Seismic Uncertainties

Fundamentals of Earthquake Prediction. CINNA LOMNITZ. Wiley, New York, 1994. xiv, 326 pp., illus. $89.95 or £66.

More than a century after Charles Darwin rode out the great Chilean earthquake of 1835, Cinna Lomnitz had a similar experience with the greatest earthquake of this century: "We could clearly see the trees leaning back and forth, tilting into and away from each other with a period of perhaps two seconds." Lomnitz observed these unusual rolling ground motions at his vantage point 200 kilometers from the epicenter of the 1960 Chilean earthquake, which had a moment magnitude of 9.5. Conventional seismic models fail to quantitatively explain the style of shaking involved, and on the basis of this and many subsequent observations of unusual ground motion and liquefaction, notably for the 1985 Mexican earthquake, Lomnitz advocates a far greater role for low-rigidity gravity waves in causing earthquake damage than does the conventional wisdom. This is one of several iconoclastic perspectives advocated in this wide-roaming book, which synthesizes many personal observations and ideas from the author's long career in earthquake seismology. Like Darwin, Lomnitz is a keen observer, and his remarkable experience base with large earthquakes around the world provides many interesting perspectives.

Any book purporting to elucidate the "fundamentals of earthquake prediction" is bound to elicit a broad diversity of response, given that some influential earthquake experts would assert that earthquakes are fundamentally not predictable. Indeed, as proves true of most books of earthquake prediction, there is only a token effort in this one to provide a first-principles theory

"Example of overturned building due to foundation failure in the 1985 Mexico earthquake. Here the piles were pulled out together with the intervening soil." [From *Fundamentals of Earthquake Prediction*]

"A jinami or 'frozen' gravity wave photographed on soft ground after the 1987 Chiba, Japan earthquake." [From *Fundamentals of Earthquake Prediction*; photo courtesy of H. Nirei]

for earthquake prediction. Lomnitz dabbles with "thermodynamics of earthquake precursors" and provides some useful insight into the probabilistic nature of nonlinear instabilities, but, as is the case with most earthquake-prediction enthusiasts, he relies largely on an intuitive faith that the earthquake process must involve precursory phenomena that can provide a basis for prediction. This perspective is unveiled in the context of enjoyable recountings of the earthquake prediction successes and failures of China, the United States, and Japan. The influence of cultural mindset on the posing of both scientific and pseudoscientific approaches to earthquake prediction is explored by a lengthy consideration of Chinese epistemology, medicine, and military science. Though he gives a somewhat critical assessment of many reported earthquake precursors (as well as of the institutions that have been set up to evaluate earthquake predictions), Lomnitz's optimism comes across in statements like "Precursory changes in flow were likely, but none were reported," with regard to groundwater perturbations associated with the 1952 Kern County, California, earthquake.

Lomnitz grapples with the very definition of earthquake predictability, an elusive concept for complex nonlinear dynamic systems. Unfortunately, he slips into loose usage of the term that conflicts with the general research community's definition involving specificity of time, location, and size of the event to occur. He equally categorizes under "prediction" efforts involving long-term seismicity patterns, short-term precursors, and insurance company probabilistic approaches. Lomnitz's definition involves almost any enhanced understanding of the earthquake occurrence and effects, ranging from statistical forecasting to hazard mitigation. This opens the door rather wide, and the author exploits that flexibility to delve into issues such as the gravity-wave hypothesis, which is relevant to shaking damage rather than event prediction.

The non-specialist will enjoy the diverse glimpses into the behind-the-scenes activities in this most controversial endeavor of the earthquake research community, including some rather soiled linen of the past few decades. But I expect that all readers will likely come away wondering whether there are in fact any "fundamentals" in this business. Unfortunately, the tremendous recent advances in our understanding of earthquake phenomena stemming from analysis of seismograms are totally unrepresented in this work. Those are deemed to be the "fundamentals" by many earthquake specialists. Though I would take issue with the author's assertion that "Today earthquake prediction is the best reason for becoming a seismologist," it nonetheless seems clear that there is tremendous merit in research to establish how predictable earthquake phenomena actually are, and under what circumstances. We do not know the answer to this question, and Lomnitz's book offers many arguments why we should strive toward an answer, even recognizing the chaotic behavior of nonlinear dynamic systems. Our state of ignorance is such that we may have to suffer sloppy empirical approaches to earthquake prediction for some time to come, but, as Lomnitz would argue, disaster preparation and improved earthquake engineering approaches are likely to be the best investments, and these can proceed apace. The greater societal issue is the extent to which operational earthquake prediction systems should be sustained when there is no cogent set of fundamentals underlying them. This book certainly provokes thought on this important issue, but it does not provide the answer.

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Virtually A-Life

The Garden in the Machine. The Emerging Science of Artificial Life. CLAUS EMMECHE. Princeton University Press, Princeton, NJ, 1994. xiv, 199 pp., illus. $24.95 or £18.95. Translated from the Danish edition (1991) by Steven Sampson.

The brief history of artificial life (or a-life) consists of two threads. One originates with the self-reproducing automata designed by John von Neumann. This mathematical approach was enlivened with a variety of com-