

# राष्ट्रीय भूभौतिकीय अनुसंधान संस्थान (वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद्) समाचार पत्रिका



## NGRI NEWSLETTER

January - March 2010

(CSIR)

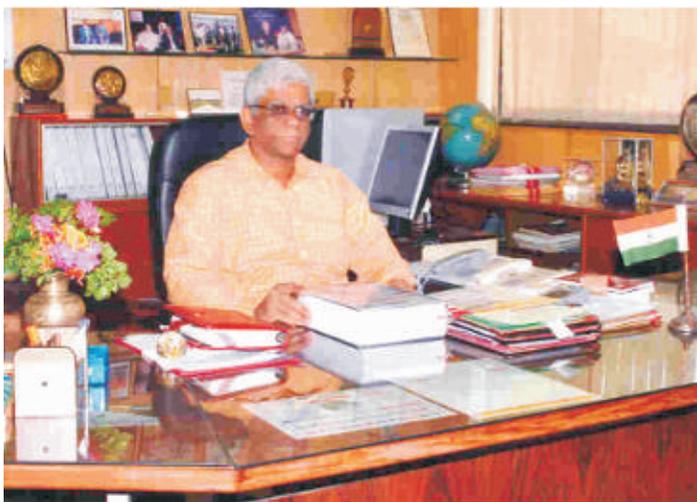
Vol. 2

Issue 1



### Dr Y.J. Bhaskar Rao takes over as Acting Director of NGRI

Dr. Y.J. Bhaskar Rao, Scientist 'G' has taken over as Acting Director of NGRI on the 28<sup>th</sup> February, 2010 from Dr.V.P. Dimri, on the latter's superannuation.



Dr. Y.J. Bhaskar Rao obtained his M.Sc. degree in Geology, in 1975 and Ph.D. in 1982 from the Osmania University, Hyderabad. He was a Postdoctoral Research Fellow at the University of Minnesota, Minneapolis, USA during 1981-82. With a basic fascination for geology, geochemistry and geochronology, Dr. Rao contributed significantly to the understanding of the formation and evolution of the Precambrian crust of India especially the Dharwar craton. Over the last decade, he also played an active part in establishing state of the art analytical facilities at the NGRI, enabling high-impact research in petrology and isotope geochemistry besides providing leadership in the formulation and execution of multi-disciplinary research programs.

Dr. Bhaskar Rao published about 50 research papers in peer reviewed SCI journals and presented over 120 papers at National and International Conferences and guided five students for Ph.D. He is the recipient of the National Mineral Award of the Ministry of Mines, Govt. of India. He is an Associate/Honorary Professor at several National and International Universities and a member of important committees of the DST and other agencies for establishment of laboratory facilities for Geochemistry and Geochronology in India. He has a long standing affiliation with learned societies such as the Geological Society of India, Indian Geophysical Union, Indian Association of Mass Spectrometry and the Mineralogical Society of India, to mention a few.

### From the Director's Desk

It gives me immense pleasure to record that the new year has brought in many exciting developments. Most importantly, the initiation of heliborne VTEM surveys for uranium exploration and an ambitious program of multi-channel data acquisition for gas hydrate exploration in Mahanadi and KG basins have taken off. We have also made subtle inroads into new avenues of research on geothermal energy and coal bed methane although these plans have to be firmed up substantially. Our colleagues deserve special appreciation for successfully organizing the AGU Chapman Conference on "Complexity and Extreme Events in Geosciences", an Indo Australian workshop on Geothermal Energy and a 5-day training program on seismology sponsored by the Ministry of Earth Sciences (MoES).

It is also time to celebrate the success of many colleagues who received awards and honors in recognition of their hard work and brilliance. Dr V. P. Dimri was conferred the

prestigious Padma Shri by the President of India. Dr. S. S. Rai was awarded the J. C. Bose National Fellowship while Dr. Ajay Manglik, Dr. V. Chakravarty and Dr. Sukanta Roy received the National Mineral Award for the year 2008. Dr. Chandrani Singh, a young Research Associate received the Indian Science Congress Association (ISCA) Young Scientist Award for the year 2009-10. NGRI's green ambience has also drawn the attention of the 'AP Environment Connect' who recognized the campus as a "Green Hub" of Hyderabad.

We, at the NGRI, are passing through an important transition phase as we enter the Golden Jubilee year of the Institute. At this crucial juncture we not only rejoice on our achievements and glory but also introspect on how to improve further and commit ourselves to ensuring a laudable position of the Institute in the geoscientific world nationally and internationally.

### Significant Contributions

#### Fluoride dynamics in the granitic aquifer of the Wailapally watershed, Nalgonda dist. India.

The Wailapally watershed in fractured granitic terrain of Nalgonda dist., AP has been characterized by high geogenic fluoride (F) concentration (up to 7.6 mg/l) in groundwater. Many of the villagers are afflicted with dental and skeletal fluorosis. Geomorphologically, the watershed has distinct recharge and discharge zones. Groundwater chemistry gradually undergone facies evolution along its path from recharge to discharge zone, and the evolution has been controlled by silicate weathering reactions. Decreasing calcium activity in the groundwater flow direction resulted in the fluorite under saturated conditions, which favor F dissolution in groundwater not only from the host rocks but also from calcretes through leaching. But, the F remained rather uniform at about 3-7 mg/l in the groundwater. The mechanism controlling the F limit in the studied groundwater is hypothesized to be removal of F from groundwater by co-precipitation with, and/or adsorption to, calcrete deposits in the weathered horizons of the aquifer leading to the F concentrations above drinking water permissible limit (1.5 mg/l).

The study shows the role played by calcretes in maintaining the equilibrium at high concentration of fluoride.

(Ref: D. V. Reddy, P. Nagabhushanam, B. S. Sukhija, A.G.S.Reddy, P.L. Smedley, *Chemical Geology*, v. 269)

#### New ways to monitor the Tsunamis Through Underwater Communication Network

Tsunamis are created by a large displacement of water resulting from earthquakes, landslides, volcanic eruptions, and even meteors hitting the ocean. Vessels far out at sea may not notice the waves passing underneath at the speed of a jetliner, because the wave heights are very small in the deep ocean. This makes their detection and monitoring a challenge. Tsunamis send electric signals through the ocean that appear to be sensed by the vast network of communication cables on the seabed, according to a new study led by Manoj Nair (presently at the University of Colorado and NOAA) and T. Harinarayana of MTS group, NGRI along with other scientists from NIO, Goa and Swiss Federal Institute of Technology, Zurich. They used computer models to estimate the size of an electric field created by the force of the 2004 Indian Ocean tsunami as it traveled over major submarine cables. Salty seawater, a good conductor of electricity, generates an electric field as it moves through Earth's geomagnetic field. It is estimated that the 2004 tsunami induced voltages of about 500 milli volts (mV) in the cables. This is very small compared to a 9-volt battery, but still large enough to be distinguished from background noise on a magnetically quiet day. By monitoring voltages across this network of ocean cables, we may be able to enhance the current tsunami warning system.

(Ref: Manoj Nair et al, *J. Earth, Planets and Space (EPS)*, Vol. 62 No. 3, pp. 353-358, 2010)

#### Significant temporal changes in $\delta^{13}\text{C}$ of groundwater related to reservoir triggered seismicity.

Carbon-13 isotope precursory studies for three years (2005-2007) in the reservoir triggered Koyna-Warna seismic area revealed significant temporal changes in  $\delta^{13}\text{C}$  of dissolved inorganic carbon (DIC) of groundwaters. The episodicity of depleted  $\delta^{13}\text{C}$  values from three deep well waters were correlated to earthquake events of  $M > 4$ . Interestingly, the maximum magnitude earthquake ( $M 5.1$  on 14<sup>th</sup> March 2005) observed during the 3 year study

period has effected maximum change in  $\delta^{13}\text{C}$ . The temporal changes in  $\delta^{13}\text{C}$  of DIC of groundwater were ascribed to earthquake induced mixing of two aquifer waters having different isotopic and chemical signatures. About 70 to 80% of deep aquifer water mixed with shallow aquifer water during the M 5.1 earthquake, thus effecting a maximum change in  $\delta^{13}\text{C}$ . The study highlights the importance of  $\delta^{13}\text{C}$  measurements in groundwater of reservoir triggered seismic area as proxies to earthquake activity.

(Ref: B. S. Sukhija, D. V. Reddy & P. Nagabhushanam, *Seismological Reserch Letters*, Vol. 81, no. 2)

### NGRI publication ranked as one of the “MOST READ” by Australian SEG

“Aeromagnetic image of a part of Peninsular India and its relation to geology and structure” by H. V. Rambabu and M.Prasanthi Lakshmi, Published in *Exploration Geophysics* (Australian SEG journal) was one amongst the most widely read/downloaded in the top 20 papers out of a few hundred papers published in the last ten years. The “Most Read” ranking was based on the daily updated statistics of the number of downloads from the CSIRO publishing website since it began collecting usage data in the year 2000.

### Patents Granted

A Nigerian Patent “Development of a Technique utilising Natural Carbon-13 isotope for identification of early breakthrough of injection water in Oil Wells” was granted Vide Patent Number NG/C/2009/308 to Dr. Balbir Singh Sukhija, Dr. Dontireddy Venkat Reddy, Shri. Pasupuleti Nagabhushanam, Shri. Dattatray Jaiwant Patil, and Shri. Syed Hussain.

A France Patent “Method for Synthesis of Geikelite-A Mantleoxide” was granted to Dr. G.Parthasarathy NGRI and S.V. Manorama IICT.

### Awards and Honours

#### Padma Shri award conferred on Dr. Dimri

The prestigious ‘Padma Shri’ Award, was conferred on Dr. Vijay Prasad Dimri, former Director of NGRI for his contribution to the field of Science and Engineering. Hon. Union Minister of Science and Technology Shri Prithviraj Chavan felicitated Dr. V. P. Dimri during a function organized at IICT, Hyderabad.



### JC Bose National Fellowship for 2010

Professor S. S. Rai, Scientist ‘G’, NGRI, has been honored with the prestigious JC Bose National Fellowship by the Union Ministry of Science and Technology. The fellowship, is initially awarded for a period of five years to Indian scientists of international repute below the age of 60 years. The award carries an amount of Rs.20,000/- per month in addition to the salary and a yearly contingency grant of Rs. 5 Lacs for the fellowship period.



Prof. Rai is also a fellow of all the three national science academies of India and recipient of prestigious awards such as the S. S Bhatnagar Prize and National Mineral Award.

### National Mineral Awards to three NGRI Scientists

Three scientists Drs. Ajay Manglik, Sukanta Roy and V. Chakravarthi of NGRI, received the National Mineral Awards which were presented by Shri B. K. Handique, Hon’ble Minister for Mines & DONER, Government of India, on 27<sup>th</sup> February 2010 at Vigyan Bhavan, New Delhi.



Dr. Ajay Manglik received the award for his contributions to the field of applied geophysics towards understanding the tectonics of the Indian plate and underlying mantle dynamics and for development of tools for multi-parametric joint inversion of geophysical data. His studies on quantification of heat and mass transport processes in

continental lithosphere through integration of crustal seismic velocity, electrical resistivity and density structure, heat flow and seismicity have provided useful insights into the thermo-mechanical state and tectonics of the Indian shield. His work on development of joint inversion tools integrating seismic and electromagnetic methods has made significant impact on exploration geophysics.



Dr. Sukanta Roy received the award for the year 2008 in the field of Geothermal Studies. Dr. Roy, who leads the Geothermal group of NGRI made significant contributions that led to advancements in understanding the thermal state of the Indian lithosphere and characterization of its geothermal

energy potential. Through acquisition of extensive geothermal datasets and adoption of innovative interpretation strategies, he has characterized the deep thermal regimes beneath the Deccan Trap, Aravalli, Dharwar and Southern Granulite terrains. He generated new models for the source of heat of geothermal springs in the Indian shield leading to re-assessment of their geothermal energy potential, and built a record of past climate changes in India by exploiting the potential of geothermal observations. Geothermal investigations initiated by him for assessing the temperature regime along proposed tunnel segments in the Himalaya have opened up new engineering applications with immense potential for upcoming hydro-power plants.



Dr. Chakravarthi received the award for his outstanding contributions in both theoretical and experimental geophysics. He applied geophysical modeling techniques for mineral and hydrocarbon exploration, and also in identifying subsurface geological structures in both onshore and

offshore regions in India.

His algorithms were published in high impact International Journals. His US patent entitled "Digitally implemented method for automatic optimization of gravity fields obtained from three-dimensional density interfaces using depth dependent density" was the first ever US patent granted to NGRI.

### ISCA Young Scientist Award

Dr. Chandrani Singh, Research Associate working in Seismology division of NGRI received the "Young Scientist award of Indian Science Congress Association (ISCA)" for the year 2009-2010 for her research work on different phenomena that might trigger earthquakes at dam sites. She received the award from Dr. A. P. J. Abdul Kalam, eminent scientist and Former President of India at the 97th Indian Science Congress organized at the Kerala University campus at Kariavattom, Kerala during Jan, 2010.



Dr. Chandrani has been working on Reservoir Triggered earthquakes of the Koyna-Warna region where seismicity is persisting over last several years without any apparent decrease neither in frequency nor in magnitude.

### On the board of Directors of GSPC Ltd.

Dr. T. Harinarayana, Scientist-G, Head, Magneto Telluric studies group, was chosen by the Government of Gujarat as an independent Director on the Board of Gujarat State Petroleum Corporation Limited (GSPC) in recognition of his outstanding contributions to various multi disciplinary mega-projects related to oil industry. He played a key role in integrated geophysical exploration projects for hydrocarbons in the trap covered regions and frontier basins of India. Dr. Harinarayana applied the MT method for the earthquake, tsunami monitoring studies, geothermal exploration and seismotectonics and deep crustal studies. His pioneering work in geothermal energy has opened up new avenues of power generation in



different regions of the country - Puga in Jammu and Kashmir, Tapovan-Vishnugad in Uttarakhand, Tatapani in Chattisgarh, Surajkund in Jharkhand.

### Appointed as Adjunct Faculty at SRTM University, Nanded, Maharashtra.

Dr. V. Balaram, Dr. T. R. K. Chetty, Dr. Bijendra Singh, Dr. T. Harinarayana, Scientist G and Dr. V. S. Singh, Emeritus Scientist of NGRI have been appointed as Adjunct Faculty (Honorary) in the School of Earth Sciences of Swami Ramanand Teerth Marathwada University, Nanded, Maharashtra for a period of five years starting from 1<sup>st</sup> March 2010.

### Indo-Tunisian Collaboration

Dr. Shakeel Ahmed led a delegation of Indian scientists to Tunisia for the 1<sup>st</sup> Indo-Tunisian workshop on collaboration in water science and technology organized at CERTE in Tunis, Tunisia during February 22<sup>nd</sup> - 26<sup>th</sup>, 2010.



Dr. Shakeel Ahmed was appointed as the Indian Coordinator for the Indo-Tunisian Collaboration on Water Science and Technology.

The delegation included the scientists from Central Ground Water Board (CGWB), IISc, Bangalore, Anna University, Chennai, IIT Kharagur and NGRI, Hyderabad. The 2<sup>nd</sup> workshop is scheduled to be organized at NGRI, Hyderabad during September, 2010.

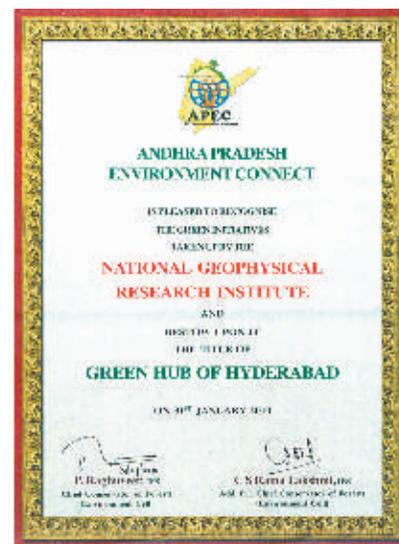
### Keynote Speech on World Water Day.

Dr. Shakeel Ahmed has delivered a Keynote Speech on "Groundwater Management in Arsenic Contaminated Multilayered Aquifer system: A Judicial Scientific approach with people's participation guarantees a viable

solution!" on March 22<sup>nd</sup> 2010 at Patna in a program organized by the Central Ground Water Board (CGWB), Patna in association with UNICEF. During the keynote speech, Dr. Shakeel Ahmed highlighted NGRI-CGWB collaboration in providing Arsenic free water in the affected areas of Bihar.

### NGRI recognized as Green Hub of Hyderabad:

Andhra Pradesh Environment Connect (APEC), a group of enthusiastic environmentalists committed to creating a better environment for future generations recognized the green initiatives taken up by the National Geophysical Research Institute (NGRI) and bestowed upon it the title of "GREEN HUB of HYDERABAD".



Sri K. R. Suresh Reddy, Former Speaker, AP Legislative Assembly as chief guest and Sri C. Madhukar Raj, IFS, Principal Conservation of Forests as Guest of honour felicitated Dr. V. P. Dimri, Director, NGRI for his efforts towards this green hub. Sri P. Raghuveer, IFS, Chief Conservator of Forests (Environment cell) and Ms. C.S. Ramalakshmi, IFS, Addl Principal Conservator of Forests (Environment Cell) were also present in the function.

### New Year Lecture by Prof. Devendra Lal

On the New Year day of 2010, Prof. Devendra Lal, FRS, Former Director, PRL, Ahmedabad and Distinguished Scientist delivered an interesting lecture on "Evidence of large century time scale changes in the Solar Activity during last 35,000 years". Prof. Lal provided the evidence based on his novel idea of measuring in-situ cosmogenic production changes of <sup>14</sup>C in Greenland Ice. Based on such measurements, he discovered two periods of very low solar activity in time bracket of 8500-9500 and 27,000-32,000 yr BP and one period of high solar activity. His studies also demonstrated a long duration low solar activity during historical period of 1750-1860 AD and thus he desired that such detailed research

studies pertaining to last 1000 years is to be taken up in future.

### Indo-Australian Workshop on Geothermal Energy Capacity Building

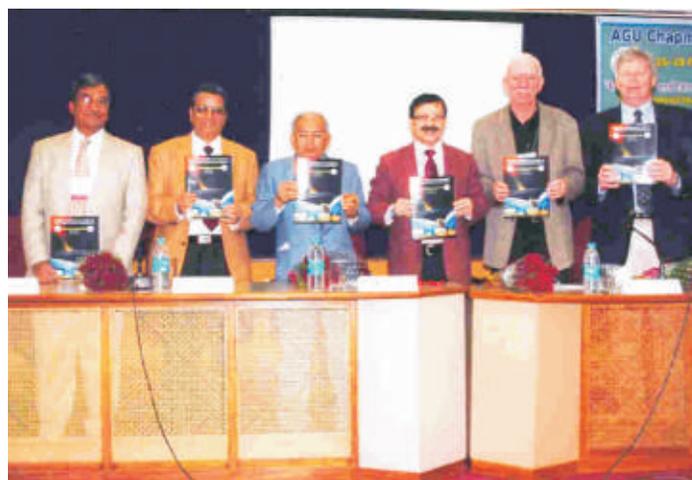
NGRI hosted a two day Technical workshop on "Geothermal Energy Capacity Building" during 8-9<sup>th</sup> February, 2010, jointly in collaboration with the Ministry of New and Renewable Energy (MNRE) and Geoscience Australia. Dr. R. N. Sawant, Director MNRE and Dr. Andy Barnicoat, Geoscience Australia, participated in the workshop. Dr. R. N. Sawant, in his inaugural address appreciated the efforts of the Geoscience Australia, and MNRE for holding this important workshop in this country. Developments have been made in terms of Engineered Geothermal System (EGS) and Hot Sedimentary Aquifer (HSA) projects. Dr. V. P. Dimri, in his welcome address explained about various R&D activities of NGRI mainly on the aspects such as magnetotelluric investigations in geothermal fields of Sutlej-Spiti, Beas- Parbati Valleys in Himachal Pradesh, Badrinath-Tapovan in Uttarakhand and Surajkund in Jharkhand. Successful identification of deeper anomalous conductive feature related to geothermal source in Tatapani in Chattisgarh and also in Puga in Jammu and Kashmir, using the 'magnetotellurics' has paved a way to search for more geothermal regions of India. Dr. T. Harinarayana, Head, MTS Division, NGRI spoke about the Conventional Geothermal Systems-Indian Scenario emphasizing on the various factors such as deep subsurface structure and deep drilling technology in high pressure, high temperature regions which play a major role on geothermal energy.

Dr. O. P. Pandey, Dr. Sukanta Roy, Dr. K. Veeraswamy, Dr. A. M. Dayal and Dr. Abdul Azeez gave an overview Geothermal Energy and also on the Heat Flow studies across the Indian Shield, to mention a few.



### AGU Chapman Conference on Complexity and Extreme Events in Geosciences

Extreme geophysical events such as floods, earthquakes, solar storms, tsunamis, etc impact significantly the human society. The American Geophysical Union (AGU) is the largest body of geoscientists and a Chapman Conference is an appropriate forum for the efforts to develop a deeper understanding of such extreme events. The AGU Chapman Conference on "Complexity and Extreme Events in Geosciences" was held at NGRI from 15-19<sup>th</sup> February, 2010 to explore this emerging interdisciplinary science, consolidate the recent understanding and define new research directions. This conference was mainly focused on common features of extreme events and quantitative relationships among them which may lead to possible methods of predictions.



The conference was inaugurated by Prof. K. S. Valdiya, Distinguished Professor, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore and Professor Seyed E. Hasnain, Vice Chancellor, Hyderabad Central University. Eminent Scientists in the field of non-linear geophysics, Prof. Suraj Lal Sharma, University of Maryland, USA, Prof. Armin Bunde, University of Giessen, Germany, Prof. Daniel N Baker, University of Colorado, USA and Shaun Lovejoy, McGill University, Canada. Prof. V.P. Dimri, spoke on the importance of data and information and emphasized how inaccurate, insufficient and inconsistent data can lead to erroneous results. Dr. Suraj Lal Sharma focused on the importance of the theme of the Conference, while Dr. Armin Bunde discussed the universal extreme events. Prof. Hasnain spoke on the

importance of upcoming field of Biomedical Geology, while Prof. K. S. Valdiya narrated about the palaeo extreme events documented in epics during the inaugural address. The conference was attended by 120 delegates including 39 foreigners.

The goal of the conference was to share information with policy makers and to illuminate the essential facts in order that decisions are effectively made on matters of importance to the society. India is a region that is subject to almost all these natural extremes. Because of the large concentrations of population in India, the effects can be particularly devastating.

Scientists from different countries deliberated on various fields such as Tsunami modeling, earthquake studies, extreme geological events, climate-studies and other relevant topics. The interdisciplinary nature of this research makes nonlinear geophysics and complexity science a unique framework for advancing our knowledge, develop predictive models and formulate mitigation strategies worldwide. An important outcome of the conference was a strong endorsement for sharing the knowledge gained from research among scientists, policy makers and public.

### National Science Day Celebrations

National Science Day was celebrated on 26<sup>th</sup> Feb 2010. Prof. K. V. Subba Rao, Director of the Center for Earth and Space Science, University of Hyderabad delivered the National Science Day Lecture on "Adding Science to Life". Dr. V. P. Dimri, Director presided over the function. Dr. Y. J. Bhaskar Rao, Scientist G introduced the speaker. In his lecture, Prof Subba Rao lucidly narrated the role of science in the evolution of civilization, and its effect on mankind and life citing examples from India, in general and Andhra Pradesh, in particular, He narrated how



visionaries such as Sir Arthur Cotton made the green revolution possible by planning a river irrigation system with the help of canals and constructing dams. After the Science Day Lecture, Prof. K. V. Subba Rao released the "NGRI Research Output 2009". Dr. D. Sarkar, Scientist G, proposed vote of thanks

### Orientation course on Seismology

NGRI organized a 5 day orientation course on Seismology from 24<sup>th</sup> to 30<sup>th</sup> March 2010 with financial support from the Ministry of Earth Sciences. About 40 participants from various research and academic institutes in India attended the course. The course covered various aspects of earthquake occurrence processes and geodynamics. Specifically, the participants were exposed to new techniques in seismological research, e.g., receiver function, seismic tomography, earthquake sources, surface wave dispersion, InSAR, tectonic geodesy, seismic hazard and microzonation, use of engineering geophysical techniques in seismic hazard analysis etc. The participants were also given training on handling various seismological instruments in the field.



### Participation in SSBM Tournament

The NGRI team participated in Cricket and Volleyball tournaments held at NPL, New Delhi. Both the teams had put up a good show. The captains of volleyball team were Mr. R. Mohan and Dr. A. S. S. R. S. Prasad while the captains of cricket teams were Dr. Abdual Aziz and Mr. A. K. Tiwari. Mr. G. Ramchandra Rao was the manager of the teams.



Lectures delivered by Distinguished Visitors

Date	Name of the Visitor	Topic
1 <sup>st</sup> January, 2010 New Year Lecture	Dr. Devendra Lal, Former Director, PRL, Ahmedabad, Distinguished Scientist, Scripps Institution of Oceanography, USA	Solar activity during the last 35,000 years
4 <sup>th</sup> February, 2010	Prof. Satish Singh Marine Geosciences, Institut de Physique du Globe De Paris France	Seismic images of the locked and unlocked Sumatra Subduction zone using 15 km streamer of CGG Veritas
5 <sup>th</sup> February, 2010	Dr. Patrick Connolly Manager, BP Corporation, London	Robust workflows for seismic reservoir characterization
12 <sup>th</sup> February, 2010	Prof. Richard Corkish University of New South Wales, Sydney, Australia	Introduction to solar cells and their applications
19 <sup>th</sup> February, 2010	Prof. Vijay Gopal U.S.A.	Scaling of Hydrological Aspects
22 <sup>nd</sup> February, 2010	Dr. M.V. Rodkin Senior Scientist, Geophysical Center, Moscow, Russia	Some new indicators of involvement in the process of seismic rupture
29 <sup>th</sup> March, 2010	Dr. Anil Kakodkar, former Chairman, AEC Chairman, Research Council, NGRI	Towards our safe and sustainable energy future

Welcome on joining NGRI

Dr. Mrs. Suchismitha Benjwal, Lady Medical Officer who joined NGRI on 07-01-2010

Superannuated Staff Members

- |   |                                       |
|---|---------------------------------------|
| 1. Mr. Syed Asharaf Ali, Technician     | 7. Dr. M. Someswara Rao, Scientist    |
| 2. Dr. T. Gyaneswara Rao, Scientist     | 8. Mr. S. Kasim, Peon                 |
| 3. Mr. MD. Jafer Ali, Technician        | 9. Mr. G. Ramulu, Technician          |
| 4. Dr. D. Muralidharan, Scientist       | 10. Dr. V. P. Dimiri, Director        |
| 5. Mr. K. Babu Rao, Tech. Officer       | 11. Mr. G. Vijaya Kumar, Technician   |
| 6. Mr. B. Mallaiah, Technician          | 12. Mr. Chandra Pal Singh, Technician |
| 13. Mr. Y. Ram Mohan Rao, Tech. Officer |                                       |

Forthcoming Events

7<sup>th</sup> Annual Meeting of the Asia Oceania Geosciences Society (AOGS 2010), will be held at Hyderabad in collaboration with Indian Geophysical Union (IGU) during July 5-9, 2010

This conference covers wide a spectrum of Geosciences and Space Sciences fields including Atmospheric sciences, Ocean sciences, Solid Earth sciences, Planetary sciences, Hydrological sciences, Solar and Terrestrial sciences, as well as inter-disciplinary fields.

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IGU Website: <http://www.igu.in>

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