



Second Circular

International Symposium

on

**“The 2001 Bhuj Earthquake and Advances in Earthquake
Science (AES 2011)”**

(22-27 January 2011)



Institute of Seismological Research (ISR)

Department of Science and Technology

Government of Gujarat



Organized by:

- Indian Society of Earthquake Science
- Institute of Seismological Research

Local Organizing Committee:

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- Jwalant Trivedi, Deputy Secretary, Science & Technology Department, Government of Gujarat.

Venue:

Institute of Seismological Research, Raisan-382008, Gandhinagar, India.

Co-sponsors:

- ✚ NGRI
- ✚ IUGG
- ✚ MOES

Contact details:

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web: <http://ises.in/ises/User/AES2011.html>

Registration fees:

Foreign Participant	US \$ 300
Indian Participant	₹ 10000
ISES Life members	₹ 5000
Research Scholars	₹ 2000

- Registration fee will include Conference material and tea/coffee

Accommodation:

- Hotel / ISR guesthouse/hostel accommodation will be arranged on request at concessional rates on prior bookings
- Hotel bookings can also be made by the delegates themselves. Following are name of few hotels near to ISR:

Hotel Haveli, Gandhinagar: <http://www.hotelhaveli.com/Home.htm>

Tariff (approx.) ₹ 3500 (\$70)

Hotel Cambay, Gandhinagar: http://www.thecambay.com/hotel_gandhinagar.htm

Tariff (approx.) ₹ 3000 (\$60)

Hotel Cambay Ahmedabad: http://www.thecambay.com/hotel_ahmedabad.htm

Tariff (approx.) ₹ 7000 (\$140)

Comfort Inn, Ahmedabad: <http://www.comfortinn.com/hotel-ahmedabad-india-II042>

Tariff (approx.) ₹ 3500 (\$70)

Cama Hotel, Ahmadabad: <http://www.camahotelsindia.com>

Tariff (approx.) ₹ 4000 (\$80)

Sarovar Portico, Ahmedabad: <http://www.sarovarhotels.com/ahmedabad-sarovar-portico.shtml>

Tariff (approx.) ₹ 2500 (\$50)

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Facilities at ISR

Conference office

This office is located at the ground floor of ISR and will be staffed during the session days from 8 hrs. to 21 hrs.

Internet facilities will be available at this office.

Registration Desk

Registration will take place in the entrance lobby of ISR. The Registration, Information and Cashier's desk will be open from 8 hrs to 19 hrs during 21st - 24th January, 2011.

Lecture Room Facilities

All lecture rooms are equipped with standard PC projectors and Loudspeaker.

Copying machines

Copying machines are available for all participants on payment.

Travel Information

The Travel and Tour Desk will be located in the entrance lobby of the ISR next to the Registration and Information Desk. The Travel Desk will hold the same opening hours as the Registration Desk. In any cases of emergency or assistances in regard to logistic services, please contact Pallabee Choudhury (Tel: +91 90990 34460, email: pallabee.ch@gmail.com).

Transport

Pick up from and drop to Ahmedabad airport is provided by some of the hotels, if not, LOC will arrange on advance request. LOC will arrange transport from hotels to venue of symposium and back.

AES-2011 Scientific Program / Sessions

- Plenary Session
- **S1:** Bhuj Earthquake and Aftershock Studies
- **S2:** Intraplate Seismicity
- **S3:** Seismicity and Earthquake Source Processes
- **S4:** Paleoseismology and Historical Seismology
- **S5:** Earthquake Precursors and Prediction Studies
- **S6:** Seismic Wave Propagation , Amplification and Basin Effect
- **S7:** Real Time Seismology, Loss Reduction and Early Warning
- **S8:** Earthquake Ground Motion and Damaging Earthquakes
- **S9:** Seismic Hazard Assessment / Microzonation
- **S10:** Tectonics and Crustal Movements
- **S11:** Earth's Interior , Structure & Dynamics
- **S12:** Remote Sensing, GPS & InSAR
- **S13:** Exploration for Oil and Crustal Structure
- **S14:** Ground Response Studies for Nuclear Power Plants
- **S15:** Tsunami Modelling
- **S16:** IGCP Session on Archeoseismology

AES-2011 TENTATIVE PROGRAM	
22nd January, 2011	
08:00 – 18 :00	Registration
10:00 – 11:00	Opening Ceremony
11:00 – 11:30	High Tea
11:30 – 13:00	Plenary
13:00 – 14:00	Lunch
14:00 – 17:00	Plenary
17:00 – 17:30	Tea
19:00 – 20:00	Cultural Program
20:00 – 21:00	Gala Dinner
23rd January, 2011	
08:00 – 18 :00	Registration
08:30 – 10:30	Scientific Session/ Poster session
10:30 – 11:00	Tea
11:00 – 13:00	Scientific Session
13:00 – 14:00	Lunch
14:00 – 17:00	Scientific Session
17:00 – 17:30	Tea
20:00 – 21:00	Dinner
24th January, 2011	
08:30 – 10:30	Scientific Session
10:30 – 11:00	Tea
11:00 – 13:00	Scientific Session
13:00 – 14:00	Lunch
14:00 – 16:00	Scientific Session
16:00 – 16:30	Tea
16:30 – 17:30	Scientific session
18:00 – 18:30	Concluding Session
20:00 – 21:00	Dinner

- **Opening Ceremony**

- **Plenary**

Conveners: Harsh Gupta: harsh123@gmail.com
B.K.Rastogi: brastogi@yahoo.com

S1: Bhuj Earthquake and Aftershocks

Conveners: B.K. Rastogi, Prabhas Pande and Jim Mori

The 2001 M7.7 Bhuj earthquake is a rare great Stable Continental Region (SCR) earthquake studied through modern era seismographs. The well-determined mechanism indicated clear reverse faulting along a steep fault and inversion of tectonics from tensile stress (normal faulting) in the rift valley environment to compressive stress (thrusting) regime now. The rupture details have also been worked out. Over 10,000 aftershocks of M 1-5 have been precisely located and well-studied by modern era local seismograph network. Seismological studies include PS, Q and b-value tomography, Crustal structure, through travel time, surface-wave dispersion and Receiver Transfer Function, anisotropy study through shear-wave splitting, Geophysical surveys have established details of crustal structure besides sediment thickness and basement configuration. All these studies have given new insights to the understanding of seismogenesis of least understood SCR earthquakes. Papers are invited on the study of Bhuj earthquake and aftershocks and similar earthquake in other SCR regions as a comparative study.

S2: Intraplate Seismicity

Convener: O. P. Mishra

The Earth's most seismically active regions and sites of its largest earthquakes coincide with the boundaries between the tectonic plates. However, the vast majority of the earth's surface and continents lie within the interiors of these tectonic plates, and 'intraplate' regions can also exhibit significant earthquake activity. Despite advent of modern seismological research, the seismogenesis in the intraplate regions of the world, including Stable Continental Region (SCR) of India is still a great puzzle for geoscientists to explore the plausible mechanism involved into intraplate seismicity. The identity and characteristics of their seismic sources remain unknown. The explanation for the intraplate seismicity necessitates understanding of the evolution, structures and processes of the shield area. Several sets of hypotheses and theories without common consensus on genesis of intraplate seismicity have been developed and put forth by different researchers for different intraplate regions of the globe (e.g., Africa, Asia, Australia, Europe North America and South America). Moreover, the frequent occurrences of the 1993 Latur – Killari (Mw 6.3), the 1997 Jablapur (Mw 6.0), and the 2001 Bhuj (Mw 7.6), Indian earthquakes beneath the intraplate stable continental regions of the Peninsular India ushered a new era of integrated seismological research coupled with multi-disciplinary geo-scientific observations to address the physics of intraplate seismicity. The focus of this session on "Intraplate Seismicity" is to understand the nature of intraplate seismicity and the forces driving it in the 'stable continental regions' of the world in general, and in 'peninsular India' in particular. Considering significant advances on intraplate seismicity research in recent years, the session on "intraplate seismicity" invites case studies on recent significance earthquakes and swarm

activity in the peninsular India and the regions of analogous geotectonic settings, elsewhere in the world. Presentations on seismotectonic processes, crustal 1-D and 2-D velocity and attenuation models, and studies of regional and local stress patterns with integrated seismo-geophysical interpretation frame work derived from multi parametric seismo-geophysical observatories are also invited. In addition, contributions on ground motion observations from intraplate earthquakes and efforts to model sub-surface seismogenic layers using local and regional 3-D velocity and attenuation tomography are also welcome.

S3: Seismicity and Earthquake Parameters

Conveners: J. R. Kayal and Prantik Mandal

The essence of seismology lies in the observation and interpretation of earthquakes in terms of seismicity, seismological characteristics, source parameters and the source processes. There is a continuing need to improve knowledge on the *intra-plate* as well as on the *inter-plate* seismicity. The information that are extracted from seismograms need to be reviewed and expanded so as to provide the best possible analysis and interpretation. Thus methods for seismological interpretation need to make an account of the Earth complexities, development of seismic modeling and intensive computation that has benefited greatly from advances in computer technology. Most earthquakes in continental areas require an understanding of the distribution of seismicity and faults beyond; how the structural and tectonic setting condition earthquakes of various kinds of geologic, geophysical and seismologic phenomena.

Contributions are invited for all aspects of the collection, analysis and interpretation of seismological data in intra-plate and inter-plate seismic environments including:

1. Developments in seismic networks and data centers-including land, ocean-bottom and planetary networks, international data exchange, management of massive data sets.
2. Comprehensive seismogram analysis at single stations, seismic networks and arrays, potentials and future developments.
3. Rapid and routine determination of earthquake parameters including location and source parameters, fault-plane solutions, seismic characteristics like b-value, p-value, fractal dimension etc.
4. Advances in wave propagation in heterogeneous media, including synthetic seismograms and waveform modeling in realistic Earth structures, theory and observations of scattering, attenuation and anisotropy.
5. Developments in seismological interpretation, including development of inversion techniques and seismic tomography.

S4: Paleoseismology and Historical Seismology

Conveners: Susan Hough, Roger Bilham and Javed N. Malik

Historical earthquake studies, which typically involve development of modern methods to analyse macroseismic data from archival sources, can provide invaluable information about earthquake processes and earthquake hazard in Asia, which boasts both wealthy ancient cultures and significant earthquake hazard. However, the historical catalogue of earthquakes is still substantially incomplete in several countries which are under the threat of earthquake hazard. Paleoseismological studies, including traditional trenching as well as other methods, provide a complimentary approach to identify and investigate the historical

and pre-historical earthquakes signature preserved in the geological record. Such investigations have also been carried out in some countries, although many targets remain to be explored to better quantify fault slip and earthquake rates. We invite papers that present the results of historical and paleoseismological investigations of earthquakes and faults in Asia, including contributions that explore the implications of results for basic questions involving fault and earthquake processes, and seismotectonics. We also invite contributions that explore the implications of results for improvements in hazard assessment.

S5: Earthquake Precursors and Prediction Studies

Conveners: B.R. Arora and R. K. Chadha

Recognizing that earthquake precursory research hold key to earthquake prediction, search for precursors and their documentation has continued in different parts of the globe. Accumulated evidences bring forth variety of precursory signals including seismological, atmospheric/ionospheric, geodetic/geomagnetic, electrical resistivity/hydrological as well as geochemical anomalies. Despite certain definite success cases, skepticism prevails as noted changes are not observed at all earthquakes sites or even for different earthquakes in the same region. The dilatancy-diffusion model based on behavior of rocks under stresses in laboratory conditions has some success in explaining some of the noted precursory signals. Induction of con-current multi-sensor measurements and availability of satellite data have begun to demonstrate the promising role of non-seismological parameters in earthquake forecasting programs. The present session shall review the advances in earthquake precursory programs to devise road map for future planning and practical application of earthquake precursory research. Papers dealing with any aspect of earthquake precursory research are welcome. Papers focusing on modern mathematical tools to isolate precursory signature in real time, establishing their space-time relation to earthquake cycle and highlighting strategies for integrating multi-sensor data are especially invited.

S6: Seismic Wave Propagation, Soil Amplification and Basin Effects

Convener: J.P. Narayan

Significant differences in structural damages in basins as compared with the surrounding exposed rocks or even in a basin itself from place to place have been observed during the past earthquakes. The theoretical studies have revealed that assessment of soil amplification and resonance frequency for layered soil deposit in basin using an empirical relation is erroneous. The recent researches have also revealed that basin-edge, shape and size of basin and the basement topography play an important role in altering the ground motion characteristics. In light of above, the research papers dealing with the following aspects are invited for presentation and discussions during the symposium.

- a. Assessment of soil amplification and resonance frequency using experimental techniques like standard spectral ratio method, horizontal to vertical spectral ratio method and H/V ratio method.
- b. Assessment of soil amplification and resonance frequency in a basin using analytical and numerical techniques.
- c. Numerical and analytical methods for simulation of seismic wave propagation.
- d. Seismic microzonation of basin.
- e. Assessment of effects of basin geometry and surface topography on the ground motion characteristics

S7: Real Time Seismology, Loss Reduction and Early Warning

Conveners: Friedemann Wenzel and R.S.Dattatrayam

The aim of real-time seismology is to collect and analyse seismological data rapidly during a seismic crisis and utilize them for developing information on hazard, potential damage of large events, actual damage, and aftershock risk, with the aim of mitigating the earthquake impact on human society. Before a main shock the focus is on providing indications for an impending event by time-dependent assessment of hazard and risk. During a shock alert and shake maps of ground shaking allow rapid assessment of the expected area and scope of the earthquake; in many cases several seconds to a minute might be available for early warning *sensu stricto* with options to shut down critical facilities, secure industrial facilities, and issue alarms where appropriate. After the main shock rapid damage estimates based on seismological information and on a modelled structural environment can be delivered to the emergency institutions. Also, the risks associated with aftershocks can be assessed. Operational systems covering some of the aspects mentioned are meanwhile in place in Japan, Mexico, Taiwan, Europe and the U.S. The session will explore the state-of-the-art of this evolving technology and highlight application options in the Indian context.

S8: Earthquake Ground Motions and Damaging Earthquakes

Conveners: Kojiro Irikura and Sumer Chopra

The high amplitude ground motions near large earthquakes cause severe damage to life and property. The high frequencies present in a near field record are due to the complexities on the fault surface and partly due to the scattering by inhomogeneities in the surrounding medium. Therefore the strong motion data are very useful in the study of details of the rupture process. The task is challenging for seismologists to study these near field records of damaging earthquakes which have occurred in the past and prepare models for predicting future large earthquakes in potential areas with reasonable accuracy. A number of techniques recently have been proposed to predict earthquake ground motions. The session aims at discussing latest techniques of predicting earthquake ground motions and lessons learnt from past damaging earthquakes.

S9: Seismic Hazard Assessment/Microzonation

Conveners: A. Peresan, Fumio Kaneko, T.G. Sitharam and Imtiaz Parvez

Development of effective mitigation strategies requires sound seismic microzonation and seismic hazard information. The purpose of seismic hazard assessment (SHA) is to provide a scientifically consistent estimate of seismic hazard for engineering design and other considerations. The time is ripe to move beyond traditional Probabilistic Seismic Hazard Assessment, because it is not based on earthquake sciences (i.e., invalid earthquake source model, misuse of statistics, and invalid mathematics). PSHA practice has become the "old good paradigms" of widespread ignorance and intolerance to any revision. Although there are many approaches available for SHA, this Session advocates the advanced methods for seismic hazard assessment and seismic microzonation that utilize up to date earthquake science and basic scientific principles to derive the seismic hazard in terms of a ground

motion or related quantity and its occurrence frequency at a site, as well as the associated uncertainty.

The Session is addressed to seismologists, engineers and stake-holders, and aims to contribute bridging modern interdisciplinary research and end-users, who have to cope with the problems of the earthquake risk management and natural disasters preparedness.

S10: Tectonics and Crustal Movements

Convener: B.K. Rastogi

The knowledge about the tectonics and crustal movements is essential for medium and long-term assessment of seismic hazard. Various geophysical surveys determine crustal and upper mantle structure including sedimentary thickness, faults orientation, basement block structure, Moho depth. Passive methods like seismic tomography receiver transfer functions, shear wave splitting provide some more details like discontinuities in the upper mantle which provide clues for deeper earth processes like hot spots and disposition of plutonic bodies which act as stress concentrator or poisson's ratio to detect fluid field zones which act as asperities or lithosphere-asthenosphere boundary which provides clues for rifting episodes. The results of VLBI, GPS and InSAR measurements are inferred in term of current crustal movements and after a major earthquake pattern of deformation in respect of shear deformation or visco-elastic process/ rheology change. The session includes papers on such aspects.

S11: Earth's Interior, Structure and Dynamics

Convener: M.Ravi Kumar

Our understanding of the Earth as a dynamic system has primarily evolved owing to development of new incisive tools to probe the Earth's interior from the crust to core, tremendous strides in acquisition of high quality data from dense observational networks coupled with enhanced computational power. Multidisciplinary knowledge accrued from high resolution studies of the continental lithosphere, nature and deformation of subducting slabs, physical and thermal state of the mantle transition zone, the lowermost mantle region and the inner core in conjunction with mineral physics experiments is continually refining the forefront of knowledge thereby unveiling the fundamental global and regional scale dynamic processes of our planetary interior. This session is intended to focus on our current knowledge of the deep structure, evolution and dynamics of the stable continental interiors and actively deforming plate boundary regions in diverse tectonic settings by bringing together researchers from a wide variety of disciplines from active and passive seismology, GPS geodesy, geodynamics, geochemistry, Magnetotellurics and mineral physics. Contributions specific to the evolution of the Indian shield and its plate boundary regions like the Himalaya, Burma and Andaman arc regions are particularly welcome.

S12: Crustal Deformation through GPS and InSAR Studies

Convener: V.K.Gahalaut

Understanding the process of occurrence of earthquakes in the plate interiors has always been a great challenge for geoscientists. These regions are characterized by very low strain rate and hence the earthquake recurrence intervals are generally very large. Such

regions become centers of large inhabitation and people tend to assume that the seismic hazard in such regions is low. In such regions earthquakes occur as a “surprise” and cause relatively more damage, as compared to the earthquakes in the high seismic hazard regions where people are aware of high seismic hazard and take care in enforcing building codes. The 2001 Bhuj earthquake is one such best example. Thus it is important to understand the strain rate, crustal deformation through earthquake cycle, mechanism of crustal deformation, crustal structure, rheology and earthquake occurrence processes in these regions. This session is aimed to focus such studies in the Kachchh and similar other regions of the world.

S13: Exploration for Oil and Crustal Structure

Convener: S.K.Biswas

Most of the oil provinces are in the areas of complex geological structure and tectonically active regions with repeated earthquakes such as, Northeastern India – Upper Assam, Arunachal, Tripura, & Andaman arc; Northwestern India & Pakistan – Rajasthan, Sind, Punjab & Baluchistan; Western and Central India – Kutch, Cambay & Narmada which are the active area for SCR earthquakes. Detailed structural studies carried out for oil exploration provide new data and perspective in the thermo-tectonic aspect of these earthquake prone areas. This may provide new insight in the crustal structure and tectonic history and help understanding the neotectonic activity and the ongoing seismicity. With this in view, papers are invited on structure and tectonics and tectono-sedimentary evolution of the petroliferous basins in the regions mentioned above, for presentation and discussion in this session.

S14: Ground Response Studies for Nuclear Power Plants

Convener: A.G. Chhatre

Nuclear Power Plants are designed for Site Specific Earthquake Ground Motion (SSGM). In a nuclear power plant, not only the civil structures but mechanical, electrical, control and instrumentation equipment for safety systems and safety support systems are designed for Safe Shutdown Earthquake (SSE). The work involves

- carrying out geological field check and seismological studies to arrive at the active faults within an area of 300 Km radius around the plant site,
- to arrive at the maximum magnitude earthquake potential of these active faults
- to arrive at Site Specific Earthquake Ground Motion (SSGM)

Subsequent to that the civil structures and also the mechanical equipment viz. Pumps, Valves, Heat Exchangers, Tanks, Vessels, Piping System, Ducting; Electrical Equipment viz. transformers, diesel generators, cable trays, low voltage & medium voltage switch gears, battery chargers, electrical panels, battery banks and delicate instruments viz., relay, contactors, push buttons, thermowells, pressure gauges, switches are seismically qualified by a combination of analysis and shake table tests to demonstrate structural integrity, pressure boundary integrity & functional performance of active components/devices.

Huge amount of technical data has been collected all over the world regarding good and poor performance of Civil structures, Mechanical Electrical and Instrumentation & Control Systems which have witnessed large number of earthquakes close to the conventional industries and Nuclear Power Plants viz., Koyna (1967) & Bhuj (2001) in India which affected petrochemical, thermal & hydro power plants, cement & general industry, Kobe (1995) in Japan which affected generally industries, Niigataken Chuetsu–Oki (2007) in Japan

which affected Kashivazaki-Kariwa Nuclear Power Plants, Noto Hantou (2007) in Japan which affected Shika Nuclear Power Plant, Chi-Chi (1999) in Taiwan which affected general industries, San Fernando (1971) earthquake in USA which affected El Centro Steam Plant, Coalinga (1983) earthquake in USA which affected Pleasant Valley Pumping Plant and oil field facilities, Imperial Valley (1979) earthquake in USA which affected Sylmar Converter Station and the Rinaldi Receiving Station etc.

There is a technical session on the topic of ground motion studies for structures, systems and equipment of Nuclear Power Plants and also on the earthquake resistance design of Industrial structures, residential buildings, and bridges. Institutes, Research laboratories & Consultants are involved in the activities of seismic design of residential buildings to a great extent and also in the design of bridges, industrial structures and Nuclear Power Plants across the country.

Papers are invited in this special session of ground response studies for structures, systems and equipment of Nuclear Power Plants, Industrial & residential civil structures and Bridges. The topics can be on

- Attenuation correlations for active and stable continental region
- Geological and seismological studies,
- Earthquake ground motion by deterministic and probabilistic method,
- Design of structures systems and equipment for Nuclear Power Plants
- Structural design of Industrial and residential civil structures, bridges
- Performance of the above structures, systems and equipment during the earthquake

Geological studies around nuclear power plants to arrive at the earthquake ground motion for design of civil, mechanical, electrical and instrumentation of control systems.

S15: Tsunami Modelling

Convener: V.P.Dimri

East coast of India is affected by tsunami generated along Andaman-Sumatra subduction zone and west coast from Makran subduction zone. Numerical modeling to determine the tsunami propagation, potential run-ups and inundation from tsunamigenic sources is recognized as useful and important tool, since data from past tsunami are usually insufficient to plan future disaster mitigation and management plans. Models can be initialized with potential worst case scenarios for the tsunami sources or for the waves just offshore to determine corresponding impact on nearby coast. Models can be initialized with smaller sources to understand the severity of the hazard for the less extreme but more frequent events and also far taking into account the shape of the coast line and shelf. Paleotsunami study is important to decipher pre-historic tsunamis. All this information then forms the basis for creating tsunami evacuation maps and procedures. Papers are invited on these topics regarding tsunami studies.

S16: IGCP Session on Archeoseismology

Conveners: Prof. Manuel Sintubin and Dr. Javed Malik.

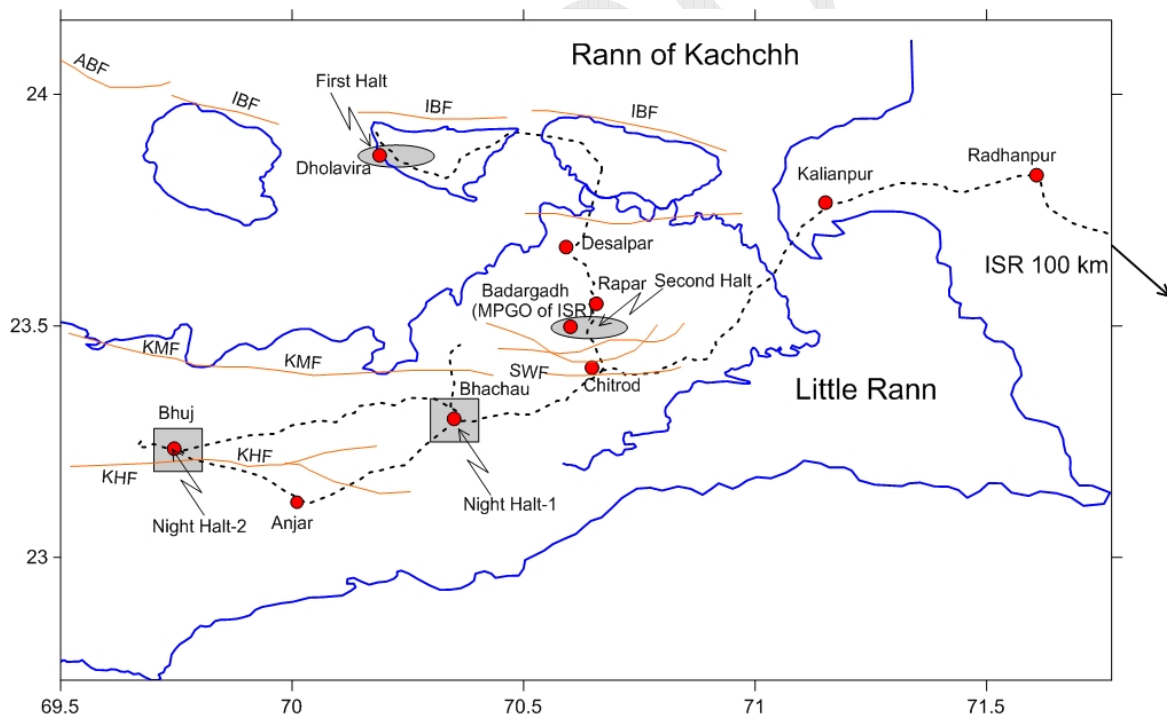
The session on Earthquake Archaeology in Central and Southern Asia invites case studies that consider the principles and/or practices of archaeoseismology within the broader Himalayan seismic zone in Central (e.g. Afghanistan, Tadjikistan, Kyrgyzstan, Tibet) and Southern Asia (e.g. India, Pakistan, Nepal, Bangladesh). This session is organized in the framework of the international geosciences programme IGCP567.

Pre symposium Field Tours (21st January 2011)

- Sound and light show: Akshar Dham (Free) : 7 pm
- Ice breaking : 8pm

Post symposium Field Tours (25-27th January 2011)

- 2001 Earthquake affected zone, active fault exposures, Little Rann (vast expanse of salt plain and sanctuary for wild ass), Dholavira Harappan Archeological Site and one of the three Multi Parametric Geophysical Observatories (MPGO) for Earthquake Prediction Research developed by ISR in Kachchh. By road 350 km (Event Organizer- S.K.Biswas, Javed Malik, M.S. Gadhvi and R.S. Bisht). Cost: Rs. 5000 (US\$ 400).
- Nal Sarovar Bird Sanctuary and boating and Lothal Archeological Site. By Road 150km Cost: Rs. 2000 (US \$50)
- Modhera Sun Temple (similar to Khajuraho and Konark), By road 100 km, Cost: Rs. 2000 (US \$50)
- Local Sight Seeing Cost Rs. 2000 (US \$50) i.e. Akshar Dham, Nature & Fossil Park, Mahatma Gandhi Ashram, Siddi Sayed Mosque, Shaking Minarets and Adalaj Vav.
- Heritage walk (Morning and evening)



Road map for the post symposium field tour to Kachchh. ABF: Allah Bund Fault; IBF: Island Belt Fault; KMF: Kachchh Mainland Fault, KHF: Katrol Hill Fault, SWF: South Wagad Fault.