Bhuj Earthquake of 26 January, 2001

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NOTES

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INTRODUCTION

A devastating earthquake hit the Bhuj region of Gujarat on the Republic day, 26 January 2001, the origin time being 08:46:53 IST. The earthquake epicenter was located at 23.362° N, 70.338°E, with a focal depth of 22 km (Fig.1). The earthquake measured 8 on the surface magnitude scale as estimated from 86 observations around the world, 7.1 being the body-wave magnitude, as measured by 23 global stations. This is the largest earthquake in this region, the only other one with a similar magnitude being the 1819 Kutch earthquake. The other great earthquakes in the Indian region in the past are the 1897 Shillong earthquake (M 8.7), 1905 Kangra earthquake (M 8.6), 1934 Bihar-Nepal earthquake (M 8.3) and the 1950 India-China border earthquake (M 8.7), all falling along the Himalayan belt and in northeast India.

Loss of life and property

There has been a widespread damage in the vicinity of the earthquake epicenter, which is located 20 km ENE of Bhuj. The estimates of the human lives lost are still debated but it could go up to 50,000. There has been a widespread damage to the structures (Figs.2 and 3) and the preliminary estimates of financial losses are in the range of 40 to 50 thousand crores of rupees. However, it will take a long time before the estimated loss of life and property is verified.

Foreshocks and aftershocks

There is no way of identifying foreshocks before occurrence of the main shock. However, the seismic activity in Bhavnagar since August 2000, with magnitudes up to 4.4, has been identified as possible precursor for the 26 January 2001, Bhuj earthquake. The aftershock activity has been intense, with 8 aftershocks exceeding magnitude 5 occurring within one week of the main shock (Fig.1). The most remarkable of them has been the aftershock of 28 January 2001 at 06:34 IST, with a magnitude of 6.0.

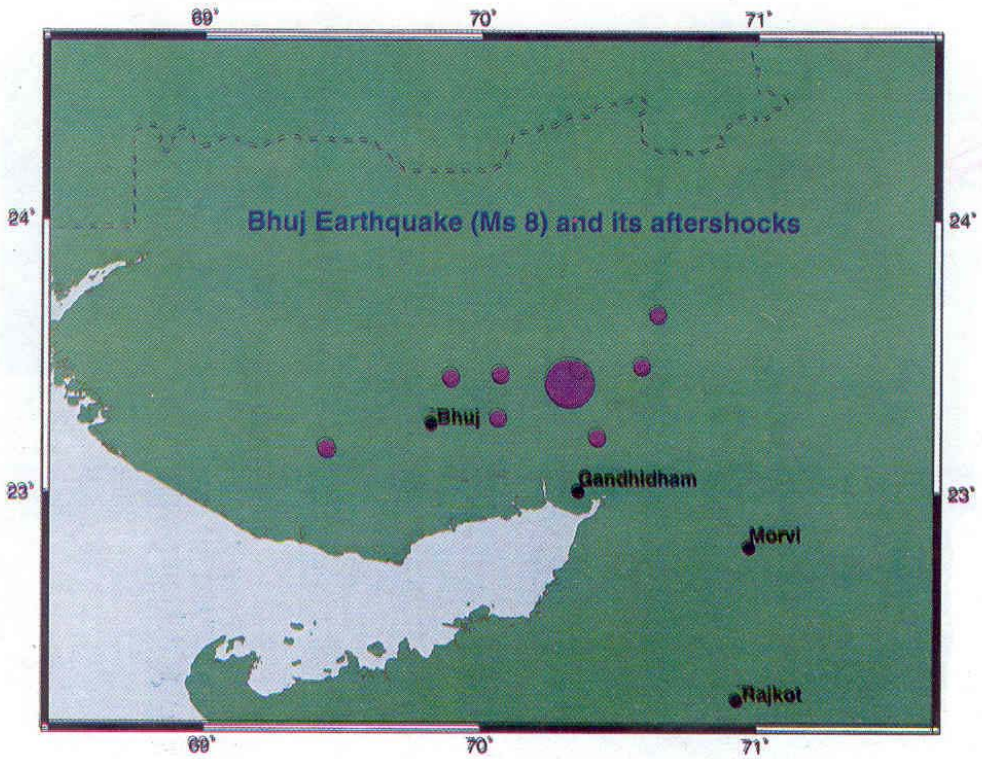

Fig.1. Epicentral map of the 26 January, 2001 Bhuj earthquake and its aftershocks.

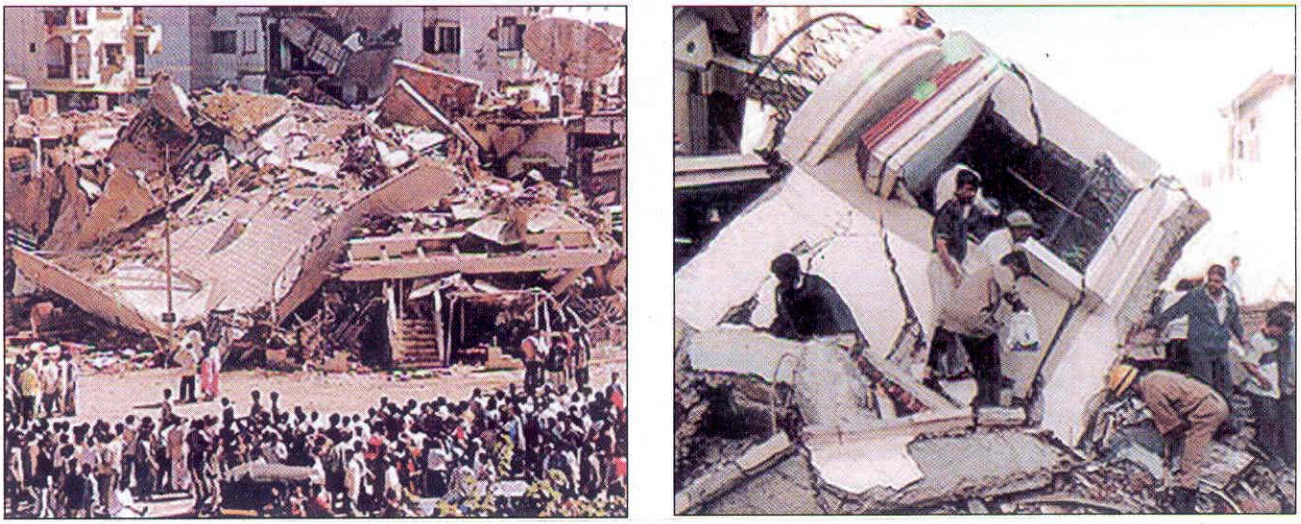

Fig.2 and 3. Collapse of modern buildings in Bhuj and nearby areas.

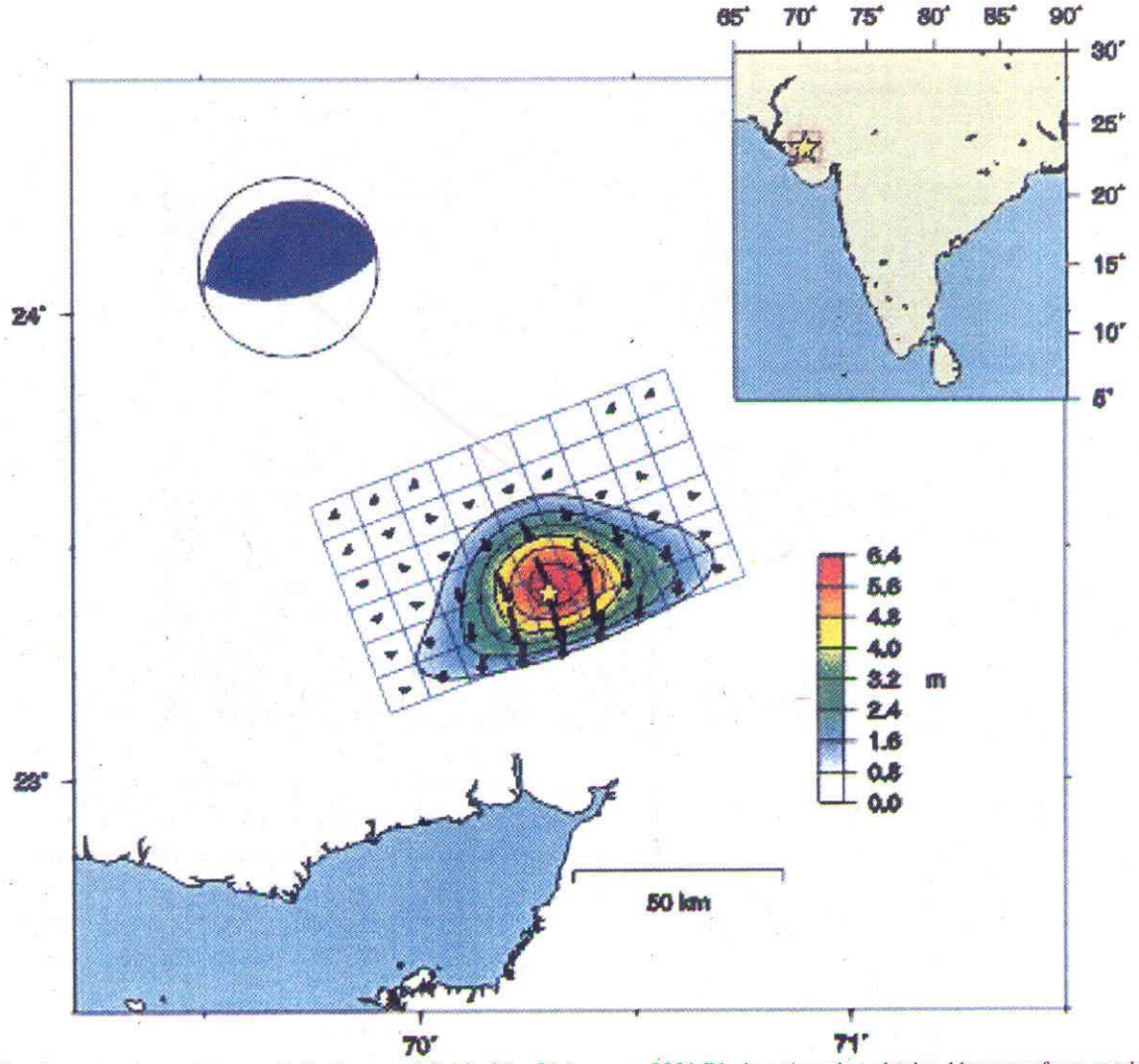

Fig.4. Focal mechanism solution and displacement field of the 21 January, 2001 Bhuj earthquake, obtained by waveform modelling of teleseismic broadband data (*after* Yagi and Kikuchi, 2001).

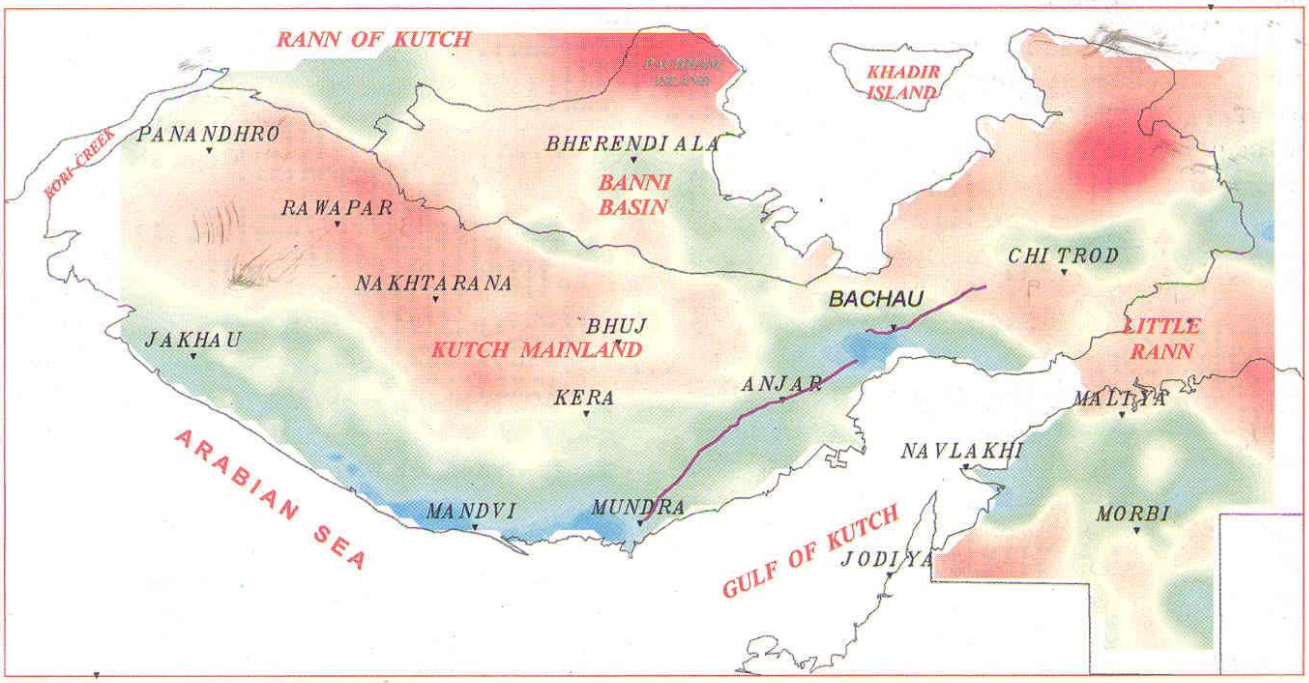

Fig.5. Integrated geophysical traverse along Mundra-Bachau, superimposed on the Bouguer gravity anomaly map. Note the sharp increase in anomaly from the southern lowlands (green) to the central mainland uplift (red).

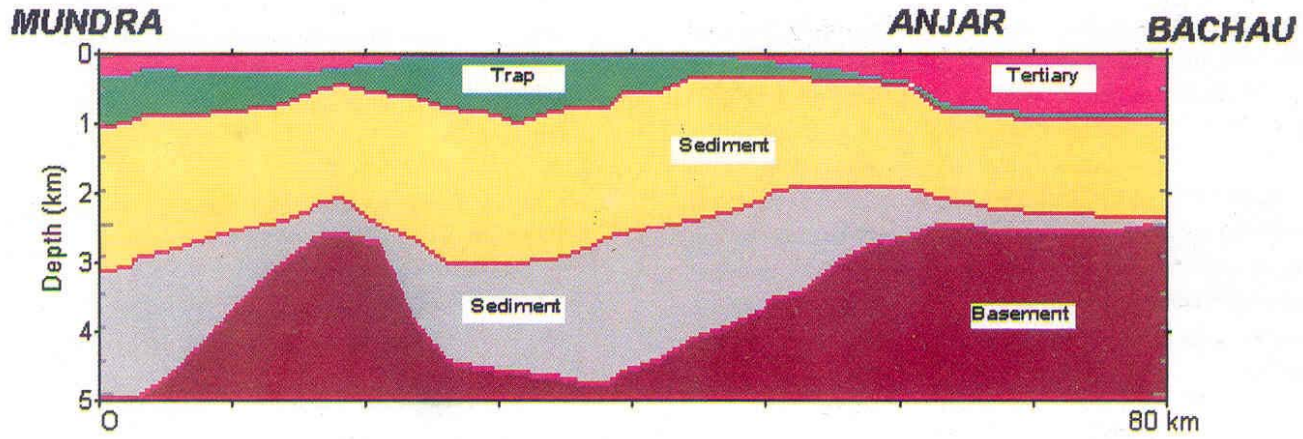

Fig.6. Subsurface geological section along Mundra-Bachau, based on integrated geophysical studies by NGRI.

The aftershock activity is likely to continue for several months. The spatial distribution of aftershocks possibly delineates the main-shock fault of this earthquake.

Historical seismic activity

Bhuj region lies in zone V of the seismic zonation map of India, prepared and updated from time to time by the Bureau of Indian Standards (BIS). This region, along with the Himalaya and Northeast India, is seismically the most active region. Previously, an earthquake of magnitude 8 occurred in the northern Kutch region on June 16, 1819. This earthquake produced a spectacular fault scarp of 100 km length, trending approximately east-west, known as the "Allah Bund". This earthquake also caused subsidence which was well documented by the Sindri Fort. A comparison of the painting before and after showed a subsidence of about 3 m. It is likely that detailed investigations will bring out similar remarkable geomorphological changes associated with the 2001 Bhuj earthquake which has caused static displacement of the order of 6 m. The other significant earthquake in this region is the 1956 Anjar earthquake of magnitude 7.

Earthquake source parameters

On the basis of the seismological data available globally, the source parameters for this earthquake have been determined (Yagi and Kikuchi, 2001). The maximum static displacement at the hypocenter, is estimated to be 6.2 m, while the inferred fault dimensions are of the order of 90 x 30 km (Fig.4). The focal mechanism basically depicts a thrust fault movement on a nearly EW-trending fault plane, with strike 249°, dip 29° and slip 79°. Such an EW-trending fault could be inferred from the results of multidisciplinary geophysical studies carried out by NGRI in Kutch (Gupta et al. 2000). The sharp gradient in the Bouguer gravity anomaly (Fig.5) most probably demarcates the boundaries of the Kutch Mainland Uplift. The previous results of seismic refraction studies along Mundra-Bachau line (Fig.6), supported by magnetotelluric data, confirm this observation, since the sudden shallowing of the granitic basement by about 2 km near Anjar coincides with this feature.

Future

Earthquake forecast is not possible as of today and may not be possible for several decades to come. It is very important to know what kind of ground accelerations are expected due to earthquakes in a region. The decade of 1990 was declared as the International Decade for Natural Disaster Reduction. During this period a programme was taken up by the United Nations to prepare a Global Seismic Hazard Assessment Map. This map has been prepared by about 500 scientists from organizations all over the world, including NGRI, during the period 1992-1999. This map gives the basic information of the expected peak ground accelerations over the next 50 years and is available on the website http://seismo.ethz.ch/GSHAP/. It is very important for us to convert this into a seismic risk map of the country, which requires microzonation studies. The first exercise in this direction has been initiated by the Department of Science and Technology for the city of Jabalpur, with the active participation of GSI, NGRI and several other State and Central government agencies. It is equally important to extend such studies to other parts of the country, for which a database of essential geological and geophysical information has to be established.

Concluding remarks

Time and again it has been demonstrated that NOT EARTHQUAKES, BUT BUILDINGS KILL PEOPLE. It is necessary to do the following:

- Implementation of building codes of BIS be made mandatory.
- Retrofit important buildings situated in zone IV and zone V of the zonation map.
- 70% of Indians live in rural areas, in houses and dwellings made without any engineering considerations. Methods are available to strengthen their dwellings by some simple, very inexpensive approaches. These should be popularized.
- Microzonation of important cities of the country is a must.

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