Rb) stream length (Lu) form factor (Rc)Circulatory ratio (Rc) and drainage density. The result shows that the anaimaduvu watershed exhibit dendric to sub dentric drainage pattern with fine to moderate drainage texture. Stream orders ranges from higher order in first, second and third, lower order in fourth and fifth. Hence from the study it can be concluded the remote sensing is valuable tool in morphometric analysis for anaimaduvu sub- watershed.

42. Earthquake Awareness Programme for Schools

L. Kamal Kanta

Project Assistant
Seismological Observatory
Department of Earth Sciences
Manipur University, Imphal

Keywords : *Earthquake Awareness, Preparedness*

The earthquake occurrence is the most terrifying experience and can neither be prevented nor predicted at present. India has suffered due to a number of big earthquakes in the last two decades. To understand the natural process and minimize the damage due to earthquakes it is essential to aware the community about the earthquakes. In the framework of the Earthquake Safety and Preparedness Programme for Schools for the Northeastern region in India, the Department of Earth Sciences, Manipur University, Imphal is training the school teachers on Earthquake School Preparedness Programme. The training course is aimed for increasing the teacher’s capacities in conducting the preventive measures and emergency responses during earthquake disaster (preparedness), as well as reading the seismograms recorded in their schools. The programme also guides the teachers in developing a school action plan for Earthquake School Preparedness Programme. In order to create awareness amongst masses through

the school children, self-learning/instructional and mass awareness material on earthquake preparedness through monographs, posters, power point presentation and audiovisuals are prepared.

43. Recent Activities along the Chindwin River

Manichandra Sanoujam

Seismological Observatory
Department of Earth Sciences
Manipur University

Keywords : *Chindwin River, Seismotectonics, Central Mollase Basin*

Seismotectonics of the seven recent felt earthquakes, between 25.13°N - 20.15°N latitude in the Indo-Myanmar Subduction zone from August 2009 to March 2010 with magnitude ranging from 4.9 to 5.9 mb are examined here. The recent seismicity and fault plane solutions of these felt earthquakes suggest that all the events occurred along the known Chindwin River, a major tributary of Irrawady River. The part of Chindwin River taken for the study can be geologically mapped as curvilinear structure in the Central Mollase Basin. All the mechanism of the faults are found to be Thrust mechanism with a small component of Strike-slip mechanism. The compressive P-axis azimuth ranges from NNW-NNE suggesting the northward movement of Indian Plate. Frequent felt earthquakes originating from the Central Mollase Basin need close and continuous monitoring for future large events.

44. A Small Satellite of the University Srm : a Demonstrator for Atmospheric Studies

M. Loganathan[1] and Narayana Rao[2]

[1]roganathan@gmail.com, [2]profdnrao2001@yahoo.com
Directorate of Research and Virtual Education,
SRM Univeristy, Kanchipuram,
Tamil Nadu-603203

Keywords : *Nano-satellite, Technology demonstration, SRMSAT Space Systems. Atmospheric science payload, Greenhouse gas monitoring*

In recent years small satellites have proven great potential in scientific, communication and military applications. "**Opportunities space**" is the word for small satellite systems. Small satellite systems strive to indentify future technological advancement to make successful programs. The Indian Space Research Organization encourages the small satellite systems, designed and developed, by universities. SRMSAT is one such university satellite designed and developed by the undergraduate students, researchers and faculty of SRM University to monitor green house gases, namely CO_2 and H_2O. The satellite will be launched by PSLV to a LEO between 600-800 km altitudes.

45. Study of Forest Cover Changes in Manipur

Yumnam Nandini Devi

Department of Earth Sciences, Manipur University
Canchipur, Imphal,
Manipur
Email : yumnam78@yahoo.com

Keywords : *Forest cover assessment, Normalised Difference Vegetation Index.*

This paper mainly deals with the forest cover assessment of Manipur as well as the district wise for the last 11 years (1997 to 2007) using the ancillary data and satellite data using Normalised Difference Vegetation Index. The forest cover of Bishnupur, Churachandpur, Senapati, Tamenglong and Thoubal are increased but remaining districts are decreased. The forest cover of the state is 17,280 km^2 (2007) which was 17,418 km^2 (1997).During 11 years the state's forest cover is decreased by 138 km^2.This forests degradation is due to timber logging, firewood extraction, floriculture on the hill slopes and shifting cultivation. Hence, there is a need for immediate actions to check this trend.

46. Data Analysis for Greenhouse Gases Monitored using a Nanosatellite in Lower Earth Orbit

Guruditya Sinha[1], Rohit Pattnaik[2], D.Sri Balaji[3], Dilip Shukla[4], Anirudh Nath[5], Akshat Agarwal[6] and S. Neeraj[7]

[1, 2, 3, 7]Department of Electronics and Communication Engineering, SRM University

[4]Department of Instrumentation and Control Engineering, SRM University

[5]Department of Computer Science and Engineering, SRM University

[6]Department of Mechanical Engineering, SRM University

Faculty of Engineering and Technology,

SRM University,

Chennai, Tamil Nadu, India

[1]guruditya007@gmail.com,

[2]rohitpattnaik@gmail.com,

[3]mail2balaji1991@gmail.com,

[4]diljustchill@gmail.com,

[5]ace.anirudh@gmail.com,

[6]akshatagarwal91@gmail.com,

[7]neerajsenguttuvan@yahoo.com

Keywords : *SRMSAT, ISRO, Payload, Greenhouse Gases, Radiative Transfer*

The objective of SRMSAT is to monitor green house gases in Near Infrared region 900nm - 1700nm. A 10:30 am Polar Sun Synchronous orbit with altitude ranges from (650 - 800) km and inclination of 98^{o} is suitable for our payload operation. A grating spectrometer is employed for this purpose for a nadir-viewing spectrometer for the monitoring of Earth-based sources and sinks of anthropogenic and natural sources of greenhouse gases. Data is analyzed using SBDART (Santa Barbara DISORT Atmospheric Radiative Transfer) Atmospheric model designed for analysis of radiative transfer problems encountered in satellite remote sensing and atmospheric energy budget studies.

47. Prospects of Ground Water Recharging at the Iari Farm through Rainwater Harvesting

P. Mookerjee, R. V. Singh and M. S. Sachdev

Nuclear Research Laboratory, IARI,
New Delhi-110012

Keywords : *Ground water, water harvesting, artificial recharge, IARI, New Delhi*

Analysis of the rainfall data of IARI for the year 2009 revealed that although the annual rainfall was 20% less than the average, there was vast scope for harvesting excess runoff generated in the farm area during the month of August and September. Study of the rainfall characteristics of the last 35 years (1976 – 2010), reveal, almost equal number of years with above and below normal, annual rains. Looking however, into the single day events, scope for conservation of the excess always remain. A contour map was drawn to work out general slope to identify locations for artificial recharge ponds. Ground water quality of the farm area was mapped to ascertain, recharging is not done in pockets with saline water. However, Water samples collected from 24 tube wells revealed EC ranging from 1.125 to 3.92 dSm^{-1}. Water table shifts were monitored to work out water balance. Two locations in the main block, MB6 and MB9 were identified for rainwater harvesting which also had access to four drainage channels. It was stressed that at least one of these fields be converted into an artificial recharge pond which would help enhancing of the ground water potentials in this region.

48. Intriguing aspects of Monsoon Low Level Jet over Peninsular India Revealed by High-resolution GPS Radiosonde Observations

M. Roja Raman[1], M. Venkat Ratnam[2], M. Rajeevan[2], V.V.M. Jagannadha Rao[3] and S. Vijaya Bhaskara Rao[1]

[1]Department of Physics,
Sri Venkateswara University, Tirupati
[2]National Atmospheric Research Laboratory (NARL),
Gadanki, Tirupati
[3]S.R.R.S. Govt. Polytechnic, Sircilla

Keywords : *Indian Summer Monsoon, Monsoon Low Level Jet, GPS Radiosonde, Re-analysis data*

The strong cross equatorial flow in the lower troposphere, widely known as the Monsoon Low Level Jet (MLLJ) plays an important role on the Indian Summer Monsoon (ISM) rainfall during June to September. Using high-resolution GPS radiosonde observations over Gadanki (13.5^{o}N, 79.2^{o}E), three important aspects of MLLJ have been reported. First, a new definition of MLLJ is proposed along with the statistics of its occurrence. Second, the MLLJ is found to exist at 710 hPa over southeast peninsular India unlike reported earlier at 850 hPa. Third, the ERA-Interim data show near realistic features of MLLJ characteristics compared to the NCEP/NCAR re-analysis data.

49. Ground Penetrating Radar Study of Punem Lake

Sinam Reema Chanu
Department of Earth Sciences,
Manipur University,
Imphal-795003
Email : reemasinam@gmail.com

Keywords : *GPR, Punem Lake, Sediment, Bathymetry, Surfer.*

GPR was used to profile the depth of Punem Lake and establish the bathymetric map. 100 MHz RTA was chosen as a balance between fine resolution and deep penetration. The water depth was mapped throughout the lake. Bathymetric map was generated with Surfer from the coordinate and depth profiles extracted from RadExplorer. It was demonstrated that GPR can be used to produce high quality sub-bottom profiles showing sediment type and lacustrine sediment thickness. Variations in the lake bottom characteristics could be identified. Since the lake is shallow, sediment is usually less than 3m with the thickest reaching 3.1m.

50. Extent and Genesis of Fluoride in Ground Water in Parts of Birbhum District, West Bengal

Ajay Bhattacharya[1] and S. K. Nag[2]

[1]Panchayet and Rural Development,
Govt. of West Bengal
[2] Department of Geological Sciences, Jadavpur University,
Kolkata-700032

Keywords : *Fluoride, Ground water, Rajmahal Trap, Basalt, Intertrappean, Birbhum, West Bengal.*

Fluorine is one of the most abundant elements of the Earth but its compound, Fluoride, when consumed in excess (maximum permissible limit 1.5 mg/litre) by human being for a long time can cause serious and irreversible physical damage. High fluoride concentrations are most often associated with ground waters as reported from many parts of India and become endemic. Fluorosis caused by intake of excess fluoride (>1.5 mg/litre) has been prevalent in India over six decades and over 62 million people in rural areas consumed water with fluoride content above permissible limit as per survey conducted by Ministry of Rural Development, Govt of India. Birbhum is the one such fluoride affected districts of West Bengal and is geologically unique in character as high fluoride concentration in ground water is found in four diverse rock types like Basalt, granite, coal seam and alluvium. Parts of Birbhum District of West Bengal, particularly Nalhati-I and Rampurhat-I Block are highly affected from this menace as high fluoride concentration up to 17 mg/l in drinking water is reported from this part of Birbhum District where large number of people is suffering from dental Fluorosis as well as Osteofluorosis.

Water sample analysis from all the available sources reflects concentration of high fluoride in some pockets of the Blocks having negative correlation of fluoride with calcium and magnesium and positive correlation with pH, sodium and potassium. The area is covered by Rajmahal Trap Basalt with intertrappean beds. Basalt is highly vesicular in nature which is covered by secondary materials. Basalts are also characterized by strongly developed columnar joints and fractures. Chemical analysis, mineralogical studies as well as XRD studies of both Basalt and intertrappean rocks as well as secondary vug filling materials

indicate absence of strong fluoride bearing minerals. Some hot and cold deep rooted springs in and around the area are present which contain high fluoride. Detailed study of Land-sat Images of the area indicate presence of three sets of strong lineament which represents weak zones. Mapping of the fluoride containing water sources indicate its presence more or less along the lineaments. On the basis of the geology of the area, chemical analysis of the water and rock samples, mineralogical studies of available rock types, XRD studies and proximity of excess fluoride bearing areas with the weak zones considered geothermal source as the definite contributor of high concentration of fluoride in ground water in this part of Birbhum District.

51. Global Morphology of Convection Indices Observed using Cosmic GPS ro Satellite Technique

Y. Durga Santhi[1], M. Venkat Ratnam[2] and S. Vijaya Bhaskara Rao[1]

[1]Department of Physics,
Sri Venkateswara University, Tirupati
[2]National Atmospheric Research Laboratory (NARL),
Gadanki

Keywords : *CAPE, GPS Radio Occultation, GPS Radiosonde, Convection indices*

Convection plays an important role in maintaining the thermodynamic structure of the atmosphere particularly in the tropical regions. It can be estimated using several indices like lifted index (LI), level of free convection (LFC), equilibrium level (EL), Convective Available Potential Energy (CAPE), etc. Initially validation study has been made by comparing all these indices with ground based GPS Radiosonde observations collected from Gadanki (13.5^{o}N, 79.2^{o}E). A very good correlation between the two is found which made us to extend the study globally. Seasonal mean of CAPE and other stability indices have been calculated globally using COSMIC GPS RO data. High CAPE values are observed in the tropical regions during all seasons where the convective activity is predominant. The seasonal shift of CAPE is also reproduced well with respect to season along with the motion of Inter Tropical Convergence Zone (ITCZ).

52. Elasticity of Mg_2SiO_4 (Forsterite) in Earth's upper Mantle

Seema Gupta, S. K. Pathak and S. C. Goyal[1,2]

[1]Deptt. Of Physics, Agra College, Agra

[2]K.P. Engineering College,

NH-2, Firozabad Road, Agra

Keyword : *Elasticity; Forsterite; High pressure; ab-initio, EOS*

Elastic properties of the low-pressure structure of the magnesium orthosilicate Mg_2SiO_4, (forsterite) are determined using a thermo dynamical method for the pressure range (0-24GPa). The geologically important quantities: second order elastic constants (SOE) and seismic wave velocity (V_p & V_s) are computed with the help of derived theory. The computed values of bulk moduli (B), shear moduli (Cs) and its pressure derivative (B') of Mg_2SiO_4 (forsterite) is tested by analyzing the compression in volume with increase of pressure with the help of phenomenological and other based on ab-initio molecular dynamic simulation equation of states (EOS). The results of C_{ij} agree well with the available experimental data in case of Mg_2SiO_4 (forsterite). Therefore, the results for the Mg_2SiO_4 (forsterite) may be important in geophysical study of these solids in earth's upper mantle.

53. Terrain Feature Extraction and Lineament Mapping from Dem

A. Shiroyleima

Department of Earth Sciences,

Manipur University

Canchipur-795003, Manipur

Email : shiroy.adhikari7@gmail.com

Keywords : *DEM, 3D Visualization, Lineament, Terrain feature extraction*

Digital elevation model (DEM) is used to express the topographic surface in three dimensions. The present study has been made to generate DEM, 3D

Visualization, lineament, topographic, morphometric and hydrological parameters. The 1: 50000 scale Survey of India toposheets were used to derive contours of 20m intervals. The digitized vector contours were then converted to DEM using ERDAS IMAGINE 9.0. The DEMs were first prepared for analysis in ArcGIS by filling any holes in the data and then was used to derive topographic features. In this study, lineaments, faults and different types of drainage pattern were able to recognize.

54. Seismicity of Northeast India Region

L. Someswar Roy
Research Assistant
Seismological Observatory
Department of Earth Sciences,
Manipur University, Imphal

Keywords : *Seismicity, Indian plate, Burmese Plate*

Northeast India comprises the seven states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. It falls under parallel 21°N to 30°N and meridian 89° E to 98° N and covers an area of about 2,55,000 km^2. NE-India is one of the seismically most active-belts of the world and considered to be one of the six most potential sites of strong earthquakes. The high seismicity in the region is due to the collision of the Indian Plate (Indo-Australian Plate) and the Burmese Plate (Eurasian Plate). The Indian Plate is subducting beneath the Burmese Plate in a trend of northeast direction. Due to this subduction, shallow and intermediate types of the earthquakes are confined in this region. The region has experienced 18 large earthquakes (M = 7) during the past 100 years, including the Shillong Earthquakes (M = 8.7) of 12th June, 1897 and the Assam-Tibet Border Earthquakes (M = 8.7) of 15th August, 1950. Besides these, several hundred small and micro-earthquakes have been recorded in this region. The mechanisms of the earthquakes of this region are mainly due to thrust and strike-slip faultings.

55. Ne Monsoon Rainfall Variability over South Peninsular India and its Teleconnections

P. P. Sreekala[1], S. V. Bhaskara Rao[1] and M. Rajeevan[2]

[1]Department of Physics,
S.V.University, Tirupati.
[2]National Atmospheric Research Laboratory,
Gadanki.

Keywords : *NEMR, ENSO, IOD, EQUINOO*

We relate the NEMR over south peninsular India with ENSO, IOD and EQUINOO. The correlation analysis between NEMR with ENSO suggests that SOI_Signal and Nino3.4 region SST during May month and SOI_Darwin during March month are significantly correlated with NEMR and the correlation is increasing during the recent years. Dipole Mode index (Previous October) and EQWIN (September) is also found to be significantly correlated with the NEMR over south peninsular India. The spatial correlation of NEMR with SST, OLR, SLP and wind anomalies is studied for a period of 54 years (1951-2004). The study reveals that the excess NEMR over south peninsula can be well explained by its positive relationship with ENSO and IOD and negative relationship with EQUINOO.

56. The Present Trend of Global Warming and its Mitigation Measures in the Greater Imphal Area, Manipur

Ngangom Senior

Department of Earth Sciences,
Manipur University, Canchipur
Imphal-795003

Key words : *Greenhouse gases, Greater Imphal Area (GIA), Caw, Winter, Pre-monsoon, Post-monsoon, Maximum temperature, Minimum temperature, LTM (Long term mean).*

This paper investigates the present trend of global warming and its mitigation measures in the Greater Imphal Area, Manipur. While analyzing the temperature data (1957-2007) of the area with the exception of 1998 and 1999, there are increases of temperature of 0.57°C in winter, 0.1°C in pre-monsoon and 0.5°C in post monsoon. The mean maximum and minimum temperatures also increase to 0.15°C and 0.87°C with respect to LTM. To mitigate this, it requires multi-disciplinary approaches at regional, national and international levels which envisages minimization of non-renewable and maximization of renewable sources of energy without affecting the rate of economic growth.

57. Organic vs Inorganic Production of Rice and its Impact on SOC Pools

Venati Girija Veni and Nirmal De

Department of Soil Science & Agricultural Chemistry,
Institute of Agricultural Sciences,
Banaras Hindu University,
Varanasi-221005, Uttar Pradesh

Keywords : *SOC pools, Walkley & black carbon, labile carbon, Microbial biomass carbon, carbon management index*

A field experiment was carried to study the effect of use of organic vs. inorganic source of nutrients on SOC pools and yield of rice. The supplementation of Nitrogen through 50%NPK (RDF) + 50% FYM enhanced the Soil organic carbon content of soil along with 19.80% increase in yield of rice. when correlation study was carried, Walkley & Black carbon showed significant positive relationships with Labile carbon (r = 0.85) & Yield (r = 0.74).On an average, Walkley & Black, $KMnO_4$ – oxidizable carbon and Microbial biomass carbon accounted for 25.85%, 5.4% &2.36% of total soil organic carbon.CMI is useful parameter to asses SOC pools.

58. The Great Assam Earthquake 1897 : A Magnetotelluric Perspective

S. S. Sanabam and Devesh Walia

Department of Environmental Studies,
North-Eastern Hill University,
Shillong-793 022
Email : deveshwa@gmail.com

The collision tectonics between the Indian plate and the Eurasian plate to the north and the Indo-Myanmar range in the east attribute to the high seismicity in the North-eastern Indian region and makes it a unique place for deep crustal study in a real time situation. After the great Assam earthquake of 8.1 M_w on 12th June 1897, many eminent researchers published several conflicting arguments regarding the nature, the spatial location and the depth extent of the seismogenic source fault. The common argument is that the 1897 great earthquake was produced by a hidden fault at the northern boundary of the Shillong Plateau (SP); the 'Oldham fault' that extends from a depth of about 9 km down to 45 km and it strikes East-SouthEast. Most of the information on the deep interior of this region is hidden under the Lower Brahmaputra sedimentary cover. The nature and disposition of tectonic elements are inferred on the basis of the interpretation of the geological features, gravity anomaly studies and from the source parameters and other seismological investigations. As a consequence, although the existence of the Brahmaputra, Oldham and Dauki faults finds a general acceptance, several conflicting arguments still abound the scientific literature regarding the nature and the spatial and depth extent of these faults.

The magnetotelluric (MT) studies over the Shillong Plateau (SP) and Lower Brahmaputra Valley (LBV) region discussed here are an attempt at deciphering the manifestation of the tectonic features in the deep crust, which could prove useful in the systematic interpretation of the tectonic activity, crustal evolutionary processes and understanding the source parameters of the 1897 Great Assam earthquake. The Oldham fault at the northern margin of Shillong Plateau is not delineated in the geoelectric section presented here, although two low resistivity features with a rather weak resistivity contrast of a factor of 5 (100 ohm-m against the surrounding resistivity of 500 ohm-m), are delineated,

extending over four sites (16–19) which are not clearly indicated in the phase pseudo-sections. Denser site spacing was not feasible in this region because of the strong cultural noise caused by the Guwahati Township and hence this low resistivity could not be effectively delineated. A detailed work is being carried out in the NE Indian region to decipher the nature, the spatial location and the depth extent of the seismogenic source faults.

59. Tracing the Evolution of Human Settlement using Remote Sensing and GIS Techniques in Manipur Valley

Ch. Debala Devi

Selection Grade Lecturer
Modern College, Porompat,
Imphal.

Keywords : *human settlement, remote sensing, GIS*

It is believed that the early human settlement in the valley of Manipur was descending downward as the submerged water level receded gradually. To trace the evolution of early Human settlement in Manipur Valley the author is applying computer simulation techniques overlapping the remote sensing images. This simulation technique is fixing at the elevation of 2000 m to define the area of emergence. It is also presumed that the area where the emergence occurs is the area of first human settlement started in Manipur.. It is clearly seen that the whole valley is submerged except the Koubru Hills. Hence it is believed that the first human migrant migrating from the northern side started settling along the Koubru hills (evident from Khamkhui Caves) when water level is 1000m most of the present foot hills emerged out. The Kanglatombi merged out which is assumed to be the place where the settlement started but still the whole valley is submerged. When the water level is 783m, Kangla was raised up and settlement begins to spread at the valley due to its congenial climate, increased of population and fertile soil. Application of Remote Sensing and GIS techniques is found to be a suitable tool for tracing out old settlement in the Manipur Valley.

60. Retrospective view of Chamoli Earthquake (Himalaya, India) with Recent Coulomb Stress Transfer Model

D. K. Gupta, S. Pamnani, S. K. Mondal and P. N. S. Roy

Department of Applied Geophysics
Indian School of Mines,
Dhanbad-826004,
Jharkhand
Corresponding email id : dpk_ism@yahoo.com

Chamoli region (Uttarakhand, INDIA) faced a destructive earthquake (M_w = 6.4) on 29* March, 1999. This earthquake was accompanied by a large number of minor earthquakes with magnitude M_w £ 3.0 that occurred for the next four months. Coulomb stress changes are used here to analyze the faults of this earthquake having its epicentre at 30.49° N latitude and 79.28° E longitude(from USGS), along the 29^W March, 1999 rupture and the production of aftershocks in the nearby region.

This region lies between the Main Central Thrust (MCT) and Main Boundary Thrust (MBT), and thus is probable to extensive deformation. Recent Coulomb 3.1 software is used to calculate the stress change caused due to the main shock, henceforth observing the strain produced in different fault plains. The main shock was found to be caused at a depth of 15 km by Alakananda thrust fault and the aftershocks observed were mainly due to the shear stress developed by the adjustment of this fault.

It is observed that the aftershocks have been triggered by the main shock disturbance. The changes on the shearing fault have been studied and a relation between the main shock and the minor aftershocks has been observed. The Chamoli earthquake produced positive stress in the eastward direction which may be major source of triggering the possibility of moderate earthquakes in that region. Thus finally the present findings support the mainshock observations of May 1999 in the nearby region.

61. Analysis of Slope and Drainage Pattern : A Case Study of Parbati Basin

[*]Niklesh Kumar and [**]Purshottam Soni

[*]Research Scholar, Dept. of Geography,
Dr. H.S. Gour Central University, Sagar (M.P.)
[**]Assistant Professor, Dept. of Geography,
Dr. H.S. Gour Central University, Sagar (M.P.)

Keywords : *Landform, Dendritic, Geomorphology*

Geomorphology is the science of landform, and systematic analysis of landscape is essential for understanding the nature, origin as well as for mutual relationship of any landform. As far as study of river basin is concerned the analysis of drainage pattern is one of the important aspects of the study. And spatial pattern of a river and its tributary stream in drainage network is always referred to as the drainage pattern. A slope is the inclined surface of a part of the earth crust. The term is also used to denote the level of inclination. As a matter of fact the study of slopes is not only significant from academic point of view but also from the point of view of human activities.

The surveys were undertaken of Parbati basin mainly to understand the geomorphology of piece of country between Rajasthan and Madhya Pradesh. Which is a sample of regions consisting of Vindhyan and Deccan Trap rock formations covering 12250 sq.kilometres. The author's aims have been (i) to study the landforms and processes in detail and try to explain the origin and development of the former, (ii) to establish the interrelationship among the different entities that make up geomorphology, form, structure, slope, processes and pattern etc. The nature of research problem being geomorphological and Investigation were carried out on the topographical contour maps which are available on the scale 1 cm to 2.5 kilometres (R.F. 1:250,000), For drainage studies, drainage map has been also prepared. Present study is based on method, which has been used by C.K. Wentworth.

The structural make up of the basin is associated with the rocks of Vindhyan Super Group and Deccan Trap. Gentle slope zone in found in the form of vertical strip in the middle part of Shahbad and Kishanganj tehsils, covering 850 sq.kilometres. The extention of gentle slope zone is up to 400 metres height. The

maximum value of slope 60° is exhibited in western part of Chhiparod, which belongs to the Deccan Trap formations. The minimum values of slope have been observed at the place of confluence of the Parbati and the Chambal. Dendritic drainage pattern is very common in the Basin, which indicate that the fluvial cycle of erosion has been encroaching to attain maturity. Rectangular drainage pattern is fairly developed along the Banganga River and also in the middle part of Chhipabarod tehsil along Andheri and Ahasi Rivers, which flow across the Deccan Trap. Trellis drainage pattern is developed along Sukni Nadi. Radial and centripetal drainage pattern covers a negligible area, which is located in the northern part of Kishanganj tehsil (Ramgarh dome). Deranged drainage pattern is recognized only in the upland region of the eastern part of the Basin. The lithology of this region consists of Vindhyan Super Group, which bears lesser permeability there fore' the rainwater is stored in the reservoirs. This entire tract of land from Kishanganj tehsil to Shahbad tehsil exhibits very peculiar examples of deranged drainage pattern.

62. Temporal Changes in the Subwatersheds of Manipur River Basin due to Practice of Shifting Cultivation : A GIS approach

Ch. Tony Singh

Department of Earth Sciences, Manipur University,
Canchipur, Imphal.
E-mail : tonypal27@gmail.com

Keywords : *GIS, Remote Sensing, Shifting Cultivation, Manipur River Basin, Subwatersheds*

This paper deals with the temporal changes in the subwatersheds of Manipur River Basin which is caused by shifting cultivation using the techniques of GIS and Remote Sensing. The LANDSAT satellite imageries of 1988 and 2000 along with IRS-1C LISS III imageries of 1998 and 2003 are used to perform the temporal change analysis and to find out the trend of shifting cultivation in these study periods. During the present study, the total shifting cultivation areas of Manipur River Basin are found to be 238.84 Km^2, 176.44 Km^2, 242.48 Km^2 and 394.29 Km^2 in the year 1988, 1998, 2000 and 2003 respectively. The remote sensing data coupled with GIS techniques have been quite helpful in studying the temporal changes occurring in this area.

63. Biogas Production from Kitchen Waste using Mixed Culture Enrichment in Batch Reactors

Sumit Kr. Bansal, Yogita Singhal, Prem Kishore Patnala and Radhika Singh?

Department of Chemistry,
Dayalbagh Educational Institute, Agra
Corresponding id : radhika1263@gmail.com

Keywords : *Fermentation, biogas production, mixed culture, ultrasonication*

In recent era, world energy demand for improvement of the biogas production by fermentation process is increasing. Biogas production from kitchen waste has been studied using mixed culture source. Implementation of various biogas enhancement method (pH 5.2-7) alkaline, acidic, ultrasonication, temperature with mesophilic (35-50^{0}C) and thermophilic (50-70^{0}C) condition and hydraulic retention time (HRT) is 15 days in 1 Litre capacity batch reactor working volume is 800ml. Kitchen waste contains 75-80% moisture, and ash content is 1.590 g, TS is 17.06 g/l.Determination of chemical oxygen demand (COD) of sample such as cow dung slurry using new methods based on the various techniques of sample preparation, modified quantities of reagents and changing refluxing time in comparing the existing refluxing method. Modified result of COD is higher is in the range of 60000-70000 mg/l of sample and the biogas is produced. This work is carried out under organizational scheme of processes using anaerobic conditions.

64. Landslide and Geotechnical Assessment between Noney-nungba along NH-53, Manipur

L. Dinachandra Singh, L. Surjit Singh and Ph. Gupinchandra

Manipur Science & Technology Council,
Imphal

The present study had been carried out along a part of NH 53 between Noney–Nungba about 63km linear stretch. The project area comprises an area of

about 173 sq.km. with geographical coordinate of 24°44'02"N to 24°53'35"N and 93°24' 17" E to 93°40' 01" E and has been taken to study the various parameters for landslides hazard Zonation and geotechnical investigation affecting the NH-53 between Noney-Nungba, Manipur. The present study is an attempt to generate landslide hazard zones and geotechnical investigation for two slides within the study area under GIS domain using (ARC-GIS 9.0, ARC-VIEW 3.2) and ERDAS Imagine 8.7 etc. and Survey of India Toposheets (SOI) 1:50,000 scale. The landslide hazard zones have been prepared on the basis of varying degree on the estimated significance of the causative factors of instability like lithology, soil type, structure, slope morphometry, relative relief, land use and land cover and hydrogeological condition. Majority of the study area are distributed with High Hazard and Very High Hazard zone. Major part of the study area falls into the category of High Hazard Zone which is about 60.58% of the total area covering 104.8 sq.km. followed by Very High Hazard Zone covering 40.2 sq.km with 23.24% of the total area. 25.2 sq. km. with 14.57% covering the Moderate Hazard zone. The study area is devoid of Very Low Hazard Zone (VLH) and Low Hazard Zone (LH).

The present approaches for the geotechnical studies i.e. Direct Shear Test and Slope Mass Rating (SMR) deal with the determination of factor of safety and slope instability of the sliding area at two slide sites. A circular type of landslide has been occurred at Awangkhull Part-II (93031'15? E and 240 49'29? N) along NH-53 which is about 26 km away from Noney. This type of failure often occurs on hill slopes characterized by overburdened soil and debris. Determination of Factor of Safety (F) at Awangkhul Part-II slide has been carried out using circular failure chart (Hoek & Bray, 1981) and the value of factor of safety of the sliding area is 0.55 indicating favourable for frequent slide. Another landslide occurred at Raungdai/Blongdai ($93^0$26'29? E and 24^0 46'19? N) along NH-53 which is about 4 km to Nungba has been considered to study slope instability by SMR approach. The area is characterized by intercalations of shale and bedded sandstone. After kinematics analysis of the orientation of discontinuities and field observations of the sliding site, the Raungdai/Blongdai landslide has been identified as Wedge failure. The SMR for Raungdai landslide site has been estimated by using the formula i.e. SMR = RMR + (F_1 x F_2 x F_3) + F_4. The calculated value of SMR by assigning various field parameters is found 37. The probable stability of the area may be bad and unstable.

65. A Geochemical Approach for Seawater Incursion Assessment in the Thiruthuraipoondi, Tiruvarur district, Tamilnadu, India

T. Ramkumar*, S. Venkatramanan, I. Anitha Mary, P. Radha, G. Gnanachandrasamy and G. Ramesh

Dept. of Earth Sciences,
Annamalai Unviersity
Annamalainagar-608 002
*Corresponding author :
tratrj@gmail.com

The delicate exploitation of a coastal aquifer usually induces problems of quantity and quality. India being the second fastest growing economy and the second most populated country in the world, the level of urbanization is expected to rise 38% by the year 2026. It is observed that majority of the development; nearly about 68% is along the coastline. India has a coat line of 7500km with 30 big and medium cities including three important metros and thousands of coastal villages. The seawater intrusion into the coastal freshwater aquifer is practically irreversible and hence the detection and monitoring of saline intrusion is essential to this valuable resource management.

Water samples for chemical analyses were obtained from 18 wells at several depths to cover the entire study area. The EC and chloride concentration distribution clearly illustrate the large extent of saline water incursion in the aquifer system of the study area. Although the ionic content of groundwater of the study area is highly variable, the dominant anions are Cl and HCO3 and the dominant cations are Na and Mg. Water in the saline parts of the confined aquifer is generally of the Na - Cl type. Evidence of cation exchange and reverse cation reaction between fresh and saltwater in the Thiruthuraipoondi aquifer system are reflected in the Piper diagram. Based on the Wilcox diagram, most of the samples fall in S3-C4 category it’s indicating that medium to high sodium hazard and high to very high salinity hazard.

66. A Study to Delineate Ground Water Potential Zones in Chhatna Block, Bankura District, West Bengal

Ghosh. P. and Nag. S. K.

Department of Geological Sciences,
Jadavpur University,
Kolkata
Email : nag_sk@yahoo.com

Keywords : *Hydrogeomorphic study, lineament density, Slope map, Groundwater potential zone*

Groundwater is a precious resource of finite extent. Over the years the importance of groundwater is growing based on an increasing need, has lead to the unscientific exploitation of groundwater creating a water stress condition. This alarming situation calls for a cost and time-effective technique for proper evaluation of groundwater resources and management planning. Groundwater development program needs a large volume of data from various sources. An integrated remote sensing and GIS study can provide the appropriate platform for convergent analysis of large volume of multi-disciplinary data and decision making for groundwater studies.

The present study area, the Chhatna Block is a part of Bankura district and is located on the eastern slope of Chotonagpur Plateau, which is mapped on toposheets no. 73I/15,73I/16 and 73M/3 and falls between latitude 23°20' 23°30'N and longitude 86°45' 86°55'E. It is about 280 kms. far from Kolkata.

IRS - LISS-III data along with other data sets e.g. existing toposheets and field observation data have been utilized to extract information on the hydrogeomorphic features, lineament density contour and slope map of this hard rock terrain. The component of the study is demarcation of groundwater potential zones. All the information layers have been integrated through GIS analysis and the criteria for groundwater potential zones mapping and have been defined. Weighted index overlay method has been followed to delineate groundwater potential zones.

67. Tearing in Subducted Slab

Bhaskar Kundu, V. K. Gahalaut, J. Catherine, L. Premkishore, A. K. Bansal, A. Ambikapathy, P. Mahesh, M. Narsaiah and K. Nagraju

National Geophysical Research Institute,
Council of Scientific and Industrial Research,
Uppal Road, Hyderabad, 500007
(rilbhaskar@gmail.com)

In geoscience text books, the fate of the subducted oceanic crust seems straightforward and stays intact. However, precise tomographic images have revealed that many descending slabs have a more complex evolution and have developed different kinds of slab architecture like necking, tears, detached from the surface plate, or even broken into fragments. Thus the idea that slabs do not stay intact but rupture as they descend through the upper mantle is not new. In fact, it has been observed in several parts of the world in Indonesia, New Hebrides, Taiwan and Alps.

We have investigated one such subhorizontal tear in the Irrawaddy region (Kundu and Gahalaut, 2010) of the northern Sunda arc, which is located north of the Andaman and south of Arakan or Indo-Burmese arc regions. Lack of detailed knowledge about the tectonics and its very low earthquake productivity makes this region very enigmatic. *"Seismically quiet window"* in Irrawaddy region can be explained by two ways. Either the region is aseismic, wherein the relative plate motion between the two plates is accommodated aseismically or the two interacting plates could be locked, and hence the region could be accumulating strain to be released in the next great or major earthquake. However, absence of seismicity at depths greater than 50 km in the Wadati–Benioff zone in the Irrawaddy region suggests that the subducting slab might not be continuing to that depth. Tomographic studies provide the most convincing evidence in favor of the presence of a tear in the subducted Indian slab (Richards et al., 2007). Another convincing fingerprint about presence of slab tearing is the lack of great historic earthquakes and inability of rupture propagation of

great earthquake ruptures (occurred in adjoining arc regions), through the Irrawaddy region. The rupture of the 2004 Sumatra–Andaman earthquake extended only north of North Andaman to about 15°N (Gahalaut et al., 2006; Subarya et al., 2006, Banerjee et al., 2007). On the other hand, although the rupture of the 1762 Arakan earthquake is not well constrained (Gupta and Gahalaut 2009), it has been suggested that the 600–700 km long rupture did not extend southward beyond 17.5°N latitude (Fig. 2). Thus, the two ruptures did not extend into the Irrawaddy region. Paleoseismological records further supports this notion. We conclude that in the event of earthquake occurrence on either side of the arc, such a shallow slab tear will prevent or defuse the effect of rupture propagation through its aseismic domain. Hence no stress transfer from one arc to another can occur, and no earthquake triggering effect appears possible. Probably such slab tear makes both arcs distinctly noninterfering systems that behave independently (Kundu and Gahalaut 2010).

68. Trend and Extreme Value Analysis of Rainfall over Homogeneous Regions in India

T. V. Lakshmi Kumar

SRM University, Kattankulathur,
Tamilnadu-603 203
Email : lkumarap@hotmail.com

Interannual and interdecatdal variability of rainfall is studied over the homogenous regions in India from 1871 to 2006. The study is focussed to investigate the trend analysis of rainfall for the premosnoon, monsoon and post monsoon seasons. It is attempted to understand the relation of monsoon rainfall with global tele-connections such as El Nino, La Nina, North Atlantic Ocean etc for which the correlation analysis has been carried out with Darwin sea level pressure, Nino 3.4 temperature, north atlantic ocean, qbo and SSTs of Indian Ocean and Arabian sea. Finally, the paper addresses the extreme rainfall analysis of different homogeneous regions from which it is inferred that the rainfall increases with the return periods.

69. Identification of Surface and Buried Placer Deposits and its Provenacne along the Coast of Tamil Nadu

M. Suresh Gandhi

Department of Geology, University of Madras,
Guindy Campus, Chennai-600 025
surgan@yahoo.co.uk

Keywords : *Buried Placers, Provenance, Pondicherry to Kanyakumari, East coast of India*

Beach sands contain the most economically important minerals accumulations; wave action deposits sand on the beach, and the heavy minerals are concentrated when backwash carries some of the lighter minerals such as quartz back into the sea. Onshore winds which preferentially blow lighter grains inland can lead to higher concentration's of heavy minerals at the front of coastal dunes. Old 'fossil' shorelines known as strandlines can now be found some distance inland. Angusamy and Rajamanickam (2000) have explained the concentration of heavy minerals in the coast with respect to wave dynamics, neotectonics and coastal configuration. Mohan and Rajamanickam (2002) have identified the buried placer mineral concentration for magnetites 1.65 to 20.08 %, ilmenite 2.01 to 22.71% and garnet 2.05 to 6.54% enrichment in the depth of 1.99 to 2.35 m depth. But, no data on buried placer studies has been noticed down to Pondicherry. So, for the present work, the area south of Pondicherry to Kanyakumari has been identified The strandline zones between Pondicherry and Kanyakumari have been identified initially by visual interpretation is made from Satellite imagery (1:250,000 and 1:50,000) and aerial photographs (1:50,000). The samples were gathered using a Vibro-Corer upto 3 mts depth (viz. 0-1m, 1-1.5m, 1.5-2.0m, 2.0-2.5m, 2.5-3.0m) from the dry sandy deposits at 10 stations a total of 50 samples. Maximum depth of 3.5 mts was covered for sampling and the samples were collected using corer by every 0.5 m depth penetration. Representative surface samples by hand auger from 47 stations also collected along strandlines in the area between Pondicherry and Kanyakumari. All the total 97 samples (core sample 50 and surface sample 47) were selected for heavy mineral studies. The heavy mineral assemblage of the study region is governed by the distribution of different type of minerals. However, the assemblage is restricted to the dominance of few selective minerals like garnet colourless, garnet pink, zircon, rutile, chlorite, etc.

In the Northern sector, zircon and garnet is found in the high percentages at Pondicherry - Narambai region. In the Karaikal -Vilunthamavadi zones shows similar pattern with the above but, the percentage is the minimum. Kyanite is dominant in the Pondicherry - Narambai region whereas in the other zone it is generally minimum Chlorite (23.08- 52.66 %) is dominant in all the zones except Tharangambadi and Karikal zone. The non opaque distribution in the sector the different grain sizes within the sector has established the prevalent presence of chlorite, kyanite, garnet, zircon and epidote.

An enrichment of heavies from Poompuhar to Karaikal is attributable to the reworking of the beach ridges, which were submerged during the present transgression, and to the role of density sorting. A depletion of heavies in the Southern sector is accounted for by the absence of a terrigenous supply and the prevalence of wave shadow conditions throughout the year. The nature of the heavy mineral assemblage reflects the derivation of sediments principally from khondalites, granites, metamorphic rocks and palcosediments.

The present study highlights the environment of placers in the Southern sector which can be earmarked to the basinal downwarping, due to the neotectonic activities, which acts the sedimentation trap. Since the Central sector is a wave shadow zone, where no waves enter the coast except at Devipattinam, due to high sedimentation, the enrichment of the heavy minerals is found to very less. In the Northern sector the heavy mineral concentration is found to be more when compared to Central sector. This could be due to the winnowing action of waves and currents and density sorting of heavy minerals. The study also concluded the sediment in the surface and core samples also exhibits more or less a similar type of concentration.

70. An Evolution of Heat Generation in the High Heat Producing Jodhpur Ring Granites in Malani Igenous Suite

Tina Prajapat and K. L. Shrivastava

Department of Geology, J.N.V. University,
Jodhpur-342005

Keywords : *HHP Granite, Malani Igneous Suite, Mineralization in Granite*

High Heat Producing granites are globally considered as fertile granites for mineralization, being capable to enhance the circulation of ore bearing fluids that concentrate the selective metals to form the deposit. In the present study, ring granites at South of Jodhpur city at Salawas-Nandanvan and Fitkasni-Rasida, of the Malani Igenous Suite have been selected for petrological, geochemical and heat generation studies. Both, pink and grey granites show mineral composition and texture typical of granite, granodiorite and adamellite with mirmekitic texture. These are subalkaline, high K granites of anorogenic type, showing their tectonic setting as 'within plate' type. On the basis of U, Th and K concentration in 16 samples of these granites, heat generation unit (HGU) have been calculated, which ranges in Fitkasni-Rasida area from 13.38 to 16.67 with an average of 14.66 and in Salawas-Nandanvan area from 6.74 to 9.85 with an average of 8.08. It is concluded that these are High Heat Producing granite, hence could have produced some economic concentration of casseterite, wolframite, fluorite etc.

71. Trail of Reunion Plume in the Malani Igneous Suite: Target Loci for Mineralization

Mamta Chauhan and K. L. Shrivastava

Department of Geology,
J. N. V. University,
Jodhpur-342005

Keywords : *Plume, Mineralization, Reunion, Malani Igneous Suite*

Economic Geologists have always remained keen in tracing path of plumes as it may produce varieties of mineral deposits on its course. Many potential host rocks including carbonatites, komatiites, kimberlites, ophiolites, peridotites are known to serve as host for PGM, REEs, chromite, Cu-Ni, Carlin gold, Flourite, diamond and atleast, Kidd creek type Massive Sulphide Deposits.

The Reunion Plume is believed to have given imprints of a trail being beneath the moving Indian plate on Malani Igneous Suite, between 68 Ma to 35 Ma. By heating it up or / and contributing mineralizers from mantle to

bimodal igneous rocks of Malani, ranging in age from 745 Ma to 680 Ma, are expected to produce more deposits than the known ones, including carbonatites at Mundwara and Dandhali ; Flourite at Ambadongar, Jalerakhurd and Karara ; and some signature of kimberlites. It is proposed that Siwana, Mungeria, Jasai and Tavidar Ring Complexes should be explored as target loci for mineralization.

72. Polymetallic Polynodule : A Guide of Rich Economic Zone in Ocean Nodule Fields

C. P. Dadhich and K. L. Shrivastava

Department of Geology, J.N.V. University,
Jodhpur-342005

Keywords : *Polymetallic Polynodule, Marine deposits, Ocean Nodule Fields, Mn- nodule.*

Polymetallic nodules are concentrations formed by concentric layers of iron and manganese hydroxide around a core. There could be more economic metals, in these nodules chiefly, Ni, Cu, and Co. The Central Indian Ocean Basin (CIOB) hosts the world's second largest economic deposit after the central pacific ocean. The 'polymetallic polynodule' show a distinct morphology by making combination of growth of 'guest nodules' over 'host nodules'. Polymetallic nodules are known to formed by hydrogeneous process in which slow precipitation of metallic compounds occur from the sea water. Alternatively, in diagenesis, manganese is remobilized in the sediment column and precipitates at the sediment water interface. Both hypothesis are greatly assisted atleast by three ways. First one is hydrothermal process in which the metal is derived from the hot springs, associated with volcanoes. Halmyrolitic process, in which metallic compound comes from the decomposition of basaltic debris by seawater, is the second mechanism. The third mechanism is biogenic process in which the activity of microorganism catalyzes the precipitation of metal hydroxides. Following either of the two hypothesis and assisted by any available mechanism it seem that the polynodules can only form where more rich metal(s) and more effective mechanism is available. Resultantly, polymetallic polynodule growth is expected, where

because there is more production of guest nodules over each of the 'host nodules'. Hence, it is logical to conclude, in the present paper, that polymetallic polynodules are indicators of more potential economic zones in the Ocean Nodular Fields.

73. Geological Characteristics and Genesis of Flourite Deposits at Jalerakhurd, in Malani Igneous Suite

Virendra Gaur and K. L. Shrivastava

Department of Geology, J.N.V. University,
Jodhpur-342005

Keywords : *Malani Igneous Suite, Flourite deposit, Jalerakhurd, Hydrothermal deposit, volcanogenic deposit.*

The Flourite deposit is situated near village Jalerakhurd (Lat. N 72^{o}08'69'' and Long. E 24^{o}48'00") in Bhinmal tehsil of Jalore district (Rajasthan) in Malani Igneous Suite of Neoproterozoic age. The host rocks consisting of lower porphyritic rhyolite and upper porphyritic trachyte. Plume tectonics, circular intrusions and collapse caldera conditions have been explained by earlier workers for the regional geology. Out of the three prominent Joint sets, only one, named Joint I, has been mineralized with its strike N43^{o}E-S43^{o}W and dip 85^{o}W. The main ore body constituting four veins of fragmental mass collectively constituting a tabular body, with its average thickness, length and depth 20m, 500m and 100m, respectively, within an elongated stockwork. There are few parallel mineralized veins available nearby. The range of geological features displayed by fluorite breccia indicate that disruptive intrusion by a turbulent fluidized system was the dominant process, initially. The intrusive aspects of fluorite breccia show angular killas fragments encompassing a wide range of sizes all cemented by microcrystalline fluorite itself. This is followed by two episodes of collapse, a major, and a minor are resulting in enclosure of early-formed fluorite fragments into later-formed fluorite matrix. These episodes were followed by pervasive silicification and metasomatic alterations. A twelve stage genetic model is suggested for the fluorite ore body, which combines the features of both hydrothermal intrusive breccia and hydrothermal collapse breccia to form the economic deposit in the volcanogenic environment.

74. Anthropogenic Impact on the Pulicat Lagoon Monitoring with Foraminifera, East Coast of India

Sundara Raja Reddy. B. C* and Reddy K. R*. Jayaraju. N.#

* Department of Geology, S.V. University,
Tirupati-517 502
#Department of Geology & Geoinformatics,
Yogi Vemana University,
Kadapa-516 003
E-mail : sundherreddy@gmail.com

Keywords : *Lake, Foraminifera, Ecology, Anthropogenic pollution, Ecological parameters*

Coastal lagoons are well investigated areas because of their economical and ecological importance. Pulicat Lagoon system which is a store house of all resources is under great threat following the anthropogenic pollution. This complex lagoon ecosystem's surface area is about 500 sq.kms. In spite of the System's conservation statutes its structure has been degenerating rapidly because of pressures fishing, tourism and agricultural activities. Fishing production of Pulicat Lagoon System is approximately 52 tons/ha/year. Although a serious fishery pressure of has been determined in the area, according to mortality rate and age compositions, it has been found that the growth of marine life in the environment is in unhealthy condition. The data show that land based and atmospheric sources account about two-thirds of the total impact of contaminants in to the marine lagoon constituting 44 % and 33 % respectively. A total of 30 sediment samples were collected with in the depth zone of 5 fathoms from the lagoon. The study yielded 50 benthic foraminiferal species belongs to 24 genera, 16 families, 8 super families and 3 sub-orders. Variations are also reflected on the foraminiferal test morphology, diversity and distribution. A high percentage of foraminifers almost exclusively *Ammonia* have damaged shells with a few channels to entire whorl missing. The phenomenon is stress response to the anthropogenic pollution. The *Ammonia-Elphidium* assemblage is dominant in all stations followed by *Spiroloculina –Bolivina* assemblage. Foraminiferal data was significantly related to selected ecological parameters, and were ordinated along axis that corrected with one another. Under studying the complexity of anthropogenic pollution, coastal waters and sediment are critical to the design and interpretation of meaningful studies.

75. The Unsettled Hypothesis on Oregenesis and Petrogenesis of Komatiites

Anju Mathur and K. L. Shrivastava

Department of Geology, J.N.V. University,
Jodhpur-342005

Keywords : *Komatiite, Spinifex Texture, PGM deposits, Ni-Cu deposits*

Komatiites are very high temperature, high Mg, ultramafic extrusive or intrusive rocks, making a series of Basalt-Komatiite Basalt-Komatiite, normally with varieties of Spinifex texture. Recently (Shrivastava et al., 2009) attempt have been made to generalized its petrological; and geochemical characteristicsn in absence of proper definition. Komatiite magmas, being very high in temperature (around 1650^{o}C) are sulphur undersaturated, a rare among mafic/ultramafic lava types to contain chalcophile elements (including Fe, Co, Ni, Au, Cu, Ti, Bi and PGM). Komatiites always remained very important primary host rock for Ni, Ni-Cu, Ni-Cu-PGM and PGE (Ru, Rh, Pd, Os, Ir and Pt). Recently, diamond is added in the list. Leaving aside the third unacceptable hybrid model, there are only two classes of competing petrogenetic models; Plume based models of anhydrous melting in interplate setting and subduction-related hydrous melting in suprasubduction zone setting. Present state of petrological, geochemical and isotopic evidences are not being completely explained by either of the two models, suggesting a possibility that different komatiite types were generated under these two contrasting geodynamic settings.

76. Comprehensive Study of Tycho-a lunar Impact Crater using Chandrayaan-1 TMC Data

K. Balaji

Indian Institute of Technology Bombay
(geobaji@iitb.ac.in)

Keywords : *Oblique impact crater, Tycho Crater, TMC, Morphology of the Craters on Moon, Pits and Polygons*

The morphological study of the Tycho Impact Crater was carried out with the help of "Terrain Mapping Camera"(TMC) datasets, Chandrayaan-1. The Terrain Mapping Camera is the stereoscopic imaging instrument in the visible spectral band on Chandrayaan-1 which was successfully launched on 22 October 2008. The swath and resolution of TMC are 20km and 5m, respectively. Tycho is a Copernican age (50-100 map) on the nearside of the moon in the outhern highlands ranges between 43S degrees-349E degrees and it is an excellent example of a complex crater(flat floors, central peak, terraced walls). It is 85km in diameter with an average depth of 3970m below the 1738 km radius lunar sphere. The main central peak rises 2400m the crater floor and the average rim crest elevation is +730m, with a mean rim crest to floor depth of 4700m. The depth-diameter ratio of Tycho is about 0.05, which is typical for fresh complex craters measured by Pike (2). It is evident from TMC visible spectral band image that there is an asymmetry of the crater ejecta. There are rays distributed asymmetrically around the crater, with an ejection exclusion zone to the SW direction (4).There are much longer rays trending to the NE than in any other directio. Based on the previous work on secondary crater field, asymmetry of the rays of Tycho, the crater appears to be the result of an oblique impact from the WSW direction (5). The rim of Tycho is morphologically distinct due to the relatively younger age of the crater. The rim crest elevation profile(Dr.Margo et al.) shows a significantly higher elevation on NE region, the highest the rim crest reaches. The lowest rim crest elevations in the SSW direction, with an elevation of about 200m, and in the NNW direction, with an elevation of about 150m. The interior of Tycho is generally asymmetrical, with a deeper floor and narrower wall on the E and NE sides. The walls of the crater are terraced, composed of cuspate, slumped blocks around the entire perimeter of the crater (1). The width of the wall is greater in the WSW region, implying more extensive slumping in that area.

77. Prospects of Ground Water Recharging at the Iari Farm through Rainwater Harvesting

P. Mookerjee, R. V. Singh and M. S. Sachdev

Nuclear Research Laboratory, IARI,
New Delhi-110012

Keywords : *Ground water, water harvesting, artificial recharge, IARI, New Delhi*

Analysis of the rainfall data of IARI for the year 2009 revealed that although the annual rainfall was 20% less than the average, there was vast scope for harvesting excess runoff generated in the farm area during the month of August and September. Study of the rainfall characteristics of the last 35 years (1976 – 2010), reveal, almost equal number of years with above and below normal, annual rains. Looking however, into the single day events, scope for conservation of the excess always remain. A contour map was drawn to work out general slope to identify locations for artificial recharge ponds. Ground water quality of the farm area was mapped to ascertain, recharging is not done in pockets with saline water. However, Water samples collected from 24 tube wells revealed EC ranging from 1.125 to 3.92 dSm $^{-1}$. Water table shifts were monitored to work out water balance. Two locations in the main block, MB6 and MB9 were identified for rainwater harvesting which also had access to four drainage channels. It was stressed that at least one of these fields be converted into an artificial recharge pond which would help enhancing of the ground water potentials in this region.

78. Study on the Common Indo-pacific Recent Foraminifera, East Coast of India and East Coast of Japan

Vikal Kumar Singh and P. K. Kathal

Centre of Advanced Study in Geology,
Dr H. S. Gour University,
Sagar-470003
vikal_singh@redifffmail.com

Keywords : *Taxonomy, Recent Foraminifera, Indo-Pacific*

Many benthic foraminifera migrated from the Atlanto-Caribbean province and entered in the warm-water masses of the Indian Ocean under the influence of westward flowing ‘Middle Miocene Equatorial Currents’. Some of them, which could reach close to Japan, the northern Pacific end are living as sublittoral fauna with warm ‘Kuroshio currents’ have been recorded considerable changes in the geological history during the middle Miocene in terms of ‘fluctuations in the sea level’ and ‘opening and closing of new traits’. Planktonic foraminiferal oxygen isotopic data from the Caribbean and the Pacific waters show that the modern

circulation patterns in the Caribbean and the eastern Pacific started 3 Ma ago when the salinity of Caribbean surface water started to increase 4 Ma ago, possibly due to shoaling of the Panama Isthmus.

Some tubulogenerids have been noted to have migrated in to the Indo-Pacific (even up to Indian Ocean) in early/middle Miocene through the Panama Isthmus. The migration of *Rotorboides granulosum* in embryonic stage and *Pulleniatina* a planktonic foraminifera indicate their entry in the Pacific through the Proto-Gulf of California before Panama Isthmus could develop during early Miocene time.

Out of 122 common Recent foraminiferal recorded from the two regions 41 have been described and illustrated namely, *Adelosina laevigata, Amphistegina radiata, Asterorotalia pulchella, Bolivina semicostata, B. subreticulata, Elphidium advenum, E. crispum, E. jenseni, E. subgranulosum, Fissurina marginata, Glabratella patelliformis, Hanzawaia nipponica, Lobatula lobatulus, Loxostomum limbatum, Nonion commune, Nonionellina* cf. *N. labradorica, Nonionoides grateloupi, Pararotalia nipponica, Pararotalia ? minuta, Planorbulina variabilis, Poroeponides lateralis, Pseudononion japonicum, Pseudorotalia indopacificana, Quinqueloculina agglutinans, Q. parkeri, Q. pseudoreticulata, Q. subcuneata, Quinqueloculina* cf. *Q. venusta, Reusella haizumensis, Rosalina australis, R. bradyii, Sigmavirgulina tortuosa, Spiroloculina angulata, S. communis, S. planulata, Textularia agglutinans, T. foliacea, Triloculina* cf. *T. rotunda, T. terquemiana, T. tricarinata* and *T. trigonula.*

79. Changing Pattern of Human Vulnerability and Risk of Natural Hazards – some Observations from Orissa

Gopal Krishna Panda

Professor, Dept. of Geography,
Utkal University,
Bhubaneswar

Realizations of the levels of risks which undermine Millennium Development Goals are the most important factors of consideration now. The accumulation of

high risks from natural hazards is slowing down the social and economic development of Orissa. The present paper makes an analysis of the impacts of the natural hazards such as flood, cyclone, heat wave, fire and lightning affecting the population in the state of Orissa of India as a case study. Besides this it aims to estimate the disaster risk by measuring human vulnerability and probability of occurrence of different hazard and their exposed population using multiple logit analysis. The findings reveal that the coastal districts are highly vulnerable to the natural hazards indicating higher degree of risk to the disasters. But however, the current trend is that there is a shift in the risk from coastal to non-coastal districts where the level of exposure is less.

The study will be based on human causality and impact data collected from the official sources of the Govt. of Orissa, Orissa State Disaster Mitigation Authority, Special Relief Commissioner's office, Bhubaneswar, Orissa. The study is to be taken up in four distinct stages comprising of Natural Hazard Analysis, Disaster Impact Analysis, human Vulnerability and Disaster Risk Index using multiple logit regression analysis. The detail outline of the methodology is given below.

The statistical model used for the estimation of the Disaster risk is based on the two concept i.e. Physical Exposure and Vulnerability. Vulnerability depends upon no. of events and exposed population. The equation for estimating the 'Disaster Risk' is given by;

$$R = (H) \times (Pop^n) \times (Vul^n) \quad \text{Eq. 1}$$

Where R is the Measure of Risk, H is the Hazard and Vul^n is the vulnerability

$$R = (Phy.Exp) \times (Vul^n) \quad \text{Eq. 2}$$

Where the product of H (Hazard) and $Popl^n$ represent the Physical Exposure of an area to a Hazard of particular magnitude. But for a geographical unit the total disaster risk can be expressed through;

$$Risk_{Tot} = \Sigma(Risk_{flood}+Risk_{cyclone}+Risk_{drought}+\ldots\ldots Risk_n) \quad \text{Eq. 3}$$

$$\text{Phy Exposure} = \Sigma F_i . Pop^n \quad \text{Eq. 4}$$

Where F_i is the number of average event & Pop^n is the Mean population during reference period the state of Orissa.

The study reveals that there is an increasing trend of the human vulnerability due to the natural hazards in spite of various preventive and mitigation measures. The coastal districts which were traditionally known as the flood and cyclone prone districts are showing relatively lesser vulnerability in comparison to the western districts where the natural hazard risk is high. But however, there is shift in the current level of vulnerability pattern and associated risk from the coastal to non – coastal districts.

There is a need to Track the Relationship between Development Policy and Disaster Risk. There is a scope to believe that the drive for growth and improvement is generating new Disaster Risk. Prospective Disaster Risk Management should incorporate Disaster Risk Reduction as a part of on going Planning & Development Process.

80. Myxomycetaceous Fossils Associated with Maastrichtian Palynoassemblage from Deccan Intertrappean Beds, Padwar, Madhya Pradesh

R. S. Singh* and Ratan Kar

Birbal Sahni Institute of Palaeobotany,
53 University Road,
Lucknow-226007
*E-mail: rs_singh1957@yahoo.co.in

Keywords *: Myxomycetes, Pollen-Spores, Maastrichtian, Deccan Intertrappean*

Myxomycetaceous fossil spores, swarm cells, sometimes in sexual conjugation stage and zygotes are recovered in association with spore and pollen assemblage from the Deccan Intertrappean beds, exposed near the village Padwar in Jabalpur District, Madhya Pradesh, are described here. The marker taxa viz. *Mulleripollis bolpurensis*, *Ariadnaesporites intermedius*, *Triporoletes reticulatus*, *Gabonisporites vigourouxii*, *Azolla cretacea* and *Aquilapollenites bengalensis* indicate a Maastrichtian age for these sediments. The assemblage recovered is rich and diverse with representation of all groups of plants but is dominated by a variety of pteridophytic spores. Conspicuous genera of the assemblage are *Cyathidites, Polypodiisporites, Todisporites Klukisporites, Lycopodiumsporites, Osmundacidites, Lycopodiumsporites, Varicostisporites, Lycopodiacidites,*

Ephedripites, Laevigatosporites, Spermatites, Araucariacites, Botryococcus, Nostoc, Azolla, Spinizonocolpites, Tricolpites, Longapertites, Araucariacites, Minerisporites, Phragmothyrites, Liliacidites and *Palmaepollenites.*

Three new fossil genera of Myxomycetaceous remains instituted after systematic morphological study are *Lithomyxomycetespora, Myxomycetesperma* and *Myxomycetezygotospora*. The spores described under *Lithomyxomycetespora* gen. et sp. nov. resemble the extant spores of *Stemonites fusca* Rothell, but are comparatively bigger in size. *Myxomycetesperma* gen. et sp. nov. represents solitary biflagellate cells related to swarm cells; whereas, *Myxomycetezygotospora* gen. et sp. nov. represents the zygospores of Myxomycetes. Five new species are described under the above genera. This group of fungi generally grows on the dead and rotten leaves and stems under hot and humid conditions. The associated palynomorphs also indicate warm and humid conditions due to the dominant presence of pteridophytic spores. The thin lignite bands from which the fungal bodies were recovered, reflects that these fungi were feeding on the plant remains that were deposited under lacustrine conditions.

81. Waste Management in Coal mines

S. Bindu and K. Deepu (B.Tech)

Abdul Kalam Institute of Science & Technology,
Kothagudem-507101

Keyword : *Erosion, Hydraulic Regime, Bio-mass, Damp, Pyretic.*

The land degradation and environmental pollution due to mining and waste material produced was abruptly extended to sub-surface with the advent of surface mining on large scale after the nationalization of coal mining industry in 1971-72. The various operations carried out during surface mining result in heavy dose of particulate matters and gaseous effluent to the environment while the dumps transform large tracts of land around the barren state. Erosion of dump covers the nearby fertile farms, making it unsuitable for agriculture while silting of the stream and river beds change the hydraulic regime of the area, the leachets from the dump pollute the water by the way of trace metals, acidic drainage and soluble impurities making the water unsuitable for normal use. The present paper discusses some of the critical issues mentioned above in case of coal mining. The waste generated

during various operations in coal mining has been pointed out. The most effective technique of waste management during these operations has been covered.

82. Thalassinoides Trace Fossils from Jodhpur Sandstone of Marwar Supergroup, Bhopalgarh Area, Jodhpur, Rajasthan

V. S. Parihar, V. Gaur, S. L. Nama and Narayan Ram

Jai Narain Vyas Uviversity,
Jodhpur-342005.
geoparihar@gmail.com

Key words : *Marwar Supergroups, Jodhpur Sandstone, Trace fossils, Bhopalgarh, Decapod crustaceans, Thalassinoides*

Well preserved Thalassinoides Trace fossils produced by decapods crustaceans were discovered from the Jodhpur Sandstone of Jodhpur group, the lower succession of the Marwar Supergroup. The Thalassinoides trace fossils are preserved full relief in fine grained sandstone and mudstone in Bhopalgarh area which is extensive outcrops of Jodhpur sandstone. The area under present investigation lies around Bhopalgarh, which is 70 km northeast of Jodhpur and sandstone of the area represents the upper sequence of Jodhpur group named as Girbhakar sandstone. The trace fossils are identified as Thalassinoides Suevicus sp. and Thalassinoides Paradoxica sp. which have been known to be produced by decapods crustaceans. No age indication provides this ichnogenus because they have been reported from Cambrian to Recent shallow sediment, accordingly they show shallow marine depositional environments. The details of lithofacies analysis are utilized to infer the various subcontinents of fluvial sedimentation in the area. According to they might have been channel fill, shallow abandoned channels deposits.

83. Landslide Hazard Zonation Along Imphal to Mao, Manipur

Dr. Thokchom Devala Devi and R. A. S. Kushwaha

Department of Earth Sciences,
Manipur University, Canchipur,
Imphal-795003
devalathokchom@yahoo.com

Keywords : *Landslide, vulnerable, zonation, mitigative measures, planners*

Hilly area of Manipur is vulnerable to instability and mass wasting processes due to the prevailing high rainfall and complex nature of terrain. The rapid pace of anthropogenic activities and seismicity has aggravated the problem of landslides in the area. To categorize the land surface into areas and arrange them according to degree of actual or potential hazard from landslide or other mass movements on slopes, an effort is made to prepare Landslide Hazard Zonation map along Imphal to Mao, Manipur covering an area of 650km2. The landslide hazard zonation maps are useful for identifying and delineating unstable hazard prone areas so that suitable mitigative measures can be adopted and will help planners to choose favourable sites for developmental schemes like road and building constructions. Based on the hazardousness to landslide the study area is divided into four different zones. The major part of the study area falls under the category of high hazard zone which is 380.43km2 (58.46%) in area, followed by moderate hazard zone covering an area of 152.27km2 (23.40%), low hazard zone (115.02 km2), and very high hazard zone (2.99 km2).

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B. D. Pathak	(1990)	S. Deb	(1965-1964)
M. N. Mehrotra	(1989)	P. R. J Naidu	(1963)
S. L. Kayastha	(1988)	K. P. Rode	(1962)
K. B. Power	(1987)	W. B. Metre	(1961)

V. S. Dubey (1960)
S. C. Chatterjee (1959)
A. C. Jhingran (1958)
Bhabesh Chandra Roy (1957)
A. M. N. Ghosh (1956)
V. P. Sondhi (1955)
H. L. Chibber (1954)
N. L. Sharma (1953)
L. A. N. Iyer (1952)
J. B. Auden (1951)
J. Coates (1950)
C. Mahadevan (1949)
P. K. Ghosh (1948)
C. S. Pichamuthu (1947)
H. Crookshank (1946)
N. N. Chatterjee (1945)
A. S. Kalapesi (1944)
J. A. Dunn (1943)
V. P. Sondhi (!942)

Geology

M. R. Sahni (1941)
L. Rama Rao (1940)
S. K. Roy (1939)
D. N. Wadia (1938)

Geology and Geography

W. D. West (1937)
B. Rama Rao (1936)

Geology

M. S. Krishnan (1935)
K. K. Mathur (1934)
N. P. Gandhi (1933)
P. Evans (1932)
G. de P. Cotter (1931)
David Penman (1930)
Cyril S. Fox (1929)
H. C Dasgupta (1928)
L. Dudley Stamp (!927)
B. Sahni (1926)
G. E. Pilgrim (1925)
W. F. Smeeth (1924)
G. H. Tipper (1922)
D. N. Wadia (1921)
P. Samiat Iyengar (1920)
L. Leigh Fermor (1919)
E. S. Pinfold (1918)
C. S. Middlemiss (1917)
W. F. Smeeth (1915)
H. H. Hayden (1914)

Geography and Geodesy

S. M. Tahir Rizvi (1941)
Shibaprasad Chatterjee (1940)
N. Subrahmanyam (1939)
A. M. Heron (1938)