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Forecasting of Earthquakes: Danger Signal for Punjab

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On all Fools Day, April 1, 1996, an earthquake of magnitude 5.4 on Richter scale occurred in Punjab in Ferozepur district with an epicentre at 31°N latitude and 74.5°E longitude in the area adjoining Indo-Pak border near Hussainiwala. Surprisingly, no loss of life and damage to property is reported in the media. Perhaps due to electioneering in Punjab, the media has ignored this important seismotectonic event which has dangerous portents for the state of Punjab. Our team made a survey of villages around Indo-Pak border on April 2 and interviewed people from various walks of life: peasants, shopkeepers, rickshawpullers and security personnel at the border check-posts. All of them reported of having experienced the main shock around 1.30 P.M. and there was panic around when people started running out of their homes. However, the earthquake did not cause any severe damage to the buildings around the epicentre as its focus was 33 km. deep down.

This earthquake has raised many questions for seismologists all over India. Punjab-Rajasthan border region is considered to be free from earthquakes as it lies in the seismic zone II, away from the Kangra valley which lies in zone V of highest seismic intensity in India. After the Kilari earthquake of 30 September, 1993 which occurred in the most stable Deccan shield, considered to be an aseismic zone, the seismic zonation map of India has become suspect and needs revision in view of recent seismic activity. On 13 October, 1993 the International Disaster Day was celebrated at Chandigarh where we submitted a proposal to Punjab Govt. for preparing a seismic zonation map of Punjab for future earthquake preparedness action plan. Fortunately, the project was sanctioned during 1995 with an equipment grant of Rs. 52 lakhs. Ministry of Science & Technology, Govt. Of India, has also provided a grant of Rs. 40 lakhs to undertake radon and helium monitoring in the Kangra and Chamba valleys. Our investigations during the last decade have established beyond doubt, the rise of seismic activity along the main boundary fault (MBF) of Himalayas passing near Palampur, Dharamsala and Dalhousie in Himachal Pradesh.

What is earthquake mechanism? Can we predict earthquakes in the same way as we are able to make predictions of global weather, hurricanes and tsunamis? To consider these questions is beyond the scope of this article. However, we provide some clues to understand the earthquake processes.

Earthquakes constitute one of the worst natural calamities on the earth. It is estimated that from the beginnings of recorded history to the present about 80 million human lives might have been lost to earthquakes with an average of 20,000 deaths per year. The damage to property runs into billions of dollars. Every year, on an average, about 1000 earthquakes of magnitude more than 5 on Richter scale, several in the 6-8 magnitude and one greater than 8 may occur, with a super-destructive earthquake of magnitude 8-10 occurring somewhere on earth once every three years. In India, where 55% of the land mass falls under active seismic zones, considerable destruction was caused by the earthquakes of Kutch(1819), Shillong(1897), Kangra(1905), Bihar-Napal(1934). Assam(1956), Koyna(1967), Bihar-Napal(1988), Uttarkashi(1991), and Killari(1993). Most of these earthquakes in India occurred in sparsely populated areas. With a growing population, damage to life and property is likely to increase manifold. According to Professor A.S. Arya, an earthquake engineer of University of Roorkee, the death rate will be more than ten times (around 3.44 lakhs) if an earthquake of Kangra type recurs now during mid-night.

Causes of an Earthquake : Earthquakes are often attributed to different types of seismic waves generated at the earthquake focus. The waves that arrive at a recording station first are called primary or P waves with velocities of the order of 5.5 to 8 km/s. The next to follow are shear or S waves, with velocities in the range of 3.3 to 4.8 km/s. Both these waves propagate radially in all directions from the earthquake focus. In addition, there are two types of surface waves, viz. Rayleigh and Love waves, which are slowest to arrive but cause maximum damage.

There are two types of earthquakes, volcanic and tectonic. The former are the effect of volcanoes and are frequent in Japan and Pacific ocean. But most of the earthquakes are tectonic in nature. According to the theory of plate tectonics, our

lithosphere is made up of six major and six minor plates floating on the Asthenosphere. When these plates interact by colliding, some stresses are built up resulting in the storage of elastic energy. Afterwards, when this energy is released, earthquake occurs associated with fracturing, faulting or other types of land deformations. According to this hypothesis, our Indian plate is moving at the rate of 5 cm/year in N.E direction and colliding with the Eurasian plate. All major earthquakes occurred on the northern boundary of the Indian plate which is underthrusting the Eurasian plate giving rise to the Himalayan belt of mountains on the Indian side and the Tibetan plateau on the other side of the collision zone.

Earthquakes are also caused by hidden faults or motion along intra-plate boundaries. The Killari earthquake of 30 September 1993 and the recent earthquake of April 1 in Punjab fall under this category. According to most probable hypothesis, the two off-shoots of Aravalli, which are burried under a thick blanket of alluvial deposits, are known as Delhi-Hardwar and Delhi-Sargodha ridge, respectively. In recent years, these ridges have become active as is evidenced by the enhanced microseismic activity around Delhi. The Delhi-Sargodha ridge, passing through Rohtak, Bhatinda and Lahore, seems to have been rejuvenated and the focus of Punjab quake lies on this ridge. Punjab plains are now sandwiched between the Himalayan frontal fault (HFF) in the north and the Delhi-Sargodha ridge on the southern edge. Hence it poses dangerous portents for Punjab in the near future. Any major earthquake in the N-W Himalaya, which is long overdue, will cause severe damage or destruction of the hydroelectric dams in Punjab and Himachal Pradesh. The neo-tectonic activity of the Delhi-Sargodha ridge can shift the course of Punjab rivers upsetting its overexploited water table. According to Professor K.S. Valdiya, an eminent geologist from Bangalore, the rivers Satluj and Yamuna were linked together and flowing as river Saraswati of the legendary Mahabharta fame. In the recent historical past, neo-tectonic activity of the Punjab plains diverted their courses in the opposite directions, turning the fertile plains of Rajasthan into a desert. Is SYL canal a logical consequence of Professor Valdiya's hypothesis ?

Earthquake Precursors: Over the past two decades, more than a dozen precursors have been identified. A precursor is a phenomenon which usualy happens prior to the occurrence of an earthquake and hence can be exploited for its prediction. These precursors are land deformation, tilt and strain, foreshocks, b-value, anomalous seismicity, seismic velocities, geomagnetism, resistivity, telluric currents, groundwater level, oil flow, gas flow and animal behaviour. All these parameters show some abnormal behaviour prior to an earthquake. In China, a group of seismologists have carried out extensive surveys on animal behaviour all over the country by consulting the caretakers of bird sanctuaries and zoos. Animals through their extra-sensitive perceptions are much more capable than humans of perceiving certain kinds of geophysical stimuli, for example, electromagnetic radiations, some gases, or ground motions. Laboratory experiments on pigeons, bats, rats, fish and kangaroos have confirmed that they show strange reaction of fear and stress before an earthquake. It was observed in China before Haichang and Tangshan earthquakes that horses and cows run like wild animals, the fish start jumping out of water; rats, snakes and other reptiles crawl out of their burrows.

A key element in the earthquake prediction programmes all over the world is the measurement of temporal and spatial variation of curstal strain, using geodetic techniques. Many studies in USA and Japan indicate that ususual crustal movements have preceded some earthquakes of magnitude 6 or more. Ground deformation can be measured by an array of tiltmeters. Monitoring of foreshocks, rise in well water, flow rate of oil wells, temperature fluctuations, anomalous emanations of helium, radon, hydrogen and carbon dioxide are some of the other useful precursors for forecasting earthquakes. A single precursor may not be helpful, the prediction programme must involve an integral approach.

Indian Scenario: Most of the seismologists believe quakes are more likely to occur in seismic gaps, the region between ~~to~~ two major earthquake sites, which has not been ruptured recently. Three seismic gaps have been identified in the Himalayas: first one in the N-E region in Assam, second in the Central Himalaya with Tehri dam on its western edge and the third gap in Himalchal Pradesh from Kangra to Kinnaur. Last year, American

seismologists Roger Bilham of the University of Colorado and Roland Burgmann of Standford University, California predicted that a major quake of magnitude more than 8 is likely to occur in the Central Himalayan gap which can damage the Tehri dam. Their prediction is based on the strain measurement using Global Positioning System (GPS) , a network of satellites stationed around the globe, that can pinpoint the displacement between two ground receivers upto the accuracy of a fraction of an inch. This quake can cause havoc in all major towns of Gangetic plain including Delhi.

India has been divided into five seismic zones. The highest danger from earthquakes lies in zone V which includes parts of Kashmir, Himachal Pradesh, Eastern U.P. and Bihar hills, N-E Indian states, Andaman-Nicobar and Rann of Kiutch. Rest of northern India foothills and adjoining plains including Delhi lie in zone IV. Parts of Rajasthan, M.P. and southern peninsula are relatively free from quakes and are placed in zone I. This map serves as a rough guide for seismologists, earthquake engineers and planners to choose proper sites for important projects like dams and nuclear plants. However, after the occurrence of Kilari earthquake on 30 September 1993 in the most stable Deccan shield, this seismic zonation map has become suspect and needs a revision. It is considered to be the most destructive intra-plate earthquake in the world which killed 10,000 people. Another area of interest for Indian seismologists is the reservoir induced seismicity (RIS) due to dams all over India. The occurrence of Koyna earthquake in Maharashtra in 1967 attracted the attention of seismologists throughout the world as it occurred in the most stable part of the Indian shield (zone I). Some other dams like Nagarjun Sagar, Hirakud, Ukai and Idduki have shown temporary increase in tremors while others like Bhakra, Pandoh and Pong are under strict surveillance. Our investigations based on radon flow rates in the Kangra and Chamba valleys have revealed that micro-earthaquake seismic activity is very high around Dharamsala, the epicentre of 1905 Kangra earthquake . From October 1992 to May 1993, the Pong Dam recorded 16 seismic events of magnitude 2-4 on Richter scale. Ranjit Sagar (Thein) and Chamera dams are situated so close to the fault line that any future quake in the region will cause irreparable loss to life and property in Punjab and Himachal. The situation is as

dangerous, if not more, as for Thein ehri dam. Do we need another Sundar Lal Bahuguna to raise the banner of revolt against the construction of dams on the fault line itself ?

Moderate earthquakes have occcurred in Himachal on 19th January, 1975 in Kinnaur and on 26 April, 1986 at Dharamsala causing severe damage to the buildings in the area. April 1st earthquake in Punjab occurred during the day time and due to its deep focus it could not cause any visible damage in Punjab. We are waiting reports of its impact in the Pakistani Punjab through International seismological centre.

Earthquake prediction is an enigma for scientists all over the world. Our own research investigations are in the positive direction and establish a perfect correlation between radon gas flow rates and the seismic activity in the Kangra valley. If we acquire the GPS technology, from USA, we may be able to make short term predictions in the near future. If we cannot predict earthquakes as envisaged during this century, we can offer earthquake preparedness action plan for the region to mitigate the quake losses. Will the Punjab Govt. awake to the danger signal ?