

NOTES

INTERNATIONAL WORKSHOP ON EARTH SYSTEM PROCESSES RELATED TO GUJARAT EARTHQUAKE USING SPACE TECHNOLOGY

The above workshop was held during January 27-29, 2003 at IIT Kanpur. The Workshop was inaugurated by Dr. Vinod K. Gaur, Indian Institute of Astrophysics, Bangalore. His inaugural talk on the Bhuj earthquake highlighted the results of Global Positioning System (GPS) studies and its importance in understanding the dynamics of the Indian plate. The workshop was attended by 80 participants from various research and academic institutions in India. Seven foreign scientists participated in the Workshop from USA, Germany, Russia and China.

In this Workshop, 44 papers were presented orally in nine technical sessions. D. Bennert (UNESCO, GARS Program) presented a paper related to India-Eurasia collision in Pakistan; he brought out a number of basement faults developed within the Indian plate during the collision. Presently, these faults are connected with numerous seismic activities in the eastern Indian plate.

H.B. Madhwal (Survey of India, Dehra Dun) presented detailed results based on GPS survey made by Survey of India in Gujarat. It was found that the area is rotating anticlockwise with maximum shift at Lakhpat (11.1m) (Gujarat), while at other sites shifts are found to be 1 to 5 m. However, the accuracy of measurements, time duration of data collection are the major factors affecting the results. Based on the gravity data, it was concluded that there is an uplift between Ahmedabad and Rajkot while subsidence was indicated between Okha, Porbandar, Jodia, Mundra and Bhuj. V. K. Rao (NGRI, Hyderabad) presented a paper based on the geophysical data which shows that the seismicity pattern in the tectonic plate of Kachchh suggests a diffuse plate boundary near the Makran subduction.

A. K. Shukla (IMD, New Delhi) gave details about the seismic observations being made by IMD and monitoring capabilities. IMD's network of seismic observatories until December 2002 have recorded more than 1000 aftershocks after Bhuj earthquake. The depth of focus of Bhuj earthquake was found to be 22.6 km deep and focal mechanism of strike-slip nature. The details of ongoing seismic activities around Bhavnagar and Jamnagar regions were also presented. V. M. Tiwari (NGRI, Hyderabad) presented a paper based on gravity and magnetic surveys. The gravity and magnetic studies have delineated a hidden

thrust fault striking NW-SE along the western margin of Wagad uplift near to the epicentral region of Bhuj earthquake.

C. P. Rajendran (CESS, Trivandrum) presented his studies on Palaeo-earthquakes/seismicity with dates. The morphological characteristics suggest that deformation due to 1819 Bhuj earthquake corresponds to a broad zone. The Bhuj earthquake exposed many fossil features related to other earthquakes. George Mathew (PRL, Ahmedabad) showed that several episodes of earth movements along the major E-W faults indicate the initial phase of incision which began around the early Holocene which continued until 5 ka along the major rivers north of Bhuj. Luminescence ages show the younging of age towards east of Bhuj. P. Mandal (NGRI, Hyderabad) found east-west trending fault, responsible for main earthquake using aftershock data. The aftershock zone is confined to a 60 km x 40 km region lying between KMF and NWF. Mandal showed the 1-D velocity model by inverting P and S waves travel time of 500 aftershocks. A high 6-value zones at 15-30 km depth was found indicating heterogeneity representative of high VP/VS and Poisson's ratio in hypocentral zone.

Sushil Kumar (WIHG, Dehra Dun) presented tomography studies in collaboration with NGRI, Hyderabad and scientists from Japan using aftershock data of Bhuj earthquake. The tomography inversion was based on the inversion of 8374 P and 7994 S waves of 1404 aftershocks data recorded by 25 temporary seismic stations. The tomography inversion gave relatively high VP/VS and low Vs in region below the hypocentre of main shock. P.N.S. Roy (BHU, Varanasi) discussed the fractal analysis of tectonic map governing seismic activity in the region and had shown low value of fractal dimension of Kutch rift block in comparison to surrounding blocks.

R. V. Karanth (Baroda University) explained the structure and tectonic framework of Kachchh. He opined that the region forms a thin-skinned thrust belt with regularly spaced asymmetrical buckle folds to recumbent folds and break-thrust folds.

B. K. Rastogi (NGRI, Hyderabad) discussed important results about the deformation due to Bhuj earthquake and inferences about stress and strain in the Kachchh region. He explained that this earthquake has occurred along a

hidden south-dipping fault at 25 km north of Kachchh Mainland Fault (KMF).

R. N. Iyenger (IISc, Bangalore) presented attenuation relations for Kutch obtained from peak ground acceleration values estimated from the assessment of structural damages near source region and the observed near source ground motion data for 2001 Bhuj main shock.

B. K. Bhadra (ISRO, Jodhpur) presented a paper dealing with the importance of IRS PAN data in assessing the observed damages caused by the 2001 Bhuj earthquake. T. K. Biswal (IIT, Mumbai) drew attention towards the small scale geological features based on remote sensing data resulting from the 2001 Bhuj earthquake. He also suggested that these features might have been caused by left lateral shear movement along the mainland fault. R. Banerjee (SAC, Ahmedabad) presented the importance of satellite imageries in estimating probabilistic hazard values as well as the direction of maximum horizontal compressive stresses.

Arun Bapat (Pune) discussed details of observed seismic precursors prior to the Bhuj earthquake. Prior to Bhuj earthquake, upwelling of Kandla port and excessive sedimentation was observed. Other precursors based on newspapers reports were: increase in frequency of micro earthquakes during September 2000 to December 2000 at Bhavnagar and Porbandar, and several wells in Gujarat and Rajasthan, which were dry for decades were suddenly filled with water during December 2000 to January 2001.

H. S. Virk (GU, Amritsar) described the Radon precursory signals observed at Palampur which is about 400 km from Chamoli and 1200 km from Bhuj where earthquakes occurred in 1997 and 2001, respectively. The Radon anomaly was observed two days before the Chamoli main shock and four days prior to Bhuj earthquakes before the main event.

Mahesh Thakkar (Lallan college, Bhuj) explained the relation between magnitude and liquefaction dimensions near the epicentral zone. R. D. Deshpande (PRL, Ahmedabad) discussed observations on release of helium associated with Bhuj earthquake.

D. Ramakrishnan (RRSSC-ISRO, Kharagpur) presented a paper based on detailed mapping of liquefaction in Bhuj and Bhachau areas using LISS-3 data, after initial evaluation of liquefaction using IRS-1C WiFS data.

Saumitra Mukherjee (JNU, New Delhi) presented a study based on correlation on the occurrence of global earthquake and earth directed Coronal Mass Ejection and change in Magnetic Field (Kp Indices) and electron flux of Earth-Sun environment. A. Narain (SAC, Ahmedabad)

presented an extensive and holistic overview of application of space technology for disaster management.

Three papers presented related to changes in geomagnetic field behavior prior to an earthquake. J.R. Heirtzler (NASA, USA) gave a succinct account of the various geomagnetic field satellites in orbit or proposed during the decade of geopotential research. Mita Rajaram (IIG, Mumbai) presented maps showing magnetic, aeromagnetic, gravity satellite data, heat flow and emphasized the need to have good data coverage of the different geophysical parameters to build a good database.

S. C. Mavrodiev (Bulgaria) presented the changes in geomagnetic field prior to Gujarat earthquake. He emphasized that the geomagnetic fields combined with tidal wave and other geophysical data can be used for prediction and location of earthquakes.

Dimittar Ouzounov (NASA, USA) presented an interesting paper based on experiments on rock deformation in terms of rise in temperature and surface potential of a granite sample at a steady rise of uniaxial stress. Javed Malik (IIT Kanpur) presented a paper on active faults in Bhuj area based on satellite imagery. R.C. Jain (CGWB, Ahmedabad) presented the detailed hydrogeologic study of the Bhuj area showing sharp increase in water level in all areas in Kutch except in Rapar after the Bhuj earthquake. R. P. Singh (IIT K) presented the result of his study on the application of multi-sensor data for early warning of intraplate earthquakes on the basis of increase in soil moisture content, doubling of fish catch, chlorophyll concentration and water vapor in atmosphere.

Six papers dealing with ionospheric perturbations and monitoring of ionospheric signals were presented. The results presented by scientists from India, Russia and Mexico have shown strong correlation of the changes in ionosphere and earthquake events. Many Scientists also believe that the behavior of aerosol and gravity waves changes significantly prior to an earthquake. Raj Pal Singh (Agra) has found ionospheric anomaly during Bhuj earthquake. A.K. Gwal (Bhopal University) presented ionospheric signatures as a precursor of earthquake. S.A. Pulnits (Mexico) stressed importance of electric field measurement within the ionosphere over the seismically active areas.

During the Workshop, panel discussions on three different topics were organized. The panel discussion on the topics "Geology, Tectonics and Seismology: Future Directions" was chaired by V. K. Gaur, Indian Institute of Astrophysics, Bangalore. Following recommendations were made:

* It was suggested that rift valleys and such other intra-cratonic

structures be delineated and mapped with illuminating details. Accordingly detailed geological maps at a larger scale and with better feature's definition be generated. Geological Survey of India and Universities may be advised to address in this activity

- * Real time monitoring of seismicity and associated phenomenon is a prerequisite for a thorough understanding of the tectonic context of earthquakes. A few pilot projects may be formulated to implement such networks
- * Palaeo seismological investigations should be initiated to understand past seismicity in a region and to upgrade earthquake catalogues
- * Available datasets generated so far by various agencies may be integrated and published to stimulate comprehensive tectonic and structural model building and testing
- * Focused Workshops on themes related to understanding of intra-continental seismicity may be organized at different Institutions in India
- * Care must be exercised while data processing and interpreting the results and emphasis be laid on detailed discussions of errors and their estimations
- * A working group on intraplate seismicity may be identified for their continual assessment of the state of knowledge of the Indian shield and its intracontinental tectonic features in associated seismicity

A panel discussion on, "Natural and Man Made Hazards Using Space Technology and International Cooperation" was chaired by J R Heirtzler (NASA, USA)

The following recommendations emerged on various issues of disaster mitigation

- * It was suggested that member countries may approach disaster management support group at ISRO, Bangalore for getting the Radarsat data for disaster management purpose
- * It was felt that there is a need for co ordination between geoscientists and civil engineers for construction of dams
- * A strong recommendation was made to initiate studies on climate change and associated phenomena at international level
- * Reservoir Induced Seismicity studies may be carried out in different dams located in high seismic zones in order to avoid dam disasters due to earthquakes
- * All the Space Agencies may discuss projects related to natural hazard management at international level for technology solutions
- * A working group may be constituted in India for international co-operation for disaster management. The working group may formulate different problems and themes related to Natural Hazards

- * Indian scientists may participate in seismo electromagnetic studies through French electromagnetic satellite to be launched during 2004
- * A working group may be constituted to participate in the Asian Seismic Hazard commission
- * The panelists felt a strong need to create a more transparent system for exchange of satellite data at International level
- * Geomagnetic field satellites detect ionospheric current system fluctuations whose origin is not yet fully understood. Weather fluctuations are related to fluctuation associated with natural hazards needs to be investigated
- * A joint Indo US satellite mission is envisaged. This mission design is to be coordinated with present geomagnetic field satellites and those in the planning stages by the international community. This is a mini-constellation to resolve the important small scale space behavior of ionospheric current systems

A panel consisting of S K Jain (IIT, Kanpur), B K Rastogi (NGRI, Hyderabad) and R N Iyenger (IISc, Bangalore) discussed the present status of "Seismic Hazard of the Country". Jain (IIT Kanpur) pointed out the importance of seismic hazard estimation including soil characteristics, liquefaction potential and site response. Further, he drew attention to the urgent need of research program on the estimation of seismic hazard using existing data. B K Rastogi (NGRI, Hyderabad) pointed out the need for more strong motion accelerographs and seismograph stations in the country which, in turn, would lead to a better estimation of PGA value and attenuation relations. R N Iyenger (IISc, Bangalore) drew attention to the importance of proper estimation of PGA values and attenuation relations for the country. Following recommendations were made by this panel

- * Installation of more numbers of strong motion accelerographs and seismograph stations in the country for obtaining a better estimation of PGA value and attenuation relation
- * Preparation of a homogeneous and consistent catalogue of Indian earthquakes
- * Designing of attenuation relationships for different regions of the country
- * Preparation of seismic Hazard maps incorporating soil characteristics, liquefaction potential, site response and better attenuation relationships for corresponding regions

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