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ijirset@gmail.com



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Historical Geophysical Methods for Earthquake Prediction : An Overview

Jyoti Singh¹, Geeta Lather², Ajoy Gosh³, Suryanshu Choudhary⁴

Assistant Professor, Department of Physics, Sant Hirdaram Girls College, Bhopal, India¹

Research Scholar, Rabindranath Tagore University, Raisen, India^{2,3}

Associate Professor Department of Physics Rabindranath Tagore University, Raisen, India⁴

ABSTRACT: An earthquake is an unpredictable natural hazard which can be destroying the world economy. The number of earthquakes increases day by day in the world. Almost 8 earthquakes occur at every 1 min on earth. There is some intriguing research about the prediction of earthquakes during the last three decades. Researchers have tried to find out different techniques of predicting earthquake for preventing the human lives. We have discussed here six geophysical methods to predict the earthquakes scientifically and it was historically examined by several researchers to minimize the human losses.

KEYWORDS: Earthquake, Prediction, Geophysical Methods.

I. INTRODUCTION

An earthquake is an unpredictable natural hazard which can be destroying the world economy. We cannot realize small earthquakes, but we realize larger scale earthquakes. The number of earthquakes increases day by day in the world. It's a very astonishment because the people to know about earthquakes from their effects and their causes. According to U.S geological survey several million catastrophe earthquakes occur per year. Around 50 earthquakes each day locates means 20,000 a year earthquakes occurred in the world. This is horrible disaster to every person who is resident in the earthquake prone regions. In the earlier times scientists was done their research reduce the earthquake corollary. But in the world human beings are on inhabits due to earthquake active. Many Asian countries like China, Japan, India, Afghanistan, Bangladesh comes under seismic region. Thousands of people died and many of the people homeless by the cause of strike the earthquake and also the social and economical destruction. To understand the earthquake occurrence, it is very important to know about earth structure. In the 1960's were studied the earthquakes causes due to motion of tectonic plates. Assumption the earth's crust consists of several plates. These plates collide with each other due to relative motion; suddenly releases energy in form of wave's. This waves is called seismic waves. The seismicity, seismic or seismic activity of an area refers to the frequency, type and size of earthquakes. Seismic perturbation is associated with the movement of plates. The Earthquakes occur along plate margins when plates move past towards or away from each other and the movement is not smooth. Mainly sources of earthquake located at the boundaries of plates. We feel that suddenly jolt, if we are close to earthquake epicenter that is followed by shaking of ground surface. The fault transmitted the energy in the form of waves. These waves can be classified into two types: Body waves and Surface waves. The experience of jolt is caused by the body waves which are propagated within the body of the earth while the experience of shaking is caused by surface waves which are propagated along its surface. There are two types of body waves: compression (or primary or P-) waves and shear (or secondary or S-) waves. Compression waves travel at great speeds and ordinarily reach first to the surface of the earth. It displaces the earth material along the direction of propagation. Shear waves travel slower but stronger than the P-waves and displace the earth material at right angles to the direction of their propagation. Surface waves propagate on the ground surface. Rayleigh waves are generated along the earth surface and displace the earth material in an elliptical, horizontal and vertical pattern along their direction of propagation. Intensity of earthquake is a calculated to how much occur trembling at a located for observations. Meseasurement of intensity is generally based on the Modified Mercalli

Intensity Scale developed by the Italian seismologist Giuseppe Mercalli at the 19th century. By Using the Mercalli scale as a Roman numeral ranging from I to XII. Table 1 shows relation between type of earthquake, relative magnitude maximum intensity (Modified Mercalli scale) and effects.

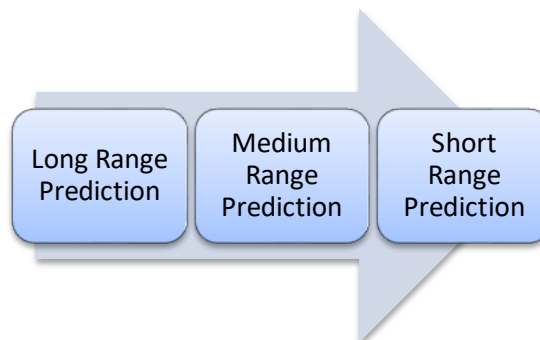
S.No	Type of earthquake	Relative magnitude	Maximum Intensity	Effects
1	Great	>8	XI-XII	Tremendous losses
2	Major	7-7.9	IX-X	Devastating damage over large areas
3	Strong	6-6.9	VII-VIII	Felt by all & serious damages
4	Moderate	5-5.9	VI-VII	Felt by all Some weak construction damages
5	Light	4-4.9	IV-V	Felt by many people
6	Minor	3-3.9	III	Sometime felt but no damages
7	Very Minor	<3.0	I-II	Not felt but detect by local instrument

Table [1] Shows relation between type of earthquake, relative magnitude maximum intensity (Modified Mercalli scale) and effects.

The number of earthquakes resulting in fatalities has been increased approximately in proportion to global populations. The cause of the apparent paradox lies in the growth of urban agglomerations where most of the world's growing population will live and the location of many of these cities near plate boundaries. The recurrence interval for damaging earthquakes varies from 30 years to 3000 years. If population densities remain high in the 21st century several megacities will be damaged by significant earthquakes Bilham et al., 1995. Many scientist researches to try to prediction of earthquake occurring for minimize the losses and human lives.

II. EARTHQUAKE PREDICTION IN HISTORY

It's very undoubtedly an earthquake is one of most fear able natural disaster. Every day the earthquakes occur in our world. In our mind the most typical question is arises that, now we predict the earthquake? Where and when the next earthquake will be occurred?. When the next earthquake will be occur, what is a particular time and day, so that we can be informed the people and saved the life. Scientists have believed that the earthquake is still an unpredictable natural disaster. Just three decades ago, earthquake prediction was not even considered to be serious. Rather it was left to astrologers, mystics and religious zealots (Press and Siever 1978). There is some intriguing research about the prediction of earthquakes during the last three decades. Researchers have tried to find out different techniques of predicting earthquake for preventing the human life. In the development scenario prediction are vague at best. Since 1960's the western world has been the accepted the earthquake prediction phenomena with using exclusively instrumental observations. Earthquakes prediction is the new branch of seismology now, as far as prediction concern with forecasting the occurrence as earthquake with having particular intensity over a specific seismic region. Range of prediction of earthquakes mainly three types long, medium and short range figure 1 shown that. In medium and short range prediction are very popular and it prevent the life while occurring of the earthquake. But some time short range forecasts have been not successful. For long range forecasts we can't understand how and where future earthquakes will be occur.

**Figure 1: Types of prediction**

A seismic gap is an area along a fault where there has not been any earthquake activity for a long period of time. Earthquake prediction has been a goal of mankind for millennia. Earthquake prediction is popular pastime for psychics and pseudo-scientists, and extravagant claims of past success are common. Predictions claimed as "successes" may rely on a restatement of well-understood long-term geologic earthquake hazards, or be so broad and vague that they are. Generally the six geophysical methods to predict the earthquake in history are:

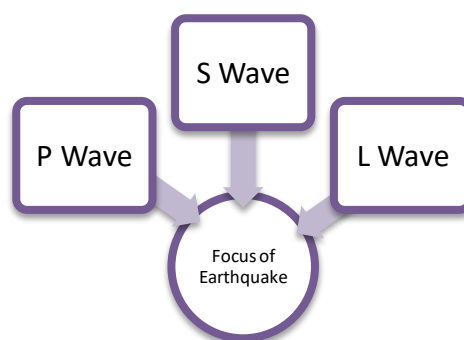
1. Unusual animal behaviour
2. Hydro chemical precursors
3. Temperature change
4. Water level change
5. Randon gas
6. Oil wells

Many researcher have been ignored the observation of unusual behavior of animals before the earthquakes. They have believed that the perception of unusual behavior of animals is an unscientific folklore to antiquity. There is no substantial evidence of observation of unusual behavior of animals can be directly related to seismic and other catastrophic events. In china 1975, after the Haichang earthquake with magnitude 7.3 was successfully predicted by using the observations of abnormal animal's behavior as part of their data as well as geophysical and geochemical precursors, then the researcher's interest is widely study of precursory animals behaviour was extended in the entire world. Some important facts are to explain the how animals do it. Mostly the species of animal easily receive the low sound frequencies that the human being whose highest frequency range 20 to 20,000 Hz. Some animal's are able to experience rumblings of the earth deep beneath like elephants it can be detect the subtle seismic oscillation from the ground. Seismic event occurs causes the changes in the electromagnetic field. Some animals are detecting electromagnetic noise. These changes can occur few hours or days before the impending earthquake .Before the earthquake most of the animals show increased restlessness. Some of the animals have a great power of sniffing, hearing, seeing and sensing than the human beings. On the basis of seismically active regions of Tadzhik and Uzbekistan, chemical composition of underground water was observed and obtained beneficial results, i.e. seismically inactive time concentration levels of dissolved minerals and gaseous components are remain constant. It is notified that anomalies occur prior to 2 to 10 days before earthquake occurred, and the concentration level of dissolved minerals had been perceptible increase. During this period variations in level of underground water, pressure, temperature and the discharge of water sources were noticed. For strong earthquake these variations are very large. But after the earthquake, sometimes these variations in anomalous and mineral components are vanishing. It probably seems to be relation between the temperature and earthquake. Lunglin et al., 1976 and Przhevalsk et al., 1970 was reported that rise of temperature by 100C to 150C before the impending earthquake. The epicentral distances where observations were taken in hot spring/well were 10 and 30Km and precursory period were 42 and were 10 and 30Km and precursory periods were 42 and 72 days respectively. It also shows the relation of spring/wells distance from epicenter and their anomalous precursory periods in table 2.

S.No.	Distance from epicenter	Anomalous Day
1	10-30Km	40-70
2	30-60Km	40-80

Table [2] Distance from epicenter and their anomalous precursory periods

Before major earthquake it was also noticed that the drastic changes in water level of wells. In Nankai earthquake (1960) falls in water level was observed. But the Lunglin in China and Przhevalsk in Russia rise of water level just 3 and 15 cm was reported. Water level variation study have been conducted in Kurile Islands earthquake in this case wells upto 410-670 meter depth are used. This is an effective process for observing the geochemical changes just few days before the earthquake.. Radon gas is a radioactive gas which is discharged from rock masses prior to earthquake. It is easily dissolved in the well water and its concentration in the water increases. In china, 50-70% increase in radon concentration was reported before the Tangshan (1976) and Luhuo (1973) at Lang fang and Guzan stations. It is located 130 and 200 Km from epicentral distances. Israel (1969), Northern Caucasus, Europe (1971) and China (1972) were reported the large scale fluctuations of oil flow from oil wells prior to earthquakes. Before these earthquakes occurred that time gave rise to increased flow of oil. It has been suggested that when the tectonics stress accumulates to a certain level, the pore pressure within a deep oil bearing level reach its breaking strength causing oil to sprout along the oil wells. Theory of seismic gap focuses on the patterns as seismicity. Seismic gap theory predicts based on irregular activities. Soviet seismologist S.A.Fedotov studied that seismic record of 12 large earthquakes shows the seismicity gap. According to his theory earthquakes activity is move outwards in the plate boundaries and less towards the centre and it will seismicity gap. Foreshocks are the tremors which are felt before the outset of actual earthquake. These can be used to predict the actual earthquake unusual animal behavior has also been related to these foreshocks. These foreshocks have been used to predict some earthquakes like Haichang earthquake in China (1975) and the most recent Bhuj earthquake in India (2001). The next prediction method is changes in seismic wave velocity. Firstly we explain the P, S and L waves those are produced from the focus of earthquake which is shown in figure 2.



P and S waves travel through the body of the earth so these waves are also called body waves, while L waves travel along the upper crust of the earth so these waves are called surface wave. Seismograph firstly detects the signal from P waves because this wave is faster rather than other waves. Seismograph is an instrument that automatically detects and records the intensity, direction and duration of earthquakes. The time lag between the arrival of P and S wave is called lead time. According to Russian seismologist, before the earthquake this lead time start to decrease significantly for days, weeks and months while just before the earthquake hit the area. An abnormality shown in wave velocity since a longer time it means to presaged a major earthquake. In 1973 Russains, Lynn sykes, Scholz and Aggarwal performed the experiment on rock samples. This experiment showed abnormal change of ratio of velocities of P waves and S waves before the earthquake. This ratio is expressed by V_p/V_s . The duration of V_p/V_s anomaly depends upon the fault



or dimensions of the aftershock area. Earthquakes are inherently predictable. We can reliably know in advance their location (latitude, longitude and depth), magnitude, and time of occurrence, all within narrow limits (again above the level of chance), so that a planned evacuation can take place. So prediction or forecasting must still have an important role to play in earthquake hazard faultlessness.

III. RESULT & DISCUSSION

Earthquake is the largest catastrophe in the world. The earthquake prediction of the Tokai and Park-field was failed and but new scientific approach by using geophysical method is reliable for earthquake prediction. Ground based and satellite based techniques have been used to solved earthquake based statistical problems. The Seismo-electromagnetic phenomenon and earth degassing theory have been proved to predict the earthquake precisely. Unpredictability of earthquake arises several answered questions.

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3. Mystics and religious Zealots (Press and Siever, 1978).
4. Lunglin et al., (1976) and Przhivalsk et al., (1970) was reported the rise of temperature before the impending earthquake.
5. Earth's surface in the earthquake preparation zone due to drop in air conductivity created by aerosols (Chmyrev et al., 1997; Krider and Roble, 1986).



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