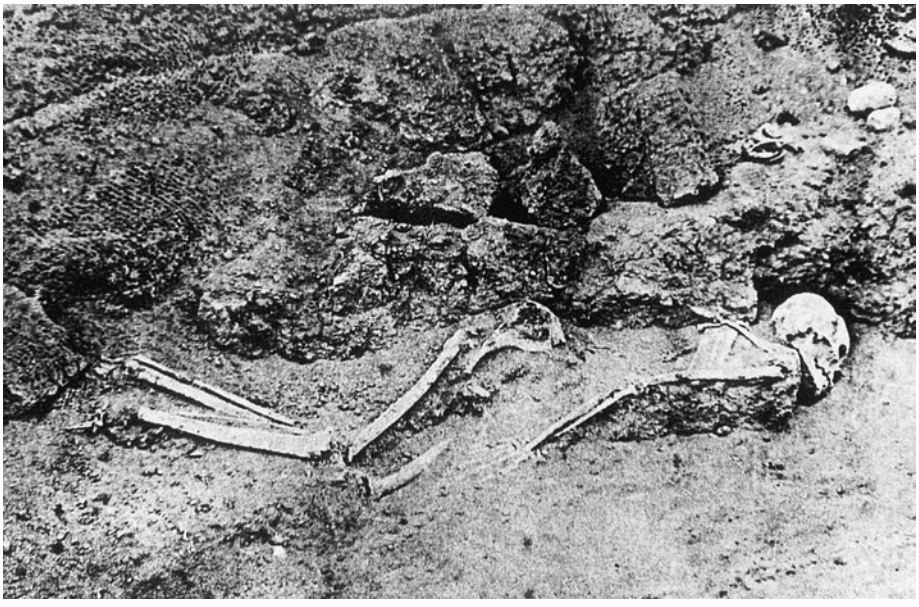
Early Earthquakes of the Americas

There is emerging interest amongst researchers from various subject areas in understanding the interplay of earthquake and volcanic occurrences, archaeology and history. This discipline has become known as archaeoseismology. Ancient earthquakes often leave their mark in the myths, legends, and literary accounts of ancient peoples, the stratigraphy of their historical sites, and the structural integrity of their constructions. Such information leads to a better understanding of the irregularities in the time–space patterns of earthquake and volcanic occurrences, and whether they could have contributed to some of the enigmatic catastrophes in ancient times.

This book focuses on the historical earthquakes of North and South America, and describes the effects those earthquakes have had with illustrated examples of recent structural damage at archaeological sites. It is written at a level that will appeal to a wide variety of individuals with different academic backgrounds. Students and researchers in the fields of earth science, archaeology, and history will greatly benefit from this book.

Robert Kovach is Professor of Geophysics and Associate Chairman of the Department of Geophysics at Stanford University. He has conducted geophysical research in Mexico, Pakistan, and the Middle East and is actively engaged in the cross-fertilization between geophysics and archaeology. He is the author of more than 200 scientific publications. Professor Kovach was the recipient of a John Guggenheim Fellowship in 1971 and was Invited Professor, Japan Society for the Promotion of Science in 1975. He designed seismic experiments for the Apollo 14, 16, and 17 missions to the Moon, for which he received the National Aeronautics Space Administration Medal for Exceptional Scientific Achievement. He is a past-president of the seismology section of the American Geophysical Union, a fellow of the Geological Society of America, and a member of the Seismological Society of America and the Society of Exploration Geophysicists. Professor Kovach is also the author of the successful text *Earth's Fury: An Introduction to Natural Hazards and Disasters* (1995).



Crushed skeleton of a man caught beneath a collapsed wall. Reproduced courtesy of the Peabody Museum of Archaeology and Ethnology, Harvard University.

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PROFESSOR ROBERT L. KOVACH
Department of Geophysics,
Stanford University

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Preface

This book involves a number of disciplines, but its foundation is seismology, the study of earthquakes. In recent decades, the science of seismology, in particular the study of individual earthquakes has expanded dramatically. Its role and importance in understanding how ancient societies and cultural centers were developed and abandoned, however, has not received as much attention. One would like to be able to simply open a window of history of past earthquake occurrences by referring to a written record, but there are many temporal and spatial gaps, omissions, and shortcomings in such a record prior to the nineteenth century. The written record for earthquakes only takes us back as far as the fifteenth century in the Valley of Mexico. Even if the written record were complete for the Americas we are still faced with a short historical time span. Considering our knowledge today of the geography of earthquakes in the Americas it is difficult to believe that earthquake occurrences did not take place prior to this time.

Early written records are useful but often reflect biases and religious beliefs of their scribes together with human exaggerations. As a result, we are left with the problem of factoring and interpreting truth from oracular propaganda. It is here that we can turn to the archaeological record. Just as many archaeologists would argue that pottery sherds speak to them, a seismologist can look for evidence of past earthquake occurrences in the material remains eagerly excavated by archaeologists. We might as a result uncover evidence by *dirt seismology* of past events, which have occurred and were not recorded or overlooked in historical texts.

For a number of years I have led a collegial dialogue at Stanford University entitled "Earthquakes of the Americas." It started as a discussion group to explore a number of interdisciplinary questions with earthquakes as an underlying theme. How did early native cultures such as the American Indians, the Aztecs, and the Maya perceive earthquakes and other natural disasters? Can we extract

facts from early myths, legends, petrographs, and glyphs? Is there evidence for past earthquake occurrences in the archaeological sites of the Americas? Could earthquakes have played a role in the abandonment of ancient settlements? In the past were earthquakes used to justify certain clerical or political viewpoints? As the dialogue evolved so did the number of earthquakes examined, providing fuel for a fascinating intellectual trail through the areas of archaeology and anthropology. The earthquake hypothesis has, of course, its critics. Evidence is often patchy and circumstantial. Yet the examination of the seismic evidence when coupled with the human historical record may eventually prove that earthquakes have been a major contributing factor towards cultural collapse.

A vast field of literature exists describing the archaeological expeditions of the Americas beginning with the explorations in the latter half of the nineteenth century carrying through the twentieth century. However, since the unifying theory of plate tectonics had not been fully developed until the late 1960s most archaeologists could not fully appreciate its implications and ramifications as the driving force for the temporal and spatial pattern of earthquake occurrences. As a result the possibility of ancient earthquake damage was generally overlooked as various archaeological sites were discovered, excavated and reconstructed to their *believed* original state.

In examining the earthquake history of the Americas it is evident that not every major earthquake of the past has left an archaeological trail of destruction. However, these earthquakes may have left geological and geomorphic manifestations. Rock horizons that have been horizontally offset or vertically uplifted can often be placed in a historical time framework. Seismically induced liquefaction has left evidence for sand expulsion features that can be recognized in coastal plain regions and dated to estimate ages of prehistoric earthquake episodes. These investigations form the basis of *paleoseismology*.

A motivation for this book was the realization that there was no single book focused on the Americas that examined the interplay and implications between archaeology, myths and legends, and past earthquake and volcanic occurrences. A challenge was to make the book useful and interesting to a wide range of individuals.

The book is organized into an Introduction, ten core chapters, and a chapter entitled Conclusions and speculations. The Introduction conceptualizes the use of the temporal and permanent imprint produced by even moderate sized earthquakes and why past occurrences merit consideration by archaeologists and historians. Chapter 2 describes the earthquake geography of the Americas. Chapter 3 examines the historical role of myths and legends. Chapter 4 describes the interplay between seismology and the search for archaeological features diagnostic of earthquake occurrences. Chapter 5 discusses the occurrence of

earthquakes in Mexico and what can be gleaned from the very early written record. Chapter 6 examines the evidence for earthquake occurrences in the Maya Empire. Chapters 7 to 11 offer discussions of earthquake occurrences in other geographical regions of the Americas. Several Appendices summarize observational data relating earthquake magnitude to various dimensions attributed to a specific value of Modified Mercalli intensity. One should note that even though some citations to source materials are found within the text, all relevant sources used are to be found in the chapter-by-chapter Bibliographic Summaries. The References following the Bibliographic Summaries list the full citations for those readers who want to delve further into specific topics.

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Any book is the product of more than one person. Many individuals have helped me in the search for reference materials and photographs, especially the staff of the Branner Earth Sciences Library at Stanford University. My colleague Amos Nur suggested the development of a book together with leading seminar expeditions to Mexico. Margaret Muir steered me through many technical formatting difficulties. The enthusiasm of my student Bernabe N. C. Garcia, Jr., who spent several months in Mexico and Peru gathering information and photographing many ruins, particularly Palenque, Monte Albán, and Mitla, is gratefully appreciated. I particularly want to acknowledge the assistance and help of my science editor, Susan Francis. Special thanks are due to Mandy Kingsmill for her expertise in editing and improving many aspects of the text. Final thanks are due my wife Linda whose clear-headedness, encouragement, and computer skills brought this effort to fruition.