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Regions of Space to Predict Earthquake Precursors

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Abstract : **This paper lays emphasis on possible regions of space that could be used as earthquake precursors based on the patterns of different atmospheric conditions changes that occur prior or during earthquake.**

Keywords: Earthquake Prediction, Earthquake Precursors, Seismometers, Crustal Deformations, Geochemical Emissions

I. INTRODUCTION

EARTHQUAKES are one of the most destructive forces known to mankind on earth. There are several earthquakes that jolt earth every year with different intensities. An earthquake on the Richter scale with magnitude greater than 7 causes great devastation of property and loss of human lives.

An earthquake Seismologists for decades have been trying to locate them in advance using the precursors. A precursor phenomenon is that occurs before a main shock and is a part of a physical preparation for the main rupture. Some of the predictions were right in past but the result of prophecy is not 100%.

There are several equipments to measure the intensity but there is none to predict it in advance with 100% guarantee.

II. NATIONAL AND INTERNATIONAL RESEARCH

An international patent was taken by NPL, New Delhi, on the application of acoustic sounding of the atmosphere in detecting extremely low frequency waves emitting prior to an earthquake. An attempt is being made to develop an automatic, digital acoustic sounding system, which will be Internet compatible, so that data could be transferred to any location in the world for studies related to pattern recognition.

In India, though emphasis is being given on precursory research and earthquake monitoring, this field is open to all new ideas. DST has been continuously supporting research projects related to the precursory studies based on Radon and Helium measurements, ULF/VLF radio emissions; GPS-based deformation studies, Borehole observations such as water level, temperature and other physical parameters in Koyna region, etc. The notable have been the geomagnetic field precursory studies in Himalaya and in Koyna by the Indian Institute of Geomagnetism, Mumbai. Geo-electrical studies for precursors were studied in the Shillong region. ULF/ VLF magnetic field emissions associated with earthquakes are in progress at the R.B.S. College, Agra. The Saha Institute of Physics, Kolkata has been regularly monitoring the geochemical constituents He, Rn, CH_4 etc., at Bakreswar spring and observed anomalies related to the 26th December, 2004 Sumatra earthquake.

The Ghuttu observatory in Himalaya has became fully operational since April 2007 and is equipped with state-of-the-art equipments such as superconducting gravimeter, Overhauser magnetometer, tri-axial fluxgate magnetometer, ULF band search coil magnetometer, radon data logger, water level recorders and is backed up by the dense network of Global Position System (GPS) and Broad Band Seismometers (BBSs). Shillong observatory has also been operating since 2007.

Several International bodies worldwide like International Association for Seismology and Physics of Earth's Interior (IASPEI), International Union of Geodesy and Geophysics (INGG), National Geophysical Research Institute, National centre of Earthquake Prediction etc aimed at generating long term multi parametric observations in the seismological active regions. Figure 1 shows the tectonic plates of earth crust. Ministry of Earth Sciences (MOES) in India has launched a National Programme on Earthquake Precursors (NPEP).

III. TYPES OF EARTHQUAKE PRECURSORS

- Abnormal behavior of budgerigars- biological precursors
- Crustal deformation
- Earthquake clouds
- Geochemical emissions
- Geo-Electrical changes
- Geo magnetic changes
- Groundwater level changes
- Infrasound
- VLF/ ULF Electromagnetic Emissions
- Thermal anomalies.

1) *Biological Precursors:* Biological species other than mankind living within seismically active area are subjected episodically to earthquake before mankind. But no plausible scenario has been presented yet for evolution of such behaviours. There are several cases reported across globe indicating migration of species before earthquakes.

Earthquake Measures:

a) Piezo electric effects of quartz is capable of generating enough electrical energy. This electrostatic charging of aerosol particles could be reason as animals exhibit sensitivity to electrical changes in environment.

b) Effects of radon gas on the level of air ionization can change the electric field gradient to which animals are sensitive.

2) *Crustal Deformations:* Catastrophic events such as major earthquakes and volcanic eruptions result when the earth's crust fails in response to accumulated deformations resulted from ongoing processes such as an accumulated seismic deformation of sub-crustal rock associated with relative plate motions, or the ascent of magma through a volcanic plumbing system. Small earthquakes play big role in redistributing the crustal stress and triggering of subsequent large earthquakes and releasing tectonics forces. The space and time domains of ground deformation are detected with geodetic measurements. Geodesy is a useful tool in monitoring active tectonic and volcanic regimes. GPS and Interferometric Synthetic Aperture Radar (InSAR) techniques are useful tools in monitoring the crustal deformation and damage due to earthquake. LIDAR can pinpoint the target for additional field study due to shorter wavelength than radar.

3) *Earthquake Clouds:* When rocks are stressed by external forces, their weak part break first and small earthquake occurs. The Ground water percolates into the crevices. Its expansion, contraction and chemistry further reduce the cohesion of the rock. The water is heated due to friction; eventually generating vapour at high temperature and pressure. The vapours erupt from an impending hypocenter to the surface through the crevices, rises and cools to condense into a cloud, denoted as Earthquake cloud. At the same time, the dehydration of rock near impending hypocenter rapidly decreases its yield strength, as seen in laboratory experiments. Thus the same physical mechanism that creates the earthquake cloud triggers the earthquake.

Earthquake prediction: An earthquake cloud is distinguished by its sudden appearance and unusual shape and movement. It comes from an impending hypocenter, so its trail generally points towards or predicts an impending epicentre. The more mass earthquake cloud has, the bigger the subsequent earthquake. By comparing the magnitudes of previous earthquakes with the masses of their associated earthquake clouds as seen in satellite images, an empirical has been developed for predicting magnitudes. Based on statistical data from about 500 events, the longest delay between earthquake cloud to its earthquake is 103 days and the average is 30 days, so an earthquake cloud can predict the time.

4) *Geochemical Emissions:* Prior to a large earthquake, an increasing radon concentration is observed, and this increase in the rate follows a power-law of the time to earthquake (time to failure).

Emission of radon: Radon is a radioactive gas. It is easy and relatively inexpensive to monitor instrumentally and its short life time means that short term changes in the radon concentration in the earth can be monitored with very good time resolution. Radon gas generated in rocks remains trapped partly in solid matrix but some amount moves to fluids in pores. Prior to earthquake, the build up of stress causes the change in strain field also, which leads to the gas emission.

The electronic radon monitor can be used to monitor radon and progeny concentration. Devices like Scintillation counter, collector, charbar, Radon Detector, RAD-7 detector etc can be used for the same as well.

Emission of other Gases: There is a significant increase in concentration of various other gases in atmosphere, such as carbon dioxide, methane etc before earthquakes. This is because large quantity of gases escape from the crust in seismic areas, particularly, when seismic areas are located in oil and natural gases enrichment places.

5) *Geo-Electrical Changes:* Earth's sensitivity is among various parameters that are bound to change by seismic activities but difficulties arises in validating these predictions due to the sensitivity of the measurement position and artificial and atmospheric noise contamination. Also the electrical potential signals larger than 50mV can arise in partially saturated rocks in response to variations of atmospheric pressure.

6) *Geomagnetic Changes:* Magnetic field changes due to stress variations. The term seismo magnetism, also called as 'tectono magnetism' refers to geomagnetic field changes associated with magnetic field occurrence. Since expected amplitude of change in the total field intensity due to the seismo magnetic effect is estimated to be a fraction of a few nano Testas (nT), modern seismo magnetic field research requires use of highly accurate instruments such as Proton Precession Magnetometers (PPM) and optically pumped magnetometers.

7) *Ground Water Level Changes:* The well water changes result in identification of pre and co-seismic precursors for earthquakes of magnitude greater than 4.3. The ground water changes in the deep bore wells are generally measured by electronic methods, where the piezo transducers convert the water pressure overlying the transducers to user defined measurements such as depth to water or water level altitude.