

## I N T R O D U C T I O N

Civilization exists by geological consent, subject to change  
without notice

—Attributed to Will Durant [US Historian 1885–1981]  
by Robert Byrne (1988)

The insight displayed by the quote above becomes clear when we combine archeology with earthquake sciences to illuminate the fates of abandoned cities and extinct civilizations. This book was written to explore how earthquakes in the distant past influenced what we have uncovered in archeological sites, and to speculate on the societal, political, and economic repercussions that affected later societies.

Using archeological evidence for the catastrophic, physical collapse of buildings, entire cities, or geographical regions to infer that earthquakes were responsible for the devastation is actually a simple idea but one that yields compelling data. This is especially so in regions where, based on modern geological and seismological data, large earthquakes have repeatedly occurred. It would be ludicrous, for example, to question whether Jericho—2 kilometers from the Dead Sea Fault, the Near East equivalent of California’s San Andreas Fault—was destroyed repeatedly by large earthquakes; the question should be which of the earthquakes that struck the area hit when the city was occupied and which when it was abandoned.

Many ruins uncovered by archeological excavations in earthquake-prone regions are the partial result of past earthquakes. The heavy structures of antiquity were designed to support their own vertical weight, but not to withstand the sudden, horizontal ground acceleration that occurs in destructive earthquakes. The Eastern Mediterranean and Near East offer some of the most spectacular examples. Traveling in those parts, one cannot fail to recognize the preponderance of ruins, the many sites that were destroyed and rebuilt again and again. Why are there so many ruins? Is it the result of wars? The passage of time? No, most of this damage is because of earthquakes. The most popular and spectacular sites have succumbed repeatedly to seismic damage: Jericho, Troy, Mycenae, Petra, Knossos, Qumran, Susita, Bet Shean, Jerash, Luxor, and Armageddon, to name a few of the most famous.

We know from modern geological and geophysical research that the Eastern Mediterranean and Near East have experienced a great many earthquakes over hundreds of thousands or even millions of years. The same region has also witnessed, over this vast period, ongoing human settlement and development, and the emergence of great civilizations that created massive structures, including fortifications, palaces, temples, aqueducts, and large masonry bridges. The larger these structures became, however, the more vulnerable they were to damage, if not complete destruction, by sudden earthquakes. The social systems that created these structures may have depended on them for governance and stability, and so the physical destruction of these structures could lead to the collapse of the corresponding social orders. I believe this occasionally happened.

This idea is an example of “catastrophism,” the sudden, typically unpredicted natural disaster that leads to abrupt changes in a culture or lifestyle that has been stable for a long time. Following such catastrophes, an entirely new societal, political, or military order can emerge, as seems to have happened when classical Greek culture emerged from its dark ages following the catastrophic collapse at the end of the Bronze Age. Sometimes the only traces of

these sudden upheavals are ruins that remind us that what was once prominent, powerful, and stable has suddenly disappeared. For example, the destruction of the Ramesseum and Ramses II statue in the first century BC, as commemorated in Shelley's *Ozymandias*, was surely caused by an earthquake in the Luxor-Thebes area of Central Egypt.

Although these are simple concepts, the idea that earthquakes played an important role in some catastrophic changes in our past—whether in the Eastern Mediterranean and the Near East or in Central and South America—has received stiff opposition. This opposition is, in part, a predictable, professional territorial issue: archaeologists do not want geophysicists to invade their excavations and interpretations, and some historians tend to be skeptical of evidence that is not textual. However, there is a more philosophical aspect that I call the “problem of proof.” Mark Rose (1999), the editor of *Archaeology*, had the following response to my paper (Nur 1998), which discussed the role of earthquakes in the cataclysmic end of the Bronze Age:

It isn't enough to say that the North Anatolian Fault is dangerous and might have unzipped between 1225 and 1175—you need to prove that it did so at that time and, beyond that, show how precisely it would have ended civilization as they knew it, from the immediate effects to ripples through political, economic, and social spheres on local and regional levels.

Rose demanded that, before one can hypothesize that an earthquake destroyed a society, one must prove not only that it happened, but exactly how it happened. Without proof, he claims, such a hypothesis is no more than a Veliskovskyian-style science fiction presented in the guise of science. I believe it is partly as a result of this attitude that some scholars simply ignore earthquakes and other natural disasters, such as volcanic eruptions.

The real question is this: What constitutes proof? The most stringent view (not often held by practicing researchers) insists on a strict interpretation of Karl Popper's notion of falsifiability. In

this strict view, no theory or idea qualifies as firm science unless it is possible to devise an experiment that could eliminate the theory if it is false. In other words, evidence supporting an idea, theory, or hypothesis is by itself insufficient to prove its validity. However, in some scientific areas, we do not have the luxury of such strict falsifiability; in geology and archaeology, for example, it is usually impossible to design tests that could falsify a theory. In these disciplines, we have to settle for a much simpler approach based on probability and a preponderance of evidence. This is especially true when we try to predict future drastic system changes or unravel past ones. Can we prove that a major future earthquake will hit the San Francisco Bay area? We cannot. However, the chance that such an earthquake will occur approaches 100 percent, given enough time. Similarly, we could not have predicted the Sumatra earthquake and the disastrous tsunami of 2004, or the Pakistan earthquake in 2005 that left casualties numbering into the tens of thousands. Still, we should have been able to estimate, given past records and our incomplete earth-deformation theories and hypotheses, that such an event would eventually happen.

Can we prove that an earthquake storm ushered in the end of the Bronze Age? Of course, we cannot. We can, however, estimate the likelihood that this could have happened and compare it to that of other alternatives (equally unprovable but even less likely). This reasoning is especially useful for guiding future exploration of sites and for preparing historians, earth scientists, and archaeologists not just to collaborate in the future but also to become reasonably familiar with one another's disciplines.

This necessity—that in some scientific fields we must reason in terms of probability rather than full certainty or proof—has led to Occam's principle:

Occam's principle states that one should not make more assumptions than the minimum needed. This principle is often called the principle of parsimony. It underlies all scientific modeling and theory building. It admonishes us to choose from a set of otherwise equivalent models of a given phenomenon the simplest one. In any given model, Occam's

razor helps us to “shave off” those concepts, variables or constructs that are not really needed to explain the phenomenon. By doing that, developing the model will become much easier, and there is less chance of introducing inconsistencies, ambiguities and redundancies. (F. Heylighen 1997)

Although one may read Occam’s principle as an excuse for ignorance, it actually represents the most common, widespread practice among scientific researchers.

Some researchers deny that earthquakes, and, by analogy, other sudden natural events, may have played a bigger role in shaping history, simply because these sudden occurrences are not man-made. The temptation of many modern historians, political scientists, and ecologists is to view major disasters in human history as resulting from man’s actions. For example, the celebrated historian Toynbee (1939) believed that “the breakdowns of civilizations . . . are not acts of God . . . nor are they the vain repetitions of senseless laws of Nature . . . we cannot legitimately attribute these breakdowns to a loss of command over the environment, either physical or human.” It is difficult to imagine a view more diametrically opposed to that of Durant.

Jared Diamond (2005) is consumed with this view in his recent book, *Collapse*. Earthquakes or volcanic eruptions are never mentioned in this book. The cases of cataclysmic breakdown that Diamond includes are all associated with man’s actions, not those of nature. Similarly, Tainter (1988) does not consider earthquakes in his extensive review of societal collapses in human history. The ultimate example, however, is the still widely preferred explanation that the catastrophic collapse of the Bronze Age in the Eastern Mediterranean and Near East ca. 1200 BC was a result of invasion by neighboring or far-traveled armies of Sea Peoples or foreign recruited soldiers.

It turns out that these ideas are not based even on Occam’s principle. The arguments are circular, proposing that because many of the main centers collapsed into ruins around 1200 BC, the collapse must have been caused by attacking armies. The existence of the

ruins is the only proof offered, and human action is blamed by default. With an earthquake storm hypothesis, however, we have at least the potential of a scientifically independent test.

The modern earthquake record indicates that earthquakes occur around the world on planes of weakness in the earth's crust, called faults, and that wherever earthquakes have occurred in the past, they are likely to recur in the future. Where earthquakes are frequent enough, scientists can estimate the probability that future earthquakes will have a certain maximum magnitude and destructiveness, and then plan building codes and public works accordingly. In the many regions where earthquakes have been sparse in modern times, there are often stories or evidence that indicate large earthquakes occurred in the ancient past; in many of these regions, building codes are primitive and rarely enforced, making them vulnerable to the tragic consequences of even small earthquakes.

The new discipline of earthquake archaeology, or "archaeoseismology," brings together the views and tools of archaeologists and earth scientists, in the hope that the combined perspective can extract new information about both the history of society and the risk of future earthquakes. The partnership, however, is an uneasy one, largely because the archaeology community distrusts catastrophism in general and earthquakes in particular as a catastrophic agent. When a city is destroyed for no apparent reason, archaeologists are far more comfortable ascribing the destruction to the vagaries of an unknown enemy than to the whims of nature.

This book reviews the evidence that earthquakes occurred in the past in various archaeological sites, mostly in the Mediterranean region, and correlates the suspected earthquake damage to the known seismic risks of each site. In some cases, there are written records of varying reliability; in others, there is physical evidence that earthquakes occurred; in still others, there is only suggestive evidence and a candidate fault nearby. Every case is controversial, and this book examines both the causes of the controversy and the far-reaching effects of earthquakes on human society.

## A SUMMARY OF THE CONTENTS

### Chapter 1. King Agamemnon's Capital

At a conference in Mycenae on archaeoseismology, I first grasped the huge gap in understanding and outlook that separates earth scientists from archaeologists. This chapter explores both the archaeological evidence for earthquakes at Mycenae, and the attitudes and preconceptions that shape our interpretations of such evidence.

### Chapter 2. How Earthquakes Happen

To understand the signs that earthquakes can leave in the archaeological record, the reader needs to know how and where earthquakes occur. This chapter explains the basics of fault formation, earthquakes, and seismology, and describes how ground motion during earthquakes can damage ancient and modern buildings.

### Chapter 3. History, Myth, and the Reliability of the Written Record

Contemporary written records of earthquakes in antiquity are rare, and the strictly historical record is brief; however, many accounts of earthquakes or events that could have been earthquakes are found in the Bible, the *Iliad*, and other pseudo-historical documents. This chapter examines the value of these records as well as how they have influenced archaeologists and scientists.

### Chapter 4. Clues to Earthquakes in the Archaeological Record

Earthquakes leave behind many types of deformation, some that are clearly diagnostic of earthquakes and others that are harder

to distinguish from the destruction of war or slow decay. This chapter catalogues examples of shifted foundations, fallen walls, deformed arches, widespread fires, and patterns of collapsed columns that could have occurred in earthquakes, and relates them to the seismic environment where they were found. The archaeological sites include Troy, Mycenae, Petra, and many other well-known ancient cities.

### Chapter 5. Under the Rubble: Human Casualties of Earthquakes

One of the most telling kinds of earthquake evidence is the discovery of skeletons beneath the debris of collapsed structures. Some critics of archaeoseismology, in fact, point to the lack of skeletal evidence in a site as proof that an earthquake could not have caused destruction there. This chapter catalogues various skeletal finds in famous archaeological sites, some of which have not been widely publicized, and discusses factors, such as the season and time of day when an earthquake hit, that determine the likelihood of finding skeletons in the ruins.

### Chapter 6. Qumran and the Dead Sea Scrolls: Destruction That Preserves?

One of the greatest discoveries of archaeology was the Dead Sea Scrolls found in caves in the Judean desert. Many of the caves in the region are filled with rubble that collapsed from the cave ceilings at some unknown time. There are historical accounts of earthquakes in this area and archaeological evidence of earthquake damage at Qumran, which some scholars believe was the home of the scribes who wrote many of the Dead Sea Scrolls. Combining all this evidence leads to a fascinating exploration of how earthquakes may have played a major role in preserving the Dead Sea Scrolls, and how other scrolls may yet await discovery under the rubble.

## Chapter 7. Expanding the Earthquake Record in the Holy Land

The goal of archaeoseismology, beyond simply increasing our understanding of the past, is to help seismologists better understand the past pattern of earthquakes around the world, and thereby estimate seismic risks in the future. An accurate assessment of seismic risk is essential for the design of safe buildings and dams. The modern record of instrumentally recorded earthquakes is far too limited to allow us to estimate the seismic risks in many regions, so we must turn to archaeology to help fill in the gaps. This chapter reviews the earthquake record in the Holy Land, and examines how advances in various disciplines are leading to better methods for verifying both archaeological evidence and questionable written evidence for ancient earthquakes.

## Chapter 8. Earthquake Storms and the Catastrophic End of the Bronze Age

Large earthquakes can have far-reaching effects on societies, and could, given the right concatenation of factors, lead to catastrophic changes in a region. Of particular interest are sequences of several large earthquakes that occur closely spaced in both geography and time, and can affect a very large region over the span of a few decades. Scholars have proposed that these sequences caused the demise of the Bronze Age civilizations in the Mediterranean region. This chapter compares the modern record of very large earthquakes and earthquake sequences to the areas affected by destruction at the end of the Bronze Age.

## Chapter 9. Rumbings and Revolutions: Political Effects of Earthquakes

The most common objection to the hypothesis that earthquakes influenced the end of the Bronze Age is that modern earthquakes

do not have lasting effects on society. Although it is true that there has never been a complete societal collapse in response to an earthquake in modern times, the earth's convulsions nevertheless have had major influences on societies when they occurred at times of political or economic stress. We examine some relatively modern examples in Lisbon, Tokyo, and Venezuela.

## Chapter 10. Earthquakes and Societal Collapse

It is ironic that, to uncover evidence of past earthquakes, we must overcome the same dismissive attitude toward earthquakes that we are hoping eventually to break down with that evidence. My hope in writing this book is that I can help open the eyes of both the archaeological community and the public to the facts I know to be true: The earth beneath our feet, with its past cataclysms, can be one key to understanding not only our prehistory but our future as well.