

Application of Remote Sensing and GIS for the Study of Surficial and Subsurficial Changes in Bhuj and Kathiawar Due to Bhuj Earthquake 2001

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ABSTRACT

26th January 2001 recorded one of the severest earthquakes ever recorded in the seismic history of India in the Kachchh region in the western state of Gujarat. The earthquake caused enormous loss to life and property. However geologically and geomorphologically it has led to significant changes on the surface as well as subsurface. Remote Sensing and GIS has provided us with tools and techniques to study such changes effectively. The present paper is an attempt to make such a study in Bhuj and Kathiawar region. The intensity of the earthquake and the area affected has been so massive that it has led to enormous surface deformation in the form of cracks and faults, lateral spreading and Liquefaction. From the study of the surficial and subsurficial changes and also past seismic record it can be concluded that the region will continue to remain tectonically an active region for a long time in the future too. A continuous study of the change occurring will further help in a better understanding of the geology and seismicity of the region.

STUDY AREA:

The present study area lies between 20°30' North to 24°30' North latitude and 69°E to 73°E longitudes. Rann of Kachchh flanks the region in the North, Gulf of Kachchh in the Southwest and the Little Rann of Kachchh in the East. It extends for approximately 250 kms from East to West and 150 Kms. from North to South. Nagar Parkar Fault in the North and Kathiawar Fault in the South flank it.

MATERIAL USED:

In this study IRS, WiFS, IRS ID and LISS III Remote Sensing Satellite data of different dates in black and white and colour composites with the help of computer have been used for visual interpretation. The false colour composite remotely sensed data of 1:2,50,000 is brought to 1:100000 scale. Indian topographical maps have also been used. These have been supplemented by pictorial images to reveal the ground truth.

GEOLOGY & GEOMORPHIC STRUCTURE OF KACHCHH:

A brief insight into the geology and geomorphic structure of Kachchh region will not be out of place here. This region lies within 400 kms of the active plate boundary zone between the Indian subcontinent and the Asian Plate along Indo-Pakistan border. Structurally the features here include east trending faults and folds. Major faults include (a) Banni Fault (b) Nagar Parkar Fault (c) Kachchh Mainland fault (d) Island Belt Fault (e) Allah Bund Fault and (6) Katrol Hill fault. The rocks in the region are primarily Jurassic to Cretaceous age sedimentary and volcanic rocks. The region is generally composed of gently dipping beds. These faults have activated periodically. This has given rise not only to new topographic features but has also resulted in the modification of existing structural patterns.

The Kachchh Peninsula presents a complex geomorphic structure. The surface configuration, drainage patterns and relief are immensely affected by tectonic activity, sea level changes and the process of erosion and deposition. Physiographic structure of Kachchh consists of several high hills interspersed by low plains. The rugged hilly terrain is composed of Mesozoic rocks. The coastal plains bordering it are narrow strips of gently dipping Cenozoic rocks. These hill ranges separated by low lying Plains run almost parallel to each other revealing the predominant control of geological factors like folding faulting etc. The region has been tectonically active right from Mesozoic times. This activity has resulted in creation of new faults, changes in drainage patterns etc. Seismically in the past 200 years 4 major and several minor earthquakes have rocked the region including the Bhuj Earthquake of 2001.

SURFACIAL & SUBSURFACIAL CHANGES:

On 26th January 2001 a massive earthquake rocked the entire state whose impact was felt not only in India but adjoining Pakistan in the West, Nepal in the North and Bhutan in the Northeast. According to U.S.G.S. the intensity of the earthquake was 7.9 on the Richter Scale. Its epicenter was located at 23°36' N latitude and 70°34'E longitude approximately 100 Kms NNE of Jamnagar in India and 290 Kms South East of Hyderabad in Pakistan. The event occurred in a diffuse zone of historical seismicity lying south of what is generally considered as main boundary between India and Eurasian plate. It lies 50 kms. South East of the 1819 Kachchh Earthquake. The estimated depth of the hypocentre ranged from 18 kms (Earthquake Research Institute University of Tokyo) to 22 kms (U.S.G.S.). The earthquake affected 21 districts and a population of 1.58 crores. It caused approximately 30,000 deaths and injured 166000 people.

The earthquake has resulted in enormous surfacial and subsurfacial changes in the form of faults, cracks, liquefaction, temporary water surges, lateral spreading etc. The surface deformation has been more severe around Lodai and Rapar with maximum around Amarsar, north of Bhachau. A ground rupture occurred along northern margin of Bhachau anticline. These are 16 kms long and .5 kms wide. Tappar Dam near Gandhidham also witnessed slumping and displacement with elongated surfacial cracks. Cracks have also been observed in the salt marshes in the epicentral area near Dhori village (**Fig. 1**) 20 kms away from Bhuj.



Fig. 1. Crack in Salt Marsh Near Dhorri Village

A fault rupture 8 kms in length trending Northwest has been observed close to and northeast of U.S.G.S. epicenter. It passes through the small town of Manfara. It is a right-lateral strike-slip fault.(Fig. 2)



Fig. 2 Manfara Fault

Another similar surface deformation has been detected at Budharmora that appears as a linear fault.(Fig.3) It runs along the Kachchh mainland fault near the epicenter. Liquefaction has been recorded on an extensive scale in several parts of the state. It has been profusely recorded in the little Rann of Kutch, Rann of Kutch as well as the coastal areas of the Gulf near Gandhidam, Kandla and between Malya and Samakhiali. The Liquefaction has manifested along long fissures and at many places it is vent type. Liquefaction is a soil behavior phenomenon in which a saturated soil loses a substantial amount of strength due to high pore-water pressure generated by and accumulated during strong earth quake ground shaking (P.K.Champati Ray). Liquefaction features in the Rann of Kutch include sand volcanoes and fissures from which volumes of sediments oozed out.



Fig. 3 Budharmora Fault Near Epicentral Area- Bhuj

The high resolution IRS WiFS images have shown significant changes on the surface and along the coasts. One IRS image prior to the earthquake has been analyzed along with post earthquake images of the area to arrive at meaningful conclusions, regarding changes on the surface and along the coasts in the Bhuj-Kachchh and Kathiawar-Saurashtra regions. The intense shaking has brought significant changes in the ocean and land surface and sub-surface. At numerous places in Kachchh, water surges on the earth's surface have been detected. Near Rapar after earthquake crater-like structure developed. Near these craters, 500-meter long cracks with Eastwest, Northwest and Southwest orientation were seen. The visual interpretation of WiFS data of 17th Feb. 2001 earthquake was analyzed and suspended solids were deduced.

The images of earthquake show drastic changes in the cracks in the Gulf of Kachchh, little Rann, and near Nal Lake. The pre and post earthquake remotely sensed data reveals that new fault zones have been developed right from the Greater Rann to Little Rann. The Kachchh Mainland fault has intensified. New faults, folds, and joints have been observed near Anjar, Bhuj, Bhachau, Kandla, Naliya, Pachham, Khadir, Bela, Morbi etc. Similar significant surfacial changes have also been observed from little Rann to Nal Lake and Nal Lake to Gulf of Khambhat. It has not only caved in the surface level but at many places lava, hot water, water channels and surges have come out from the bowels of the earth.

RESULTS AND CONCLUSION:

The above study shows that there have been significant surfacial and sub-surfacial changes in the form of faults, cracks, lineaments, surface displacement etc in Bhuj and Kathiawar Region as a result of the Bhuj Earthquake 2001. The changes have been more pronounced in the areas in close vicinity to the epicentral area. These surfacial and sub-surfacial changes and also the past seismic record reveals that the region will continue to remain tectonically an active region for a long time in the future too..

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