Preface

More than 6400 people died in the Kobe Earthquake on January 17, 1995. At the time I was living 40 km away from the epicenter and I felt helpless thinking of the dead and injured. Like everyone else I heard the stories of trapped people urging family members to abandon their rescue attempts before they lost their own lives in the spreading fires. Some students left university to do voluntary work, but I was unable to relinquish my duties.

Two to three million people died in earthquakes during the 20th century. More than 240,000 perished in the Tangshan Earthquake in China and 20,000 in the Izmit and Indian earthquakes. I longed for some way to forewarn of these tragedies and so reduce the toll of injury and death but there were high levels of skeptisicm in the scientific community about short-term earthquake prediction and most had left the field to study earthquake mechanisms.

I have been involved for 30 years in an interdisciplinary field between solid state physics, geology and anthropology. My specialty has been dating, based on detection of accumulated unpaired electron spins produced by natural radiation in various materials, including gouge in geological faults (summarized in my book *New Applications of Electron Spin Resonance*). Obviously, knowledge of the Earth's past isn't of much use in reducing earthquake casualties, but I wondered if I might have a contribution to make based on my years of working between several disciplines, that is, as an amateur having a scientific background making no claims to any professional expertise in earthquake prediction.

I began to apply my experience to what I was hearing from witnesses of the Kobe Earthquake. Some professors and students saw earthquake light (EQL) just before the Kobe Earthquake. I started analysis of the light based on my *electromagnetic (EM) model of a geological fault*. Electric discharges ahead of the main shock seemed to explain EQL as an atmospheric dark glow.

Earthquake precursor reports, which were retrospectively collected upon request through mass media and published as *1519 Statements on Precursors before the Kobe Earthquake* by Wadatsumi (1995), and also collected and analyzed by a subcommittee of the Kansai Science Forum*, echoed the stories common in our folklore and in the book *Earthquake Catfish* by K. Musha. We also collected stories of pre-earthquake phenomena before the earthquakes in Taiwan and Izmit (Ulusoy and Ikeya, 2001) in 1999, from refugees from the epicenter area. I found

the stories were also similar to the legends and to a database classified by Rikitake (1976, 2001) and discussed by Tributsch (1982).

I don't deny that there are difficulties with the lay reports but there were trends that seemed to me could be tested scientifically. I wondered if the unusual animal behavior commonly mentioned in reports might be produced by the same electric pulses that created earthquake light and decided to try the principle on animals and plants but at much lower intensities, again using the EM model. I found that fish aligned themselves in formation (as the reports said), mimosa (the sensitive plant) closed its leaves and bowed and animals behaved much as the legends described. Mysterious earthquake precursor phenomena in legends and puzzling modern reports on malfunctioning home electric appliances, which science considers anecdotal, were simulated in EM experiments conducted in the laboratory.

The EM model of a fault was found to be an appropriate explanation—not just at the point of fault movement but also at the microfracture level—of the means by which EM waves could travel to the surface and have the effects that were being produced in the laboratory and reported in precursor statements. There are a number of mechanisms—relating to increasing pressure and diffusion of water into microfractures—by which an increasing amount of separated charge can be produced in underground rock. Any change in position of charge or in charge density can generate EM waves in a wide range of frequencies. Low frequency (ULF) waves (unlike higher frequency waves) can travel to the surface without a conductive path, and, on the surface, are capable of creating intense electric fields and generating EM waves up to very high frequencies (VHF). In our laboratory experiments animals, plants and electronic objects were exposed to pulsed and static electric fields and their behavior compared with the electric field expected from the EM model.

We settled on the piezoelectricity (electric polarization) of quartz as the principal mechanism for the production of underground charge. Many earthquake-prone areas are granite or volcanic and, so, high in quartz, and the charge is produced as a result of stress on the quartz crystals in such rock. Piezo-compensating charge (produced to cancel out piezoelectric charge) also adds to the increasing amount of charge, all of which, on movement, generate EM waves. In non-volcanic or non-granite regions other mechanisms of charge generation may be at work underground, though quartz grains are present in most rock, including sedimentary rock, and only a tiny amount of orientation of the crystals is necessary for a considerable amount of charge to be produced. There will be regions of the earth where tectonic action is so deep that no ULF waves can reach the surface, in which case there will be no EM precursors.

However, when I started to write up these findings for publication in scientific journals, I met outright rejection by referees on grounds that anecdotal statements by lay citizens were not a legitimate subject of scientific research and that, in any case, prediction was not possible in principle. Some students and friends regarded the work as "high risk and no return" and advised me to quit. I alternated between excitement and despair: excitement at the outcome of the experiments and the development of a new theory, and despair at the resistance I met in the scientific community. I felt like *Alice in Wonderland* caught between fantasy and reality. No wonder most scientists avoid investigations on the boundary of science and legend. I could not get any research grant and struggled in a scientific wilderness. However, 40 related papers were still published in scientific journals over eight years and two books for the Japanese market, *Why Do Animals Behave Unusually?* and *Precursors of Large Earthquakes.*

The general public and the mass media were sympathetic. They expected me—a scientifically trained person—to look for some scientific basis to the stories of pre-earthquake phenomena and to develop a method of prediction if possible. A few friendly seismologists constructively suggested that short-term forewarning might be possible if limited to unusual animal behavior produced by electromagnetic fields, and invited us to join discussions.

I am not arguing for earthquake prediction using the animal precursors described in *Earthquakes and Animals,* if, by prediction, we are meaning an exact forecast of time, epicenter and magnitude of an earthquake. In that case no prediction is possible for any fracture phenomena. Besides, the research is too young and animal behavior relative and sometimes idiosyncratic. But I *am* arguing that there is a scientific basis to many of the legendary and reported precursors. I am also arguing for the use of some animals e.g. the catfish, *along with electronic observation of other SEMS anomalies,* in general forecasting of large earthquakes. That is, I believe that an informed interpretation of such amalgamated data should permit a rough estimate to be made of the likely region, time and magnitude of a large quake. The region and magnitude can be derived from the extent and intensity of known animal responses and other SEMS activity, though time might remain rather vaguely defined e.g. sometime within a few weeks.

A population generally educated about earthquake precursors is a prepared population. People usually need to be prodded into earthquake preparedness and observation of a range of precursor anomalies (from the odd behavior of pet animals to malfunctioning home appliances and cell phones) over a relatively short period, helps to do that.

Of course, nobody can stop an impending large earthquake, but people can at least take simple precautions like fastening furniture to the wall and checking

emergency items. I do hope that precursor phenomena caused by SEMS will be taken seriously by people living in earthquake-prone areas. If there is an earthquake, lives and property will be saved; if there is no earthquake we can simply be glad.

I believe that science is now mature enough that scientists from different specialties working cooperatively, and also working with laymen, might be able to reduce earthquake casualties. In this research I have moved too far from my field of specialization and I appreciate this will invite criticism by specialists. The research may also look elementary to specialists, but, again, this is inevitable in such interdisciplinary work. I welcome constructive criticism, comments and more elegant experiments and theories. If I have made mistakes, I still consider some loss of reputation a small price to pay for work that may help save lives.

I wrote this book to show that many ancient legends warning of impending quakes have a scientific basis; they are not merely superstitions but can be explained as rare natural electromagnetic phenomena that may forewarn of earthquakes and therefore help minimize casualties. The experiments described in this book are simple enough: educational for the general public, and may be demonstrated in high school classes, general lectures and science shows, as I am doing regularly.

Chapters 1 and 2, respectively, of *Earthquakes and Animals* describe legends and recent retrospective reports of earthquake precursors. Chapter 3 gives elementary descriptions of earthquakes and electromagnetism and may be skipped over by scientists; Chapter 4 describes experiments on animals showing behavioral responses to electromagnetic pulses and Chapter 5 describes a rock compression experiment and animal responses to EM waves produced by fracture. Chapter 6 discusses plant reactions to EM exposure; Chapter 7, unusual atmospheric phenomena such as earthquake light, clouds, fogs, rainbows and unusual formations in the sky. Chapters 8 and 9 offer EM explanations for other unusual earthquake-associated phenomena that have been left unexplained or for which alternative explanations have been offered, and also describe laboratory simulation of reports of malfunctioning domestic electric appliances. In the absence of any sure-fire methods of earthquake prediction, Chapter 10 presents automated monitoring of unusual animal behavior, in particular the catfish, as an experimental forecasting model. Chapter 11 generally surveys the seismo-electromagnetic signals (SEMS) research field, which has made significant advances since the Kobe Earthquake. Chapter 12 summarizes the book, and two appendices present results of a questionnaire on precursor phenomena and a short section on disaster prevention.

Throughout the research, I was aware of those millions who have been killed by earthquakes, and their families, and carried the hope that the results would help reduce the death toll. I also enjoyed the science. Again I thank the editors of *Earthquakes and Animals* and all those listed in the acknowledgements—not for

getting those members of the general population who encouraged me to complete the work on their behalf.

January, 2004, Motoji Ikeya

* The Third Subcommittee on the Utilization of the Information on Earthquake Precursors, chaired by N. Kumagai, former President and Professor Emeritus of Osaka University