

PREFACE

Of all the natural calamities, earthquakes are the most feared due to their extremely unpredictable nature and immense power of destruction. In the twentieth century alone two to three million people were killed by earthquakes, especially in countries like China, Japan, Turkey, Taiwan, India and Iran. Although spectacular progress has been made in the field of forecasting natural hazards like thunderstorms, typhoons etc., forecast or prediction of earthquakes still remains one of the most challenging problems in modern science, which has an enormous effect on the society at large. With the advent of new technologies, newer conceptions in earthquake mechanism, and an openness or inclination to study some phenomena in hitherto uncharted areas like the pre-earthquake unusual animal (both pet and wild) behavior, unusual cloud formation etc., mid-infrared or thermal emission of ground and above all the availability of various measuring instruments with very high resolution and accuracy, the perception of earthquake prediction has undergone a great change over the years from the realm of sheer pessimism to a certain extent of optimism. Unlike the situation a few years back, more and more researchers working in different fields are engaged in deciphering the various types of premonitory signals or precursors of earthquake, which were earlier not found fit to be considered at all for such study.

The prediction of an earthquake, in effect, concerns with the probability that an earthquake will going to occur within a specified time interval, a specified location range and a specified range of magnitude. Generally, there are three categories in this prediction scenario based on the time period after which an earthquake is going to strike. In popular perception the short-term earthquake prediction limits itself to the occurrence of an earthquake in the time range of a day to a few months at the most, whereas the intermediate-term prediction covers the interval from about a year to a decade. Long-term prediction, however, covers intervals longer than a decade before a great earthquake.

Study on the short-term forecast of large earthquakes is making a remarkable progress in recent years. However, it is still not easy to achieve a very good compliance with the probability factor predicted for an imminent large earthquake, though the existence of a variety of geo-scientific precursors has been recognized. It has also long been known that the symptoms, called macroscopic anomalies preceding an earthquake are sometimes associated with large earthquakes. Typical anomalous animal behavior, underground water level change and earthquake light are amongst the macroscopic anomalies. These types of anomalies have been reported from every part of the world since ancient times. It is regrettable that the precursor phenomena accompanying a large earthquake have earlier been avoided by scientists. After the Kobe-Japan (M7.2, 1995) and İzmit-Turkey (M7.4, 1999) Earthquakes, 1519 and 1026 precursor statements on animals, atmosphere, land-sea, electric appliances and plants were collected retrospectively in addition to the statements for India, and more than 2465 for Taiwan Earthquake (M7.7, 1999). The evaluation of data has indicated that the statements are similar to the legends and database classified by Rikitake (1976, 2001). Based on his extensive interdisciplinary experimentations over almost a decade Prof. Motoji Ikeya of Osaka University, Japan (2004) has shown that there is a scientific basis to many of the legendary and reported precursors, and it is important to use observations on some animals

e.g. the catfish, mouse, birds along with electronic observation of other seismo-electromagnetic signal (SEMS) anomalies, for general forecasting of large earthquakes.

While I was working on fault dating by electron spin resonance (ESR) for my post-doctoral research at Osaka University, Japan during 1998-99, I was introduced to this subject by Prof. Ikeya who has more than forty related papers published in scientific journals and three books in this field, including the well known book "Earthquake and Animals; From Folk Legends to Science" (World Scientific, Singapore, 2004). After the İzmit Earthquake in Turkey, I together with him collected numerous unusual precursory statements prior to the earthquake and published the results in a Turkish popular science book, "Deprem Habercisi Olaylar ve Bilimsel Yorumlar - Precursor Statements of the Earthquake and Scientific Comments (Ministry of Culture Pub., Ankara - Turkey, 2001)". Then, we started to evaluate the data for writing a scientific paper and also presenting the statements as a database in English to international readers. But he died suddenly on the 14th of March, 2006 as a result of a cardiac arrest while our work was on the verge of completion. He has also some other unpublished works in this line. This event prompted me to publish a collection of original studies in the different interdisciplinary fields being done with the aim of devising better forecast methods of earthquakes.

This book is divided into four main parts;

Part I. Retrospective Statements of Earthquake Precursors by Eye-witnesses: It covers the chapter on "Retrospective Statements on Unusual Phenomena Before the İzmit-Turkey Earthquake (M7.4, August 17, 1999) and Their Relevance to Earthquake Forecast". In this work, statements of unusual phenomena on animals, atmosphere, land-sea, electric appliances and plants witnessed by lay citizens before the İzmit earthquake were evaluated scientifically. Temporal and spatial distributions of the statements have been studied in correlation with geological structure of the area. The information may give clues for earthquake prediction to interdisciplinary researches.

Part II. Biological Models: This part covers three chapters: "Sensing of Seismic Precursors and Possible Electromagnetic Perception by Heart and Brain", "The Auto-correlation-Periodogram and the Phasegram: for Automated Detection of Unusual Animal Behavior" and "Bio-antenna Model-Animal's Response to the Seismo-electromagnetic Field -, Considering the Internal Conductive Wire (Nervous System) as an Antenna".

The first chapter on the experiments on the heart and brain describes two cases of bio-electromagnetic studies which reveal a possible and direct sensing of electromagnetic field by animals and humans. The chapter on analyzing circadian rhythmicity of animals will be helpful for introduction of proper observation techniques, which have a direct bearing on the quantitative measures for periodic animal behavior vis-à-vis their unusual behavior before large earthquakes. In this chapter, two automated methods for period and phase determination of circadian rhythmicity of animals have been introduced. In the chapter on bio-antenna model, the effects of electromagnetic (EM) waves on animals have been studied on a model of a mouse, in which a line antenna formed of simple wire components (like nervous system), has been simulated in a computer based on the moment method.

Part III. *Seismic Precursor Investigation:* This part contains the chapters on “The Precursor Phenomena of the 1999 M_w 7.6 Chi-Chi, Taiwan Earthquake: The Seismicity Aspect” and “Prediction of Strong Earthquakes in Taiwan”.

In the chapter on the seismicity aspect, the author has reviewed a set of precursor phenomena related to the Chi-Chi earthquake, viz., the seismic activation, seismic quiescence and seismic reversal. Additionally, by means of the region-time-length (RTL) and the pattern informatics (PI) algorithms, the epicenter of the Chi-Chi main shock have been found to exhibit signatures of anomalous activity related to the seismic activation and quiescence in the Taiwan region over a time span of about 6 years before the main shock. A theoretical approach, viz. the Self-Organizing spinodal (SOS) model also has been found to explain observations concerning these precursory phenomena in seismicity of this region.

The chapter on the prediction of Taiwan earthquakes introduce several distinct imminent precursors, as observed by the authors, like abnormal infrasonic wave signals, sudden change in crustal stress signals, abnormal jumping frequency of the budgerigars, abnormal ground tilt and superposition of tide generating resonance. Based on analysis and research of all these methods of information, a number of earthquakes in Taiwan were predicted. Here the authors put forward the notion that not any single method of precursor observation is sufficient to predict earthquakes, instead it should be a multidisciplinary approach.

Part IV. *Land and Space Precursors:* This part covers the chapters on “Earthquake Precursory Electric Field Signatures”, “Gas-Geochemical Precursors in Spring Emanations Related to Earthquake”, “Applications of the Space Technology and SAR-Based Differential Interferometry for Earthquake Prediction” and “Earthquake Precursors – from Legends to Science and a Possible Early Warning System”.

In the first chapter, the author indicates that the analysis of low frequency (DC to extremely low frequency) electric field changes over a region would imply a credible indication to determine earthquake precursory structural variations. A method developed to determine structural changes in time by using specially developed stationary measurement device as well as in space by using mobile version of the system is described. The study has observed that each region has electrocardiogram-like typical electrostatic field patterns and the deviation of spectral density in time is correlated to seismic events. In the chapter on the gas-geochemical precursors, the author points to the observation that temporal anomalous fluctuations of helium, radon and in some cases deuterium in spring emanations can provide early evidence to upcoming seismo-tectonic disturbance like earthquakes. This work indicates that the shape and amplitude of variations of the geochemical parameters could be used as diagnostic tools for the precursory studies. In the chapter on the applications of the space technology to earthquake prediction, the authors have discussed about the theoretical aspects and usefulness of different satellite-based earthquake precursors, which can be divided into three different categories: the geodetic precursors, thermal and mid-infrared precursors and electromagnetic signal. Additionally, they investigated the practical use of the remote sensing satellites for detection of these precursors, including the thermal infrared ones and analyzed

the existing case studies concerning the Bam Earthquake (M6.8, 2003) of Iran and of others. They conclude that continuation of research for development of more efficient systems and technologies, along with integration of data of all the available sensors and all the promising precursors seems to provide more reliable precursors for earthquake prediction in future. In the last chapter on possible early warning system, the scheme to detect several precursor events, which can be explained as seismo-electric phenomena associated with the earthquakes has been described.

Thus the major theme of the book is scientific evaluation of different categories of unusual phenomena i.e. precursors prior to large earthquakes and the explanation of their occurrence using electromagnetic models. In addition focus has been targeted to consider various scientific methods in the arena of interdisciplinary fields mainly on the short term forecasting of the large earthquakes, which is making a remarkable progress in recent years. The book presents an integrated approach to the concept of earthquake prediction as a whole, based on studies of precursors related to the living things, underground, land and atmosphere. We hope that the book will play an important role in the understanding and developing new and effective systems for earthquake prediction, based on multidisciplinary approach, which will ultimately help in reducing the earthquake related loss of lives and property.

I would like to express my great appreciation to co-editor Dr. Himansu Kr. Kundu (Geological Survey of India, Calcutta) for his help in editing the manuscripts eagerly. He was also initiated in the study of earthquake precursors by Prof. M. Ikeya, when he visited his laboratory in the Osaka University, Japan in 1999 and was amongst the contributors in editing the book by Prof. M. Ikeya – Earthquake and Animals: From Folk Legends to Science.

I would also like to express my deep appreciation to Assoc. Prof. Chihiro Yamanaoka (Osaka University, Japan) for his support for this book project; to Prof. Li Jun-zhi (Institute of Earthquake Prediction, Beijing University of Technology, China), Prof. Chien-chih Chen (Dep. of Earth Sciences and Graduate Institute of Geophysics, National Central University, Taiwan), Assis. Prof. Berk Üstündağ (Electrical & Electronics Engineering Faculty, İstanbul Technical University, Turkey), Dr. Nisith Kr. Das (Variable Energy Cyclotron Centre, Kolkata, India), and Dr. Abbas Alimohammadi (Department of GIS, Faculty of Geomatics Engineering, K. N. Toosi University of Technology, Iran) and their co-authors to accept my invitation to give their valuable contributions, to Assoc. Prof. Ulvi Ulusoy (Dept. of Chemistry, Cumhuriyet University, Turkey) for his valuable advice on the book project. I am thankful to Ms Maya Columbus (Editor of the Nova Science Publishers, USA) who encouraged us for publication of this book.

Ülkü Ulusoy
10 March, 2008.

P. S. from editors: We are deeply shocked. A great M7.9 earthquake happened on May 12, 2008 at 06.28.01 UTC (14.28.01 local time) in Sichuan Province of China, epicenter being Wenchuan (Lat. 31.021N, Long. 103.367E), killing more than 80,000 people and damaging huge property over a vast area.

We have come to know from internet and other sources that there were indeed some forecasts of an impending EQ based on geological considerations, unusual cloud formation

(picture posted in internet before the EQ), lightning clouds in various colors in the night, unusual animal behavior (like unusual increase in jumping frequency of budgerigars, thousands of toads coming out of the rivers, millions of butterflies disappearing, uneasiness of the animals in the farm etc.), terrible sounds from the underground, terrible sounds like thunder in the clear sky, exhausting the pool just later split of the ground, appearance of abnormal infrasonic wave signals and some other studies details of which are not available at the moment. The forecasts became so widespread that Sichuan Provincial Government website of Abeizhou Seismic Bureau had to post a notice that they were just rumors, but the notice could not be found later. There was even an indirect admission by the Xinhua News agency that there were indeed some early warnings of this EQ. There is a report that a NASA scientist had observed unusual thermal emission of ground over Sichuan area for a few days before the EQ and he brought this to the notice of his colleagues. We are just mentioning these to stress upon the fact that there should be more emphasis on multidisciplinary earthquake precursor studies, as attempted to be described in the book so that earthquake prediction becomes more and more credible and precise.

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