Why the Earth Shakes:

Pre-Modern Understandings and

Modern Earthquake Science

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Abstract

Using historical sources comprised of earthquake stories of multiple genres – personal anecdotes, prayers, sermons, natural histories, philosophical treatises, poems – as well as texts about modern scientific theories, this project demonstrates how unpredictable and incompletely understood phenomena like earthquakes both expose and challenge the boundaries of knowledge. The process of European expansion to the Americas in the early modern period provides some geographical and temporal structure to the broad scope of this project, which discusses stories that come from across the globe and cover the period from roughly the eighth century BCE to the present. Special attention is paid to scientific or natural philosophical views of earthquakes, and to religious and mythological stories about the phenomenon, in order to show how a fuller understanding of earthquakes requires expanding beyond traditional limits of knowledge. So far, no individual explanation for why the earth shakes – whether ancient or modern, religious or scientific – has proven to be complete. Until such time as we have complete knowledge—if that time ever comes—a diversity of perspectives can help us to frame our understanding of earthquakes and their impact on human history.

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INTRODUCTION

Earthquakes have been terrifying and fascinating people for millennia. Since at least 2000 BCE, Babylonians, Hebrews, Greeks, Romans, Chinese, Japanese, Indonesians and other Pacific islanders, natives of the Americas, residents of Southern Europe and the Mediterranean Basin, and myriad other groups have been telling stories about uncontrollable and unpredictable earthshaking events.[1] Some of these stories have been preserved in written form, while others have been passed on orally. In many cases, the stories have not only been handed down to subsequent generations, but have been transmitted across cultures and geographies as well. Indeed, the prevalence of these earthquake stories and their preservation across the globe for over four millennia is tantamount to a cult following of sorts. Earthquakes, it seems, have their own culture.

More precisely, of course, it is the people narrating and perpetuating the stories about earthquakes that fashion an earthquake culture. The people come from all walks of life, regardless of the era or region in which they live, for earthquakes do not discriminate. Race, class, gender, sexuality, age, religion, nationality, and level of education do not matter. Earthquakes happen anyway and affect individuals of every background. The act of the earth shaking is a common experience that binds together

[1] 2000 BCE is a conservative chronological estimate. There are textual references to earthquake events purported to reach as far back as 6500 BCE. See, for example, Appendix A ("The Hittite and Armenian myths as potential sources of information about natural disasters of the ancient time") of "Evidence of historical seismicity and volcanism in the Armenian Highland (from Armenian and other sources)," by Arkady Krakhanian and Yelena Abgaryan, *Annals of Geophysics* 47 (April/June 2004), 793-810. As will be seen in Chapter 3, there is not consistent scholarly agreement about archaeological evidence supporting the existence of earthquakes before 2000 BCE. After 2000 BCE, however, there is a higher quantity and quality of mutually reinforcing evidence about earthquake narratives.

seemingly disparate people. That bond is reinforced in a multitude of ways as individuals and groups share stories about the event, stories that circulate in many forms: personal anecdotes, firsthand accounts, news reports, poems, letters, diaries and journals, treatises and essays, sermons and religious texts, philosophical and scientific works, popular literature, plays, films, folklore, myths and legends, memoirs, and chronicles and other histories. An expanded network of earthquake connections is created as these stories reach beyond persons immediately affected by the initial event, to others outside of that earthquake zone who either have minimal firsthand experience with earthquakes or have their own earthquake event to which they can compare the new earthquake story. Stories about earthquakes are told and retold, exponentially increasing their reach across time and geography.

Not surprisingly, the geographical origins of earthshaking tales are found in highly seismic regions of the globe where earthquakes not only repeatedly occur, but also tend to have the strongest magnitude. These places can by and large be identified topographically by their vicinity to volcanoes, island chains, or mountains, especially mountains found along a continental coast. A notable example is the almost continuous series of volcanoes, islands, and mountains that lines the perimeter of the Pacific Ocean Basin. Known in modern parlance as the Pacific Ring of Fire, this region is home to almost three-quarters of all known volcanoes and the place in which about 90 percent of

the world's earthquakes occur.[2] This horseshoe-shaped ring extends along the entire west coast of the American continents from the southernmost tip of South America to the top of North America; continues across the Aleutian Islands and over to the Eurasian continent; and then runs down through Japan, the Philippines, Indonesia, and other Pacific Islands to New Zealand. There are other areas on the globe devoid of these topographical features that experience earthquakes, but tremors occur there with comparably much less frequency. One example is the New Madrid Seismic Zone in the central United States, which extends 150 miles from Illinois to Arkansas along the Mississippi River Valley.[3]

Certain landscape characteristics may provide visual cues signaling proximity to a seismic area, but modern scientists prefer to define earthquake zones in terms of a feature found underneath the earth's surface. According to the theory of plate tectonics, which was developed in the 1960s and has been readily accepted since, the outermost part of the

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[2]W. Jacquelyne Kious and Robert I. Tilling, *This Dynamic Earth: The Story of Plate Tectonics* (Denver: United States Geological Survey, 1996). Also available in its entirety on the USGS website: http://earthquake.usgs.gov/learning/glossary.php?term=Ring%20of%20Fire.

[3]Although occurring less frequently than in other seismic zones, earthquakes in the New Madrid region can nevertheless be quite powerful. Shaking the area from December 16, 1811 to February 7, 1812, was a sequence of four of the strongest earthquakes to strike the contiguous United States in recorded history, each of which registered around an 8.0 moment magnitude. Because these seismic events did not happen along what modern seismological theory considers a typical earthquake fault, or an interplate boundary, the New Madrid earthquakes have proven to be something of a riddle for scientists. See, for example, Arch C. Johnston and Eugene S. Schweig, "The Enigma of the New Madrid Earthquakes of 1811-1812," *Annual Review of Earth and Planetary Sciences* 24 (1996), 339-384. A recent overview of the New Madrid earthquakes is Susan E. Hough, "Scientific Overview and Historical Context of the 1811-1812 New Madrid Earthquake Sequence," *Annals of Geophysics* 47 (2004): 523-537.

For an excellent historical account of the New Madrid Earthquakes, see the classic work by James Lal Penick, Jr., *The New Madrid Earthquakes*, rev. ed. (Columbia and London: University of Missouri Press, 1981). With the 100th anniversary of the earthquakes in 2011-2012, there will likely be a new spate of scholarly publications on the subject.

earth is comprised of puzzle-like pieces called plates that float atop a more fluid interior space. Movement along the boundaries between plates is what causes earthquakes and creates the topographical indicators most often associated with earthquake activity.[4]

Like modern scientific theory, explaining the cause for earthquakes, or answering the "how?" question of their occurrence, is at the heart of many earthquake stories, regardless of the historical period or geographical location from which they come. Within many world cultures, these tales attribute ground tremors to the movement of an animal upon whose back the earth rests.[5] In the frequently shaken areas of Borneo, Bulgaria, Anatolia, Malaya, and the Lesser Sunda Islands, for example, the mighty buffalo is the bearer of the earth's weight. An earthquake occurs when the beast tires of its burden and shifts its feet to redistribute the load. A similar story is told about the

[4]This is a basic definition of the complex and highly technical theory of plate tectonics. A good primer on tectonic theory that includes some useful images is the USGS pamphlet by Kious and Tilling cited above in footnote 2. A brief summary can also be found in the first chapter of *Earthshaking Science: What We Know (and Don't Know) about Earthquakes*, by Susan Elizabeth Hough (Princeton and Oxford: Princeton University Press, 2002). For a more detailed study of plate tectonics, see Edward A. Keller and Nicholas Pinter, *Active Tectonics: Earthquakes, Uplift, and Landscape* (Upper Saddle River, NJ: Prentice Hall, 1996) or, for the more scientifically-minded, Eldridge M. Moores and Robert J. Twiss, *Tectonics* (New York: W. H. Freeman and Co., 1995).

[5]Following Dorothy B. Vitaliano in *Legends of the Earth: Their Geologic Origins* (Bloomington and London: Indiana University Press, 1973), the majority of earthquake stories about animals recounted here, except where otherwise noted, are taken from L. Don Leet, *Causes of Catastrophe: Earthquakes, Volcanoes, Tidal Waves, and Hurricanes* (New York and London: McGraw-Hill Book Company, 1948). *Legends* and *Causes* are the only studies that narrate such a wide-range of earthquake legends. Unfortunately, Leet's book, upon whom Vitaliano relies heavily, does not provide references for further study.

Not narrated here are the few earthquake stories in which a creature responsible for earthquake activity is said to live in the earth rather than underneath it, and those tales in which the earth rests on not just one animal, but on a sequence of stacked animals.

turtle by the Algonquin and Iroquois Indians of North America,[6] about the serpent in the Moluccas and on Sumatra, about the crab in Persia, and about the hog in Sulawesi (formerly Celebes).[7]

In Mongolia, the story of the earth-bearing frog is more nuanced than the other animal tales. The earth was said to quake whenever the animal moved. More specifically, the locals identified a correlation between a particular movement of the frog, such as shaking its head or stretching out one of its legs, with an earthquake in a certain region. The earthquake was said to happen in the place on the globe immediately above where the frog's individual body part moved. L. Don Leet, a seismologist at Harvard University who collected a wide-range of earthquake legends, takes notice of this frog story. Because of its specificity, Leet considers it a "refined version of inspired doctrine [that] was a major advance in seismological theory [because] it had the merit of explaining the local character of earthquakes, with which Mongolians were more familiar than many benighted outlanders."[8] Made in passing and not explored further, Leet's comment is nevertheless significant. Though a modern seismologist, he was able to recognize and affirm valuable information about earthquakes contained in a myth. In

[6]The Algonquin Indian reference is from Leet (12) and Vitaliano (81). The Iroquois myth is mentioned briefly by Robert Kovach in *Early Earthquakes of the Americas* (Cambridge: Cambridge University Press, 2004), 28.

[7]The hog tale differs slightly from the buffalo's. The earth quakes because the hog holding it scratches itself against a palm tree. Leet (12); Vitaliano (81-82).

[8]Leet, *Causes of Catastrophe*, 12.

particular, he calls attention to the importance and quality of local earthquake knowledge gleaned from people living in a seismically active region.

Probably the most well known creature held responsible for earthquakes is the catfish, or *namazu*, of Japan.[9] Although the catfish legend had been present in Japanese folklore for at least four centuries, the namazu became further culturally entrenched after the Ansei Earthquake of 1855, when earthquake stories about catfish were circulated along with *namazu-e*, color woodblocks of Earthquake Catfish Pictures.[10] According to legend, a giant namazu that lives under the earth with his head located under the province of Hitachi (Kashima) is kept in check by the Kashima deity, who holds down the fish with a sword or a stone (*kaname-ishi*). During the 10th lunar month when the deity is gone for his annual meeting of the gods, the catfish takes advantage of Kashima's absence and causes an earthquake with his wriggling and writhing.[11]

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[9]The Japanese literature on the namazu is extensive, but it is outside the language skills of this author. The classic and single monograph in a western language is Cornells Ouwehand, *Namazu-e and their Themes: An Interpretative Approach to some Aspects of Japanese Folk Religion* (Leiden: E. J. Brill, 1964), which includes copious references to the Japanese literature.

The specific type of fish connoted by the term "namazu" is briefly discussed by Ouwehand in his introductory chapter on pages 4-5. His determination is that the namazu depicted in the 1855 prints "is undoubtedly the *Parasilurus asotus* (Linné) [*Silurus asotus*, *Silurus japonicus* (Temminck & Schlegel)], family *Siluridae*, order *Nematognathi*, otherwise known as the mud fish or catfish. At later points throughout the book there is further discussion about the different kinds of animals possibly represented by the term "namazu" in earlier versions of the legend.

[10]Similar to the amount of scholarly work done on the namazu, there is an abundance of Japanese literature on the namazu-e as well. In English, besides Ouwehand's book, see a brief article by renowned seismologist Bruce A. Bolt, "Namazu-e," *Pacific Discovery: A Journal of Nature and Man in the Pacific World* 29 (November-December 1976), 10-13, and a longer, more recent one by Gregory Smits, "Shaking up Japan: Edo Society and the 1855 Catfish Picture Prints," *Journal of Social History* 39 (2006), 1045-1078.

[11]This is a sketch of the basic namazu story. There are different versions of the catfish legend that are much more complex. Ouwehand discusses these throughout *Namazu-e and their Themes*.

Following Leet in his acknowledgement of information contained within the frog tale, a couple of elements in the namazu story are worth noting. Like the Mongolians who correlate a specific movement of the frog with earthshaking in a particular region, the Japanese are explicit in describing the location of the catfish's head in relation to an actual place. Not only do both groups have an explanation for *what* is causing the earth to shake, but they also have a geographical perspective on *where* it shakes. The namazu story goes a step further and addresses the issue of *when* an earthquake happens. The phrase "10th lunar month" is a descriptor for the time of year earthquakes are thought to occur, and suggests an implicit knowledge about the ability to predict earthquake activity.

One of the fascinating aspects of the stories about the catfish and other animals like the frog or turtle is the creature's connection to earthquake prediction and actual earthquakes. Sometimes it is not clear from each story why people might have picked a particular creature as the culprit responsible for earthshaking, but these archetypal earthquake animals were not chosen at random. In many cases, they were repeatedly observed to exhibit strange behaviors prior to an earthquake, behaviors that seemed to have no rational explanation until after the ground had trembled. For instance, catfish, typically tranquil creatures, are reported to thrash violently before an earthquake. Similarly, snakes, frogs, and earthworms, which normally hibernate underground during winter, have been known to come to the surface immediately preceding ground tremors.[12]

[12]These are but a few examples of odd animal behaviors preceding an earthquake. For a quick list, see "Legends and proverbs about animals before earthquakes" on page 11 of Motoji Ikeya, *Earthquakes and Animals: From Folk Legends to Science* (Singapore: World Scientific, 2004). Ikeya cites for his list a

Given these behaviors, it makes more sense that a specific creature like the catfish came to be associated with an earthquake legend from a region in which it lived, such as Japan, a country of over 3,000 islands. If catfish indeed sense the onset of an earthquake and thrash around in anticipation, one can imagine the periodic spectacle of thrashing catfish in a highly seismic country permeated by water.[13]

Like other earthquake stories, accounts of bizarre animal behavior as earthquake predictors have been disseminated over centuries and across cultures, contributing to the corpus of knowledge about earthquakes. In East Asian societies, tales of animals predicting earthquakes have been told for thousands of years and continue to circulate widely.[14] Perhaps because of the cultural value placed on the long tradition of story-telling, scientists in Asia have taken more seriously than their counterparts elsewhere, especially in the United States, the idea that animal behavior can help predict earthquakes and have done considerable research about it.

Work done in Japan in the 1930s, 40s, and 50s, for example, not only "confirmed the connection between the unusual activity of fish and a subsequent earthquake," but

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source that is unfortunately not included in his bibliography. A longer discussion of animal behavior and earthquakes can be found in, Helmut Tributsch, *When the Snakes Awake: Animals and Earthquake Prediction*, translated by Paul Langner (Cambridge and London: The MIT Press, 1982).

[13]So far, the author has not yet located studies exploring the correlation between individual earthquake archetype animals and their environmental origins. Ikeya hints that there is such information available, but he does not give a citation: "Ancient peoples sought to predict earthquakes from observation of animal behaviors like those of the archetypal underground animal." Ikeya, *Earthquakes and Animals*, 13.

[14]Ikeya, 9.

also purports to "have demonstrated this connection conclusively."[15] At Tohoku University, researchers performed extensive scientific experiments by subjecting namazu to shock movements and measuring the results.[16] "The investigators came to the conclusion that a great many phenomena such as changes in the composition of the water, changes in water currents, and underwater sounds and electric radiation were perceived by the namazu by means of a very sensitive system of nerve cells in the feelers and on the sides of the body."[17] This seemed to suggest that the fish's nervous system acted as a registering apparatus, one that reacted "with far greater sensitivity than the seismograph."[18] Supplementing these findings was a meticulously gathered collection of historical accounts about fish having predicted earthquakes, including one about a fisherman who observed the namazu behaving strangely, then ran home and saved his family before the 1855 earthquake struck.[19] Added to the namazu data compiled from the scientific experiments and collected stories was a massive study "to determine degrees of sensitivity [in fish] and [to find out which] fish are especially sensitive."[20] Their findings

[15]Ouwehand, 56.

[16]Ouwehand provides references to the sources in Japanese that discuss the research conducted at Tohoku University and elsewhere. See footnote 3 on page 55, footnotes 1-3 on page 56, and footnote 1 on page 57.

[17]Ibid., 56.

[18]Ibid.

[19]Ibid., 55-56.

[20]Ibid., 56.

offer little doubt as to why the namazu was chosen over every other creature as the archetypal earthquake animal in Japanese myth.

> Among 28 identified species of fish, 14 non-specified salt water and 6 non-specified fresh water species, the squid, octopus, crab, and lobster, the prediction time was found to vary between a few minutes and a few months before the earthquake actually occurred. The namazu was not only one of the best documented species, but was also found to be one of the most earthquake-sensitive fish.[21]

The research undertaken at Tohoku University is one example of how earthquake stories can inform and be integrated into scientific practice. More practically, the project's results make it seem possible that careful observation of animal behavior could help predict an earthquake. China successfully accomplished such a feat in 1975.

In August 1971, the State Seismological Bureau of China began its own investigation of earthquake prediction phenomena. Four years of careful study of the 2,200-year earthquake history in Liaoning province, including the collection of reports of unusual animal behavior, combined "with precise seismological, geodetic, and geomagnetic measurements" led the country's National Earthquake Bureau in June 1974 to issue a warning that an earthquake would strike the region in the next one or two

[21]Ibid., 56-57.

years.[22] The warning precipitated the expansion of a scientific surveillance network so that physical data could be monitored more closely and with greater frequency.

The warning was also a call to mobilize the people to enlist their help in reporting to a central clearing house recognizable signs of imminent earthquakes, a course of action that had been in place since 1966 as part of the national earthquake prediction program. "Most of the more than 100,000 honorary observers were to watch for the mysterious portents that according to 3,000-year-old Chinese tradition were supposed to announce the coming of a catastrophic earthquake."[23] Experts trained the individuals in what to look for, while radio programs and other media outlets reinforced what the people had learned. Of the many signs about which the volunteers had been educated, "the most widespread and most noticeable sign of an approaching earthquake [was the] 'unusual behavior' of animals."[24]

The combined efforts of the scientists and the amateurs led to the successful prediction of a series of small earthquakes that shook the region around Haicheng from 22 December 1974 to the beginning of February 1975. Using data gathered by research groups, on the morning of February 4 the scientists were certain that a big earthquake was imminent. Evacuation of the city began. "People were housed in previously prepared emergency shelters, animals were led from their stables, motor vehicles were parked

[22]Ikeya, 9; Tributsch, *When the Snakes Awake*, 7-8. Ikeya's account of these events is brief. Tributsch's narrative, which is followed here, is more detailed.

[23]Tributsch, 8.

[24]Ibid.

away from buildings, and valuables were removed from the buildings. To entertain the evacuated people and to keep their spirits high, movies were shown outdoors."[25] The time and resources invested in the evacuation and the four years of earthquake research were not wasted. At 7:36 p.m., an earthquake measuring 7.3 on the Richter scale shook Haicheng, home to half a million people. Although there was considerable physical damage to the urban landscape, it is estimated that the evacuation of the city saved close to 100,000 lives.[26]

The examples of China and Japan illustrate well two different ways that earthquake stories can inform and benefit science. Scientists in neither place found it strange to incorporate into their professional practice three millennia worth of tales about unusual animal behavior and other portents believed to signify an impending earthquake. In fact, quite the opposite is true. Since at least the middle of the twentieth century, earthquake research agendas in both countries have included the gathering, recording, cataloguing, and analyzing of data either found in earthquake stories or related to them. Researchers have made active use of sources that are generally dismissed because they are social, cultural, or religious—rather than scientific—in nature. Chinese and Japanese scientists clearly consider these materials valuable and worthy of study, an attitude that the 100,000 people saved in the Haicheng earthquake no doubt appreciate.

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[25]Ibid., 9-10.

[26]Ikeya, 9.

In many countries outside of China and Japan, there is strong resistance to the idea that non-scientific texts could significantly inform the study of earthquakes, especially regarding prediction. In these other countries, science of a particular kind is the ultimate authority when it comes to knowledge about earthquakes. This entrenched set of attitudes can be illustrated by looking briefly at two official statements made by a highly regarded scientific institution in the United States.

Either inspired or challenged by China's success in predicting the Haicheng earthquake, in 1978 the United States Geological Survey (USGS) funded "Project Earthquake Watch," a study undertaken by the independent, nonprofit research institute SRI International, which investigated the feasibility of using animal behavior to predict earthquakes.[27] The project was halted after four years, however, and the subject has not been revisited since.[28] The current official stance of the USGS is that while "anecdotal evidence abounds of [creatures] exhibiting strange behavior anywhere from weeks to seconds before an earthquake [,] . . . consistent and reliable behavior prior to seismic

[27]Susan West, "Pet Seismologists," *Science News* 117 (1980), 376.

[28]I have yet to locate the project's final report, which was published by the USGS in August 1985. In 1976, the year after the Haicheng quake and two years before the advent of "Profect Earthquake Watch," the USGS issued a short report offering *A Summary of the Literature of Unusual Animal Behavior before Earthquakes*. The two scientists from the National Center for Earthquake Research in Menlo Park, California, and one researcher from SRI who authored the text are careful to make clear that their investigation of stories about strange animal behavior does not indicate their belief in the veracity of these "legends." W. H. K. Lee, M. Ando, and W. H. Kautz, *A Summary of the Literature of Unusual Animal Behavior before Earthquakes*, U. S. Geological Survey Open-File Report 76-826, 1976.

events, and a mechanism explaining how it could work, still eludes us. Most, but not all, scientists pursuing this mystery are in China or Japan."[29]

Their choice of language here is both curious and telling. The USGS acknowledges the existence of numerous stories connecting bizarre animal behaviors with earthquakes, but they dismiss these reports as merely "anecdotal." The evidence about animals predicting earthquakes that exists is neither "consistent" nor "reliable." Further, this evidence is not valuable because it has not been able to produce a "mechanism" or structure that explains how the process works. This being the case, the USGS argues, the correlation between animal behaviors and earthquake activity remains hidden, a "mystery," and only scientists in Asia spend their time studying it.

The subtext of the USGS's statement reveals two strong biases common within the larger scientific community outside of China and Japan that have a significant impact on the way people think about earthquakes. The first prejudice is against theories and data that do not fall within the traditional purview of scientific study, such as those relating to strange animal behaviors before earthquakes. The second bias is a disregard for the people who research alternative hypotheses about earthquake predictability, regardless of whether or not their theories have merit. To take one example in the United

[29]The complete statement is: "The earliest reference we have to unusual animal behavior prior to a significant earthquake is from Greece in 373 BCE. Rats, weasels, snakes, and centipedes reportedly left their homes and headed for safety several days before a destructive earthquake. Anecdotal evidence abounds of animals, fish, birds, reptiles, and insects exhibiting strange behavior anywhere from weeks to seconds before an earthquake. However, consistent and reliable behavior prior to seismic events, and a mechanism explaining how it could work, still eludes us. Most, but not all, scientists pursuing this mystery are in China or Japan." USGS Earthquake Hazards Program, "FAQs – Common Myths about Earthquakes: Can animals predict earthquakes?," <http://earthquake.usgs.gov/learning/faq/?faqID=14>, accessed 9 October 2009.

States, there is a growing network of individuals who actively research and write about the ability to predict earthquakes by observing animal behaviors. Probably the most well known member of this group is Jim Berkland, a retired USGS geologist who claims a greater than 75% accuracy rate in predicting earthquakes by correlating the lunar-tide cycles with the number of missing pet ads in the daily newspaper. The USGS does not mention at all the work of Berkland or others like him.[30]

As revealing as is the USGS's statement about animals predicting earthquakes, it becomes all the more fascinating when one considers the organization's current official stance on earthquake prediction in general. In response to the question "Can you predict earthquakes?" the USGS gives the following response:

> No. Neither the USGS nor Caltech nor any other scientists have ever predicted a major earthquake. They do not know how, and they do not expect to know how any time in the foreseeable future. However [,] based on scientific data, probabilities can be calculated for potential future earthquakes. For example, scientists estimate that over the next 30 years the probability of a major EQ occurring in the San Francisco Bay area is 67% and 60% in Southern California. The USGS focuses their efforts on the long-term mitigation of earthquake hazards by helping to improve the

[30]For more information on Berkland, see Cal Orey, *The Man Who Predicts Earthquakes, Jim Berkland, Maverick Geologist: How His Quake Warnings Can Save Lives* (Boulder, CO: Sentient Publications, 2006). Also visit Jim's website: www.syzygyjob.com.

> safety of structures, rather than by trying to accomplish short-term predictions.[31]

This answer is startling. In contrast to the other statement, the language here is unequivocal. According to the USGS, absolutely no one is, has been, or possibly ever will be able to predict a major earthquake. That includes scientists at two of the most respected earthquake research institutions in the world and also any "other" scientists. No scientist anywhere has the knowledge to predict a major earthquake, nor is it anticipated that such knowledge will be acquired any time soon. That being the case, the USGS can only use "scientific data" to calculate the "probability" of a future earthquake. According to this data, the USGS estimates that there is roughly a two-in-three chance that California will be struck by an earthquake in the next thirty years. The organization's function with regard to earthquakes, then, is not to focus on the "short-term" goal of prediction, but rather to spend time and resources on improving structural safety over the "long-term."

This statement by the USGS is remarkable for a number of reasons. First, not only did the State Seismological Bureau of China successfully predict a major earthquake, the large one that struck Haicheng on 4 February 1975, but it also predicted

[31]USGS Earthquake Hazards Program, "FAQs – Common Myths about Earthquakes: Can you predict earthquakes?," <http://earthquake.usgs.gov/learning/faq/?faqID=13>, accessed 9 October 2009.

the series of smaller tremors that occurred during the two previous months.[32] Second, the vague term "scientific data" makes it unclear how distinct that data must be from the anecdotal evidence the USGS criticizes in its first statement. Third, it is common knowledge among natives and long-term residents of California that earthquakes happen more frequently than a two-in-three chance every thirty years; they do not need a scientific institution's forecast to tell them that. Fourth, it seems strange that a respected geological institution would focus its energies on making structures safer and more earthquake-friendly rather than on finding a better way to predict earthquakes. Finally, disregarding the "short-term" goal of prediction is tantamount to risking the 100,000 lives saved from the Haicheng earthquake.

The position on the study and prediction of earthquakes taken by the USGS seems incongruent with its long and distinguished track record of scientific research and development. The two official statements communicate that the organization has essentially given up on its effort to predict earthquakes, despite the immeasurable value that ability would have for people in seismic areas within the United States and all over the world. The case of China demonstrates that it is possible to predict a major earthquake, which makes all the more curious the USGS's resistance to even trying.

The USGS includes on its website a link to "What Ever Happened to Earthquake Prediction?" a 1997 article that offers several clues to the organization's earthquake

[32]The USGS's disregard for the accomplishment of Chinese scientists in their prediction of the 1975 earthquake is a classic example within the scientific community of the still-pervasive prejudice against the Eastern "other," so well described by Edward W. Said in *Orientalism* (New York: Pantheon Books, 1978).

prediction stance.[33] Written by Christopher Scholz of the Lamont-Doherty Earth Observatory in New York, the article begins with Scholz noting how a recently published conference volume on earthquake prediction "succeeds admirably in talking around its subject," with the contributing authors showing more embarrassment than enthusiasm for their topic.[34] By contrast, Scholz recalls "the [1970s] heyday of scientific cockiness in the predictability of earthquakes," which included the development of a potentially fruitful theory of earthquake prediction put forward by him and two colleagues, as well as the successful prediction of the 1975 Haicheng earthquake.[35] "The euphoria" of earthquake prediction brought on by these two events was, however, short-lived. Tests on Scholz's and his colleagues' theory proved both it and the "particular form of earthquake precursor" the theory described were ineffective for earthquake prediction.[36]

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[33]Christopher Scholz, "What Ever Happened to Earthquake Prediction?" *Geotimes* 42 (1997): 16-19.

[34]Scholz, 17. The volume of which he speaks are the proceedings from a colloquium on earthquake prediction sponsored by the National Academy of Sciences and held in Irvine, California in February 1995. Leon Knopoff, *Earthquake Prediction: The Scientific Challenge* (Washington, D.C.: National Academy of Sciences, 1996).

More direct in addressing the subject of earthquake prediction are two key texts in the field, which are, not surprisingly, written by scientists in Japan: Tsuneji Rikitake, *Earthquake Prediction* (Amsterdam; New York: Elsevier Scientific Publishing Col, 1976) and Kiyoo Mogi, *Earthquake Prediction* (Tokyo: Academic Press, 1985).

At the time of completing this manuscript, the first general book on earthquake prediction was published: Susan Hough, *Predicting the Unpredictable: The Tumultuous Science of Earthquake Prediction* (Princeton and Oxford: Princeton University Press, 2010). Written for a popular audience by a scientist, the book narrates in greater detail several of the earthquake prediction stories recounted here. Hough claims earthquakes to "occur like clockwork" on a geological time scale, but "are vexingly, almost determinedly irregular" on a human time scale. Earthquakes' unpredictability is therefore only a matter of perception, and will remain so until earthquake science catches up. In her words, "given the state of earthquake science at the present time, earthquakes are unpredictable." (p. 222)

[35]Scholz, 17.

[36]Ibid.

Around the same time, more news from China seemed to supply convincing evidence that earthquakes could not be consistently predicted. As Scholz reports,

> In 1976, a US team visited China to investigate the Haicheng prediction. They found that the prediction was apparently the result of an unusually pronounced foreshock sequence coinciding with a sort of widespread public hysteria associated with a Cultural Revolution declaration that the earthquake prediction could be accomplished through the unfailing efforts of the 'broad masses of the people.' However one judged the merits of this prediction, it did not lead to any method that could be translated into western scientific practice. To cement this disillusionment, the famously unpredicted and disastrous Tangshan earthquake struck, killing 250,000 people in northern China in 1976.[37]

The U.S. team's negative association of earthquake prediction with the Chinese Cultural Revolution is certainly understandable in the context of Cold War politics in the 1970s, and the Tangshan earthquake was indeed a deadly catastrophe. Regardless, what Scholz makes abundantly clear is there is a dividing line between "western scientific practice" and the research method used in China, whose inadequacies were soundly proven by the unexpected and "famously unpredicted" 1976 quake.[38]

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[37]Ibid.

[38]The unpredictability of the 1976 Tangshan earthquake was in large part due to the lack of foreshocks, in contrast to the 1975 quake in Haicheng. See Cinna Lomnitz and Larissa Lomnitz, "Tangshan 1976: a case history in earthquake prediction," *Nature* 271 (1978): 109-111.

Scholz is quick to point out that "the ready, even eager, acceptance of these negative conclusions reflects the fact that the western scientific community has never viewed earthquake prediction with anything shy of extreme suspicion, if not doctrinaire disbelief."[39] As representative of the view held by many scientists in the U.S. "that earthquake prediction is not a valid topic for scientific investigation," Scholz invokes the spirit of well known seismologist Charles Richter, who frequently made statements to the effect of, "Bah, no one but fools and charlatans try to predict earthquakes."[40] Scholz supposes this strong stance to be a reaction to the long-standing struggle "in the West" between the competing authorities of science and religion, and remarks, "the prediction of earthquakes, long a province of the occult, is for that reason alone beyond the pale of respectable scientific study."[41]

Scholz clearly has no patience for people, a few scientists included, who claim the power of earthquake prediction. "Self-proclaimed oracles" like Jim Berkland, the former USGS geologist who uses pet obituaries as source material for earthquake prediction, Scholz finds "simply amusing," unless, as Scholz quips, "you happen to be the USGS spokesperson repeatedly called on to debunk them."[42] For Scholz, "more annoying are cases like that of Iben Browning, who provoked a nationwide media frenzy. . . with his

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[39]Scholz, 17.

[40]Ibid. Hough tells a similar anecdote about Richter in *Predicting the Unpredictable*, 64.

[41]Scholz, 18.

[42]Ibid.

prediction of an earthquake in New Madrid, Missouri," which Browning said would occur in 1990.[43] Scholz considers even more problematic scientists who claim success for a particular method for earthquake prediction, such as the Greek physicists Panayotis Varatsos, Caesar Alexopoulos, and Kostas Nomicos whose predictive method using electric signals—eponymously named VAN—continues to provoke controversy.[44]

The "western scientific practice" of earthquake prediction has not been entirely absent from scientific research in the U.S. Enacted by Congress in 1977 was the National Earthquake Hazards Reduction Program (NEHRP), which includes four components: earthquake prediction, hazard mitigation, earthquake engineering, and earthquake science. Of course, not all parts received equal attention, especially prediction, which, according to Scholz, "was never a major [research] activity."[45] In fact, what little research was done on prediction decreased to such a degree that now there is but one official endeavor of this type. As Scholz reports,

> At its peak, prediction studies accounted for no more than 20 percent of the USGS-administered part of the program, and this share gradually decreased. During the early years of NEHRP there was a sizable group of

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[43]Ibid. For an official USGS response to Browning's failed prediction, see: William J. Spence, R. B. Hermann, A. C. Johnston, and B. G. Reagor, *Responses to Iben Browning's Prediction of a 1990 New Madrid, Missouri, Earthquake* [Geological Survey Circular 1083] (Washington, DC: U.S. Geological Survey, 1993).

[44]Ibid. For an introduction to this method, see P. Varatsos, K. Eftaxias, F. Vallianatos, and M. Lazaridou, "Basic principles for evaluating an earthquake prediction method," *Geophysical Research Letters* 23 (1996): 1295-1298.

[45]Ibid.

> independent prediction researchers, both inside and outside of the USGS, but their numbers dwindled over time, due to the unusually severe peer criticism applied to this particular line of research. Eventually, virtually all prediction work became concentrated in one officially sanctioned activity, the Parkfield Prediction Experiment.[46]

The Parkfield Experiment is a joint research venture of the USGS and the State of California under the auspices of the NEHRP. It studies the moderate-sized earthquakes that have occurred along the San Andreas Fault near the town of Parkfield, California. The significance of this series of earthquakes is that they have happened at fairly regular intervals – 1857, 1881, 1901, 1922, 1934, and 1966 – and have ruptured along the Fault in close enough proximity to one another to suggest, the USGS reports, "that there may be some predictability in the occurrence of earthquakes, at least in Parkfield."[47] In other worlds, the regularity and seeming similarity U.S. scientists have discerned in this particular series of earthquakes along a particular section of the San Andreas Fault indicates the possibility of earthquake prediction, even if it is only true for the town of Parkfield.

The limited focus on, and pessimistic attitude about, earthquake prediction research in the United States contrasts starkly to that of Japan. Following three decades

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[46]Ibid.

[47]USGS Earthquake Hazards Program, Tectonic Setting of The Parkfield, California, Earthquake Experiment, <http://earthquake.usgs.gov/research/parkfield/geologhy.php>, accessed 2 October 2010.

of research on earthquake prediction since being launched as a national program in 1965, in 1994 Japan established the Earthquake Prediction Research Center (EPRC).[48] Devoted entirely to the task of predicting large earthquakes, "particularly those at shallow depths which are so dangerous to humankind," the EPRC, unlike the USGS, is "proud of [the] scientific challenge" offered by such a venture. Japan's frequent and often destructive earthquakes are tangible reminders for the EPRC of not only the scientific importance, but also the social and economic significance of the organization's strong emphasis on earthquake prediction, as opposed to hazard mitigation alone, as is the case with the USGS. From Japan's point-of-view, effective hazard mitigation is, in fact, epitomized by successful earthquake prediction, something the 1975 Haicheng earthquake bears out.

There has been much debate and disagreement in the scientific community about to what degree China actually predicted the 1975 quake.[49] It is clear that earthquake precursors did lead to evacuations, and many lives were saved. However, exactly how that happened remains incompletely understood. Part of the challenge lies in the amount and quality of information about the earthquake initially made available by the Chinese government. Part of the challenge also lies, as Scholz noted, in the seeming incompatibility of the prediction method used by the Chinese and that of "western scientific practice." What stands out in this regard is a distinction between China's

[48]Information cited here from the EPRC's website: <http://wwweprc.eri.u-tokyo.ac.jp/EPRC_E.html>, accessed 30 September 2010. For an overview of the state of earthquake prediction the decade before the founding the EPRC, see the article by noted Japanese seismologist Kiyoo Mogi, "Recent Earthquake prediction Research in Japan," *Science* 233 (1986): 324-330.

[49]Hough highlights the main points, although from a decidedly "western science" bias in a chapter entitled "The Road to Haicheng."

willingness to use qualitative data such as animal behavior in their earthquake research, while scientists in the United States remain staunchly opposed to using such data. This difference in approach toward earthquakes could easily be attributed to a divergent philosophy of science or to political and economic factors, but there seems to be a larger issue at work that is specific to the anomalous physical phenomenon of earthquakes.

What China does that the United States and many other countries do not, is to honor their long tradition of discussing and dealing with earthquakes in a multitude of ways. For millennia in places throughout the world, people's awe and fascination with unpredictable phenomena have produced earthquake stories that have been dispersed across cultures and geographies. These stories are of all types, reflecting the fact that earthquakes affect every aspect of human society. Indeed, earthquakes' violent and unpredictable character makes it impossible to talk about them in any one way. In a sense, earthquakes demand a variety of responses in order to be understood, a fact that China and also Japan seem to grasp in a way that the U.S. does not.

Standing in the way of scientists and many other people in the U.S. having a fuller appreciation for earthquakes, their many facets, and the long-standing culture created around them is the legacy of the 1755 Lisbon earthquake.[50] Within scientific circles, the

[50]The multi-lingual literature on the 1755 Lisbon earthquake is vast, and has increased more so since the earthquake's 250th anniversary in 2005. Two edited volumes offer the best introduction to the issues surrounding the 1755 quake. *The Lisbon Earthquake of 1755: Representations and Reactions*, eds. Theodore E. D. Braun and John B. Radner (Oxford: Voltaire Foundation, 2005), whose essays are written primarily in English but also include several written in French, provides a historical and mostly literary perspective. The more recent *The Lisbon Earthquake Revisited*, eds. Luiz A. Mendes-Victor, Carlos Sousa Oliveira, João Azevedo, and Antónia Ribeiro (New York: Springer, 2009), is the result of a 2005 international conference held in Lisbon in commemoration of the earthquake's 250th anniversary, which

Lisbon earthquake marks the birth of modern earthquake research, especially the field of seismology.[51] In matters of public policy, the 1755 event is judged "the first modern disaster" because of the well organized recovery and forward-thinking reconstruction efforts enacted under the leadership of the enlightened head of government, the Marquis of Pombal.[52] Linking the scientific and public policy components is a decidedly rational approach toward earthquakes and other disasters, which is presented as being more relevant and practical than other ways of thinking about earthquakes, especially religious or other-worldly ones. As typically presented, Pombal embodied this ideal, as he simultaneously rebuilt the city of Lisbon to a new state of modern splendor, and also expelled the Jesuits for their supposed religious interference in the process.[53]

For the average person, the 1755 Lisbon earthquake is very often the earliest historical earthquake of which he or she has any knowledge. This is in part due to the memorialization of the earthquake by famous eighteenth-century French writer and philosopher Voltaire in his still popular novel *Candide*, whose pessimistic outlook echoes

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this author was fortunate enough to attend. In contrast to the Braun and Radner volume, this collection of essays is very focused on issues related to science, seismic engineering, risk management, hazard mitigation, earthquake-resistant architecture, and global response. Worth noting from a historical point of view are two essays: "The Lisbon Earthquake of 1755 in Spanish Contemporary Authors," by Agustín Udías and Alfonso López Arroyo; and "The Lisbon Earthquake of November 1st, 1755: An Historical Overview of its Approach," by Maria do Rosário Themudo Barata.

[51]As an example, Charles Davison, *The Founders of Seismology* (Cambridge: Cambridge University, 1927). Though published almost a century ago, Davison's book epitomizes the place of the 1755 earthquake in the history of seismology.

[52]Typical in this regard is Russell R. Dynes, "The Lisbon Earthquake of 1755: The First Modern Disaster," in *The Lisbon Earthquake of 1755*, eds. Braun and Radner.

[53]The recent book by Nicholas Shrady is a classic example of this approach: *The Last Day: Wrath, Ruin, and Reason in the Great Lisbon Earthquake of 1755* (New York: Penguin Books, 2009).

the phrase "everything is meaningless," which is found in the Bible's book of Ecclesiastes. The general unfamiliarity with earthquake events or stories occurring before the 1755 earthquake is also due to the limited scholarly work done on earlier earthquakes.[54] Most people express surprise upon learning about the many earthquakes that preceded the Lisbon event.

That is not to say that the earthquake that shook Lisbon on 1 November 1755 is not important. The event was devastating and significant. First of all, the earthquake was massive. With an epicenter in the Atlantic Ocean a few hundred miles due west of the Strait of Gibraltar, tremors were nevertheless reported as far away as France, Switzerland, and Italy, while the tsunamis that followed caused flooding along the distant coasts of Ireland, Holland, and several places in the Antilles. The hardest hit areas were those closest to the earthquake's epicenter, most notably Morocco, Algeria, southern Spain, and Portugal, especially the capital city of Lisbon, where innumerable buildings were destroyed and tens of thousands of people lost their lives. Lisbon's status as an international trade city ensured that reports of the earthquake were disseminated throughout the known world, evoking a fervent reaction from scholars, preachers, and literati like Voltaire. News of the earthquake stimulated discussions about earthquakes' physical mechanisms, and prompted individuals all over Europe to begin compiling earthquake catalogues, which have become a mainstay in the scientific study of

[54]A notable exception is Charles Walker, who has recently published the only monograph on an earthquake event before the 1755 Lisbon earthquake: *Shaky Colonialism: The 1746 Earthquake-Tsunami in Lima, Perú, and its Long Aftermath* (Durham and London: Duke University Press, 2008).

earthquakes. At a practical level, the work of reconstruction in Lisbon by the Marquis of Pombal was noteworthy. The "Pombaline" architectural style designed during his tenure, for example, continues to be much discussed. Moreover, the intellectual aftershocks of the 1755 earthquake have become legendary, and much has been gained from studying this noteworthy event.

Unfortunately, however, the quantity and type of scholarly emphasis placed on the 1755 earthquake has significantly hindered the study of earthquakes occurring before 1755; it has also limited the scope of historical research about earthquakes more generally. The strong focus on the 1755 event has blocked from view the variety and abundance of earthquake stories that have been circulating for millennia. Because earthquakes continue to defy human understanding, they require a broader view than the specific context of one earthquake event provides. The large corpus of earthquake stories reflects a number of approaches to earthquakes, and forms an earthquake culture from which people draw in their efforts to come to terms with the unpredictable phenomenon. The 1755 Lisbon earthquake was not a magical moment in history when the knowledge about earthquakes suddenly and completely changed, but rather an event whose interpretation revealed only certain aspects of a much larger earthquake culture.

This project is a significant first step towards elucidating a culture of earthquakes, and it does so without invoking the 1755 Lisbon earthquake. By examining and exploring different stories about and approaches to earthquakes from the last several millennia, this project reinstates a small portion of the long tradition of earthquake

knowledge that has been lost because of the focus on the 1755 Lisbon earthquake. Source material for this study includes numerous earthquake stories recorded in a variety of forms, from personal anecdotes, prayers, and sermons, to natural histories, philosophical treatises, and poems. In order to demonstrate how a fuller understanding of earthquakes requires engaging a multitude of perspectives, particular attention is paid to the scientific or natural philosophical views discussed in these stories, and to the religious and mythological components of the narratives. Doing so reveals not only the tensions between the traditional rivals of science and religion, but also the complementarities and compatibilities evident between them. People living in different geographies across time have been affected by earthquakes, and individuals drew upon knowledge of all types as they struggled to understand the unpredictable and potentially destructive phenomenon that affected their lives.

In taking such an inclusive approach, this project accomplishes a number of important tasks. First, it shows how countries outside of Asia have treated earthquakes historically, generating additional knowledge not unlike that found in China and Japan that can be used for further study of earthquakes. Second, it uncovers a shared legacy of earthquake stories that not only bridges the perceived divide between East and West, but actually spans the globe. Third, it dislodges the 1755 Lisbon earthquake as the definer of earthquake studies by examining the broader framework of earthquake culture as the model for the way that all earthquake events can and should be studied. Finally, this project demonstrates how unpredictable and incompletely understood phenomena like

earthquakes expose the limits of science, especially when seen from the earthquake survivor's point-of-view. This study argues that the narrow approach to scientific research about earthquakes undertaken in countries like the U.S. needs to be broadened to include a greater variety of sources containing information about the physical world. Alternate ways of understanding earthquakes that cannot be reconciled with the scientific viewpoint also need to be respected. This applies to religious views in particular, which continue to have a strong influence on how people make sense of earthquakes, because they bring value and meaning to the earthquake event that current scientific theories and explanations about earthquakes do not.

The project's geographical and chronological boundaries are broad. Stories discussed come from all parts of the globe and cover the period from roughly the eighth century BCE to the present. Comprehensive coverage of all regions and eras would be impossible, so the process of European expansion to the Americas in the early modern period provides some geographical and temporal structure. Before setting off across the Atlantic Ocean, Europeans were already quite familiar with earthquakes and their stories. However, encountering the New World offered new opportunities and challenges for thinking about and understanding both earthquakes and the physical world more generally. Thus, this project will focus on the Atlantic World region, in particular the countries and empires of Spain and England, from the time of first European contact with the American continent in 1492.

The project is organized into four chapters. Chapter One focuses on "Ancient Earthquake Knowledge." Ancient earthquake narratives such as Plato's myth of Atlantis are foundational for an understanding of earthquakes because they have been in circulation for millennia and still exert influence. The entry point for this discussion is a look at the growing field of geomythology, which values myths as a source of knowledge about the physical world. Many earthquake-related myths address the issue of cause, and generally give an explanation in one of three basic forms: animal, supernatural, and environmental—the last of which is also the explanation found in science. How an earthquake occurs is important to know, but it is ultimately irrelevant to survivors of an actual earthquake. More pertinent is the issue of why an earthquake strikes, which ancient stories address by describing an angry deity rendering judgment.

The "why?" question of earthquakes is the subject of Chapter Two, "The 1580 Earthquake in London: A Case Study of Three Writers' Reactions." The historically understudied 6 April 1580 earthquake that shook London supplies a neutral scholarly context within which to explore the potentially contentious subject of earthquakes as divine punishment, an idea most poignantly depicted in the Christian Bible. An examination of three English earthquake accounts shows how each author struggled to reconcile his entrenched religious views with what he understood about "nature," broadly defined. The root of this struggle lies in the absence of a term for "nature" in the Hebrew Bible, the collected writings of ancient Israel that are also part of the Christian Old Testament, and where some of the most potent stories of earthquakes and God's wrath

are found. In contrast to the context of the three sixteenth-century English writers, the integrated worldview depicted in the Hebrew Bible does not allow for a strong distinction between God and the creation. Thus, the three sixteenth-century authors struggled, not always successfully, to resolve the separation between their belief that the earthquake was a sign of God's judgment and their understanding of nature.

An exploration of the physical world is the subject of Chapter Three, "Earthquakes, Volcanoes, and the New World: Breaking the Boundaries of Knowledge." This chapter proposes that not only physical earthquakes, but also intellectual ones provide the impetus for reaching beyond traditional boundaries of knowledge. Europeans' 1492 arrival to a land previously unknown to them was an unforeseen catalyst for a dramatic change in how the physical world, especially the earth, was understood. In particular, the meticulous and century-long efforts of Spaniards to gather and report as much firsthand information about the Americas as possible were foundational in changing European perceptions about the world. One unintended and often overlooked consequence of Europeans' encounter with the American continents was that it represented an important step toward thinking about the whole earth as a physical unit. In the long aftermath of European exploration and discovery, it finally became possible to formulate global scientific theories like continental drift and plate tectonics, which have only been in vogue since the mid-twentieth century. However profound these theories are, it is important to remember that all scientific theories are subject to the intellectual earthquake of revision or replacement. As demonstrated by the

example of the Spaniards, openness to a variety of source material containing detailed knowledge about the physical world is an effective way both to prepare for and to negotiate an unforeseen paradigm shift.

The project concludes with Chapter Four, "Deep Seismic Events and Views of Spain's Earthshaking Empire," whose underlying premise is that exceptions stimulate the most profitable avenues of research. Within the field of seismology, deep seismic events, which make up approximately one-quarter of all earthquakes, are little studied relative to shallow earthquakes, because most scientists incorrectly assume that deep earthquakes are not as destructive as shallow ones, and because deep earthquakes call into question the very mechanism by which shallow earthquakes are understood to operate. Interestingly, the location of three notable exceptions to twentieth-century understandings about deep earthquakes—characterized by one scholar as "the big," "the bad," and "the curious"—correspond to regions that were part of the Spanish Empire in the sixteenth, seventeenth, and eighteenth centuries. Such a correlation is not mere coincidence. The broad geographical scope of the Spanish Empire included a disproportionate number of highly seismic territories, a characteristic that distinguished it as an earthshaking empire. This unusual geopolitical configuration, the exceptional nature of deep earthquakes occurring within Spain's earthshaking domain, and the empire's detailed and voluminous record-keeping combine for a fresh research opportunity to begin thinking about earthquakes in new and exciting ways.

CHAPTER 1

Ancient Earthquake Knowledge

The earliest known human civilizations formed in earthquake country, from Mesopotamia, the Indus Region, and East-Central China during the fourth millennium BCE, to the entrepôts budding along the Mediterranean Sea a thousand years later, and the cultures of Central America and the Andean coastal region in the second millennium BCE. Textual and archaeological data documenting specific earthquakes in these regions so long ago are few, and one cannot assume that the last century or so of quantitative data measuring seismic frequency in those areas reflects earthquake activity occurring in past millennia.[1] Nevertheless, it can be no coincidence that the most ancient and pervasive stories about earthquakes are told by or about people living in these particular geographies.

People across time who have suffered an earthshaking event have had to find a way to deal with that event, both in the concrete aspects of day-to-day living and in an otherworldly sense, whatever that means for them. Consistently, humans have proven to be creative in solving difficult problems and in tackling ostensibly unfathomable questions, and their handling of earthquakes has been no different. The quest to uncover earthquakes' mysteries is a large part of what drives the creation of stories about them

[1]Among the diverse groups of scholars who study ancient earthquakes – seismologists, archaeologists, scholars of ancient texts – there is little agreement about what data can be trusted, the process by which it can most effectively be used, and the conclusions that one can draw from it. The many threads of thought and approaches entangled in this web of debate will be drawn out in this and subsequent chapters.

and contributes to these tales' longevity. Because so much about earthquakes remains unknown, ancient earthquake knowledge provides a foundation for understanding these dramatic and unpredictable phenomena.

For the last half-century, an increasing number of scientists have recognized the persistence and potential significance of ancient earthquake stories, as well as of long-standing tales about other catastrophic geological phenomena such as volcanoes or tsunamis that often occur in tandem with earthquakes. Researchers have categorized many of these older narratives as myths, legends, or folklore – fluid and much debated terms that connote fiction – even if the story's original impetus was an actual historical event or person. The stories' fantastical elements, as well as their often orally transmitted nature have discouraged most scientists from using them as evidence. Many of these investigators acknowledge the existence and cultural permeation of such stories, sometimes doing so by including the tales in respected scientific works, but their search for documentable, quantifiable, and verifiable data, which the stories are not always able to provide, precludes them from exploring the tales further. There is, however, an emerging field within the earth sciences that studies mythical stories about earthquakes and other geological phenomena: geomythology.

The term "geomythology" was coined in the late 1960s by Dorothy B. Vitaliano, a geologist at the United States Geological Survey (USGS).[2] Since childhood, Vitaliano

[2]According to Vitaliano, she originally conceived of the term in a conversation with colleagues in late 1966, and articulated it further in subsequent years. An explication of the term and Vitaliano's approach to it will be discussed in more detail below.

had been fascinated by all types of mythology and folklore, but until 1961 it had not occurred to her that her seemingly disparate personal and professional interests might share a common ground. In that year she encountered an article by a Greek seismologist who persuasively connected a known geological event with two ancient Greek myths.[3] That man was Angelos Galanopoulos, head of the Seismological Department at the University of Athens and a researcher who had spent a great deal of time studying the incidence of tsunamis affecting Greece from ancient times to the present day.

Although devastating earthquakes are quite common in Greece's history, Galanopoulos found that destructive tsunamis, huge waves caused by sea floor displacements such as earthquakes, are surprisingly uncommon by comparison. In particular, of the 613 larger-scale earthquakes known to have struck Greece from 600 BCE to 1958 CE, only 41 of those were accompanied by tsunamis, and only 16 of those tsunamis were severely damaging.[4] Statistically speaking, then, the odds of wholesale destruction by water are not high, a curious finding given that two of Greece's most ancient and enduring myths tell not only of earthshaking and volcanic eruptions, but also of devastating floods. Through his study, Galanopoulos was able to make a credible link between the violent eruption of the Santorini volcano, an event which scientists date to roughly 1500 BCE, and the two Greek myths, the Deluge of Deucalion and the lost island of Atlantis.

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[3]A. G. Galanopoulos, "Tsunamis Observed on the Coasts of Greece from Antiquity to Present Time," *Annali di Geofisica* 3-4 (1960): 369-386.

[4]Galanopoulos, 381.

The Deluge of Deucalion is a Greek version of a well-known tale about a great flood that destroyed all or part of humankind. The basic outline of the Deucalion iteration is that "Zeus became angered at the human race because of their wickedness, and sent a flood to destroy the world. Warned by his father Prometheus, Deucalion, king of Thessaly and ancestor of the Hellenes, built a vessel in which he and his wife Pyrrha rode out the flood, coming to rest nine days later on Mount Parnassus."[5] One may recognize almost immediately the striking similarities between this story and the older narrative of Noah's Flood found in the biblical book of Genesis, with differences found mainly in minor details such as character names more appropriate to each story's geographical and cultural context.[6] Also comparable is the Babylonian flood story found

[5]Quoted from Vitaliano, "Geomythology," *Journal of the Folklore Institute* 5 (1968), 10, who provides the most compact summary. Ovid (*Metamorphoses*) and Apollodorus or Pseudo-Apollodorus (*Bibliotheca*) provide the most complete versions of the Deucalion story. A shorter account is found a few centuries earlier in Pindar (*Olympian 9*).

There are a number of flood stories in Greek myth, most of which are believed to describe only a local event rather than a universal one. According to the Greek sources, there were three floods that occurred before the Deucalion story. The oldest is the flood of Ogyges, which is dated by three different authors (Varro, Julius Africanus, and Eusebius) between 1750 BCE and 2136 BCE. Less well documented are two others, including the one of Dardanus. In his *Critias*, Plato does not address these floods by name, but indicates a common knowledge of them when he makes reference to "the third terrible deluge before that of Deucalion." Plato, *Timaeus* and *Critias*, translated and with an introduction by A. E. Taylor (London: Methuen and Co., 1929), 114. James G. Frazer provides a discussion and analysis of the Ogygian and Dardanian floods in some detail in his lengthy essay "Ancient Stories of a Great Flood," *The Journal of the Royal Anthropological Institute of Great Britain and Ireland* 46 (July-December 1916), 271ff.

[6]One major difference between the two accounts is that the Deucalion story makes no mention of animals, while they are a noteworthy presence in the Noah tale. Animals are also of importance to the Babylonian and Sumerian versions of the story. See Kenneth F. Kitchell, Jr., "The View from Deucalion's Ark: New Windows on Antiquity," *The Classical Journal* 88 (April-May 1993), 341-357.

The Deucalion tale is, however, only one of many flood tales that has circulated in Greek myth. Another one, which was written in Greek by the Babylonian Berossus in the third century BCE and likely influenced by the Hebrew, Babylonian, and Sumerian flood stories, has a decided interest in animals. See Emil G. Kraeling, "Xisouthros, Deucalion, and the Flood Traditions," *Journal of the American Oriental Society* 67 (1947): 177-183.

in the ancient literary work the Epic of Gilgamesh, whose lead character, Utnapishtim, like Deucalion and Noah, survives the god-sent flood in a boat that lands high and dry on a mountain after the water subsides.[7] To what extent these and other flood narratives borrowed from each other and perhaps describe a universal event continue to be a matter of debate.[8] Nevertheless, each individual story originated in a particular place at a particular time. In the case of the Deluge of Deucalion, "this story has been dated fairly accurately, as such things go. There was a king [either] named [or titled] Deucalion, and the flood with which that name is associated occurred about 1500 BC[E],"[9] roughly the same time as Santorini exploded. Galanopoulos' extensive study and cataloguing of tsunamis occurring along the coasts of Greece revealed to him the cause and effect relationship between the two events. Likely preceded and/or accompanied by an earthquake or series of earthquakes, the eruption of Santorini, a volcano less than 150

[7]Most familiar as a Babylonian story, this flood narrative was in all likelihood borrowed from the Sumerians, ancient predecessors of the Babylonians, making it the oldest of all known flood stories. For millennia the Babylonian Epic of Gilgamesh remained unknown to western scholars, and the flood story was known only from a Greek version written in the third century BCE (see footnote 6). However, excavations of the ancient city of Nineveh undertaken in the nineteenth century uncovered in the library of King Ashurbanipal (r. 668-626 BCE) a series of literary fragments, which, when put back together, comprised the Epic of Gilgamesh. Subsequent excavations undertaken at different sites revealed much older Sumerian versions of the story. For a useful narrative of these discoveries, as well as an informative overview of each of the Babylonian, Hebrew, and Greek flood stories, see Frazer, "Ancient Stories." Although almost a century old, Frazer's essay is an excellent introduction to each of these three well known flood stories and to some of the main themes still prevalent in scholarly discussions about them.

[8]Most scholars today would agree that the Sumerian version of the flood story is the oldest, from which at least part of the Noah story in Genesis borrowed. To what extent the multitude of other tales from across the world about a Great Deluge are associated with one another, either in the form of borrowing content or in describing a universal event, has its own considerable scholarly literature. For a quick introduction to these materials with a global perspective, see the collection of essays edited by Alan Dundes, *The Flood Myth* (Berkeley: University of California Press, 1988).

[9]Vitaliano, "Geomythology," 10.

miles from the Greek mainland in the Southern Aegean Sea, generated a tsunami that flooded Greece and inspired the Deucalion tale.

Galanopoulos also proposed that there was a connection between the Santorini explosion and the lost island of Atlantis, whose legend comes exclusively from the *Timaeus* and the *Critias*, two dialogs by Plato, who lived in the fourth and fifth centuries BCE. According to Plato, Atlantis was an island in the Atlantic Ocean "larger than Libya and Asia put together" located in front of the Pillars of Hercules. Although a mighty sea power that had aggressively attacked cities throughout Europe and Asia, Atlantis was eventually defeated by the Athenians. Shortly thereafter, around 11,500 BCE,[10] "there were earthquakes and floods of extraordinary violence, and in a single dreadful day and night...the island of Atlantis...was swallowed up by the sea and vanished."[11] The historicity of Plato's narrative was questioned almost as soon as it was written. Even Aristotle, Plato's own pupil, considered the story of Atlantis pure fiction.[12] Yet others

[10]Plato's timeframe is not this exact; rather, 11,500 BCE is the dating scholars originally estimated based upon the relative time between events given by Plato. As with the physical location of Atlantis, the dating of its cataclysmic disappearance has been of great interest to researchers. See further below.

[11]Quotations are taken from the translation of Plato's *Timaeus* and *Critias* done by H. D. P. Lee (London: Penguin Books, 1971), but they differ little from other translations of the same passages on the Atlantis story. Plato's telling of the actual destruction of Atlantis is quite brief. Of the two texts, *Timaeus* contains the only complete reference to Atlantis' demise, which is contained in the equivalent of a mere paragraph (25). Plato's *Critias* is dedicated almost entirely to a discussion of Atlantis, but the majority of the text recounts the splendor of Atlantis itself. Only one sentence makes a direct reference to Atlantis having been destroyed, and the story ends with a cliffhanger allusion to Atlantis' impending doom (the text remained unfinished). "And the god of gods, Zeus, who reigns by law, and whose eye can see such things, when he perceived the wretched state of this admirable stock, decided to punish [the Atlanteans] and reduce them to order by discipline. He accordingly summoned all the gods to his own most glorious abode, which stands at the center of the universe and looks out over the whole realm of change, and when they had assembled addressed them as follows..." Lee, 143.

[12]Phyllis Forsyth, *Atlantis: The Making of Myth* (Montreal: McGill-Queen's University Press, 1980), 1.

have argued vehemently for the opposite position and "claimed that every word about Atlantis was true."[13] The debate between these two extreme positions, as well as the discussions of more moderate standpoints, have remained lively for over two millennia, with no sign of abating.[14]

A major point of contention has been where Atlantis was physically located before it vanished. For centuries it was assumed to have been situated in the Atlantic Ocean, exactly as described by Plato just west of the Strait of Gibraltar, known in antiquity as the Pillars of Hercules. For some Europeans in the sixteenth century, encountering the Americas seemed to confirm the lost island's Atlantic location. Since the American continents had been previously unknown to them, the Europeans were finally able to conceive of not only Atlantis' existence, but also of its physical placement within the Atlantic Ocean. In other words, Plato's description made sense.[15] In the

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[13]Forsyth, *Atlantis*, 1. A specific example Forsyth provides is Cantor, one of the editors of Plato's *Timaeus*.

[14]The number of works published on Atlantis numbers well into the thousands. A few key texts published in the last several decades worth noting are: James Bramwell, *Lost Atlantis* (California: Newcastle, 1974); A. G. Galanopoulos and Edward Bacon, *Atlantis: The Truth behind the Legend* (Indianapolis: The Bobbs-Merrill Company, 1969); and J. V. Luce, *The End of Atlantis* (London: Paladin, 1970). In addition to the many monographs on the subject are numerous but sometimes overlooked portions of other texts whose authors weigh in on the Atlantis controversy. Vitaliano, for example, dedicates one chapter of *Legends* to Atlantis, and most translations of the *Timaeus* and *Critias* published since about 1970 include an appendix discussing Plato's legendary island.

[15]According to Forsyth (p. 2), "a moving force" to this belief "was the study of native American civilizations" because some explorers connected their "primitive achievements" to "the now-lost advanced civilization of Atlantis." She cites as one example the writing of Diego de Landa, who was a Spanish Catholic bishop in the Yucatán in the sixteenth century.

Not all Europeans who encountered the Americas agreed with Plato, however. José de Acosta, for instance, a contemporary of Landa, considered Plato's story of Atlantis to be "absurd" and "more like fables or stories by Ovid than history or philosophy worthy of the name." José de Acosta, *Historia Natural y Moral de las Indias, en que se tratan de las cosas notables del cielo, y elementos, metales, plantas, y*

nineteenth century the argument for an Atlantic Ocean site seemed to gain further strength with the discovery of part of the Mid-Atlantic Ridge, a rugged, volcanic mountain range that runs along the Atlantic Ocean floor roughly 40,000 miles from Greenland in the north to Bouvet Island in the south. While primarily submarine, the Ridge does peek above the water line here and there, where it appears as an island or series of islands. Most notably for Atlantis enthusiasts are the Azores Islands, which are located less than one thousand miles due west of the Strait of Gibraltar. In 1882, in what is still considered to be the classic work on Atlantis, Ignatius Donnelly argued convincingly that the Mid-Atlantic Ridge was "the backbone of the ancient continent" of Atlantis, whose mountain peaks were the Azores.[16]

Unfortunately for Donnelly and those who subscribed to his views, further scientific study showed that an Atlantic Ocean location for the lost island was virtually impossible. This opened the way for alternative geographical sites, with "claims to have

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animales dellas: Y los ritos, y ceremonias, leyes, y gobierno de los Indios, compuesto por el Padre Joseph de Acosta (1590), edited by Edmundo O'Gorman (Mexico City: Fondo de Cultura Económica, 1962), Book I, chapter 22. Also available in English: José de Acosta, *Natural and Moral History of the Indies*, edited by Jane E. Mangan, with an introduction and commentary by Walter D. Mignolo, and translated by Frances López-Morillas (Durham and London: Duke University Press, 2002). References follow Acosta's organization of the *Historia* into Books, which are further subdivided into short chapters. English quotations are taken directly from Mangan's edition.

The lengthy notes in volume one of Thomas H. Martin's translation of Plato's *Timeus* include a discussion of the speculations made about Atlantis from the sixteenth through the eighteenth centuries. *Études sur le Timée de Platon* (Paris: Ladrange Libraire-Éditeur, 1841), 261ff.

Whether or not everyone agreed about the historicity of Plato's Atlantis story, it nevertheless inspired a number of writings, of which the most famous is probably Francis Bacon's *New Atlantis*, which was published in Latin in 1624 and in English in 1627.

[16]Ignatius Donnelly, *Atlantis: The Antediluvian World* (San Francisco: Harper and Row, 1971), 46.

found Atlantis in places as far apart as Britain and Antarctica."[17] Whatever the location, each still had to fit Plato's basic criteria that a large landmass containing a superior sea-faring people had sunk into oblivion in a dramatic, one-day catastrophe around the mid-twelfth millennium BCE; otherwise, the philosopher might be considered "incorrect in his basic facts about the lost island."[18]

In the early twentieth century archaeological excavations conducted around the Mediterranean basin began uncovering evidence of previously unknown ancient civilizations, including one on the island of Crete known as Minoa, a sophisticated, maritime civilization named after Minos, the sea king of the Theseus myth. The wholesale destruction of structures and entire towns found on the island led to the suggestion in 1913 that the fall of the Minoan Empire might be a possible source for the Atlantis legend.[19] Initially, this proposal was not given much attention. However, two decades later there emerged new evidence that "the sudden collapse of the Minoan empire may have been the result of a natural catastrophe, the Krakatoa-like eruption of

[17]Forsyth, 97. According to Galanopoulos and Bacon, "there are few places in the world, where traces of prehistoric culture have been discovered, which have not been considered as either the homeland or a colony of the Atlanteans." Galanopoulos and Bacon, *Atlantis,* 76.

[18]Forsyth, 97.

[19]The Minoan civilization was uncovered early in the twentieth century by the excavations at Knossos of Sir Arthur Evans, whose decades-worth of work was published as *The Palace of Minos at Knossos*, 4 vols. (New York: Biblo and Tannen, 1921-1936). Evans' find led K. T. Frost to suggest Crete as the possible site for the lost island of Atlantis: "The *Critias* and Minoan Crete," *Journal of Hellenic Studies* 33 (1913), 189-206.

[Santorini] some 60 miles to the north of Crete."[20] Further study showed that the Minoan civilization "may [in fact] have succumbed to a combination of disasters, all associated with the eruption," including a series of earthquakes and a powerful tsunami.[21] Whether or not Crete was the original Atlantis, the evidence for such large-scale destruction of a civilization like the Minoan made more plausible the idea that Atlantis lay in proximity to the erupting Santorini volcano in the Southern Aegean Sea. Galanopoulos, the seismologist who studied tsunamis on the coasts of Greece, further strengthened this hypothesis by identifying an error in the translation of Plato's numerical estimates. Correcting this inaccuracy reduced by a factor of ten Plato's chronology, thus placing the destruction of Atlantis in the same Bronze Age era as the Santorini eruption.[22]

Galanopoulos' research illustrates the endurance of ancient stories like the Deluge of Deucalion and the lost island of Atlantis. Although millennia old, these two tales and hundreds like them continue to captivate people. Earthquakes, tsunamis, volcanic eruptions, and other catastrophic events are certainly dramatic fodder for great stories.

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[20]Vitaliano, "Atlantis: A Review Essay," *Journal of the Folklore Institute* 8 (June 1971), 67. Spyridon Marinatos was the first to make a link between a volcanic eruption and the destruction of Minoa. See, "The Volcanic Destruction of Minoan Crete," *Antiquity* 13 (1939), 425-439.

The 1883 eruption of Krakatoa was one of the most powerful volcanic eruptions in recorded history. The United States Geological Survey estimates the Krakatoa event to measure six out of eight on the Volcanic Explosivity Index (VEI), each of whose intervals represents an increase by a factor of ten. A typical VEI 6 explosion could generate an eruption column of up to 80,000 feet, expel a bulk volume of physical material of approximately four cubic miles, and leave a one-foot deep ash coating up to 100 miles away. The eruption of Krakatoa, which is estimated to have killed over 35,000 people and whose subsequent tsunamis wiped out well over 100 villages, was felt up to 3,000 miles away. "Description: 1883 Eruption of Krakatau," http://vulcan.wr.usgs.gov/Volcanoes/Indonesia/description_krakatau_1883_eruption.html, accessed 20 February 2010.

[21]Vitaliano, "Atlantis," 68.

[22]Besides adjusting the dating, correcting the translation error also reduced to more reasonable dimensions Plato's description of the size of Atlantis. Galanopoulos, "Tsunamis," 370.

Indeed, with the upheaval these geological phenomena can cause for humans and their civilizations, it is no wonder that reports of their occurrence can become the stuff of legends.

Exploring these legends is what Vitaliano set out to do after she encountered the work of Galanopoulos. She recognized the strong influence that some of nature's more dramatic agents can have on humans and their story-telling, and began her own investigation into the relationship between geological phenomena and myths about them, a method of study she eventually termed "geomythology." First presented in lecture form, which was subsequently published as an article, Vitaliano's research was well received in both scientific and non-scientific circles. The "enthusiastic reception" her work continued to garner, including an invitation by Indiana University Press to publish it, finally led Vitaliano to expand her work into a book. From its publication in 1973, *Legends of the Earth: Their Geologic Origins* was considered a pioneering work.[23] The first systematic presentation of and approach to the geological foundations of human myth, *Legends* continues, almost four decades later, to be regarded as the definer of the emerging discipline of geomythology.[24]

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[23]Vitaliano, *Legends of the Earth: Their Geologic Origins* (Bloomington: Indiana University Press, 1973).

[24]In 2007, "the first peer-reviewed collection of papers discussing the study of the geological reality lying behind myths and legends of the past" appeared in print. The volume grew out of a session on "Myth and Geology" held at the 2004 International Geological Congress, for which Vitaliano gave the keynote address. Her talk is presented as the first chapter. L. Piccardi and W. B. Masse, eds., *Myth and Geology* (London: The Geological Society, 2007).

Initially Vitaliano considered her research process "the geological application of euhemerism,"[25] the theory held by the fourth-century BCE philosopher Euhemerus who considered "the interpretation of myths as traditional accounts of real historical events and people."[26] Within myths and legends, then, one could find evidence "of actual geologic events that might have been witnessed by various groups of people."[27] This approach echoes the one taken by Galanapolous, who saw in both the Deluge of Deucalion and the story of Atlantis indicators of real historical episodes; this approach also represents the methodology used by most scientists who study geomythology. For them, presumably fanciful tales about earthquakes, volcanoes, floods, and the like at least have the possibility of containing elements of fact that can help to inform current knowledge about specific events in the earth's past.[28] Likewise, contemporary understandings of nature's operations can inform interpretations of geological myths and, as Vitaliano suggests, "help to convert mythology back into history."[29]

Myths that contain some record of an actual geological event are, however, only one kind of story. Vitaliano's research expanded beyond these euhemeristic narratives also to include "etiological or explanatory myths, those made up to account for various

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[25]Vitaliano, "Geomythology," 5.

[26]*Shorter Oxford English Dictionary on Historical Principles*, 5th ed., vol. 1 (Oxford: Oxford University Press, 2002), 867.

[27]Vitaliano, *Legends*, 1.

[28]Not everyone agrees. See discussion further below.

[29]Vitaliano, "Geomythology," 5.

features of man's environment."[30] In geological terms, these stories offer explanations for what seem from a human perspective to be two opposing extremes. On the one hand are large-scale landforms or other landscape characteristics that were formed in the distant past, sometimes even millions of years before humans were on the planet. Examples of these features include mountains, lakes, islands, and mineral deposits. A case in point in the United States is Devil's Tower, a 1,200-foot high land protrusion with vertical-grooved flanks located in northeastern Wyoming. The existence of this prominent landmark has prompted a number of stories speculating about its origin, most of which describe the rock as having shot out of the ground at the behest of an endangered human, and attribute its distinctive flank markings to the clawing of a bear that was giving chase.[31]

In contrast to landforms, whose appearance materialized long ago and whose processes are not visible to the human eye, are sudden and singular manifestations of geological processes such as earthquakes and volcanoes, which occur "very rapidly and afford...a glimpse of the tremendous forces operating within the earth."[32] In the case of earthquakes, Vitaliano claims that "earthquake lore seems to be almost entirely

[30]Vitaliano, *Legends*, 1.

[31]Ibid., 41-42.

[32]Ibid., 10.

etiological," with only a few exceptions.[33] In other words, it is the rare earthquake myth that points to an actual earthquake.

Fundamental to all stories explaining earthquakes is the issue of cause, or—framed as a question—Who or what causes the earth to shake? Answers to this question come in three basic forms – animal, supernatural, and environmental processes. It should not be assumed that one answer is mutually exclusive of any other, is "better" than any other, or answers the question in the same way. All three types of explanations were created to serve a specific purpose or several purposes at once, and assumptions should not be made about them, even if the original motivation for the explanation remains obscure. Earthquakes' violent and unpredictable character elicits a variety of human responses, all of which deserve attention and respect.

As we saw in the Introduction, many tales from across the globe attribute earthquakes to an animal or stack of animals that live either under or in the earth and whose movement causes the earth to shake.[34] The type of animal varies from story to story, as does the kind of bodily action required to make the earth shake. In some versions it is the buffalo shifting his feet to redistribute the load of the earth resting on his back, while in others it is the turtle, serpent, or crab doing likewise. One story tells of a hog whose back-scratching on a neighboring palm tree is what causes the earth carried on

[33]Ibid., 81.

[34]The animal stories recounted here are an abbreviation of those presented in the Introduction, pp. 4-7. Unless otherwise noted, these animal stories are taken from: L. Don Leet, *Causes of Catastrophe: Earthquakes, Volcanoes, Tidal Waves, and Hurricanes* (New York and London: McGraw-Hill Book Company, 1948), and Vitaliano, *Legends*.

the hog's back to move. Another tale identifies the earth-bearing frog as the culprit for earthquakes, with its movement of a particular body part corresponding to a quake in the place on the globe immediately above where the body part moved. A few earthquake stories attribute ground tremors to the swimming or wriggling of aquatic creatures. In one account, for example, the fish is surmounted by a stone and then a cow, on whose horns the earth is carried. The most well-known fish tale, and likely one of the more famous of all of the animal stories, is that of the catfish, or *namazu*, whose wriggling and writhing is kept in check by an occasionally absent deity.

Stories that attribute earthquakes to animal behaviors tend to be promptly dismissed. At the forefront of that dismissal is the assumption that only a primitive mind would concoct such tales, as fascinating or entertaining as they may be. Some scholars implicitly assume, for example, that there is a progression in intellectual development from animal to supernatural to environmental explanations for what causes earthquakes. Harvard seismologist L. Don Leet made such an assumption in his book *Causes of Catastrophe: Earthquakes, Volcanoes, Tidal Waves, and Hurricanes*.[35] Leet begins his chapter on earthquakes with an account of miscellaneous ideas about earthquake causes before the mid-eighteenth century.[36] As a lead-in to the discussion, he declares:

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[35]Leet, *Causes of Catastrophe*, op. cit.

[36]Leet gives as his endpoint the specific date of 1755, the same year as the infamous Lisbon earthquake. However, Leet's marker is not the Lisbon quake, but rather the Boston earthquake that struck on November 18, 1755, and is often forgotten in the wake of discussions about Lisbon. Considering Leet's location at Harvard, this makes sense.

> From the beginning [of humankind], certain individuals showed an aptitude for sensing the personal advantages of appearing to possess inside information explaining natural events, especially the violent and the unusual. Lacking facts, these alert ones inevitably relied heavily upon the imagination. The first ideas took the form of animal analogies and, with growing popular demand, drew more and more upon the supernatural.[37]

After describing a number of animal stories, he moves on to tales about deities and claims: "In time, a feeling got around that perhaps this was asking too much of the known strength of everyday animals, so it became popular to invent fantastic beings liberally endowed with the necessary energy. At this stage, seismic theories left the realm of folklore and entered that of mythology."[38] Leet follows an account of "mythology's contribution" to an understanding of earthquakes' cause with a brief critique of the deficiency of facts and observation in the development of other pre-modern ideas about earthquakes, such as those propagated by Aristotle. Leet finally moves to the heart of his argument, an extended discussion of "modern information on causes and effects of earthquakes." He explains scientific theories and ideas about earthquakes in vogue at the time he was writing in the 1940s, concepts that did not yet include the theory of plate tectonics, which would not be articulated in full for another twenty years.

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[37]Leet, *Causes*, 11.

[38]Ibid., 14.

Although Leet published his book over six decades ago, many modern authors retain his assumption that there is a primitive quality to pre-modern explanations of earthquakes' cause that eventually gave way to modern thought. Embedded within this notion is a clear privileging of rational and scientific thought above any other kind of knowledge. Writing twenty-five years after Leet, Vitaliano follows his lead and considers myths to be a "product of the naive imagination," which uses "the supernatural or the physically impossible to explain" what has been observed.[39] Scientific theories, on the other hand, "must be consistent with [observed facts and] everything...known about the natural world up to their time."[40] In Vitaliano's context, one of these theories included plate tectonics, which had been built from the concept of continental drift, hypothesized by Alfred Wegener in the 1910s. Interestingly, Wegener's concept had initially been met with skepticism and even overt hostility from the scientific community because he could not support it with concrete evidence.[41] Only in the 1950s, after scientists began retrieving new kinds of data from rocks and minerals that supported Wegener's hypothesis, did his ideas gain favor.[42] Although his ideas were not accepted

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[39]Vitaliano, *Legends*, 7.

[40]Ibid., 7.

[41]The debate is explored in detail by Naomi Oreskes in: *The Rejection of Continental Drift: Theory and Method in American Earth Science* (New York: Oxford University Press, 1999). For a briefer look at the debate, see Henry Frankel's essay "The continental drift debate," in *Scientific Controversies: Case Studies in the Resolution and Closure of Disputes in Science and Technology*, eds. H. Tristram Engelhardt, Jr. and Arthur L. Caplan (Cambridge: Cambridge University Press, 1987).

[42]This new evidence is also what helped to "prove" plate tectonic theory. For an "insider's" look at how scientists came to an understanding of the earth as defined by the theory of plate tectonics, see the collection of essays written by scientists who participated in this process in the 1960s and 1970s. Naomi

at the time, no scientist today would consider Wegener's original proposal "a product of the naive imagination" because it eventually proved to "be consistent with [observed facts and] everything...known about the natural world." Stories that explain earthquake cause in terms of animal movement, however, do not measure up to this scrutiny, so the argument goes, and should therefore be used with great caution, if not dismissed altogether.

Work in the field of geomythology has made it difficult for any scientist to reject outright the potential value of studying ancient earthquake stories. Nevertheless, there continues to be strong resistance to this notion. In a recent book on the growing field of historical seismology, the two scientific authors are highly critical of the work done by Vitaliano and those who have followed in her footsteps.[43] They doubt, for example, whether it is "critically acceptable and legitimate" even to attempt to use myths to draw out "a rationalist interpretation."[44] They go on to suggest that part of the problem lies in the "lack of rigor" employed by earth scientists, whose methodologies are not as well informed by expertise in seismology and ancient history as they should be, which implies

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Oreskes, ed., *Plate Tectonics: An Insider's History of the Modern Theory of the Earth*, with Homer Le Grand (Cambridge, MA: Westview Press, 2001).

[43]Emanuela Guidoboni and John E. Ebel, *Earthquakes and Tsunamis in the Past: A Guide to Techniques in Historical Seismology* (Cambridge: Cambridge University Press, 2009). It is important to note that these authors do not use the term "geomythology" to define any sort of field.

[44]Guidoboni and Ebel, *Earthquakes*, 42.

that only a particular set of specialists conducting research in a particular way can produce a type of knowledge that is "acceptable and legitimate."[45]

Such a bias against certain ways of knowing about the world more generally and about earthquakes in particular appears in subtle but telling ways in a variety of places. For instance, in the earthquake section of the children's website of the Federal Emergency Management Association (FEMA) is a list of nineteen legends from around the world that "have attempted" to explain earthquakes.[46] Included in this list are several of the animal stories cited above. A backhanded acknowledgement of alternate perspectives on earthquakes, the legend page serves as a foil for the rest of the earthquake section, which seeks to inform its youthful readers about the current scientific understanding of earthquakes. Succinctly put:

> Earthquakes are the shaking, rolling, or sudden shock of the earth's surface. Earthquakes happen along 'fault lines' in the earth's crust. Earthquakes can be felt over large areas although they usually last less than one minute. Earthquakes cannot be predicted – although scientists are working on it![47]

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[45] Ibid.

[46] Federal Emergency Management Association (FEMA) web page. <http://www.fema.gov/kids/eqlegnd.htm>. Accessed 23 July 2009.

[47] FEMA web page, accessed 23 January 2010.

With readers appropriately informed, they can then be educated as to the proper response to an earthquake: "The most important thing to remember during an earthquake is to drop, cover and hold on. So remember to drop to the floor and get under something for cover and hold on during the shaking."[48] Any school-age child living in a highly seismic zone in the United States during the last few decades no doubt recalls the regular earthquake drills that accompanied these instructions. A routine part of school life, these drills serve to instill a sense of order and preparedness for—ironically enough—an unpredictable event that is anything but orderly.

The approach to earthquakes as presented on the FEMA website reflects a broader societal trend that emphasizes disaster preparedness and mitigation over other endeavors, such as expanded research efforts to predict earthquakes. Since the 1970s, much has been written on environmental hazards, risk assessment and management, vulnerability and marginalized populations, and the incorporation of all these elements into public policy.[49] These endeavors gained new momentum after the United Nations, in response to the increasing losses in human lives and property sustained from natural disasters,

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[48]Ibid. "Duck, cover, and hold" was an emergency procedure first implemented in the early 1950s in the new age of nuclear weapons and used until the end of the Cold War in the 1980s.

[49]The literature is extensive. Several key texts from the early decades include: Gilbert F. White, *Natural Hazards: Local, National, Global* (Oxford University Press, 1974); William J. Petak and Arthur A. Atkisson, *Natural Hazard Risk Assessment and Public Policy: Anticipating the Unexpected* (New York: Springer-Verlag, 1982); and Kenneth Hewitt, ed., *Interpretations of Calamity: From the Viewpoint of Human Ecology* (London: Allen and Unwin, 1983). For earthquakes specifically, see *The Assessment and Mitigation of Earthquake Risk* (Paris: Unesco, 1978), the final report of the Intergovernmental Conference on the Assessment and Mitigation of Earthquake Risk, which was held in Paris in 1976. Published later, but also an important work, is: James K. Mitchell, ed., *Crucibles of Hazard: Mega-Cities and Disasters in Transition* (New York; Tokyo: United Nations University Press, 1999).

declared the 1990s the International Decade for Natural Disaster Reduction (IDNDR).[50] A decided shift in the approach to disasters took place over the course of those ten years. While previously the emphasis had been on response to and recovery from a disaster after it had occurred, by the end of the decade-long initiative most participants agreed that concentrating on preventative measures to mitigate the effects of a natural hazard before it happened was the better course of action.'[51] Goals toward achieving this mission consisted of nebulous tasks such as "improve risk assessments," "implement mitigation strategies," "improve technologies that support warnings and the dissemination of, and response to, warnings," "improve the basis for natural disaster insurance," and "assist disaster-prone developing nations."[52] Mitigating disaster damage also comes in many more practical forms, including, in the case of earthquakes, stricter building codes, increased monitoring of seismic activity, and, as seen with FEMA, educating people about the most orderly way to respond to earthquakes. The relative success of these strategies, however, depends upon one's point-of-view.

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[50]For an informative summary of progress achieved during IDNDR, as well as the articulation of goals to be attained after its conclusion, see the article written by the Board on Natural Disasters (BOND) of the National Research Council of the United States, "Mitigation Emerges as Major Strategy for Reducing Losses Caused by Natural Disasters," *Science* 284 (June 1999), 1943-1947.

Conceived just before and published just after the IDNDR began, Keith Smith's *Environmental Hazards: Assessing Risk and Reducing Disasters*, now in its fourth edition (London; NY: Routledge, 2004), provides a useful introduction to environmental hazards, their creation, and possible methods for their alleviation.

[51]BOND, "Mitigation Emerges," 1943. In the formal sense, mitigation includes actions taken not only before, but also during and after a disaster occurs, as the overall goal is to minimize the event's impact. Nevertheless, a strong emphasis of mitigation, in contrast to "response and recovery," is to implement preventative strategies before rather than after the event.

[52]BOND, 1945-1946.

From the perspective of the earthquake victim, mitigation efforts only go so far, and the irony of rational pre-planning becomes all too clear when an actual earthquake occurs. One can have moved to a building retrofitted for earthquakes, purchased the most up-to-date earthquake insurance, gathered an earthquake kit full of emergency supplies, practiced doing "duck, cover, and hold," and understand that plate tectonics is responsible for earth-shaking, but when an earthquake strikes, anything can happen. Just ask survivors of the 1989 Loma Prieta earthquake or the 1994 Northridge quake, both of which shook California, one of the most "earthquake prepared" states in the U.S. and arguably one of the better prepared regions in the world.[53] Assuming for the moment that all of one's earthquake preparedness measures performed as planned, there is still something perplexing about an earthquake. There is still something unsettling about the earth moving beneath one's feet. There is still something mysterious and unknown about it, even if one accepts as true that shifting tectonic plates is what causes it to happen.

The intangible and unknowable aspects of an earthquake are what confront people anew each time an earthquake occurs. Scientific theories, by definition, evolve and change as new data are identified so they reflect as accurately as possible "everything...known about the natural world up to their time," as Vitaliano phrased it. Indeed, this ability to assimilate massive amounts of seemingly unrelated information

[53]Indeed, since only a few years after the devastating earthquake and fire in San Francisco in 1906, California has actively built its reputation as the nation's earthquake capital. For a useful discussion on the development of California's identity as "earthquake country," see "Disaster as Archetype," a chapter in Ted Steinberg, *Acts of God: The Unnatural History of Natural Disaster in America* (Oxford: Oxford University Press, 2000).

into a single theory is one of the great strengths of science. So far, plate tectonics seems to be the best possible physical explanation for earthquake cause. Even though it does not account for every piece of information known about earthquakes, such as the anomalous New Madrid Seismic Zone in the central U.S.,[54] it does incorporate a great many characteristics of the phenomena that had previously remained unexplained. The scientific emphasis on earthquakes' known aspects, however, gives an impression of comprehensibility, of security, of solidity, when in fact that is not the case. Much still remains unknown about earthquakes—for example, exactly when, how, and where they will strike—data that are at least as critical to the preservation of life and property as the establishment of building codes or the implementation of orderly survival techniques. The unknown elements of earthquakes also provoke the contemplation of larger questions about life and meaning, especially in the wake of an actual event.

A characteristic common to all earthquake stories is an exploration of the unknown that is grounded in a known reality. This is true for scientific theories about earthquakes, as well as for earthquake narratives of a different kind, such as myths. With a shared interest in explaining the cause of earthquakes, both approaches delve into the unknown and, in fact, employ both the known and the unknown in their search for answers. A fundamental way this happens in science is through the formulation of a hypothesis that is then tested to determine its correctness. Once established, the

[54]Arch C. Johnston and Eugene S. Schweig, "The Enigma of the New Madrid Earthquakes of 1811-1812," *Annual Review of Earth and Planetary Sciences* 24 (1996), 339-384. A recent overview of the New Madrid earthquakes is Susan E. Hough, "Scientific Overview and Historical Context of the 1811-1812 New Madrid Earthquake Sequence," *Annals of Geophysics* 47 (2004): 523-537.

hypothesis then moves from the realm of conjecture to become something that is known. The reception of Wegener's theory of continental drift is a clear example of this. While his original concept was no doubt based on careful study and thought, it was nevertheless rejected by the scientific community because it could not be corroborated by data known at the time. After being verified, however, Wegener's theory became a fundamental building block for the continuing effort to learn more about what remained unknown concerning earthquakes.

Analogous to the development of scientific theories about earthquakes, the creation of other kinds of earthquake narratives also involves an exploration of the unknown that uses both the known and the unknown, although with a slightly different approach. Scholarly work in geomythology has shown that at least some of what had previously been assumed to be unknowable about the natural world in myths could actually be knowable. This makes sense because all earthquake stories, even myths, originated in a known reality. Vitaliano's claim that most earthquake lore is merely explanatory rather than a description of an actual earthquake event diminishes the real experience in which these stories were grounded. In a highly seismic region where earthquakes are a part of lived reality, there may not be a need for, or indeed the time to, produce a story every time the earth shakes. In such cases, explanatory narratives, including myths, could serve as a record of collective earthquake experiences in place of countless tales of individual events. The stories that describe animal movements as responsible for earthquakes are an illustrative case-in-point.

As has already been suggested, the choice of animal blamed for the disturbance in each story is not necessarily random, but instead draws upon real-world observation of the animal's erratic behavior either preceding or during an earthquake.[55] An especially apt example is the Japanese tale of the catfish, which has been in circulation for at least four hundred years.[56] In the first half of the twentieth century, scientific research done in Japan demonstrated conclusively the connection between the wild thrashing of catfish and the onset of an earthquake.[57] Such evidence creates doubt that the story's original creators and subsequent narrators were simply "naive" or using only their imaginations, as has so readily been assumed. Perhaps they did not actually believe the catfish was responsible for earthshaking, but rather they created the story as a way to illustrate what they had observed and what they knew.

A similar case can be made for another earthquake story. Like the frog tale described in the introduction, from West Africa comes a story that offers a perceptive explanation of local earthquake experience. According to this story, after creating the earth, God placed it on the head of a giant. The trees, plants, and other growing things became the giant's hair, while all living creatures became its parasites. The giant had been sitting facing east, when God crowned him with the earth. When he decided to turn to the west, he did so quietly and with no disturbance. However, the giant's turn back

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[55]Introduction, 6-7.

[56]Motoji Ikeya, *Earthquakes and Animals: From Folk Legends to Science* (Singapore: World Scientific, 2004), 13.

[57]Introduction, 8-9.

toward the east provoked much chaos that knocked down houses and uprooted trees, thus explaining why earthquakes always seemed to come from the west in that part of the world.[58] As fantastical as this account may appear, its basic observation is correct. Although the African continent is seismically stable overall, it is nevertheless "rimmed by marginal fractures which are seismically active."[59] In West Africa, then, "shocks would come from the west."[60]

While all earthquake narratives are rooted in what is known, the quest for the unknown exhibited in certain kinds of earthquake stories has a decidedly different texture than that found in scientific theories, because they explore the otherworldly meaning of an earthquake event. In these stories, the answer to the underlying question of "who or what causes the earth to shake?" is an extraordinary being, most often a deity. Similar to most animal stories about earthquakes, there are a number of supernatural explanations that do not ascribe much significance to earth shaking beyond the tangible act itself. In some highly seismic cultures, for instance, a god (or gods) causes a quake either by carrying the earth with him as he walks or by shifting his earthly burden from one shoulder to another.[61] In one tale from Africa, the earth resting on a rock in Lake

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[58]Leet, *Causes*, 15; Vitaliano, *Legends*, 82-83.

[59]Vitaliano, 82-83.

[60]Ibid.

[61]According to Leet, these include the Tlascaltans of Old Mexico, an aboriginal group in southern California, and some tribes in Colombia, 14.

Victoria shakes whenever the son of the lake god walks around too quickly.[62] Nevertheless, these few examples are the exceptions. The majority of stories that attribute earthquakes to a deity's intervention or influence delve into issues beyond the event's physical cause, issues that most scientific theories are neither able nor willing to examine. If scientific explanations seek to answer the question of "how" earthquakes happen, then earthquake stories about deities' activities and behaviors address the question of "why."

The basic plot of these supernatural tales depicts an angry god who sends an earthquake, sometimes accompanied by other dramatic natural phenomena, to punish people for their failure to do something required of them. As with the flood narratives introduced earlier, individual earthquake stories from different regions and cultures vary in some details, but most follow the same overall structure.[63] From the Indonesian islands comes the story of the earth-bearing demon Ba-Ouvando, who shakes the earth in fury if inhabitants fail to make the proper sacrifices to him.[64] Familiar to fans of Greek mythology is the ill-tempered god of the sea, Poseidon, also known as the "Earth Shaker," who produces earthquakes, tsunamis, and storms whenever he feels offended or

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[62]Leet, 15; Vitaliano, 82.

[63]One exception is an iteration of the Japanese catfish tale, which describes the *namazu* as the dispenser of punishment. After returning from his annual meeting of the gods to find what the catfish has done, the Kashima deity forgives the creature for his behavior because he rightly punished inhabitants for their wicked behavior. Charles Ouwehand, *Namazu-e and their Themes: An Interpretative Approach to Some Aspects of Japanese Folk Religion* (Leiden: Brill, 1964).

[64]Leet, 15; Vitaliano, 82.

ignored.[65] Earthquakes as a sign of divine wrath are also a common theme throughout the Hebrew Bible, with the god Yahweh meting out earthly destruction whenever he grows tired of people's sinfulness.[66] In all of these examples, earthquakes are seen to be at the exclusive control of the deity, an interpretation reflected in the phrase "act of God" to connote any event that occurs outside of human control. Such a stance gives "God" ultimate power and authority over everything, at least everything over which humans have no control, and this is one of the primary sticking points in discussions between those age-old rivals, religion and science.

Notwithstanding the great gains made over the last several decades in bridging the gap between religion and science, "God" and his (or her) place in the universe, especially as it relates to the natural world, continues to be debated, and for reasons that are entirely understandable.[67] From the perspective of science, a single-minded focus on an unseen

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[65]The cliffhanger ending of Plato's *Critias* suggests that Zeus, not Poseidon, was responsible for raining down destruction upon the inhabitants of Atlantis for their "wretched state." See footnote 11.

[66]The content of these stories will be discussed in more detail in chapter two.

[67]"Religion and science" is a broad term that can be defined in a number of ways. As a result, the literature on religion and science is extensive and continues to grow. A recent publication addresses the general debate between religion and science: Harold W. Attridge, ed., *The Religion and Science Debate: Why Does It Continue?*, with an introduction by Keith Thomson (New Haven: Yale University Press, 2009). Specific to the field of geology is: Martina Kölbl-Ebert, ed., *Geology and Religion: A History of Harmony and Hostility* (London: The Geological Society, 2009). Within the general field of the history of science, a classic work on religion and science is the volume edited by David C. Lindberg and Ronald L. Numbers, *God and Nature: Historical Essays on the Encounter between Christianity and Science* (Berkeley: University of California Press, 1986). See also Gary B. Ferngren, ed., *Science and Religion: A Historical Introduction* (Baltimore and London: The Johns Hopkins University Press, 2002).

A fundamental element of the debate between religion and science is the conflict between biblical cosmology, especially the issue of creationism, and current scientific understandings of the physical world, most notably Darwinism or evolution. For an introduction to the issues, see: Robert T. Pennock and Michael Ruse, eds., *But Is It Science?: The Philosophical Question in the Creation/Evolution Controversy*, rev. ed. (Amherst, NY: Prometheus Books, 2009). While the scientific views on these issues are in the

divine being diverts attention away from science's primary goal of discovering more of what can be known about the physical world. At the same time, religious adherents can claim just as rightly that focusing exclusively on what can be known does not address what still remains unknown about the world and human experience in it. Indeed, both views are legitimate, which is an important reason that most attempts to find common ground between them prove to be so contentious.

A frequently used explanation for why religion and science can never be reconciled is that they ask different questions and take different approaches to answering those questions, which is a reasonable explanation given the sharp distinction so often made in defining the differences between the two sides. As with most dichotomies, however, the lack of similarities between the two extremes can be exaggerated, which recent scholarly work on religion and science demonstrates.[68] This fact is made all the more clear when dealing with a natural phenomenon like earthquakes. Because earthquakes' full array of behaviors and characteristics continues to remain a mystery, both the viewpoint of science and the perspective of religion remain essential for

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mainstream and usually well known, the religious perspective is less so. An important historical study is Ronald L. Numbers, *The Creationists* (New York: Alfred A. Knopf, 1992), and another recent book demonstrates that creationist beliefs are not limited to the United States: Simon Coleman and Leslie Carlin, eds., *The Cultures of Creationism: Anti-Evolutionism in English-Speaking Countries* (Aldershot: Ashgate, 2004). Two older but significant works by proponents of biblical cosmology are: Henry M. Morris, *Biblical Cosmology and Modern Science* (Grand Rapids, MI: Baker Book House, 1970), and Walter E. Lammerts, ed., *Why Not Creation?* (Grand Rapids, MI: Baker Book House, 1970). Also worth noting is the highly influential book by John C. Whitcomb and Henry M. Morris, *The Genesis Flood: The Biblical Record and its Scientific Implications* (Phillipsburg, NJ: P & R Publishing, 1960).

[68]In a recently published book, scholar Elaine Howard Ecklund reports her findings in a study on the influence of religion on scientists, which shows the dividing line between science and religion to be rather blurred. Elaine Howard Ecklund, *Science vs. Religion: What Scientists Really Think* (Oxford: Oxford University Press, 2010).

understanding these perplexing and still unpredictable events, especially for people who experience them firsthand.

Unfortunately, the veneration of the scientific method in countries like the U.S. has precluded recognition, let alone acceptance, of other earthquake explanations, especially those with a religious bent. Supporting this notion is the fact that earthquake explanations are generally put in one of two categories, scientific or whatever is not scientific. The typical distinction made between these two types of earthquake accounts is to regard one as fact and the other as fiction, labels that refer to the kind of information that each narrative incorporates. Scientific explanations of earthquakes discuss facts, reality, or what is known about the world, while all other explanations discuss what is fictional, imaginary, or unknown. Yet, as has already been shown, there are surprising similarities in the general process used to create both narratives, with the known and the unknown each playing a part.

What is also worth remembering here is the question fundamental to all earthquake stories, including scientific and religious ones: who or what causes the earth to shake? At the heart of this question is the issue of responsibility. From the perspective of modern science, an environmental process is responsible for earthquakes. Since the 1970s that process has been referred to as plate tectonics. Over two thousand years ago, the best science identified the process as the movement of winds or waters through the

concavities of the earth.[69] Modern science also holds that the responsibility for earthquakes resides in the functioning of the physical world.

Individuals who claim earthquakes are an "act of God" view responsibility quite differently. Proponents of this view are often accused of focusing solely on God, when in fact that is only part of the story. The emphasis on the action of a deity in the phrase "act of God" makes it easy to overlook the original impetus for a god's intervention – human error or failure. Had people conducted themselves differently, whether by offering more appropriate sacrifices, being less offensive, or refraining from sinful acts, it would have been unnecessary for the deity to get involved and enforce some discipline. Thus, they believe that human beings, not gods, are ultimately responsible for earthquakes.

This issue of human responsibility has been a dominant thread in discussions of earthquakes throughout history, with earthquake stories about deities arguably being one of the oldest models. To take two instances, the tales of the Greek god Poseidon and the Hebrew god Yahweh were recorded at least as early as the fifth and eighth centuries BCE, respectively. How long they had been in oral circulation prior to that time is uncertain, but their sustained influence since being written down is unquestionable. The idea that inappropriate human behavior can elicit from a divine being a punitive response in the form of an earthquake continues to resonate. Following the devastating earthquake that shook Haiti on 12 January 2010, evangelist Pat Robertson boldly declared that the event was divine retribution for a "pact with the devil" that the Haitians had supposedly

[69]See chapter three for a brief discussion of these ancient views.

made in the eighteenth century in order to put an end to French occupation.[70] Whatever one's opinion of Robertson's stance, it is nevertheless a reminder of the staying power of ancient earthquake stories even millennia after their original telling. It is also a poignant example of how significant the question of human responsibility becomes in the aftermath of a disastrous event such as an earthquake. Plate tectonics may provide the physical explanation for what causes the earth to shake, but who is to blame for the event becomes a primary focus once the tremors have stopped.

Human actions thought responsible for the destructive results of an earthquake can generally be categorized in one of two ways. First are the intentional choices by people who are aware that potentially harmful consequences may result from those choices. Stories of earthquakes resulting from divine justice for improper human conduct certainly fall within this category. If people had behaved differently, then there would have been no need for an "act of God." A similar argument has been directed toward greedy political leaders and their cohort who label a disastrous event as an "act of God" as "a way to evade moral responsibility for death and destruction."[71] Although natural hazards such as earthquakes pose a real threat, the political leaders are accused of

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[70]There was a firestorm of reactions to Robertson's claim, which he made just a day after the earthquake on the Christian program "700 Club," which he hosts. A few months later, a report from CNN associated Robertson's comment with that of Muslim cleric Hojatoleslam Kazim Sadeghi, who claimed that "women who dress provocatively and tempt people into promiscuity are to blame for earthquakes." Sadeghi is a prayer leader in Iran, a country which experiences frequent earthquakes. CNN Wire Staff and Reza Sayah, "Promiscuous women cause earthquakes, Iran cleric says," <http://www.cnn.com/2010/WORLD/meast/04/20/iran.promiscuity.earthquakes/index.html>, accessed 4 April 2010.

[71]Steinberg, *Acts of God*, 192.

creating and implementing public policies that guarantee disaster for certain populations, especially the poor, in the case of an actual event.[72]

A second perspective focuses on social activities and processes that have deleterious, though unintended, consequences in the event of an earthquake or similar disaster. In this view, the evolution of larger and more complex human societies over time creates vulnerabilities to natural hazards that were unanticipated.[73] The development of mega-cities such as Tokyo, Mexico City, or San Francisco, all located in active earthquake zones, is one example of this.[74] The combination of increased population density, expanded building projects, and the accompanying tensions placed on local ecosystems sets up new societal and environmental conditions with which people are neither experienced nor prepared to deal in the event of an actual earthquake. People are responsible for creating the societies in which they live, but they do so in concert with environmental realities such as seismic activities, which are "not ultimately reducible to human construction."[75] Thus, there is a reciprocal influence between a society and its

[72]As an example in the United States, this argument has been taken up with renewed fervor since Hurricane Katrina made landfall in August 2005.

[73]See, for example, the work of anthropologist Anthony Oliver-Smith on Perú. Anthony Oliver-Smith, Perú's Five Hundred Year Earthquake: Vulnerability in Historical Context," in *Disasters, Development and Environment*, ed. Ann Varley. Chichester, UK: John Wiley & Sons, 1994; and "Lima, Perú: Underdevelopment and Vulnerability to Hazards in the City of the Kings," in *Crucibles of Hazard*, ed., Mitchell.

[74]Mitchell, *Crucibles of Hazard*, op. cit.

[75]Mitchell, *Crucibles of Hazard*, 2.

physical environment, in which both participants carry some responsibility for creating a disaster.

The tensions created by the interplay between human actions and physical processes are fundamental characteristics of an earthquake culture, and also of other cultures formed in relation to natural phenomena such as volcanoes or hurricanes that are "not ultimately reducible to human construction." Although these tensions may not be as evident during periods of quiescence when the phenomenon is not visibly active, in the aftermath of such an event, especially one that is particularly strong and destructive, the tensions come to the fore and become immediately recognizable. The fact that "there is no consistent judicial approach to what [constitutes] an act of God in law" is evidence of this.[76]

Also manifesting these anxious energies are the stories written about destructive natural events. At one end of the spectrum are texts that focus primarily on the natural phenomenon itself. At the other end are writings that discuss issues of human responsibility, in some cases as they relate to the divine. The majority of the stories, however, fall somewhere in the middle and reflect both the tensions existing within society and the internal struggles of individuals to come to grips with a very real and often dramatic experience in their physical environment. Science may provide a reasonable explanation for how an earthquake operates, but that does nothing for a person trying to cope in the wake of an actual event.

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[76]C. G. Hall, "An Unsearchable Providence: The Lawyer's Concept of Act of God," *Oxford Journal of Legal Studies* 13 (Summer 1993), 228.

That is where other types of earthquake explanations come into play, because they provide answers to the "why" question, a question with which science has become increasingly disinterested since the seventeenth century. Scientific developments over the last three-and-a-half centuries have no doubt improved some aspects of human existence on this planet, but they have yet to provide an effective way to help people deal with violent and unpredictable natural phenomena like earthquakes. Therefore, when an earthquake strikes, people draw upon resources that fall outside of the purview of science in order to help them make sense of something that is so difficult to understand. Part of the legacy of ancient earthquake stories, then, lies in their ability to speak to an issue important to people from diverse cultures and eras who have suffered an earthquake event: "Why?"

CHAPTER 2

The 1580 Earthquake in London: A Case Study of Three Writers' Reactions

One of the most influential sources for answers to the "Why?" question of earthquakes are the writings of ancient Israel known as the Hebrew Bible. This collection of books is also contained within the Old Testament of the Christian Bible, although the books appear there in a different order than in the Hebrew Bible.[1] The stories of death, destruction, and God's judgment recounted in this ancient text have been circulating for millennia and continue to exert enormous power over how people think about and respond to earthquakes. Not only earthquakes, but other dramatic phenomena such as thunder, lightning, fire, storms, hail, and powerful winds also appear, often in concert with earthquakes, which makes for a spectacular and lively narrative and helps to sear the story into the minds of those reading or listening to it. Whether or not one believes or agrees with the views about earthquakes contained within these texts, one no doubt has a general understanding of their overall message. In answer to the "Why?" question, these stories respond that earthquakes are divine punishment for human sin.

The continued resonance in diverse cultures across millennia of God's punishment for human moral failure as an explanation for earthquake cause, suggests that a particular historical or cultural context does not alter or influence this biblical interpretation of earthquakes to as large a degree as one might suppose. The message that

[1]Unlike the Protestant Old Testament, the Old Testaments of the Roman Catholic and Eastern Orthodox traditions contain additional books not included in the Hebrew Bible.

an earthquake was sent by God to discipline evil-doers evokes strong reactions in people, regardless of historical context, especially in the wake of an actual earthquake. This requires that any discussion about this sensitive topic be handled with respect and care. An effective way to do that is to explore the issue from a historical distance. Discussing God's judgment and human moral failure within the context of the recent and devastating earthquake in Haiti, the series of strong earthquakes that struck Chile soon after, or even the 1989 Loma Prieta earthquake in California, would likely prove ineffectual, if only for the intense reactions it would provoke. Choosing an earthquake event that happened centuries ago, on the other hand, provides a more neutral space within which to begin a productive dialogue that allows room for addressing not only the subject of religion, but also the equally-difficult topic of the relationship between religion and science.

The 1580 earthquake in London is an ideal case to use as the basis for a discussion about religious views of earthquakes and their points of contact with scientific perspectives on the phenomena, for a number of important reasons. Most significant is that the source base for studying that particular earthquake is plentiful, of which only a handful of scholars in either the humanities or the sciences have taken full advantage. Scholars in the humanities have relied on the printed sources written in English about the 1580 earthquake, most of which are available in published reprints, accessible through Early English Books Online (EEBO), or contained in the holdings of The Huntington

Library in San Marino, California.[2] Within the humanities, this rich and easily accessible source base has been appropriated by researchers working in two general fields: literature and history. Literary scholars have understood the 1580 earthquake event and its sources within the context of their studies about significant literary figures of the period, particularly with regard to the dating of works of literature. A classic example is William Shakespeare's "Romeo and Juliet," whose first act contains this statement by the Nurse:

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[2]These works include: Church of England, *The order of prayer vpon Wednesdayes and Frydayes, to auert and trune Gods wrath from vs, threatned by the late terrible earthquake, to be vsed in al parish churches. Set foorth by authoritie*. Imprinted at London: by Christopher Barker printer to the Queenes Maiestie [and Henry Bynneman], [1580]; Thomas Churchyard, *A warning for the wise, a feare to the fond, a bridle to the lewde, and a glasse to the good. Written of the late earthquake chanced in London and other places, the. 6. of April 1580. for the glorie of God, and benefite of men that warely can walke, and wisely can iudge. Set forth in verse and prose, by Thomas Churchyard Gentleman. Seen and allowed*. Imprinted at London: By Iohn Allde, and Nicholas Lyng [and Henry Bynneman?]: and are to be solde [by Nicholas Ling] at the weast dore of Paules Church, Anno 1580. April. 8; Arthur Golding, *A discourse vpon the earthquake that hapned throughe this realme of Englande, and other places of Christendom, the first of Aprill. 1580. betwene the houres of fiue and six in the euening. Written by Arthur Golding, gentleman*. At London: Imprinted by Henry Binneman dwelling in Thamis streate nere Baynerds castle, 1580; Gabriel Harvey and Edmund Spenser, *Three proper, and wittie, familiar letters: lately passed betvveene tvvo vniuersitie men: touching the earthquake in Aprill last, and our English refourmed versifying. With a preface of a wellwiller to them both*. Imprinted at London: by H. Bynneman, dvvelling in Thames streate, neere vnto Baynardes Castell, 1580; Anthony Munday, *A vievv of sundry examples Reporting many strunge murthers, sundry persons periured, signes and tokens of Gods anger twoards vs. What straunge and monstrous children haue of late beene borne: and all memorable murthers since the murther of Maister Saunders by George Brovvne, to this present and bloody murther of Abell Bourne Hosyer, who dwelled in Newgate Market. 1580. Also a short discourse of the late earthquake the sixt of Aprill. Gathered by A.M*. Imprinted at London: b[by J. Charlewood] for William Wright, and are to be sold [by J. Allde] at the long shop, adioyning vnto S. Mildreds Church in the Pultrie, 1580; Thomas Twyne, *A shorte and pithie discourse, concerning the engendring, tokens, and effects of all earthquakes in generall: particularly applyed and conferred with that most strange and terrible worke of the Lord in shaking the earth, not only within the citie of London, but also in most partes of all Englande: vvhich hapned vpon VVensday in Easter weeke last past, which was the sixt day of April, almost at sixe a clocke in the euening, in the yeare of our Lord God. 1580*. Written by T. T. the 13. of April. 1580. London: Printed by [John Carlewood for] Richarde Iohnes, 1580; and a collection and translations of different texts by Abraham Fleming, *A bright burning beacon, forewarning all wise virgins to trim their lampes against the comming of the Bridegroome. Conteining a generall doctrine of sundrie signes and wonders, specially earthquakes both particular and generall: a discourse of the end of this world: a commemoration of our late earthquake, the 6. of April, about 6. of the clocke in the euening 1580. And a praier for the appeasing of Gods wrath and indignation. Newly translated and collected by Abraham Fleming. The summe of the whole booke followeth in fit place orderly diuided into chapters*. Imprinted at London by Henrie Denham, dwelling in Pater noster rowe at the signe of the Starre, 1580.

"'Tis the earthquake now eleven years." (I, ii. 23) For some scholars, the Nurse's comment serves as proof of a 1591 date for the play, while others argue either that it refers to a 1584 earthquake or that the statement should not be taken literally.[3]

Serving a similar role are the three "earthquake letters" exchanged between Edmund Spenser, noted author of *The Faerie Queene*, and "his epistolary companion," the humanist Gabriel Harvey, which were registered for publication June 30, 1580. Specialists have used these texts as markers for placing in chronological order the numerous other works produced by each author, for tracing over time each author's creative development, and for exploring the intellectual relationship between the two men. As an example, Kendrick W. Prewitt examines the second of the "earthquake letters," which was written by Harvey and addressed to Spenser, within the context of Harvey's other writings in order to uncover Harvey's practice of method.[4]

Historians who have studied the 1580 earthquake at any length, of which there are only two examples, consider the event within a larger historical context. Alexandra Walsham recounts the 1580 earthquake event in London within a broader discussion of

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[3]See, for example, Sarah Dodson, "Notes on the Earthquake in Romeo and Juliet," *Modern Language Notes* 65 (February 1950), 144; Sidney Thomas, "The Earthquake in Romeo and Juliet," *Modern Language Notes* 64 (June 1949), 417-419; and ibid, "On the Dating of Shakespeare's Early Plays," *Shakespeare Quarterly* 39 (1988), 187-194.

[4]Kendrick W. Prewitt, "Gabriel Harvey and the Practice of Method," *Studies in English Literature, 1500-1900* 39 (1999), 19-39. Two other articles of note with regard to Harvey and the earthquake are: Winfried Schleiner, "Early Modern Recovery: Harvey's Gendered Response to an Earthquake in Essex, England, on 7 April 1580," *Cahiers Elisabethains* 70 (2006), 15-20; and Gerard Passannante, "The Art of Reading Earthquakes: On Harvey's Wit, Ramus's Method, and the Renaissance of Lucretius," *Renaissance Quarterly* 61 (2008), 792-832.

other premonitory natural phenomena in early modern England.[5] In a more recent book on the noted English writer Richard Hakluyt, Peter C. Mancall provides an excellent summary of the details of the earthquake reported in the primary materials, which serves as an aside within his larger argument about Hakluyt.[6]

So far, only scientists have made use of the breadth of sources available in multiple languages about the 1580 earthquake. In 1983, during a period of renewed political discussions between Britain and France about constructing a tunnel across the channel between the two countries, three geologists from the Natural Environment Research Council of the British Geological Survey issued a paper in which they shared their findings about "The 'London' Earthquake of 1580, April 6."[7] Through exhaustive study of over one hundred sources accessible on both sides of the channel, and after a complicated series of calculations, this team of geologists determined that the earthquake, which "affected all of northern France, Britain possibly as far north as Edinburgh, and the Low Countries and Germany beyond Cologne and Duisburg," had its epicenter offshore in the Strait of Dover and yielded a magnitude of between 6.2 and 6.9 on the Richter scale. The work of these geologists is an important reminder that earthquake effects are felt well beyond the city with which a particular earthquake event becomes identified.

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[5]Alexandra Walsham, *Providence in Early Modern England* (Oxford: Oxford University, 1999). Walsham's discussion of the 1580 earthquake is on pages 130-135.

[6]Peter C. Mancall, *Hakluyt's Promise: An Elizabethan Obsession for an English America* (New Haven and London: Yale University Press, 2007).

[7]G. Neilson, R. M. W. Musson, and P. W. Burton, "The 'London' Earthquake of 1580, April 6," *Engineering Geology* 20 (1984), 113-141.

In addition to a plentiful source base, there are several additional reasons that the 1580 earthquake in London is a good case study for exploring the relationship between religious and scientific views of earthquakes. First, London is not typically associated with earthquakes, which makes it detached from mainstream conversations about more highly seismic cities such as San Francisco or Mexico City. Second, the basic history of England in the late sixteenth-century is well known, associated with Queen Elizabeth I, who ruled from 1558 to 1603, and so provides a familiar historical context for most readers. Third, as a fundamental component of both society and politics in this period, religion figured into virtually all local discussions and appears prominently in texts about earthquakes. Finally, since Francis Bacon, the English philosopher widely recognized by modern scholars as the "father of empiricism" and the major catalyst for scientific development in England, was only nineteen when the earthquake struck, England was not yet caught up in the many changes taking place within science, which modern scholars have labeled the "Scientific Revolution," a much-discussed and often-debated term.[8] Taken together, all of these factors make the 1580 earthquake an ideal case study, one in which few modern readers are significantly invested either in the content of a discussion about religion, science, and earthquakes, or in its outcome.

As a way to introduce both the variety of authors who published texts about the 1580 earthquake and the context within which they wrote those works, the discussion

[8]For a thorough discussion of the "Scientific Revolution" and its many facets, see H. Floris Cohen, *The Scientific Revolution, A Historiographical Inquiry* (Chicago and London: The University of Chicago Press, 1994).

begins by supposing what an observant person in sixteenth-century England would have known and likely thought about earthquakes. The worldview of such an individual would have comprised three main threads. First was the importance of religious thought, either Catholic or Protestant, whose fundamental ideas are drawn from the Christian Bible. In all likelihood, this would have included a belief in God's providence over everything in the world, especially those things not completely understood, and in God's impending judgment of sinful humanity. Our hypothetical observant person may also have had a sense of living in the last days or the end times, which would have made more acute an awareness of the coming Day of Judgment.

The second thread of this individual's worldview was literacy and occupation. The ability to read and write, and training in one or more vocations would have had an influence on his worldview. Possible career options for our hypothetical person include being a member of the clergy, a soldier who had fought as a mercenary for a variety of political leaders, and/or an author, poet, or playwright. Foreign language skills and the ability to translate texts of all kinds may have been acquired along the way. With or without a formal education, we can suppose that our individual would have had a working knowledge of ancient authors such as Aristotle, Pliny, Seneca, and Lucretius, which formed the basis for an understanding about the physical world. Finally, life experience would have had an effect on the individual's worldview. Because life experience varied from person to person, its effects would depend on a variety of factors,

some of them related to social and political connections, but some so highly personal that they would have stayed hidden to the outside world.

England in 1580 provided the historical context in which such an individual functioned. The Protestant-leaning Queen Elizabeth I had been in power for twenty-two years, having assumed the throne following the death of her Catholic half-sister Mary. The effects of the Protestant purges conducted under Queen Mary, also known as "Bloody Mary," continued to permeate society. Under Elizabeth, the Church of England, begun after her father Henry VIII's break with the Catholic Church in the 1530s, had become more firmly established than it had been, but tensions between Catholics and Protestants within England remained. Finally, England's political exploits were marked by an intense rivalry with Catholic Spain, and included Elizabeth's support for the Low Countries, which had begun a protracted revolt against the Spanish Habsburgs in 1568.

Also in 1580, England's golden age of literature was reaching its peak, where it would stay for the next two decades. In 1577, theaters had reopened following much debate about their promotion of vice, and they were subsequently graced by actors such as Richard Tarlton, Queen Elizabeth I's favorite clown, and, soon, William Shakespeare. Also in the late 1570s, there had been a series of curious happenings: weird seasons, new stars, comets, eclipses, strange lights in the sky, heavy snow, excessive rain and flooding, and strong frosts. As individual episodes these events might not amount to much, but clustered together they signaled that something bigger was to come, and come it did.

Sometime "betwene the houres of fiue and sixe in the euening"[9] on April 6, 1580, the Wednesday before Easter, an earthquake shook London and its environs.[10] According to reports, this "wonderful motion and trembling of the earth"[11] caused churches, palaces, houses and other buildings to quiver and shake, tossing inhabitants to and fro and tottering tables, stools, brass, pewter, and other furnishings. Even houses on the London Bridge were shaken, as was the river below it. The Abbey Church at Westminster lost more than a foot of one of its pinnacles when its stones fell to the ground, and "the Steeple in the Pallace so shoke, that the bell of the great clock"[12] rang on its own. Queen Elizabeth I and those present with her at White Hall noted the strangeness of the occasion, while gentlemen dining in "the new hall" were so afraid that the walls would fall that they "ran forth with their knives in their hands."[13] At Christ's Church in Newgate market, where Thomas Cobhed was preaching, great stones from the roof fell and killed instantly Thomas Gray, a servant of shoemaker John Spurling, and mortally

[9]Churchyard, *A warning to the wise*, B.

[10]This narrative of events is compiled from the three earthquake accounts of Thomas Churchyard, Arthur Golding, and Anthony Munday, all of which report the same basic information. Because the narrative of earthquake events included in each of the three earthquake accounts is short and easily identified within each text, citations here will be limited to direct quotations only.

[11]Churchyard, B.

[12]Ibid., Bij.

[13]Ibid.

wounded another servant, Mabell Everet, who died a few days later.[14] In other places throughout the city, chimneys, stones, and pieces of mortar also fell, but injuries were minor, mostly bruises acquired by people who were hastening to flee, such as theater-goers who leapt from the stands.

Although the earthquake lasted not much more than a minute, caused few fatalities, and did not require significant rebuilding of the city, it was a noteworthy event for a region typically devoid of seismic activity. "Within hours of the tremor, printers [in London] were eager to publish books and pamphlets about the event."[15] The earliest accounts appeared in less than two days, with at least a dozen more texts surfacing by the end of June.[16] The variety of authors includes soldiers, translators, clergymen, and poets, which lends diversity to the genre of works they produced and to the detail contained within the texts. However, what is common to all of them is their quest to explain the cause for the earthquake and to discover its meaning. An examination of a few of these publications gives a taste for how writers viewed this particular earthquake event, and

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[14]Churchyard's account was published so quickly after the earthquake that the girl had not yet died. He reports, "Mabell Everet...was stricken on the heade with a stone, being daungerously hurt, but is not dead." (Bij) Golding and Munday both specify the girl was initially injured then died a few days later.

[15]Mancall, *Hakluyt's Promise*, 328, footnote 52.

[16]For a list of these works, see pages 167-170 of *A Transcript of the Registers of the Company of Stationers of London; 1554-1640 A.D.*, Volume II, ed. Edward Arber (London, 1875). Of the roughly twenty earthquake-related texts entered from April 7 through June 30, more than half appear on or before April 25. Unfortunately, not all of these works are extant.

In the front matter to a reprint of Thomas Twyne's earthquake discourse, R. A. Ockenden includes a bibliography of contemporary pamphlets published following the earthquake, as well as a list of "other works" printed into the nineteenth century which reference the 1580 earthquake. R. A. Ockenden, ed., *Thomas Twyne's Discourse on the Earthquake of 1580* (Oxford: Pen-in-Hand Publishing Co., 1936), 7-14.

provides a basis for discussing the strong influence of religion on people's interpretations of earthquakes and the often nebulous relationship between those views and their understanding of the physical processes of earthquakes.

The first text under review is *A discourse vpon the earthquake that hapned throughe this realme of Englande, and other places of Christendom, the first of Aprill. 1580. betwene the houres of fiue and six in the euening. Written by Arthur Golding, gentleman.*[17] Arthur Golding, who was in his mid-40s at the time of the earthquake, is best known for his translation of Ovid's *Metamorphoses*, which was the first such translation in English and upon which Shakespeare relied heavily.[18] His "discourse upon the earthquake" is one of only three original texts by him. The remaining works in his extensive bibliography are almost exclusively translations, including many sermons and texts by the religious reformer, John Calvin.[19]

The key message of Golding's earthquake discourse is that God sent the earthquake as a judgment for sin, and so everyone should repent and mend their ways

[17]Golding, *A discourse*, cited in footnote 2 above. Golding's earthquake discourse is reprinted in full in the classic study of Golding and his work by Louis Thorn Golding, *An Elizabethan Puritan: Arthur Golding the Translator of Ovid's Metamorphoses and also of John Calvin's Sermons* (New York: Richard R. Smith, 1937), 184-197. All citations taken from Golding's discourse are from Louis Thorn Golding's book, which will hereafter be referred to as *Elizabethan Puritan*, for the sake of clarity. For a brief discussion of the different iterations of Golding's earthquake discourse that were published, see Llewellyn M. Buell, "Arthur Golding and the Earthquake of 1580," *Philological Quarterly* 24 (1945), 227-232.

[18]For studies of Ovid, Shakespeare, and Golding, see: A. B. Taylor, ed., *Shakespeare's Ovid: The Metamorphoses in the Plays and Poems* (Cambridge: Cambridge University Press, 2000), in particular chapter ten on "Ovid, Golding, and the 'rough magic' of The Tempest," by Raphael Lyne; and Gordon Braden's *The Classics and English Renaissance Poetry: Three Case Studies* (New Haven: Yale University Press, 1978), of which one case study is "Golding's Ovid."

[19]For a look at Golding's efforts at translation, see James Wortham, "Golding and the Translation of Prose," *The Huntington Library Quarterly* 12 (1949), 339-367.

before something worse happened. According to Golding, God always gives fair warning before taking destructive measures, as seen in several biblical stories such as Noah's flood. These warnings come in the form of "signes, tokens, and wonders,"[20] categories that include things such as monstrous births, comets, eclipses, plagues, pestilences, famines, diseases, and earthquakes. Since the earthquake came from "the very finger of God," Golding argues, it is important that no one ascribe this "miracle to some ordinarie cause in nature," lest he become distracted and avoid seeing his own wretchedness.[21] The earthquake is an opportunity for the readers to examine themselves and check their faults, and Golding provides a long list of sins to help them with their self-reflection. In addition to the more common sins of envy, pride, gluttony, and idleness, Golding indicates there have been women wearing men's clothes, men dressing and acting like women, and a lot of misbehavior on the Sabbath, including going to taverns, gambling, and attending stage plays.[22] Whatever the sin, punishment is imminent, and the longer the readers wait, the worse things will be.[23] If this earthquake warning sent by God is not heeded, Golding contends, then they will "be caste out with [their] children into utter darkenesse: and in ye

[20]*Elizabethan Puritan*, 185. Golding uses all three terms at numerous points throughout his text.

[21]Ibid., 188-189.

[22]Ibid., 191ff.

[23]"The Axe is layde to the roote of the tree: and the longer that Gods vengeance is in coming, the sorer it smyteth when it is come." Ibid., 195.

terrible day of Judgement here [the] dreadful sentence of the just Judge pronounced against us."[24]

While the divine message of the earthquake is clear to him, Golding is well aware there are "naturall operations" at play, and in fact uses his knowledge of those operations to further his case. He argues that even nature agrees that God is responsible for the earthquake, because everything Golding knows to be true about earthquakes did not happen in this instance. His argument proceeds along two lines. First, he begins by describing what physical activity causes earthquakes, a standard explanation during this period that is largely based on Aristotle's *Meteorology*:

> [N]aturally Earthquakes are sayde to be engendred by winde gotten into the bowels of the earth, or by vapors bredde and enclosed within the hollowe caves of the earth, where, by their stryving and struggling of themselves to get oute, or being haled outwarde by the heate and operation of the Sun, they shake the earth for want of sufficient vent to issue out at.[25]

Although Golding concedes that this may be the case in some instances, he contends that it is not so with the 1580 earthquake, because the "substancial soundnesse and massie firmnesses [in England], are not to be pierced by any windes fro wythout, nor haue any holloweness wherein to conceive and breede any such aboundance of vapors."[26] Further,

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[24]Ibid., 197.

[25]Ibid., 189.

[26]Ibid.

had the venting of winds been the cause of this earthquake, it would have lasted longer than it did in order to travel the amount of geographical distance required to shake "so many places so farre off," or it would have struck "with great[er] furie" a specific locale out of which the winds were released, which was not the case in England.[27]

Not only are the known physical causes for earthquakes inapplicable to the one that shook England, but Golding considers also the earthly precursors to the event. He reports that "in Earthquakes that proceede of naturall causes, certaine signes and tokens are reported to go before them."[28] Those indicators include a "tempestuous" sea, fair weather, no wind, calm and cold air, dim Sun, long and thin clouds that appear after sunset, unsettled water in wells, which is often accompanied by a foul odor, and rumbling noises coming from within the earth.[29] None of those things happened before the 1580 earthquake, Golding argues, "and, therefore, we may well conclude...that this miracle proceeded not of the course of any naturall causes, but Gods only determinate purpose."[30] From Golding's perspective, God caused the 1580 earthquake precisely because what he knew to be true about the physical aspects of earthquakes did not apply in this case; by all

[27]Ibid.

[28]Ibid.

[29]Ibid., 189-190.

[30]Ibid., 190.

accounts, Golding's understanding of the "natural" processes of earthquakes reflected common knowledge in the period.[31]

While Golding is thus able to reconcile his belief in God's providence with what he knows about the physical realities of earthquakes, Thomas Twyne remains more ambivalent. Twyne, ten years Golding's junior, was a physician, skilled in astrology, and a friend of John Dee, a noted English polymath whose skills in mathematics, astronomy, and navigation were widely recognized. Twyne was probably best known for having translated into English the eleventh, twelfth, and thirteenth books of the *Aeneid*, though he did write a few original works as well.[32]

One of those original works was the text he published just a week after the earthquake: *A shorte and pithie discourse, concerning the engendring, tokens, and effects of all earthquakes in generall: particularly applyed and conferred with that most strange and terrible worke of the Lord in shaking the earth, not only within the citie of London, but also in most partes of all Englande: vvhich hapned vpon VVensday in Easter weeke last past, which was the sixt day of April, almost at sixe a clocke in the euening, in the yeare of our Lord God. 1580*.[33] Twyne's earthquake discourse shares with Golding the

[31]"Common knowledge" about earthquakes ranged widely, which reflected the disagreement among ancient philosophers about the phenomenon. See chapter 3 for further discussion.

[32]Ockenden, 5-6. There is little written about Twyne's life, save a short entry in the *Oxford Dictionary of National Biography* and a couple of paragraphs included in Ockenden's introduction to Twyne's earthquake discourse.

[33]Thomas Twyne, *A shorte and pithie discourse*, cited in footnote 2 above. All Twyne citations are taken from Ockenden's reprint edition, which hereafter will be referred to as Ockenden.

essential message that "this most dreadfull & daungerous earthquake" is one of the many "sygnes and tokens" sent by God to call people to repentance.[34] However, unlike most other works written about the earthquake, Twyne does not provide a narrative of the earthquake event or include a lengthy section about the wrath of God. Instead, he spends most of his time discussing natural philosophy regarding earthquakes. He echoes some of the information about earthquakes in general that Golding describes, such as what times of day and in which seasons earthquakes are most likely to occur, but his discussion is more substantive and contains greater detail.

Twyne acknowledges his reliance upon the ancient philosophers, whom he calls "the prophane wryters, who haue most dilligently laboured in the search of naturall causes."[35] Chief among these philosophers is Aristotle, who outlines the three efficient causes – "the Sun, the other sixe Plantes, and a spirite or breath included within the bowelles of the earth" – and the one material cause, an exhalation of hot, dry air, whose blowing through the caverns of the earth is what prompts the earth to shake.[36] Following Seneca, Twyne reports that there are three types of earthquakes: one that shakes towards one side like a "trembling or rocking;" one that lifts up in the middle like a "Pulse," which is the most dangerous of all; and one that is a combination of the two.[37]

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[34]Ockenden, 18.

[35]Ibid., 19.

[36]Ibid.

[37]Ibid., 22-23.

Reflecting upon his own experience with the 1580 earthquake, Twyne recalls the "quaking was not at one instant in all places wheras it was fealt, but rather came by degrees, and distance of time, after the maner of the beating of the pulse." He reasons that the earthquake seemed to move from east to west, with the eastern parts (e.g. Kent) feeling the shaking more strongly. The earthquake seemed to follow a path, "perhaps according to ye stretching foorth of ye strange exhalatiue impression, whereof I made mention before." All that being the case, Twyne notes with seeming relief, "Earthequakes God be thanked [are] rare in England."[38]

Twyne's ruminations are, in part, to be "better able to discerne" whether the earthquake, "this wonderfull worke of God...be meere naturall, or no."[39] Although clearly versed in specific knowledge about earthquakes, he is nevertheless unsure exactly how the natural and divine fit together in explaining the 1580 quake. He ascribes ultimate responsibility for the earthquake to "the finger of God" and makes clear he believes "Goddes iudgements [to have] already begun," but he is not ready to declare that the natural or efficient causes play no part. Twyne states somewhat ambivalently that "this earthquake [is] not altogither naturall."[40]

In contrast to Golding's and Twyne's pieces, one of the more lively texts written in response to the earthquake is a short pamphlet by Anthony Munday, a playwright and

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[38]Ibid., 31-32.

[39]Ibid., 23-24.

[40]Ibid., 35.

translator who was around twenty years old when the earthquake struck.[41] Munday's linguistically colorful work is full of voyeuristic anecdotes about a multitude of events, the categories of which are described in his title: *A vievv of sundry examples Reporting many strunge murthers, sundry persons periured, signes and tokens of Gods anger twoards vs. What straunge and monstrous children haue of late beene borne: and all memorable murthers since the murther of Maister Saunders by George Brovvne, to this present and bloody murther of Abell Bourne Hosyer, who dwelled in Newgate Market. 1580. Also a short discourse of the late earthquake the sixt of Aprill.*[42] Munday's desire is that the text will "be perused of all faythfull Christians." His overall point is summed

[41]Munday's long writing career had just begun at the time of the earthquake. He wrote prolifically and in many different genres. By the time of his death in 1633, he was widely recognized for his literary and historical contributions to the City of London. Munday also must have been quite a character, for he found himself embroiled in controversy on a regular basis. Of note are his contribution in the trial and subsequent execution of several Catholic priests, including Edmund Campion, whom he had met while visiting in Rome in the late 1570s, and his anti-Puritan efforts on behalf of the archbishop of Canterbury in the famous Martin Marprelate controversy.

For decades, Munday was considered by literary and historical scholars to be merely a self-serving and opportunistic hack writer. Several recent studies have begun to chip away at that long-standing opinion and give Munday his due as a significant literary figure in sixteenth- and seventeenth-century England: Tracey Hill, *Anthony Munday and Civic Culture: History, Power and Representation in Early Modern London, 1580-1633* (Manchester; New York: Manchester University Press, Palgrave, 2004); Donna B. Hamilton, *Anthony Munday and the Catholics, 1560-1633* (Aldershot: Ashgate, 2005); and G. D. George, "Earning a Living as an Author in Early Modern England: The Case of Anthony Munday," Ph.D. dissertation (Bowling Green State University, 2006).

[42]Munday, *A vievv of sundry examples*, cited in footnote 2 above. The seemingly bizarre contents of Munday's pamphlet bring to mind the work of Charles H. Fort (1874-1932), a New Yorker of Dutch ancestry who spent much of his life researching anomalous and unexplained phenomena. Like Munday, Fort was quite a character, and his influence was such that the term "Fortean," used as a noun to describe Fort's followers or as an adjective to connote paranormal phenomena, is a recognized word in the *Oxford English Dictionary*. In 1919 Fort published a collection of the eccentric data he had gathered, a work that remains in print and has recently become available in one volume with many of his other works: *The Book of the Damned/ The Collected Works of Charles Fort* (New York: Jeremy P. Tarcher/Penguin, 2008). Two of the few biographies on Fort are: Damon Francis Knight, *Charles Fort: Prophet of the Unexplained* (Garden City, NY: Doubleday, 1970); and the more recent book by Jim Steinmeyer, *Charles Fort: The Man Who Invented the Supernatural* (New York: J. P. Tarcher, 2008).

up well by the biblical citation that precedes the main section of the pamphlet. "Job 14: Man is borne of a woman hath but a short time to live, and is full of miserie, he commeth up, and is cut down like a flower, he flyeth as it were a shadow." Full of hope he certainly does not seem to be.

Munday supports this dark message with story after story that demonstrates how "the world [is] bent to all kinde of wickedness." He narrates a handful of anecdotes about perjurers, or those who swear falsely. For example, in 1574 in Cornhyll in London, the widow Barnes, "who frequented much swearing," was caused by the Devil to "cast her selfe out at her window into the streete, and there brake her neck."[43] The year before, at Hackney, ending "most miserably" was the "wretched lyfe" of one Arthur Miller, "a very lewde talker, a common blasphemer and swearer," whom Munday also ties to "the Divell."[44] "The Divells temptations" are what led Berry, a man who "had willfully periured him selfe," to "cruellie cut his owne throte" in 1575.[45] In February of that same year, the widow Anne Aueries died a few days after being struck down by God's judgment for having been dishonest about her purchase of materials for hand spinning.[46] In the margins, Munday notes that Anne's story is "a notable and straunge example to

[43]Munday, Biij.

[44]Ibid.

[45]Ibid., Biij-Biiij.

[46]More specifically, "she tooke up there six pound of Towe, and departed without paying therefore, when she was required eyther to send the Towe againe, or to pay the money therfore." "Towe" (or "tow") are the short, course fibers of flax used for spinning. Ibid., Biiij.

terrify all wicked and cruell blasphemers."[47] Munday rounds out his discussion about those who swear falsely with a report about Father Lea, a perjurer, who, "with a rusty knife, rypped his owne belly, and griped his guts with his owne handes, and so ended his life" on 21 January 1577.[48] After offering a refresher on Old Testament passages in which God speaks to the potentially life-ending consequences of swearing,[49] Munday gives a warning "to be circumspect in our dealyngs" lest "we hyghlie offend the Maiestie of God."[50]

Alongside these grisly reports of blasphemers, Munday relays a number of murder accounts.[51] He includes the cases of Paule Green, who was hanged for having slayed Maister Thomas Templeneer; "the two Sheriffes that hung themselves at Glocester"

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[47]Ibid., Biiij.

[48]Ibid.

[49]The passages are taken from the Old Testament books of Leviticus (6:2-5; 19:12; 24:15-16), Ecclesiastes (29:9-13, 15), and Zechariah (5:2-4). Ibid., Biiij-C.

[50]Ibid., C.

[51]Munday's pamphlet would have appealed to the widest possible audience because of his inclusion of certain kinds of murders. According to John Bellamy, murder in sixteenth-century England was defined as planned slaying, usually with an element of stealth or with the victim taken unawares, was not then a common crime." (Bellamy, 1) At that time, murder by poisoning was virtually unknown and multiple or serial murders was also uncommon. Although a vast majority of men over women were accused of murder (excluding infanticide and witchcraft), women were among the most desirable characters in a murder story. Domestic murders, or those murders that involved family members, were also alluring. Details about the state of the victim's body were given special attention, as was information about the discovery, arrest, and punishment of the murderer. The method of slaying was also appealing to readers and "rarely omitted by the commentators." (Bellamy, 9) The most common methods of death were a blow to the head followed by the cutting of a victim's throat (reminiscent of slaughtering beasts) and stabbing with a knife or dagger. Shooting with a firearm was a rare method of murder, as was poisoning, which was considered the most reprehensible and the method used most often by women. If Bellamy is correct, then Munday clearly knew his audience. John Bellamy, *Strange, Inhuman Deaths: Murder in Tudor England* (Westport, CT; London: Praeger, 2005), 1-13.

(1579); the "lewd and wicked" John Morgan, who was executed for killing his brother-in-law Maister Turberuile (1580); Marmeduke Glouer, who was executed (28 March 1580) for having murdered Sergeant Grace when the officer was trying to arrest him; and Richard Tod, who "murdered and cruelly massacred" old Mistres Skinner for her money, an act for which he was executed on 29 March 1580.[52] There are examples of several gentlemen who killed either their mother or their mistress, as well as tales of women who slew another woman or their own children. Munday's longest anecdotes are reports of two popular murders whose basic story would have been familiar to his audience, a fact of which he was clearly aware, because he included the victims' names in the title of his work. He begins the pamphlet with a moralizing narrative of the murder of London merchant George Saunders,[53] whose killing in 1573 had been widely publicized and continued to be the source of local gossip,[54] and he also includes extensive details of the

[52]Munday, C-Cij.

[53]Bellamy summarizes well the story's basic facts: "Saunders was a London merchant-tailor, a well-off middle-aged man, apparently well respected in London financial circles. One of the conspirators responsible was his wife, Ann, mother of his several children. Another conspirator was her friend, the sinister widow Ann Drury, notorious for her psalmistry and 'surgery' (practice of medicine). The actual killer, George Browne, a 'gallant' with Court connections, was identified by a servant whom Browne believed he had slain at the same time as Saunders. Ann Saunders seemed to many to be innocent of the charges until she was virtually at the gallows, which added to the notoriety of the case, as did the interference after trial of a Protestant minister who, hoping to marry her, tried to persuade Ann Drury to take the whole blame on herself. In all, it was a heady brew." Introductory comments by Bellamy, 171-172. For a more detailed exploration of this case, read the entire chapter from which this excerpt was taken, "A Female Conspiracy: The Murder of George Saunders," in Bellamy, 171-192.

[54]Printed in the same year as the crime was an anonymous pamphlet, now credited to the pen of Arthur Golding, entitled *A briefe discourse of the late murther of master George Saunders, a worshipfull Citizen of London: and of the apprehension, arreignement, and execution of the principall and accessaries of the same*. This lengthy narrative is over six thousand words and contains both moralizing and titillating detail about the crime. In 1577, Golding's pamphlet was reissued under the same title with only slight emendations, according to Joseph H. Marshburn, "'A Cruel Murder Donne in Kent' and Its Literary

circumstances surrounding the slaying of Abel Bourn, a hosier, who had recently been found dead by the brick kiln.[55]

In addition to bizarre events carried out by human hands, Munday includes strange things happening in the physical world. He provides six examples of "straunge and monsterous" births, including children born with either two heads or none.[56] He reports about a tempest or storm that happened in Bohemia in 1579, and provides "Examples of blazing starres and other Accidents." Munday recounts several "manyfolde motions, sundrye signs, yea and exceeding examples of [God's] wrath and displeasure." These include comets or blazing stars, "great flames and flashing of fire issuing out of the North part of the Ellement," "two great tides" occurring in one hour which is "contrary to

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Manifestations," in *Studies in Philology* 46 (April 1949), 133. The 1577 edition of the pamphlet is reproduced with little commentary by Louis Thorn Golding in his book on Arthur Golding, op. cit., 164-184. Additionally, Marshburn claims, with little evidence, that another tract, *A Cruell murder donne in Kent*, which was licensed to print in 1577 but is no longer extant, "dealt with the Saunders murder." Marshburn, 133.

The Saunders murder continued to capture the public's attention into the seventeenth century. The murder was included in multiple editions of the chronicles by Holinshed and Stow. In 1599, more than a quarter-century after the fateful event, appeared an anonymous play entitled *A Warning for Fair Women. Containing, The most tragicall and lamentable murther of Master George Sanders of London Marchant, nigh Shooters hill. Consented vnto By his owne wife, acted by M. Browne, Mistris Drewry and Trusty Roger agents therin: wihth their seuerall ends*. Printed at London: by Valentine Sims for William Aspley, 1599.

[55]Bellamy supposes that the prompt for "Munday to take up his pen" was the recent arrest of the chief suspect in Bourn's murder. Bellamy, 49. However, it seems clear that it was the earthquake, not any development in the Bourn case, that prompted Munday to write his pamphlet.

[56]Munday, Cij-Ciij. The literature on monstrous births is vast. The collaborative work of Lorraine J. Daston and Katharine Park is widely recognized as the earliest and defining scholarship in the field of monstrosities. Daston and Park, "Unnatural Conceptions: The Study of Monsters in Sixteenth- and Seventeenth-Century France and England," *Past and Present* 92 (1981): 20-54; and *Wonders and the Order of Nature*, 1150-1750 (New York: Zone Books, 2001).

nature," and reports of "straunge flyes, which on their wings bare the example of Gods iustice."[57]

Finally, however, is the earthquake of April 6, which is the culmination of Munday's text. He gives a brief running account of earthquake effects on buildings and people, which he presumably borrowed from other sources. He adds a detail or two, such as noting that Mabel Euerite, the servant girl who had been struck by a falling stone while in church and initially survived, had died four days after the earthquake. He also makes note of felt effects in regions across the Dover Strait, such as Calais and Antwerp. Having reported the pertinent facts, Munday declares that the earthquake was no doubt "a token of the indignation of our God against our wicked living." He recalls a number of cities that had been punished for their sin, such as "three of the fairest Cities in Asia," Constantinople, and cites several biblical examples, including Sodom and Gomorrah, Jerusalem, and Nineveh. Munday concludes by summoning everyone to call out to God and repent of their sins so that they may be forgiven.[58]

Though Munday's text is relatively short, it is rich with detail and provides much fodder for a variety of scholarly conversations. Two significant elements stand out for the present discussion. First, it is important to note what kinds of events he chose to

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[57]I have yet to locate a reference of any kind which speaks about flies with unusual markings on their wings.

[58]Complete passage: "Let us lift up our harts cheerfully unto God our salvation, be sory for our former offences, and from the very bottome of our harts inwardly lament them. Let us turn to the Father of all mercy saying. O Father wee have sinned against heaven and against thee, we are no more worthy to be called thy Children. [Luke 15] So wil the Lord of his fatherly mercy forgive our sinnes, and make us pertakers of his kingdome which God graunt us for his sonnes sake. Amen." Munday, Diiij.

group together. There are suicides, murders, monstrous births, tempests, blazing stars or comets, flashings of fire, tides flowing contrary to nature, strange flies, and, last but certainly not least, an earthquake. Perhaps strange as a grouping to modern sensibilities, these items fit together well within Munday's worldview, something that is also reflected in Golding's discourse. Although decidedly more sensational in his collection of anecdotes, Munday is nevertheless only one of many writers who discuss the 1580 earthquake against the backdrop of other curious events, with the presence of God looming large over all.

The second important element in Munday's work is how he talks about "nature," broadly defined. In comparison to other texts about the 1580 earthquake in London, Munday's pamphlet is exceptional in that it does not articulate in an explicit way a struggle with reconciling the role of the physical world of nature with an earthquake that was clearly sent by God. Nevertheless, he is quite concerned with the issue of human nature, particularly its elements of sin and wickedness, as evidenced by his compilation of bizarre and often grotesque anecdotes of murder and mayhem carried out by human hands. What is fascinating is that he includes alongside these tales of human agency reports of equally strange manifestations in the physical world. Both types of stories appealed to readers then as they do today, and it is quite possible that Munday was merely an opportunistic writer in search of income. However, by choosing to group together the anecdotes he did, Munday makes a correlation between human nature and

the physical world, even if he is never explicit about the relationship between those two things.

Munday's pamphlet communicates a circular and rather hopeless argument from the human perspective. In Munday's view, human beings are destined to a life full of misery because they are born into a world bent on wickedness. At the same time, God sends earthquakes and other happenings in the physical world to remind his human creatures to repent of their sinfulness and wicked living; otherwise, God will judge them for their abhorrent behavior. Munday expresses ambivalence about the earthquake similar to Twyne, who had considered it "not altogether natural." One wonders if Golding would have articulated a similar uncertainty had the physical precursors and effects of the earthquake been different, making it less easy for him to explain them away. Regardless, there is something underneath Munday's and Twyne's ambivalence toward the earthquake that remains unidentified, and that something appears to have roots that extend well byond the immediate context of sixteenth-century England.

The primary source from which Munday, Twyne, and Golding gleaned their udnerstanding of earthquakes as divine punishment for sin is the Christian Bible. Although there are earthquake stories in both the Old and New Testaments, the vast majority of these narratives appear in the Old Testament. The potency of these ancient earthquake stories can best be appreciated not as part of the Christian canon into which they were adopted, but rather within their original literary context of the Hebrew Bible of the ancient Israelites. Within this highly influential text, one finds a striking feature that

speaks not only to the ambivalence of Munday and Twyne, but also to the seeming irreconcilability between religion and science: there is no word for "nature" in the Hebrew Bible.[59]

From the point of view of the Hebrew Bible, irrelevant to the ancient Israelite would have been many of the questions people have asked about the dichotomy between God and nature, such as 'Is the event natural or supernatural?' or, more pertinent to scholarly discussions of the past few decades 'How natural is a natural disaster?' Asking either of these questions of an ancient Israelite would not simply have been met with a blank stare, because the questions could not have been posed in the first place. "Nature" as defined by the terminology used in other linguistic contexts does not exist in the Hebrew Bible, which presents a significant challenge in trying to understand such a worldview. This perhaps explains some of the misunderstandings about and controversy surrounding religious perspectives on the physical world.

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[59]Although this seems to be assumed by scholars who study the issue of nature in the Hebrew Bible/Old Testament, it is only stated in explicit terms by Hector Avalos, "Nature, Natural Phenomena," in *New Interpreter's Dictionary of the Bible*, vol. 4 (Nashville: Abingdon Press, 2007), 238.

Scholarly interest in the role of nature not only in the Hebrew Bible, but also in the Christian Bible has increased dramatically since the 1967 publication of medieval historian Lynn White's article that blamed the ecological crisis on the human dominion-over-nature model found in the biblical text. Lynn White, "The Historical Roots of our Ecological Crisis," *Science* 155 (1967): 1203-1207. More recent scholarship has brought a much-needed corrective to White's perception . In addition to the sources cited in the following discussion, two articles written by geographer Jeanne Kay are worth noting: "Concepts of Nature in the Hebrew Bible," *Environmental Ethics* 10 (1988): 309-327; and "Human Dominion over Nature in the Hebrew Bible." *Annals of the Association of American Geographers* 79 (1989): 214-232. Important for any study of nature in the Hebrew Bible are two articles by Jesuit scholar John L. McKenzie, both of which were published fifteen years before White's article: "God and Nature in the Old Testament: Nature in Modern Philosophy and Science," *Catholic Biblical Quarterly* 14 (January 1952): 18-39, "God and Nature in the Old Testament: Fertility Cults," *Catholic Biblical Quarterly* 14 (April 1952): 124-145.

As a point of contrast, one may consider the many definitions of "nature" found in other languages. For instance, the English word "nature" comes from the Latin *natura*, which has fifteen definitions.[60] Though not always stated in explicit terms, all fifteen meanings deal with a characteristic inherent in something, be it a person, place, or thing. These characteristics can be physical, such as size or shape, or less tangible, as in a person's temperament or abilities. One definition of *natura* denotes the physical world itself, a concept important to both Golding and Twyne, and another speaks to the idea of human nature, which was at the forefront in Munday's text. Roughly one-third of the fifteen definitions refer to a power, guiding principle, course of events, or category of existence that determines the properties of a human being or the physical world. All of the definitions relate to the material world and the humans who live in it. With one small exception, which is noted in a short parenthetical statement, no definition makes reference to the presence or activity of a divine being or creator, a noteworthy point given the importance of God for all three authors writing about the 1580 earthquake. From the point of view of the Latin language, the joint domain of humanity and the physical world is distinct and not connected to a divine realm.

The worldview conveyed in the Hebrew Bible is categorically different, with a basic structure described as follows:

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[60] *Oxford Latin Dictionary*, Fascicle V, ed. P. G. W. Glare (Oxford: Clarendon Press, 1976), 1158-1159. For an examination of the Greek concept of *phusis*, which is usually translated as *nature*, see Gerard Naddaf, *The Greek Concept of Nature* (Albany: State University of New York Press, 2005).

> The primary differentiation in the world is between the creator God and the creation. God creates the inhabitable world yet remains distinct from it. The creation itself is secondarily divided between humans and [the physical world]. But this differentiation should not obscure the essential unity of the creation. Humans and [the physical world] are of the same substance.[61]

The relationship between humans and the physical world is reciprocal, such that creation can be thought of as an integrated system rather than comprising two distinct parts. As such, an action or event in one aspect of creation (e.g. the human realm) both reflects and is reflected by an action or event in the other (i.e., the material world).

The relationship between the creator God and the creation is similarly organism-like, but not equally reciprocal:

> [T]he creation is dependent upon God. The habitable world was created by and is continually affected by God's actions. But God also relies upon the creation to fulfill God's purposes. God does not stand outside the creation acting independently of it. The frequently attested Hebrew expression 'heaven and earth' bears witness to God's presence in the creation. This expression reveals the division between the terrestrial and

[61]Ronald A. Simkin, *Creator and Creation: Nature in the Worldview of Ancient Israel* (Peabody, MA: Hendrickson Publishers, 1994), 118. In order to be more precise about what it is being discussed, in this passage the phrase "the physical world" replaces "nature," a term that Simkin uses throughout his book.

> the extraterrestrial realms. God reigns uncontested in the heavens, whereas God shares the domain of the earth with humans. However, this expression also attests to the totality and unity of creation. There is no reality apart from God and the creation. There is no realm for God to dwell in other than the creation. Therefore, God's presence is necessarily in the creation, and God's actions are limited by and expressed in terms of the creation.[62]

Because this worldview is articulated from the human point-of-view, descriptions of both the creator God and the creation, whether human or material, are expressed in personal terms. The creator God, for example, exhibits behavior identified with the expression of human feelings, such as jealousy, compassion, or anger. Because God can only communicate to human beings from within the creation, then God's actions manifest both in human affairs and in the physical world, with no distinction made between the two.[63] Thus, a drought, a storm, and an abundant harvest are no different in kind than an important leader's unexplainable absence, the arrival of a powerful invading army, or a victory over a long-standing enemy. Unlike the many definitions of the Latin *natura*, in the Hebrew text the creator God is part-and-parcel of every aspect of the creation and humanity's experience within it. This integrated system is therefore starkly contrasted to

[62]Simkin, *Creator and Creation,* 151.

[63]Ibid., 152.

the world of the three authors of discourses about the 1580 earthquake, all of whom exerted significant effort in order to reconcile (or not) two distinct categories of knowledge, their understanding of the "natural" aspects of the earthquake and their belief in God.

The fluidity and harmony of the Israelite worldview as portrayed in the Hebrew Bible is best illustrated by how the text depicts God's appearance. Since God's presence was always assumed, the form of God's appearance is what helped the Israelites to discern God's message.[64] According to biblical scholar Ronald A. Simkin, there are a number of examples in the biblical text where God's form is depicted as anthropomorphic, such as the three men in Genesis 18 who visited Abraham to tell him he would have a son despite his old age, or the man with whom the very stubborn Jacob wrestled in Genesis 32:22-32.[65] However, God's appearance is most often described in relation to phenomena of the physical world, dramatic attention-getters that served as an exclamation point to God's communication.[66] The most prominent of these manifestations is the thunderstorm, a phenomenon indigenous to the local environment

[64]What "form" God takes is a tricky question. "As James Barr notes, 'form' and 'appearance' are correlative in Hebrew thought. The "Israelites would have made no distinction between God's form and appearance." Quote from Simkin, but he gets his information from James Barr, "Theophany and Anthropomorphism in the Old Testament," in Congress Volume, Oxford 1959. Supplement to Vetus Testamentum 7 (1960): 32 (31-38). Leiden, Brill. Have VT supplement in Wilson.

[65]Simkin, 144.

[66]Less descriptive is Simkin's terminology, which is that the "ancient Israelites recognize[d] an intensification of God's presence in natural phenomena." Ibid., 145.

that scholars consider to be "the most dangerous and awe-inspiring"[67] and "the single most powerful natural phenomenon" experienced by people of the eastern Mediterranean world.[68] Indeed for most scholars, the influence of this mighty physical spectacle cannot be emphasized enough. As author Alberto R. W. Green notes in his study of *The Storm-God in the Ancient Near East*:

> For millennia, the ominous impact of the thunderstorm, accompanied by frightening roars, fiery streams of lightning, and foreboding heavy black clouds, constituted a typical and awesome description of [the appearance of god] among ancient peoples. This *Storm-god* concept has been one of the most potent forces in the evolution of the religious experience of early man.[69]

The impact of thunderstorms on peoples of the Ancient Near East was so strong that they became associated with gods in different cultures, including the God of the ancient Israelites.[70]

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[67]Luis I. J. Stadelmann, *The Hebrew Conception of the World* (Rome: Biblical Institute Press, 1970), 111.

[68]Simkin, 146.

[69]Alberto R. W. Green, *The Storm-God in the Ancient Near East* (Winona Lake, IN: Eisenbrauns, 2003), 1. For clarity, the phrase "appearance of god" replaces the more formal term "theophany."

[70]Much has been written on these "Storm-Gods," as evidenced by the work of Green, *The Storm-God*. Although the depiction of the God of Israel contains many of the same "weather-god" elements as other Near Eastern deities, biblical scholars are quick to point out the God of Israel is nevertheless distinct from these other gods because the Israelite God is never to be confused with the physical phenomena. In addition to Simkin, Stadelmann, *The Hebrew Conception of the World*.

Specific to the Hebrew Bible, the thunderstorm is no doubt one of the more common physical indicators of God's communication. So significant is this particular phenomenon within the Hebrew text that one scholar claims the thunderstorm is responsible for many of the other phenomena of the physical world that accompany God's presence:

> Even many of the other biblical examples of God's appearance in natural form, such as the pillar of fire and cloud, the so-called volcanic eruptions on Sinai, and the repeated references to the wind of God, can be traced to the thunderstorm . . . . The violent phenomena of the thunderstorm – raging winds, lightning that causes smoke when it strikes the earth, hail, darkness, torrential rains, and earth-shaking thunder – signal the presence of God.[71]

Notwithstanding these many and varied physical manifestations that are associated with a thunderstorm, what stands out most in the biblical text is the storm's thunderous rumbling. The two Hebrew terms primarily used to signify thunder are *r'm* and *qôl*, and both connote noise to one degree or another. *R'm* is understood to connote thunder or its accompanying noise in a more literal sense, while *qôl*, which appears more than five

[71]Simkin, 145-146. Simkin also cites the work of three other scholars in this regard: Thomas Mann, "The Pillar of Cloud in the Reed Sea Narrative," *Journal of Biblical Literature* 90 (1971), 15-30; Robert Luyster, "Wind and Water: Cosmological Symbolism in the Old Testament," *Zeitschrift für alttestamentliche Wissenschaft* 93 (1981), 1-10; and the classic work by Frank Cross, *Canaanite Myth and Hebrew Epic: Essays in the History of the Religion of Israel* (Cambridge: Harvard University Press, 1973), 163-169.

hundred times in the Hebrew Bible, is generally associated with "sound" or "voice." From the Israelite point of view, when thunder roars it is no doubt the voice of God.[72]

There is much to be said for this interpretation, but the thunderstorm was not the only powerful phenomenon native to the region, nor the only one that brought with it earth-shaking noise. Earthquakes were and still are common in that part of the world, and they figure prominently in the biblical text. One story that immediately comes to mind is that of God's appearance to Elijah on Mount Horeb in I Kings 19:11-12:

> [God] said, "Go out and stand on the mountain before the Lord, for the Lord is about to pass by." Now there was a great wind, so strong that it was splitting mountains and breaking rocks in pieces before the Lord, but the Lord was not in the wind; and after the wind an earthquake, but the Lord was not in the earthquake; and after the earthquake a fire, but the Lord was not in the fire; and after the fire a sound of sheer silence.[73]

The linguistic evidence for earthquakes in the Hebrew Bible is less prolific and more ambiguous than that for thunderstorms, and so there is scholarly disagreement as to what degree the Israelites were aware of an earthquake as a phenomenon separate from a

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[72]Francis Brown, S. R. Driver, and Charles A. Briggs, *The Brown-Driver-Briggs Hebrew and English Lexicon, with an Appendix Containing the Biblical Aramaic*, reprint (Peabody, MA: Hendrickson Publishers, 1999); Stadelman, *Hebrew Conception*, 111-114; John I. Lawlor, "Thunder and Lightning," in *New Interpreter's Dictionary of the Bible*, vol. 5 (Nashville: Abingdon Press, 2007), 590-591; W. White, Jr., "Thunder," in *The Zondervan Encyclopedia of the Bible*, vol. 2 (Grand Rapids, MI: Zondervan, 2009), 852.

[73]All biblical citations are taken from *The New Oxford Annotated Bible: New Revised Standard Version With the Apocrypha*, 4th ed., (Oxford: Oxford University Press, 2010).

thunderstorm. In the passage from I Kings just mentioned, for example, one Hebrew lexicon claims the term used here for earthquake, *ra'aš*, connotes an actual earthquake,[74] while another theological dictionary argues that it signifies a storm.[75] The scholarly confusion is understandable. Appearing only 47 times in the Hebrew Bible, the Hebrew root (*r'š*) for this most common term for earthquake, *ra'aš*,[76] "denotes a phenomenon involving both sound and movement" and covers a semantic range "from earthquake (Amos 1:1) through the clatter of chariots (Jeremiah 47:3) and the tramping of boots (Isaiah 9:4) to the rattling of bones (Ezekiel 37:7)."[77] Interestingly, the term never appears in the Pentateuch,[78] the first five books of the Hebrew Bible.

The divergence of opinion about earthquakes in the Hebrew Bible extends well beyond linguistic concerns. There is tremendous conflict within earthquake studies about the seismicity of the region in the eastern Mediterranean in which the stories of ancient Israel took place. Among the diverse groups of scholars who study ancient earthquakes – seismologists, archaeologists, scholars of ancient texts – there is little agreement about which texts are reliable reports of ancient earthquakes, the process by which they can

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[74]*Brown-Driver-Briggs*, 950.

[75]G. Johannes Botterweck, Helmer Ringgren, and Heinz-Josef Fabry, eds., *Theological Dictionary of the Old Testament*, Vol. XIII, translated by David E. Green (Grand Rapids, MI: William B. Eerdmans Publishing Company, 1977), 591.

[76]There are several other Hebrew root words which connote shaking or quaking, such as *harad*, *ragaz*, *ra'ad*.

[77]*Theological Dictionary*, 589.

[78]R. Laird Harris, ed., *Theological Wordbook of the Old Testament*, vol. 2 (Chicago: Moody Press, 1980), 2197.

most effectively be used, and the conclusions that one can draw from them in order to identify particular earthquake events that happened in the past. Tangled up in this web of debate is incredible tension about the issues of religion and archaeology. Most of the ancient textual sources that discuss earthquakes come from the Hebrew Bible, and much of the work done in archaeology during the early- to mid-twentieth century was carried out by individuals with a decided interest in substantiating stories recounted in the Hebrew text.[79] While at least some of these archaeologists' methodology and the evidence they uncovered have proven valuable, the religious overtone of their efforts has made any acknowledgement of their accomplishments difficult, particularly for seismologists who are looking for hard data to verify or refute the occurrence of an actual earthquake.[80] Some scholars claim the area inhabited by ancient Israel "is probably the

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[79]Although biblical archaeology had been practiced since the mid-nineteenth century, proving the historicity of the Bible through archaeological efforts took on new life after the founding of the Biblical archaeology school in the early twentieth century by William Foxwell Albright. Albright published prolifically, with over a thousand publications to his name. For a complete list of works, see David Noel Freedman, The *Published Works of William Foxwell Albright: A Comprehensive Bibliography* (Cambridge, MA: American Schools of Oriental Research, 1975).

[80]Earthquakes are not the only phenomenological events described in the Hebrew Bible which researchers are interested in proving actually occurred. Take as an example an article by Y. K. Bentor, in which he discusses several of these phenomena: the earthquake described in Amos 1:1; the drying up of the Jordan River (Joshua 3:14-17 and 4:18); the destruction of Sumer by a tsunami (a.k.a. Noah's flood); the destruction of Sodom and Gomorrah (Genesis 19:23-25); Lot's wife becoming a pillar of salt (Genesis 19:26); the burning bush (Exodus 3:2-3); and vulcanism and Mt. Sinai (Exodus 19-20). Y. K. Bentor, "Geological Events in the Bible." *Terra Nova* 1 (1989): 326-338.

Of the events Bentor mentions, one of the most studied is the destruction of Sodom and Gomorrah, which has its own rich archaeological and scientific literature. Frederick G. Clapp, "The Site of Sodom and Gomorrah. Diversity of Views," in *American Journal of Archaeology* 40 (July-September 1936), 323-344; J. Penrose Harland, "Sodom and Gomorrah: The Location of the Cities of the Plain," in *The Biblical Archaeologist* 5 (May 1942), 17-32; Harland, "Sodom and Gomorrah: The Destruction of the Cities of the Plain," in *The Biblical Archaeologist* 6 (September 1943), 41-54; and Willem C. van Hattem, "Once Again: Sodom and Gomorrah," in *The Biblical Archaeologist* 44 (Spring 1981), 87-92. Although not well respected, one of the only monographs in this field is David Neev and K. O. Emery, *The Destruction of Sodom, Gomorrah, and Jericho: Geological, Climatological, and Archaeological Background* (New York:

only region on Earth where evidence for earthquake activity has been documented in one way or another over the past four millennia."[81] Other researchers, however, argue just as strongly that few, if any, of the oldest earthquakes in that long chronological spectrum can be substantiated on either textual or archaeological grounds.[82]

Oxford University Press, 1995). More recent work includes technical studies that use scientific modeling, such as S. K. Haigh and S. P. G. Madabhushi, "Dynamic Centrifuge Modelling of the Destruction of Sodom and Gomorrah," in *Proceedings of the 1st International Conference on Physical Modelling in Geotechnics* (St. John's, Newfoundland, Canada), eds. R. Phillips, P. Guo, and R. Popescu (Leiden: A. A. Balkema, 2002), 507-512.

The search for the ruins of Sodom and Gomorrah has been of interest to archaeologist and religious alike for centuries. For a fascinating study of an expedition undertaken by the U.S. navy, see Andrew C. A. Jampoler, *Sailors in the Holy Land: The 1848 Expedition to the Dead Sea and the Search for Sodom and Gomorrah*, (Annapolis, MD: Naval Institute Press, 1995).

[81]Ari Ben-Menaham, "Four Thousand Years of Seismicity along the Dead Sea Rift," *Journal of Geophysical Research* 96 (1991), 20,195-20,216. Scholars of similar ilk include Y. K. Bentor and others like him who research the earliest stories of meteorological and geological phenomena recorded in the Hebrew Bible (op. cit.), as well as authors such as Amos Nur and Hagai Ron, who consider the "the Holy Land" to have "the longest and perhaps the most continuous historical record of earthquakes on earth." Nur and Ron, "Armageddon's Earthquakes," *International Geology Review* 39 (1997): 532. Nur, a professor of geophysics at Stanford, expanded the geographical scope of his research to include other parts of the Mediterranean and elsewhere, the results of which he published in a recent book undoubtedly written to appeal to a popular audience. *Apocalypse: Earthquakes, Archaeology, and the Wrath of God* (Princeton and Oxford: Princeton University Press, 2008).

Another scholar of note is Martin R. Degg, a lecturer in the Department of Geography in Chester College (UK), who has done important research for the London Reinsurance Offices Association on earthquakes in this region. See Degg, *Earthquake Perils in the Middle East: An Historical Catalogue, 2600 B.C.-1899 A.D.* (London: Reinsurance Offices Association, 1987); "Earthquake Hazard Atlas. Israel," (London: Reinsurance Offices Association, 1989); and "A Database of Historical Earthquake Activity in the Middle East," *Transactions of the Institute of British Geographers*, New Series 15 (1990): 294-307.

[82]D. H. Kallner-Amiran's "Revised Earthquake-Catalogue of Palestine," for example, "does not include earthquakes occurring before 100 B.C. [because] their dates and particulars [are] too uncertain." Amiran, "A Revised Earthquake-Catalogue of Palestine" (Part I), *Israel Exploration Journal* 1 (1951): 223-246; "A Revised Earthquake-Catalogue of Palestine" (Part II), *Israel Exploration Journal* 2 (1951): 48-65.

Of the many seismologists who question the work done in biblical archaeology on ancient earthquakes and critique those who continue to rely upon such research, Nicholas N. Ambraseys, a long-time professor and researcher in engineering seismology and civil engineering at Imperial College in London, stands out because of his extensive study of earthquakes in the Middle East and surrounding areas. The list of his published works is long, its quality impressive. Most recent to appear is what will likely be considered his magnum opus: *Earthquakes in the Mediterranean and Middle East: A Multidisciplinary Study of Seismicity up to 1900* (Cambridge: Cambridge University Press, 2009). Almost one thousand pages in length, this volume is the culmination of Ambraseys' career and incorporates five decades' worth of research. For a

Further complicating the conflict of religion, archaeology, and earthquakes is a political component that will likely not be resolved any time soon, for many of the earthquake sites of which the Hebrew Bible speaks are located in the Middle East, especially the hotly contested area that includes Gaza, the West Bank, Golan Heights, and the political nation of Israel. It is certainly no coincidence that the emergence of a strong biblical archaeology and the establishment of the modern state of Israel happened around the same time. Indeed, identity formation in this region is very much wrapped up in the connection between archaeology and the stories found in the Hebrew Bible. Since the 1990s, when peace talks among several Middle Eastern countries began, there has been increasing archaeological collaboration across borders that has contributed to new understandings about the larger history of the region,[83] but these collaborative gains nevertheless remain small.[84]

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quick sampling of Ambraseys' scholarly opinion about ancient earthquakes in the eastern Mediterranean, see "Historical Earthquakes in Jerusalem – A Methodological Discussion," *Journal of Seismology* 9 (2005): 329-340, and "Descriptive Catalogues of Historical Earthquakes in the Eastern Mediterranean and the Middle East; Revisited," in *Historical Seismology: Interdisciplinary Studies of Past and Recent Earthquakes*, eds. Julien Fréchet, Mustapha Meghraoui, and Massimiliano Stucchi (New York: Springer, 2008): 25-39.

[83]Held up as a model of the "new" or revisionist interpretation of the Hebrew Bible that is drawn from more recent archaeological discoveries is the work of Israel Finkelstein, professor of archeology at Tel Aviv University. For a monograph-length overview of his stance, see the book he co-authored with Neil Asher Silberman, *The Bible Unearthed: Archaeology's New Vision of Ancient Israel and the Origin of its Sacred Texts* (New York: Touchstone, 2001). A more recent text compares in parallel format the viewpoint of Finkelstein with the research of another respected archaeologist, Amihai Mazar. Israel Finkelstein and Amihai Mazar, *The Quest for the Historical Israel: Debating Archaeology and the History of Early Israel*, ed. Brian B. Schmidt (Atlanta: Society of Biblical Literature, 2007).

A staunch opponent of Finkelstein is William G. Dever, former professor of Near Eastern Archaeology and Anthropology at the University of Arizona-Tucson (he retired in 2002). Though he does not consider himself a proponent of biblical literalism along the lines of Albright, Dever is nevertheless critical of the work of Finkelstein and others of the revisionist school because they minimize the significance of the biblical text. See, for example, his review of Finkelstein's and Silberman's book and their response to it:

Despite the discord among scholars from a variety of disciplines about earthquakes in the Hebrew Bible, the one point about which most everyone agrees is that the earthquake referred to in Amos 1:1 was an actual historical event.[85] This is no small matter, not only from a scholarly standpoint, but from a religious one as well. Amos was a shepherd and orchard keeper from the southern kingdom of Judah. He was called by God to be a prophet to the rival northern kingdom of Israel, a role he performed during the unusually long and peaceful reigns of Jeroboam II of Israel (788-747 B.C.E.) and Uzziah of Judah (785-733 B.C.E.). Amos is considered the earliest of the classical

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William G. Dever, "Excavating the Hebrew Bible, or Burying It Again?" *Bulletin of the American School of Oriental Research* 322 (2001): 67-77; and Finkelstein and Silberman, "*The Bible Unearthed*: A Rejoinder," *Bulletin of the American Schools of Oriental Research* 327 (2002): 63-73. Dever has published extensively and is well respected in his field. A handful of books both by and about him worth noting are: Dever, *Recent Archaeological Research and Biblical Research (*Seattle: University of Washington Press, 1990); Dever, *What Did the Biblical Writers Know, and When Did They Know It?: What Archaeology Can Tell Us About the Reality of Ancient Israel* (Grand Rapids: William B. Eerdmans Publishing Company, 2001); Beth Alpert Nakhai, ed., *The Near East in the Southwest: Essays in Honor of William G. Dever* (Boston, MA: American Schools of Oriental Research, 2003); and Seymour Gitin, J. Edward Wright, and J. P. Dessel, eds., *Confronting the Past: Archaeological and Historical Essays on Ancient Israel in Honor of William G. Dever* (Winona Lake, IN: Eisenbrauns, 2006).

[84]A popular and well informed account of the relationship between the Hebrew Bible, archaeology, and politics in the Middle East is: Amy Dockser Marcus, *The View from Nebo: How Archaeology is Rewriting the Bible and Reshaping the Middle East* (Boston: Back Bay Books, 2000).

[85]Of note are the following sources: *Brown-Driver-Briggs*, 950; *Theological Dictionary*, 591; W. G. Dever, "A Case-Study in Biblical Archaeology: The Earthquake of Ca. 760 B.C.E.," in *Eretz-Israel: Archaeological, Historical and Geographical Studies*, vol. 23 (Jerusalem: The Israel Exploration Society, Hebrew Union College – Jewish Institute of Religion, 1992), 27-35; Francis I. Andersen and David Noel Freedman, *Amos: A New Translation with Introduction and Commentary* (New York: The Anchor Bible, Doubleday, 1989), 193-199; Emanuela Guidoboni, *Catalogue of Ancient Earthquakes in the Mediterranean Area up to the 10th Century*, with the collaboration of Alberto Comastri and Giusto Traina (Rome: Istituto Nazionale di Geofísica, 1994), 105-108; and Ambraseys, *Earthquakes in the Mediterranean and Middle East*, 68-78.

prophets and "the first [prophet] to be associated with a book"[86] that purports to preserve his words.

The collection of writings begins in verse 1 with a superscription most likely added by a later editor: "The words of Amos, who was among the shepherds of Tekoa, which he saw concerning Israel in the days of King Uzziah of Judah and in the days of King Jeroboam son of Joash of Israel, two years before the earthquake." The seemingly benign nature of this verse belies the scathing invective Amos heaps on his listeners. The main thrust of Amos' message is a condemnation of the Israelites for their abhorrent behavior, in particular for the socio-economic injustices that continue to plague society. Although Israel may have contained the chosen people of God, that did not mean they could avoid God's judgment. In fact, Amos argues, the "day of the Lord,"[87] for which the Israelites longed as a day of salvation and rescue from their enemies, was actually going to be a day of judgment and punishment not only for foreign nations, but for Israel as well. As the text so eloquently phrases it:

> Alas for you who desire the day of the Lord!
>
> Why do you want the day of the Lord?
>
> It is darkness, not light;
>
> as if someone fled from a lion,
>
> and was met by a bear;

[86]Bryan D. Bibb, "Book of Amos," *New Interpreter's Dictionary of the Bible*, vol. 1, 135.

[87]For an introduction to this much-debated topic, see the entries for: "Day of Judgment," by Richard H. Hiers; "Day of the Lord," by Richard H. Hiers; and "Day of Yahweh," by K. J. Cathcart in the *Anchor Bible Dictionary*, vol. 2, 78-85.

> or went into the house and rested a hand against the wall,
>
> and was bitten by a snake.
>
> Is not the day of the Lord darkness, not light,
>
> and gloom with no brightness in it?
>
> I hate, I despise your festivals,
>
> and I take no delight in your solemn assemblies.
>
> Even though you offer me your burnt offerings and grain offerings,
>
> I will not accept them;
>
> and the offerings of well-being of your fatted animals I will not look upon.
>
> Take away from me the noise of your songs;
>
> I will not listen to the melody of your harps.
>
> But let justice roll down like waters,
>
> and righteousness like an ever-flowing stream. (Amos 5:18-24)

Amos turns on its head the traditional interpretation of what constituted the day of the Lord. No longer are his listeners to consider it a day of light, but a day of darkness and gloom, one from which they cannot escape. Not surprisingly, the words of doom spoken by the self-proclaimed prophet from the south were not received well by the hearers in the north, and Amos was effectively run out of town.[88]

[88]Amos 7:10-17.

Amos left Israel, and by all accounts his departure signaled the end of his prophetic career. It did not, however, mark the end of his influence; quite the contrary, in fact. Included in the oracles and visions of the book of Amos was Amos's prediction of an earthquake. In verse 9:1 he says, "I saw the Lord standing beside the altar, and he said: Strike the capitals until the thresholds shake, and shatter them on the heads of all the people..." As luck or divine timing would have it in that seismically-active part of the world, Amos got his earthquake. More to the point, Israel received the earth-shaking punishment from God that the trouble-making prophet had said they would get. How big the earthquake was and the extent of the damage it inflicted is a matter of debate, but one suspects those issues did not matter as much to the people of Israel as the fact that an out-of-town shepherd claiming to be a divine prophet had accurately predicted that God would render judgment on them through a specific physical phenomenon in a surprisingly short amount of time. Indeed, this earthquake vindicated Amos the prophet and ultimately defined his career. As seen in verse 1:1, the earthquake is what was used to date his prophecies.[89] More importantly, the earthquake's inclusion in the book's superscription bespeaks of Amos's great power both as a prophet and as a predictor of earthquakes.

Amos's redefinition of what constituted the "day of the Lord" and its fortuitous pairing with his successful prediction of an earthquake have had far-reaching effects. As two examples, Zechariah, who prophesied two centuries after Amos, reminded his

[89]Andersen and Freedman rightly point out that "the definite article ('*the* earthquake') was sufficient to identify it when the book was published, which could only be done if the event were unique in recent memory." Andersen and Freeman, *Amos*, 193.

hearers that "a day was coming for the Lord" in which "you shall flee as you fled from the earthquake in the days of King Uzziah of Judah,"[90] and it has been argued that the earthquake "forms the basis of [the prophet] Isaiah's 'Day of the Lord.'"[91] This is a regular theme in the Hebrew Bible, except in the five books of the Pentateuch, in which the most common term for earthquake is never used. One wonders if this omission was deliberate or accidental on the part of the writers and compilers. The story of Noah's flood recounted in the Pentateuch carries enormous significance within the larger narrative of the Hebrew Bible as the measure of God's ultimate judgment on sinful humanity. Given this, one suspects the exclusion from the Pentateuch of a specific earthquake, even Amos's earthquake, was intentional.

Amos's earthquake was certainly a different breed of event than Noah's flood. While Amos and Noah were both informed by God that destruction was imminent, only Amos was instructed in the text to warn others. In Noah's case, God had seen the extent of humans' wickedness, which caused God to regret ever having made them in the first place and saw no need to alert them to the divine plan to wipe them out and start all over. Amos's earthquake was also a quick and to-the-point, one-day occurrence that was intended for humanity only. Noah's flood, by contrast, lasted much longer, for it took time to obliterate the entire creation with water, a specific kind of event from which

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[90]Zechariah 14:1, 15.

[91]Jacob, Milgrom, "Did Isaiah Prophesy During the Reign of Uzziah?" *Vetus Testamentum* 14 (April 1964): 164-182.

derives the term "cataclysm."[92] Another significant difference between the two stories is that in Amos God gives no indication that the "day of the Lord" and its accompanying earthquake would not happen another time, whereas in Noah God makes a covenant with every living creature that God will never again send a flood to destroy creation.[93]

Despite God's lack of assurance about future events, God does offer some hope in Amos. There will certainly be a day when, as God says, "All the sinners of my people shall die by the sword, who say 'Evil shall not overtake or meet us.'" Ironically, however, it is on that particular day that Israel can begin looking forward to a brighter future, a message with which the book of Amos concludes:

> On that day I will raise up the booth of David that is fallen,
> and repair its breaches,
> and raise up its ruins,
> and rebuild it as in the days of old...
> I will restore the fortunes of my people Israel,
> and they shall rebuild the ruined cities and inhabit them;
> they shall plant vineyards and drink their wine,
> and they shall make gardens and eat their fruit.
> I will plant them upon their land,
> and they shall never again be plucked up out of the land I have given them,

[92]From the Greek, *katacylsmos*: deluge; cataclysm: "A great and general flood of water, a deluge; especially the Noachian deluge, the Flood." *Oxford English Dictionary Online*, accessed 10 August 2010.

[93]Genesis 9:8-17.

says the Lord your God.[94]

This theme of destruction and renewal clearly echoes the one found in the flood story. In fact, both Amos's earth-shaking "day of the Lord" and Noah's all-encompassing deluge follow the pattern of a catastrophe/new-creation myth found in many ancient cultures throughout the world, a myth that "attests to a fundamental insight . . . that the creation of a new world entails the destruction of the present world."[95]

How each story reflects the myth is merely a matter of temporal perspective for the narrator.

> [For the authors of the flood story], this myth is projected back to the beginning and is thus combined with a creation myth in order to explain and give meaning to their present situation. [For prophets like Amos], on the other hand, this myth is projected into the future. They envision that the present order will be destroyed because of the sins of Israel and the nations. Human rebellion against God has polluted the world beyond restoration. But the creation will not end in destruction . . . . The present order will be destroyed so that the creation can be remade into the world that God intended.[96]

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[94]Amos 9:11, 14-15.

[95]Simkin, 209.

[96]Ibid., 209-210.

With the flood event well in the past and sealed with a promise by God never to destroy creation again, more relevant to hearers in the present moment are the messages of prophets like Amos who provide no guarantees other than that catastrophe will come. Who specifically will survive the destruction is anybody's guess, so reports that a new order of things will immediately follow the devastation offer little comfort. Amos's prophecies to Israel made this point in a new and powerful way, because his redefinition of what constituted the "day of the Lord" eliminated any remaining ray of hope for the chosen people of God. Chosen or not, Israel could not escape God's judgment for unacceptable behaviors any more than its foreign neighbors, something that the subsequent earthquake confirmed.

The aftershocks of Amos's supposed earthquake prediction continue to be felt. The dual-theme of earthquakes and the "day of the Lord" preserved in the Hebrew Bible were subsequently carried into the New Testament many centuries later. Most people steeped in or influenced by Christianity to one degree or another are likely more familiar with the stories of earthquakes and God's judgment found in New Testament books like Revelation. Perhaps one of the more familiar passages is Revelation 16:16-20:

> And they assembled them at the place that in Hebrew is called Harmagedon [Armageddon]. The seventh angel poured his bowl into the air, and a loud voice came out of the temple, from the throne, saying "It is done!" And there came flashes of lightning, rumblings, peals of thunder, and a violent earthquake, such as had not occurred since people were upon

> the earth, so violent was that earthquake. The great city was split into three parts, and the cities of the nations fell. God remembered great Babylon and gave her the wine-cup of the fury of his wrath. And every island fled away, and no mountains were to be found.

Although the message and imagery of physical phenomena invoked here are strikingly similar to those contained in the Hebrew Bible, the distinctiveness of the earthquake is unmistakable. There are no blurred boundaries between the thunderstorm and the earthquake, for the earthquake is the instrument of God's wrath, the dispenser of God's justice, as it was for the people of Israel in Amos's time.

Golding, Twyne, and Munday, the authors who wrote discourses following the 1580 earthquake in London, plainly subscribed to the idea that the earthquake was sent by an angry God as punishment for human sin. However, they were not living in the world described in the Hebrew Bible, in which all of creation was perceived as a unified whole and of which God was an integral part. Thus, all three men had to grapple with their own understanding of what the earthquake was about. Both Golding and Twyne sought to reconcile their knowledge about the earthquake's physical characteristics with what they understood to be true about God's judgment, but each man drew a different conclusion. Golding was able to use what he knew about an earthquake's "natural operations" to confirm that the 1580 quake was sent by God. Twyne, on the other hand, was less clear, and made the ambiguous declaration that the earthquake was "not altogether natural." Munday, for his part, remained unconcerned about the earthquake's

physical operations, and instead focused on the hopelessness of the human predicament in a "world bent to all kind of wickedness." Each discourse has a decidedly different emphasis, yet all three reflect a conundrum that has been around since the first person sought to reconcile the integrated worldview depicted in the Hebrew Bible with an understanding of "nature" as a distinct entity. By defining "nature," one divorces God from the rest of creation and also divides creation into two distinct parts – humanity and physical environment. These divisions are generally not problematic when discussing aspects of the physical world that operate within well established scientific paradigms, but they become more difficult to negotiate when confronted with dramatic, destructive, and unpredictable phenomena like earthquakes. Especially from the perspective of an earthquake survivor, an earthquake is a potent reminder that science does not always provide the answers people are looking for, and that alternate ways of experiencing and understanding earthquakes need at least to be acknowledged and not summarily dismissed.

CHAPTER 3

Earthquakes, Volcanoes, and the New World:

Breaking the Boundaries of Knowledge

One advantage to defining nature as an entity distinct from humanity and the divine is that it creates an opportunity to explore the physical world and its many characteristics and behaviors in more detail than might otherwise be possible. Nowhere is this more evident than in the numerous branches of science that have developed over the last few hundred years. The different disciplines have distinct names intended to define the kind of science a researcher is undertaking, such as biology, chemistry, or physics. Some specialists find it necessary to periodically reinforce the defining limits of their respective disciplines,[1] but the boundaries between them are not always clear.[2] In

[1]Defining the limits of a particular discipline is a tricky business, and often results in controversy. In his 1947 address as outgoing president of the Paleontological Society, J. Brookes Knight chose as his topic "Paleontologist or Geologist" (*Geological Society of America Bulletin* 58 (1947): 281-286). His conclusion, in short, was that although both geology and biology are related to the work of paleontologists, the field of paleontology nevertheless remains a distinct discipline of science. Knight's address and its subsequent publication provoked a firestorm of reactions, several of which were put into print: J. Marvin Weller, "Relations of the Invertebrate Paleontologist to Geology," *Journal of Paleontology* 21 (1947): 570-575; Raymond C. Moore's address as outgoing president of the Paleontological Society in 1948, "Stratigraphical Paleontology," *Geological Society of America Bulletin* 59 (1948): 301-326; Norman D. Newell and Edwin H. Colbert, "Paleontologist – Biologist or Geologist?" *Journal of Paleontology* 22 (1948): 264-267; and a response to Newell and Colbert by J. Marvin Weller, "Paleontologist – Biologist and Geologist," *Journal of Paleontology* 22 (1948): 268-269.

[2]In 1966, the journal *Bioscience* produced a special issue entitled "The Biologist in the Pharmaceutical Industry," which explored a number of discipline-related topics. Of note is an article by Gilbert F. Otto, a specialist in parasitology and then-researcher at Abbott Laboratories in Chicago. In "The Biologist Defined," Otto offers a well balanced look at the discipline of biology, and concludes with: "A biologist is a scientist concerned with and a student of the phenomenon of life and of living things. The biologist, male or female, may be found in diversified roles in many academic disciplines." Otto, "The Biologist Defined," *Bioscience* 16 (No. 10: "The Biologist in the Pharmaceutical Industry") (1966): 680-681.

some cases they are becoming increasingly blurred as new disciplinary hybrids evolve, for example the fields of paleobiogeography,[3] geoarchaeology,[4] and archaeoseismology.[5]

As an alternate example, the field of statistics finds points of contact between different disciplines of science which rely heavily on data analyses. See two articles by David R. Brillinger, Professor of Statistics at UC-Berkeley: "Statistical Methods for Random Process Data from Seismology and Neuophysiology," *The Annals of Statistics* 16 (1988): 1-54, and "Examples of Scientific Problems and Data Analyses in Demography, Neurophysiology, and Seismology," *Journal of Computational and Graphical Statistics* 3 (1994): 1-22.

[3]Bruce S. Lieberman, Professor both in the Department of Geology and in the Department of Ecology and Evolutionary Biology at the University of Kansas, explores a new methodological avenue for the discipline of paleobiogeography in an article he published several years ago: "Paleobiogeography: The Relevance of Fossils to Biogeography," *Annual Review of Ecology, Evolution, and Systematics* 34 (2003): 51-69. Lieberman is also the author of *Paleobiogeography: Using Fossils to Study Global Change, Plate Tectonics, and Evolution* (New York: Kluwer Academic/Plenum Publishers, 2000). Although not entirely positive, C. J. Humphries' review of Lieberman's work gives a brief historiographical overview of the field and includes a short bibliography. C. J. Humphries, review of *Paleobiogeography*, by Bruce S. Lieberman, *Journal of Paleontology* 76 (2002): 1110-1112.

[4]As a field, geoarchaeology expanded considerably in the 1970s and 1980s, following special symposiums at annual meetings of the Geological Society of America in 1977 and 1978. One outgrowth was a separate GSA division, now titled "Archaeological Geology," which is home to the journal *Geoarchaeology*, established in 1986. In the 1990s developed a "Geoarchaeology Interest Group" in the Society for American Archaeology.

A sampling of works on geoarchaeology include: Karl W. Butzer, *Environment and Archaeology, An Ecological Approach to Prehistory*, 2nd ed. (Chicago: Aldine, 1971); D. A. Davidson and M. L. Shackley, eds., *Geoarchaeology: Earth Science and the Past* (London: Duckworth, 1976); Bruce G. Gladfelter, "Geoarchaeology: The Geomorphologist and Archaeology," *American Antiquity* 42 (1977): 519-538; Fekri A. Hassan, "Geoarchaeology: The Geologist and Archaeology," *American Antiquity* 44 (1979): 267-270; Bruce G. Gladfelter, "Developments and Directions in Geoarchaeology," *Advances in Archaeological Method and Theory* 4 (1981): 343-364; Jack Donahue and James M. Adovasio, "Teaching Geoarchaeology," *Anthropology & Education Quarterly* 16 (No. 4 "Teaching Anthropology) (1985): 306-310; Michael R. Waters, *Principles of Geoarchaeology: A North American Perspective* (Tucson: University of Arizona Press, 1992); George R. Rapp, Jr., and Christopher L. Hill, *Geoarchaeology: The Earth-Science Approach to Archaeological Interpretation* (New Haven: Yale University Press, 1998); Norman Herz and Ervan G. Garrison, *Geological Methods for Archaeology* (Cambridge: Cambridge University Press, 1998); and Paul Goldberg, Vance T. Holliday, and C. Reid Ferring, eds., *Earth Sciences and Archaeology* (New York: KluwerAcademic/Plenum Publishers, 2000).

In her review essay of a handful of books in geoarchaeology, Tina M. Niemi notes the disproportionate number of geologists reaching across the disciplinary boundaries to archaeologists, in comparison to the relatively little work done in archaeology to reciprocate, and she issues a call for that imbalance to be corrected. Tina M. Niemi, Review Article: "Geoarchaeology – Where Do We Go From Here?" *American Journal of Archaeology* 103 (1999): 525-528.

[5]Archaeoseismology is relatively new on the scientific scene, and there continues to be some debate how distinct it is from the discipline of geoarchaeology. Works specific to archaeoseismology are few, and tend

The impetus for defining a new or hybrid discipline often stems from the necessity of using multiple approaches and methodologies to more effectively address a specific research question or to investigate a particular physical phenomenon. This is true in the study of earthquakes, a phenomenon whose lack of precise definition both requires and inspires new kinds of questions and fresh avenues of investigation. The scientific discipline most obviously relevant to earthquakes, in name at least, is seismology, literally "the study of (-ology) earthquakes (seismos)," but earthquakes also fall within the purview of many other research fields, such as geology, geophysics, oceanography, paleontology, and volcanology. Disciplinary boundaries are important because they define who is responsible for what, which helps to legitimize and give meaning to the individuals and institutions involved. However, they can also serve as a barrier, particularly when the physical phenomenon being studied eludes definition and does not always operate within known limits. The pairing of earthquakes' amorphous character with the boundary-laden worlds of scientific enterprise and human experience creates an enormous challenge, one that requires innovation and adaptability.

Europeans faced such a similar challenge, an intellectual earthquake of sorts, after 1492, when the Genoese Christopher Columbus and his Spain-sponsored expedition

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to be regionally focused. Two monographs relating to the eastern Mediterranean are: S. C. Stiros and R. E. Jones, *Archaeoseismology* (Athens, Greece: Institute of Geology and Mineral Exploration: British School at Athens, 1996), and Victoria Buck, *Archaeoseismology in the Atalanti Region, Central Mainland Greece: Theories, Methods and Practice* (Oxford: Archaeopress, 2006). Stiros and Jones, and Buck, along with I. Stewart, also contributed essays to: *The Archaeology of Geological Catastrophes* (Geological Society Special Publication 171), eds. W. J. McGuire, D. R. Griffiths, P. L. Hancock, and I. S. Stewart (London: Geological Society, 2000). The American continents have been the geographical focus of the research of Robert L. Kovach, Professor of Geophysics at Stanford University: *Early Earthquakes in the Americas* (Cambridge: Cambridge University Press, 2004).

encountered the Americas, a landmass previously unknown to them. From a geographical standpoint, the European worldview before 1492 had been confined to the three known continents, Europe, Asia, and Africa, knowledge reflected artistically in the commonly used T-O map. This geographical boundary did, however, define more than physical limits. It also established a perimeter for Europeans' understanding of the world in terms of politics, society, economy, culture, religion, and physical environment. Knowing where this outer limit lay provided a comfort zone within which they could function as a larger community and as individuals within that community. By returning to Spain after his first voyage and reporting what he had found, Columbus unknowingly dealt a decisive first blow to a seemingly secure worldview that would, over the following centuries, be dismantled and rebuilt.

At the heart of the "old" European worldview was knowledge grounded in classical texts, including both biblical sources and works written by ancient philosophers such as Aristotle, Pliny, and Seneca. None of these texts spoke directly about the Americas or the flora, fauna, land, climate, and people Europeans encountered there.[6] If Europeans were going to make sense of it all, then they were going to have to acquire the

[6]Although these ancient texts did not address the Americas directly, because they were foundational to the European worldview, people nevertheless sought to find within them allusions to the newly-found continent and its many aspects. These speculations were prevalent enough for the Jesuit José de Acosta to address them in his *Natural and Moral History of the Indies,* which was published in Spain in 1590. Acosta refutes suggestions that Christian authors Lactantius and Augustine and ancient writers Aristotle and Pliny offered evidence of specific knowledge about the New World, and in fact considers Plato's mention of Atlantis to be the only direct allusion, even if he does not believe everything Plato reported about it. Book I, chapters 7-12.

knowledge themselves by gathering as much data as possible.[7] Fortunately for all of Europe, it was the highly bureaucratic and detail-oriented Spaniards who were first on the scene, and they remained the primary knowledge-gatherers and organizers of information about the Americas for close to a century.[8] During this almost-hundred year period, Spaniards of all backgrounds researched, explored, and recorded information about the Americas of a quantity that boggles the mind. Attesting to this are the plethora of unpublished sources accessible in Spain's many over-flowing archives, as well as an enormous number of printed works, all of whose circulation in the Atlantic world contributed, over time, to a reevaluation and reorganization of existing knowledge about the physical world that built a foundation for later intellectual and philosophical developments in Europe.[9]

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[7]An important study of the displacement of ancient philosophical views in response to knowledge acquired in the Americas is Anthony Grafton's *New World, Ancient Texts: The Power of Tradition and the Shock of Discovery*, with April Shelford and Nancy Siraisi (Cambridge, MA and London: The Belknap Press of Harvard University Press, 1992). For a more general look at the many ways Europeans sought to integrate what they learned about the New World, see the three important works of: J. H. Elliott, *The Old World and the New* (Cambridge: Cambridge University Press, 1970); Karen Ordahl Kupperman, ed. *America in European Consciousness, 1493-1750* (Chapel Hill and London: University of North Carolina Press, for the Omohundro Institute of Early American History and Culture in Williamsburg, VA, 1995); and Anthony Pagden, *European Encounters with the New World from the Renaissance to Romanticism* (New Haven: Yale University Press, 1993).

[8]This is true for regions of the Americas not including Brazil, which, from the European perspective, fell under the purview of Portugal as defined in the Treaty of Tordesillas of 1494. Portugal did not arrive to the region until 1500, when Pedro Álvarez Cabral and the Portuguese fleet he commanded landed on the east coast of South America.

[9]A recent and explicit articulation of Spain's sixteenth-century contributions to and strong influence on knowledge shifts that occurred in Europe in subsequent centuries is: Antonio Barrera-Osorio, *Experiencing Nature: The Spanish America Empire and the Early Scientific Revolution* (Austin: University of Texas Press, 2006).

Accomplishing this enormous feat required participation and contributions from anybody and everybody, especially the missionaries, explorers, royal officials, navigators, bureaucrats, entrepreneurs, and New World natives, with first-hand knowledge about the Americas. Indeed, since the classical texts offered little practical help, experience was what counted. Whatever the motivation, whether it was to evangelize the natives, make a fortune, serve the king, build a new life, or find adventure, every Spaniard or other European who came to the New World in the first few decades after Columbus had to engage in a continuous process of learning and trying new things if he was going to be successful. The same was true at the institutional level, as the Spanish crown established numerous ways to harness the information coming in from the Americas for its own benefit. Two important "clearinghouses" for New World knowledge were established, the Casa de la Contratación in 1503, and, following Spain's foray into Mexico, the Council of the Indies in 1524. Within both institutions there was constant tension between those with "on the ground" experience in the Americas and the theoreticians in Spain who were trying to bring some semblance of order to the mass of data coming in so that it could be used to further the maintenance and building of empire. Although outcomes of disagreements were not always to everyone's liking, the tensions nevertheless managed to be negotiated until the communities in the Americas finally declared their independence from Spain three centuries later.

Spain's long-term operations in the New World testify to the effectiveness of a research enterprise marked by flexibility, cooperation, creativity, clear communication,

and a delicate balance between a commitment to a particular position or research agenda and openness to new ways of thinking and doing. As much as the Spanish government wished to exert control over the knowledge acquired in the Americas, it was nevertheless dependent upon that knowledge, and could not afford to be particular about who supplied it. Likewise, Spaniards with first-hand experience in the New World needed help from the Spanish crown in order to achieve their goals. When the crown increasingly added "formal mechanisms" for gathering information about the Americas, such as requesting reports or soliciting feedback on questionnaires, respondents did not have to comply, but enough did so to support an ever-growing bureaucracy.[10] Similarly, the government chose to respond to, rather than to ignore, solicitations from its constituency, such as requests for subsidies or for official sanction for further conquests. A mutually-dependent and extensive network was required in order to make the most of the many opportunities the Americas offered.

The importance of networks and of the sharing of information is exemplified in the compilation and writing of histories about the New World's physical environment. The first of these was Gonzalo Fernández de Oviedo's *De la natural historia de las Indias*, commonly referred to as the *Sumario*, which was published in 1526, widely disseminated in several languages, and dedicated to Holy Roman Emperor Charles V, who was also King Charles I of Spain. Unlike earlier reports about the Americas, the *Sumario* was the first to discuss the region's physical aspects, which Oviedo "jubilantly

[10]Barrera provides a discussion of these mechanisms in "Circuits of Information: Reports from the New World," chapter four of *Experiencing Nature*.

frames...as part of Charles's massive empire."[11] In 1532, the Spanish government appointed Oviedo "Chronicler of the Indies," a position he would hold until his death in 1557, and charged him with the task of writing the land's natural and social history. To support Oviedo's assignment, the crown dispatched royal decrees to its officials across the Atlantic Ocean soliciting information specific to the Americas' physical environment. Oviedo relied on data acquired from these and other official reports, as well as used his many personal connections to notable figures of the period, such as Columbus's sons, the Pizarro brothers, and Bernal Díaz del Castillo, to compose his dense, fifty-volume *Historia general y natural de las Indias*, whose descriptive contents run the gamut from pineapples, canoes, and Amazonian women, to the conquest and colonization of different parts of the New World.[12] Writing such a massive work took close to thirty-five years, and only twenty books of what would eventually become fifty books were published in Oviedo's lifetime. Nevertheless, the parts of the *Historia* initially published were "immediately recognized by [Oviedo's] contemporaries" because "the text offered the

[11]Kathleen Ann Myers' recent book *Fernández de Oviedo's Chronicle of America: A New History for a New World* (Austin: University of Texas Press, 2007), 17.

[12]Gonzalo Fernández de Oviedo, *Historia general y natural de las Indias* (Seville: Juan Cromberger, 1535). Only Part I (books 1-19) and what would become book 50 of part II were published in Oviedo's lifetime, originally in 1535, then again in 1547 and 1557, along with translations in other European languages. It was not until the 1850s that the first full edition of all parts along with Oviedo's revisions was published: *Historia general y natural de las Indias*, Vols. 1-4, edited by José Amador de los Ríos (Madrid: Imprenta de la Real Academia de la Historia, 1851-1855). This full version was reprinted in 1956 and again in 1992 with a new introduction by Juan Pérez de Tudela Bueso as Volumes 117-121 of the series Biblioteca de Autores Españoles (Madrid: Atlas, 1959; reprint, 1992). See the helpful annotated bibliography of Oviedo's works in Myers, *Oviedo's Chronicl*, 301-302, as well as the older bibliography by Daymond Turner, *Gonzalo Fernández de Oviedo: An Annotated Bibliography* (Chapel Hill: University of North Carolina Press, 1966). Myers' book and the work done by Antonello Gerbi in *Nature in the New World* (Pittsburgh: University of Pittsburgh Press, 1985), are must-reads for any study of Oviedo.

most comprehensive coverage of the Indies in the first half of the sixteenth century" and because it assembled in one place many of the first-hand accounts about the Americas.[13]

The tradition begun with Oviedo manifested in a new way five decades later in the work of José de Acosta, a Spanish Jesuit who spent fifteen years in various parts of Spanish-ruled America. In 1586 Acosta published *Natura novi orbis*, which was translated into Spanish and incorporated as Books I and II of his much longer *Historia natural y moral de las Indias*, which appeared in full in 1590 and was immediately translated into Italian, French, English, Dutch, and Latin.[14] Unlike Oviedo, Acosta was able to benefit from almost a century's-worth of data-gathering about the Americas and its physical environment. This knowledge base established a foundation upon which Acosta and later writers could consider possible causes for the unusual plants, animals, climate, and people they encountered in the New World rather than provide only utilitarian descriptions about them, as Oviedo had done.[15] Acosta, for example, mused at length about the reasons why there were both hot and cold temperatures in the "Torrid Zone" along the equator where much of the Spanish Americas were located. Among

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[13]Myers, 3.

[14]José de Acosta, *Historia Natural y Moral de las Indias, en que se tratan de las cosas notables del dielo, y elementos, metales, plantas, y animales dellas: Y los ritos, y ceremonias, leyes, y gobierno de los Indios, compuesto por el Padre Joseph de Acosta* (1590), edited by Edmundo O'Gorman (Mexico City: Fondo de Cultura Económica, 1962). Also available in English: José de Acosta, *Natural and Moral History of the Indies*, edited by Jane E. Mangan, with an introduction and commentary by Walter D. Mignolo, and translated by Frances López-Morillas (Durham and London: Duke University Press, 2002). References follow Acosta's organization of the *Historia* into Books, which are further subdivided into short chapters. English quotations are taken directly from Mangan's edition.

[15]Barrera, *Experiencing Nature*, 115.

several causes, Acosta deduces the first cause to be the New World's proximity to the ocean, which helps to temper the sun's heat.[16]

While much of what the Spaniards saw in the New World was new to them, there were two features of the physical environment about which they already knew and with which they had some experience: earthquakes and volcanoes. Earthquakes were common in many parts of Europe, for example in Italy, regions near the Alps, and the Iberian Peninsula, as well as throughout the Mediterranean region where Europeans had political, economic, and social connections.[17] Volcanoes were also familiar, primarily those found in Italy, which rumbled with relative frequency. Particularly well recognized were Mount Etna and Mount Vesuvius, the latter made popular by its massive eruption in 79 C.E. and the accompanying story recorded by Pliny, the Younger, of his uncle's untimely demise while investigating the exploding mountain.[18] Additionally, earthquakes and volcanoes and their characteristics and causes were discussed, usually together, by many of the ancient texts so fundamental to Europeans' understanding of the world, classical

[16]Acosta, *Historia*, Book II, Chapter II.

[17]A sampling of earthquake catalogues testifies to the frequency of earthquakes in Europe before 1492: Emanuela Guidoboni, *Catalogue of Ancient Earthquakes in the Mediterranean Area up to the 10th Century*, with the collaboration of Alberto Comastri and Giusto Traina and translated from the Italian by Brian Phillips (Rome: Instituto Nazionale de Geofisica, 1994); Emanuela Guidoboni and Alberto Comastri, *Catalogue of Earthquakes and Tsunamis in the Mediterranean Area from the 11th to the 15th Century* (Rome: Instituto nazionale di geofisica e vulcanologia, 2005); Frédéric Montandon, *Les tremblements de terre destructeurs en Europe, catalogue par séismiques de l'an 1000 á 1940* (Genève, 1953); and Daniele Postpischi, ed., *Catalogo dei terremoti italiano dell'anno 1000 al 1980* (Bologna: Consiglio Nazionale delle richerche, Progetto finalizzato geodinamica, Sottoprogetto rischio sismico e ingegneria sismica, 1985).

[18]Pliny the Younger, reports the story of his namesake uncle, Pliny the Elder, in Book VI of his *Epistulae* (Letters).

works which originated in the eastern Mediterranean, home to both phenomena. Most prominent in this regard was Aristotle's *Meteorologica*, which enunciates the philosopher's theory that blowing winds in the concavities of the earth cause both earthquakes and volcanoes.[19] With this background knowledge in place before arriving in the Americas, Spaniards' reports about the two phenomena were therefore focused less on the dramatic qualitative contrast between earthquakes and volcanoes in the Old World and those found in the New World. Instead, these reports emphasized how quantitatively different earthquakes and volcanoes were in the Americas, noting in particular how large they were and how frequent they occurred.

A case-in-point is the information about earthquakes and volcanoes found in Acosta's *Historia*. Having discussed the heavens above and the climate of the New World, Acosta turns his attention to the physical world. In Book III of the *Historia*, he focuses on matters related to the elements of air, water, and earth, an organizational structure modeled for him by ancient authors.[20] Interestingly, he omits the traditional fourth element of fire because he sees "no special qualities of fire [in the Americas] that

[19]Other ancient philosophers frequently cited by Europeans discussing earthquakes and volcanoes were Lucretius (*De Rerum Natura*), Seneca (*Naturales Quaestiones*), and Pliny the Elder (*Naturalis Historia*). For a quick look at these and other ancient authors' explanations for earthquakes, see: L. Châtelain, "Théorie d'auteurs anciens sur les tremblements de terre," *Mélange d'archéologie et d'histoire* 29 (1909): 87-101 and Constantino Marmo, "Le teorie del terremoto da Aristotele a Seneca," in *I terremoti prima del Mille in Italia e nell'area mediterranea; storia, archeologia, sismologia*, ed. Emanuela Guidoboni (Rome and Bologna: ING-SGA, 1989), 170-177. Kathryn Payne's useful Ph.D. dissertation, "Greek Geological Concepts to the Age of Alexander" (Ph.D. diss., University of Missouri-Columbia, 1990), provides a broader context of ideas about the earth within which to better appreciate and understand the ancients' explanations for earthquakes and volcanoes, which she discusses in more detail in Chapter 7, "Processes that Shape the Earth."

[20]Acosta, Book III, chapter 2.

differ from those in other places."[21] Acosta addresses the three elements in turn – air, water, and earth – and explores issues and phenomena related to each, devoting roughly one-third of the book's twenty-seven chapters to each of the three elements. Of the eight chapters that discuss the earth, three deal specifically with earthquakes and volcanoes.[22]

Acosta first talks about volcanoes, which seem to be of greater interest to him than earthquakes.[23] He notes that volcanoes are found in other places, for example Mount Etna and Mount Vesuvius in Italy, but he finds them "extraordinarily frequent" in the Americas, and also quite tall. The most famous volcanoes are those in Guatemala, "both for their large size –[which can be seen from far away]– and for the fury of fire they emit." Following an earthquake in Guatemala on 23 December 1586, which destroyed the city, Acosta reports that the volcano erupted continually for six months, ejecting "from its summit, like vomit, a river of fire." Acosta is fascinated by the amount of physical material discharged from the volcano. As he says, "It taxes the human imagination to understand how the volcano could have ejected from its center all the material that it threw out during those months." He finds this true for volcanoes in the Americas in general and considers the subject "worth discussing because it seems a prodigious thing, and one that exceeds the course of nature, that they bring up from their interiors the amount of material that they vomit forth." Acosta wonders, "Where does

[21]Acosta, Book III, chapter 2.

[22]Acosta, Book III, chapters 24-26.

[23]Two of the three chapters deal with volcanoes. Acosta, Book III, chapters 24-25. All quotations in the following two paragraphs come from these two brief chapters.

that material come from and who provides it? How is it made?" He disagrees with those who say that the material will eventually run out. To begin with, he argues, "the material they eject is almost infinite in quantity and could not all fit into the bowels of the mountain at one time." More importantly, there are a number of volcanoes "that stay the same for hundreds and even thousands of years and unvaryingly throw off smoke and fire and ash," such as the temperamental Mount Vesuvius. Acosta reports that the seeming inconsumability of fire in some volcanoes led "a greedy priest" to believe "that the burning material had to be gold, concluding that anything that burned for so many years without being consumed could be no other substance or metal." The priest attempted to harvest the precious material from the volcano, but was thwarted when the iron tools he tried to use melted.

In addition to the famous Guatemalan volcanoes, Acosta calls attention to the volcano near the Puebla de los Angeles in Mexico, which emits great clouds of ash and smoke at intervals almost daily. He reports there is some discussion about the "connection between this volcano and the nearby mountains of Tlaxcala, for this would explain why so many thunderstorms and lightning and even thunderbolts are often experienced in them." He also indicates that "Spaniards have climbed this volcano and entered it and have extracted sulphur from it to make gunpowder." Intriguingly, the one person Acosta names in this regard is the Spanish explorer Hernán Cortés, who, Acosta notes briefly, "tells of the efforts he made to discover what was in [the volcano]." Like his Spanish contemporaries in the early decades after 1492, Cortés was in the Americas

for his own purposes, and he needed to acquire knowledge about the land to help him realize his goals. His experience with and resulting report about the volcano in Mexico, upon which Acosta clearly relied, illustrates the degree to which Spaniards of various backgrounds were interested in and perpetuated knowledge about the new physical environment in which they found themselves.

Between 1519 and 1526, Cortés wrote a series of five letters to King Charles I of Spain (aka Charles V of the Holy Roman Empire).[24] Cortés's main purpose in writing was to secure royal approval for his conquest and settlement of New Spain—modern-day Mexico. Technically speaking, Cortés had begun his mission under the legal authority of the governor of Cuba, Diego Velázquez. However, Cortés thought Velázquez ineffective as a leader, particularly in matters of exploration and conquest, and instead followed his own plan, soliciting official endorsement for it after-the-fact. This was a politically risky move, not least because some of the men under his command were loyal to Velázquez. As one commentator remarks, "[successfully conquering the Aztec empire] was in some respects the least dangerous of the enemies Cortés had to face...he had more to fear from some of his own countrymen."[25] Nevertheless, the potential political and financial rewards were lucrative and Cortés was determined to succeed.

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[24]The first letter was technically addressed to the Queen Doña Juana and her son, Emperor Charles V, also Charles I of Spain.

[25]J. H. Elliott, Introduction to Hernán Cortés, *Letters from Mexico*, translated and edited by A. R. Pagden (New York: Grossman Publishers, 1971), xii.

Keeping this larger context in mind, one is not surprised by the content of Cortés's letters. Data specific to circumstance change from letter to letter, but overall the subject matter is what one would expect of such politically-motivated texts. Cortés chronicles his and his men's military successes, describes the tangible treasures found in the region, and contrasts his selfless labors on behalf of the ever-expanding Spanish empire to the self-serving actions performed by other Spanish explorers. Velázquez, of course, is at the top of Cortés's list of disappointing Spaniards. Among the many complaints that Cortés turns against him is that in previous exploratory efforts Velázquez had failed to learn anything about the land.[26] He may have made contact with the natives and acquired small amounts of gold, but he did so while remaining at sea and without making landfall, rendering it impossible for him to have seen "any other thing on that land worthy of note" or learned anything "of its secrets."[27] This lack of firsthand experience, therefore, renders untrue any previous accounts of the region because, Cortés claims, they were "written according to [those men's] fancies."[28] Cortés, on the other hand, endeavored "to see and learn the secret[s]"[29] of the land and so can "render a true

[26]Hernán Cortés, *Cartas de la conquista de México* (Madrid: SARPE, 1986), 26; *Letters from Mexico*, 9. Unlike Acosta's well organized *Historia*, whose content is easily identified in both the original Spanish and the English translation, Cortés' Spanish letters can be cumbersome to follow. For precision, page citations are provided to both the Spanish and English versions.

[27]Cortés, *Cartas*, 26; *Letters*, 9.

[28]Ibid.

[29]Ibid., 35; 29.

account of all that is to be found [there]."[30] For Cortés, "the land" was an all-encompassing term for plants, animals, people, and terrain, including volcanoes.

In his first letter, Cortés makes note of "a great range of the most beautiful mountains."[31] According to Cortés, some of the mountains were "exceedingly high," but there was one that was so much higher than all the others that its top half was often covered in clouds during bad weather. "At other times, however, when the day is very fine," Cortés reports, "one can see the peak rising above the cloud, and it is so white we think it to be covered in snow, and even the natives say it is snow." Despite the color cues and confirmation from the locals, Cortés still has his doubts about the snow. For one thing, he saw it only from a distance and "not very clearly." For another, even though it may look like snow, he cannot be certain because the region is so hot. In other words, Cortés's knowledge about warmer climates tells him that the presence of snow in such a place is unlikely. That being the case, he is not willing to claim anything definitively until he has further proof. And so he writes to the Spanish Crown, "We shall endeavor to see and learn the secret of this and other things of which we have heard."[32]

By the time Cortés wrote his second letter a year later in 1520, there was no doubt that the white substance atop any of the mountains was snow. In an area west of where

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[30]Ibid., 29, 18.

[31]The Sierra Madre, which contains the highest peak in Mexico, Orizaba, which Cortés goes on to describe. For a short study of volcanoes in Mexico, see: Esperanza Yarza de De la Torre, *Volcanes de México* (Aguilar, 1971).

[32]Cortés, 34-35; 29.

the Spaniards had seen the first mountain, Cortés and his men encountered two other "very high and very remarkable mountains."[33] Cortés reports that from the higher of the two "there appears often both by day and by night a great cloud of smoke as big as a house which goes straight as an arrow up into the clouds, and seems to come out with such force that even though there are very strong winds on top of the mountain they cannot turn it." This seemed to Cortés "something of a miracle" and he wanted an explanation. So in keeping with his effort to render as true an account as possible, Cortés sent ten of his men along with some native guides and "urged them to climb the mountain and discover the secret of the smoke, whence it came, and how." Deep snow, whirlwinds of ash and smoke, and bitter cold prevented the climbers from reaching the summit and learning the mountain's secret, but they did not return empty-handed. They "descended and brought [with them] much snow and icicles for [the others] to see," physical evidence of what lay atop the mountain. This was a significant act because, as Cortés explains, "this seemed to be something very rare in these parts, so the [ships'] pilots have believed until now, because of the warm climate."[34]

The mystery of the "smoking mountain," however, still remained to be solved, and Cortés returns briefly to the subject in his third letter, written on May 15, 1522.[35] The natives, he says, "gave us to believe that [the mountain] was a most evil thing and

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[33]Commonly known by their abbreviated Nahuatl nicknames as Popo and Ixti.

[34]Cortés, 53; 77-78.

[35]"Smoking Mountain" is the translation of Popcatepetl, the Nahuatl name for the mountain.

[that] all those who climbed it died." Not one to be deterred by such suggestions, Cortés therefore ordered some Spaniards "to climb it and see what it was like up there." After three attempts, some of the men finally "reached the opening from which the smoke [came]," an opening that was "so deep they were unable to see the bottom." The mouth of the opening was also quite large. They calculated the diameter to measure the equivalent length of two crossbow shots (roughly 760 yards or 700 meters) and the circumference to be approximately three-quarters of a league around (about 2 ½ miles or 3 ½ kilometers).[36] While there, the men noticed sulphur deposits left as residue by the smoke, knowledge that proved helpful at a later time when munitions were depleted. As Cortés reports in his fourth letter, they lowered a Spaniard tied to a rope into the mouth of the mountain approximately 70-80 fathoms (around 450 feet or 137 meters) in order to harvest sulphur, a much-needed component of gunpowder.[37] The initial moment of discovering the sulphur, however, was short-lived. The mountain began to rumble, so the men quickly scurried down.[38]

It appears that Cortés never again wondered about the mystery of the smoke. He seems to have satisfied his curiosity, if for no other reason than he was able to locate and

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[36]Cortés, 156-157; 279.

[37]Ibid., 180; 325. In footnote 60 of his notes on Cortés's fourth letter, editor A. R. Pagden reports that the best account of this story is given by Francisco Cervantes de Salazar, *Obras que Francisco Cervantes de Salazar a hecho, glosado y traducido . . La Segunda es un diálogo dela dignidad del hombre . . . comenzado por el maestro Oliva, y acabado por F. Cervantes de Salazar* (Alcala de Henares, 1546). Pagden, Notes on the Fourth Letter, *Letters from Mexico*, 508.

[38]Cortés, 156-157; 279.

acquire an important munitions resource. Regardless of his intentions for investigating the "smoking mountain," Cortés' detailed report about what he found is one of many texts that contributed to the knowledge-building about the New World taking place in the early decades of the sixteenth century.[39] The fact that Acosta had no hesitance in relying upon Cortés' report about volcanoes illustrates the extent to which what constituted authoritative knowledge was defined as much by a person's firsthand experience with physical phenomena as by, or perhaps more than, a person's theoretical understanding of them.

Having tackled the subject of volcanoes, Acosta shifts to a brief discussion of earthquakes. He begins by countering the view of some people who claim that the frequent earthquakes in the Americas are caused by the volcanoes. That is not possible, Acosta argues, since earthquakes also happen there in places "where there are no volcanoes nearby."[40] Following Aristotle, Acosta continues:

> It is indeed that earthquakes and volcanoes have a certain resemblance to each other, for the hot blasts that originate in the deep hollows of the earth seem to be the chief element in the volcanoes' fire, which causes other, heavier material to catch fire and produces those smokes and flames that emerge from them; and those same blasts, unable to find an easy outlet underground, shake the earth violently as they emerge, causing the horrific

[39]Cortés's training as a notary helps to explain the clarity of detail in his letters. I am grateful to William Phillips for this important reminder about Cortés's background.

[40]Acosta, Book III, chapter 25.

> noise that is heard under the ground and the movement of the earth itself, stirred by the fiery blast.

Acosta contends that earthquakes are common in the New World because of its proximity to so much water, pointing out that the coastal areas are particularly hard hit because the water blocks the vents from which the hot blasts of air contained within the earth are seeking escape.[41] As with volcanoes, he is struck by the frequency of earthquakes in the Americas and cites several recent examples, including those that occurred in Arequipa in 1582, Lima in 1586, and Quito in 1587. There was also a large earthquake in Chile, whose precise date Acosta cannot recall, "which brought down whole mountains and shut off the course of rivers with its debris and made lakes of them and destroyed towns and killed a large number of people." The earthquake also "caused the sea to inundate the land for several leagues, leaving ships stranded and very far from their anchorages, and other similar and very terrifying things." A giant sea wave, though decidedly smaller, had also occurred in Lima following the earthquake in 1586.

Acosta's brief discussion of earthquakes and volcanoes and Cortes' report of his experience with the volcano in Mexico are but two of many Spanish commentaries on one or both phenomena within larger works written about the New World. With a foundational understanding of earthquakes and volcanoes before arriving to the Americas, Spaniards like Acosta and Cortés were understandably unconcerned with

[41]Acosta uses his understanding of this occurrence in coastal regions of Europe that experience frequent earthquakes as a point of comparison.

earthquakes' and volcanoes' distinctiveness as phenomena; instead, they were fascinated by the large size and frequent occurrence of both in the New World in comparison to what they had known in Europe. This was also true for Oviedo, official chronicler of the Indies, who went so far as to advise the Spanish crown against settling in either Guatemala or Nicaragua because of the frequency of earthquakes and volcanoes there.[42] Although Oviedo's advice clearly went unheeded, his observations, along with those of Acosta, Cortés, and others form a rich corpus of data about the two phenomena, whose characteristics and behaviors continue to challenge human comprehension. The three Spaniards certainly did not consider earthquakes and volcanoes the most significant aspects of the Americas' physical environment, nor were the phenomena the authors' primary motivation for writing. Earthquakes and volcanoes were one part of a larger New World landscape that Spaniards worked hard to understand and to incorporate into their new and evolving worldview, a process they recorded in masses of documents, decade-after-decade for close to a century. Men like Acosta, Cortés, and Oviedo clearly paid attention to what they encountered in the Americas. They had to, because their success there, whether defined individually or collectively, depended on it.

The piles of quantitative and qualitative data gathered about the New World by Spaniards for almost a century influenced a shift in Europeans' mental outlook, although how and to what degree that happened will likely be discussed for some time. Only over the last decade or so has there been a significant exploration and reevaluation of many

[42]Oviedo, *Historia,* XLI, 3: PT, IV, 361-362.

works about the New World written by Spaniards and Spanish Americans in the centuries following Columbus' arrival. Motivating this new research is an effort by scholars specializing in Spain and Latin America to offer a corrective to the demonizing "Black Legend," a long-standing notion that all things Spanish are vile, corrupt, and backward.[43] Within the history of science, the main challenge for researchers who study science in Spain and/or Latin America before the nineteenth century is the entrenched idea that a "Scientific Revolution" that took place beginning in the mid-sixteenth century in several parts of Europe did not include Spain or any region within its political domain.[44] Spain is not directly excluded from the "Scientific Revolution," but rather is left out by virtue of how the term has been defined. As traditionally articulated, the so-called Scientific Revolution was a period of transformation in only a handful of disciplines, most notably physics, astronomy, mathematics, and anatomy. To counter that approach, much of the early work done on Spain and science in the mid-twentieth century was mainly reactive, as Spanish scholars sought to insert the names and publications of sixteenth-century

[43]The term "Black Legend" ("La Leyenda Negra") was coined in 1914 by Julían Juderías, *La leyenda negra y la verdad histórica* (Madrid, 1914). Worth noting from the vast literature on the "Black Legend" are several important works written by Anglophone scholars in the Civil Rights era of the late 1960s and early 1970s: Benjamin Keen, "The Black Legend Revisited: Assumptions and Realities," *Hispanic American Historical Review* 49 (November 1969): 703-719; Lewis Hanke, "A Modest Proposal for a Moratorium on Grand Generalizations: Some Thoughts on the Black Legend," *Hispanic American Historical Review* 51 (February 1971): 112-127; Keen, "The White Legend Revisited: A Reply to Professor Hanke's Modest Proposal," *Hispanic American Historical Review* (May 1971): 336-355; Charles Gibson, ed., *The Black Legend: Anti-Spanish Attitudes in the Old World and the New* (New York: Alfred A. Knopf, 1971); and William S. Maltby, *The Black Legend in England* (Durham: Duke University Press, 1971).

[44]For a thorough discussion of the "Scientific Revolution" and its many facets, see H. Floris Cohen, *The Scientific Revolution, A Historiographical Inquiry* (Chicago and London: The University of Chicago Press, 1994).

Spaniards into the existing narrative of the Scientific Revolution without providing useful historical analysis or questioning the intellectual framework into which they were working so hard to fit their countrymen.[45]

Fortunately, research published in the twenty-first century is more thorough and attacks the notion of what defines the Scientific Revolution head-on. As an example, in *Experiencing Nature: The Spanish American Empire and the Early Scientific Revolution*, historian Antonio Barrera argues unequivocally for a redefinition of the Scientific Revolution. Barrera contends, "the Scientific Revolution did not start with Nicolaus Copernicus and his heliocentric ideas [in 1543], or with the publication of books by artisans and painters," but he argues convincingly "that it started in the 1520s, in Spain, when merchants, artisans, and royal officials confronted new entities coming from the New World and had to devise their own methods to collect information about those lands."[46] Within the United States, several other notable scholars in the field include Jorge Cañizares-Esguerra,[47] Daniela Bleichmar,[48] and Alison Sandman.[49] In an

[45]Typical in this regard is the prolific writings of José María López Piñero, for example, *Ciencia y Técnica en la Sociedad Española de los Siglos XVI y XVII* (Barcelona: Editorial Labor, S. A., 1979).

[46]Barrera, 2.

[47]For example, Jorge Cañizares-Esguerra, "Iberian Science in the Renaissance: Ignored How Much Longer?" *Perspectives on Science* 12 (2004): 86-124, and *Nature, Empire, and Nation: Explorations of the History of Science in the Iberian World* (Stanford: Stanford University Press, 2006). Although it questions the so-called Enlightenment rather than the Scientific Revolution per se, Cañizares' book *How to Write the History of the New World: Histories, Epistemologies, and Identities in the Eighteenth-Century Atlantic World* (Stanford: Stanford University Press, 2001) helped pave the way for the recent and much-needed scholarship on Spain and the Scientific Revolution.

[48]Three recent works include: Daniela Bleichmar, *Visible Empire. Colonial Botany and Visual Culture in the Eighteenth-Century Hispanic World* (University of Chicago Press, forthcoming); "Atlantic

international conference held in Valencia, Spain, in 2005, Barrera, Cañizares-Esguerra, Bleichmar, and Sandman joined a number of other important scholars from the Iberian Peninsula and elsewhere to discuss "Más allá de la Leyenda Negra: España y la Revolución Científica/Beyond the Black Legend: Spain and the Scientific Revolution." The conference was noteworthy because it was the first to address in a significant way the many issues surrounding Spain's absence from the narrative of the Scientific Revolution, while also taking a tangible first step towards bridging the gap between scholars working in the field in Spain and those working in the U.S. The resulting volume of conference papers, which was published in 2007, is an important resource for anyone interested in Spain and science in the sixteenth and seventeenth centuries.[50] Unfortunately, its many essays written in Spanish prevent the volume's influence from reaching an English-speaking audience, where correctives to the narrative of the "Black Legend" are most needed.

Spanish contributions to a Scientific Revolution notwithstanding, the dismantling and rebuilding of the European worldview instigated by Columbus' arrival in the New

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Competitions: Botany in the Eighteenth-Century Spanish Empire," in *Science and Empire in the Atlantic World*, eds. James Delbourgo and Nicholas Dew (New York: Taylor and Francis, 2008); and the volume she co-edited with Paula DeVos, Kristin Huffine, and Kevin Sheehan, *Science in the Spanish and Portuguese Empires (1500-1800)* (Stanford: Stanford University Press, 2008).

[49]Alison Sandman, "Sebastian Cabot between Spain and England," *Renaissance Quarterly* 57 (2004): 813-846; and "Controlling Knowledge: Navigation, Cartography, and Secrecy in the Early Modern Spanish Atlantic World," in *Science and Empire in the Atlantic World*, eds. James Delbourgo and Nicholas Dew (New York: Taylor and Francis, 2008).

[50]Victor Navarro Brotóns and William Eamon, eds., *Más allá de la Leyenda Negra: España y la Revolución Científica/Beyond the Black Legend: Spain and the Scientific Revolution* (Valencia: Instituto de Historia de la Ciencia y Documentación López Piñero; Universitat de Valéncia: C.S.I.C, 2007).

World involves another profound aspect that has had an immeasurable influence within the sciences, particularly the earth sciences. Before 1492, the geographical extent of Europeans' known world comprised three continents – Europe, Asia, and Africa. In 1492 that limit was shattered. Europeans' concept of a geographical boundary began expanding to include the Americas, a landmass that effectively completed their knowledge of the latitudinal circumference of the earth, knowledge that was confirmed by the first successful circumnavigation of the globe from 1519 to 1522. Columbus' making landfall in the New World was an event that marked an enormous leap toward thinking about the earth as a complete physical unit. The gradual incorporation of the Americas into Europeans' geographical understanding contributed significantly to the ability of Alfred Wegener to formulate his theory of continental drift in the early twentieth century. In short, without the Americas, there would be no theory of continental drift.

In its most basic form, the theory of continental drift describes what seems obvious to a school-aged child looking at a world map: that the continents once fit together like pieces of a puzzle. Since at least the sixteenth-century, individuals have noticed the continents' physical complementarity.[51] Columbus arrived in the Americas in the late fifteenth century, but it took Europeans several generations of mapping the

[51]Although much scholarly work has been done on cartographers, in particular those of the sixteenth century, e.g. Robert W. Karrow, Jr., *Mapmakers of the Sixteenth Century and Their Maps: Bio-Bibliographies of the Cartographers of Abraham Ortelius, 1570* (Chicago: Speculum Orbis Press for the The Newberry Library, 1993), there has been virtually no research on these individuals' recorded perception of continental congruence, except for Abraham Ortelius. So obvious is the jigsaw-puzzle fit of the continents that one imagines Ortelius cannot be the only cartographer to make note of it.

coastlines of the American continents before enough progress was made so anyone could see the congruence between them and Europe-Africa. This long delay was in part due to the amount of time it took to travel both on land and by sea in order to acquire the knowledge necessary for creating a map. As a point of reference, in the sixteenth century round trip transatlantic voyages typically took a minimum of one year, so as to avoid seasonal bad weather and allowing for the time it took to conduct business. The time gap between Europeans' arrival in the New World and their production of accurate maps was also because their lack of knowledge about the physical details of the Americas meant that they were starting with a literal blank slate. The advancement of cartographical representation, therefore, was dependent upon the acquisition of new geographical knowledge, a process that took place in an intermittent and non-linear fashion. The depiction of the continental coastlines progressed similarly, so that later maps were not necessarily more comprehensive in their representations of the continents than earlier ones.

The mapping of the American continents is what first made it possible for anyone to see their congruity with the west coasts of Europe and Africa. It is not surprising, then, that the person scientists have identified as one of the earliest proponents of continental drift was a sixteenth-century map-maker. Abraham Ortelius was a Dutch geographer whose world map *Theatrum Orbis Terrarum* (*Theatre of the Worlds*) was published in

1570, and is considered by many to be the first modern world atlas.[52] From the viewpoint of the history of science, the significance of Ortelius lies in his having identified the congruity of the continents so early and also in his intentional efforts to reconcile the speculative, ancient knowledge he had about the world with what he observed about the continents, rather than trying to force his observations into an old paradigm. In other words, he is venerated for having ideas and an approach similar to what is found in science today. The process of identifying a historical person like Ortelius in this way says more about the scientists evaluating him than about the actual person, a matter that will be addressed further below.

Ortelius, who had an interest in classical antiquity, also compiled a dictionary of classical toponyms, which was first published in 1578 under the title *Synonomia* (*Synonyms*) and then renamed *Thesaurus Geographicus* (*Geographic Thesaurus*) for two subsequent editions in 1587 and 1596. Ortelius includes in his dictionary speculation "about the geographical content of Greco-Roman myths."[53] In particular, he discusses Plato's tale of Atlantis, which recounts the sudden and catastrophic demise, caused by earthquakes and floods, of the island of Atlantis, said to be located just west of the Strait of Gibraltar. The Atlantis story had been much discussed by Europeans since their arrival in the Americas, for their new knowledge of a landmass previously unknown to

[52]Ortelius' *Theatrum* is considered by many to be the first modern world atlas. For a good introduction to Ortelius and his contributions to the history of cartography, see the collection of essays edited by Marcel van den Broecke, Peter van der Krogt, and Peter Meurer, *Abraham Ortelius and the First Atlas: Essays Commemorating the Quadricentennial of his Death, 1598-1998* (Utrecht: HES Publishers, 1998).

[53]James Romm, "A New Forerunner for Continental Drift," *Nature* 367 (1994), 408.

them made it easy to suppose that the New World or at least some part of it was the lost island of Atlantis.[54] Spanish historian Francisco López de Gómara, for example, made this suggestion explicit in his *Hispania Victrix*, published in 1553.[55] Nonetheless, Ortelius seems to be the first individual who sought to reconcile the story of Atlantis with his own knowledge of geography in an intentional way.

Plato's account indicated that the easternmost portion of Atlantis had survived the conflagration of physical disasters, having been shorn off from the rest of the island when it sank into the sea, and that it remained intact as Gadir, the modern-day Cádiz.[56] In its basic outline, Plato's story made sense to Ortelius. No doubt this was buttressed by Ortelius' assumption that Plato's account was true,[57] but it also agreed with what he observed. Ortelius noticed the matching coastlines of Europe-Africa with the Americas and reasoned that only a catastrophic event of epic proportions could have caused the continents to separate. Plato's story of Atlantis certainly speaks to a great catastrophe. The only detail Ortelius thought required reinterpretation was Plato's claim that most of the island had sunk into the sea. If this were literally true, then a landmass such as the

[54]This is a general claim made by a variety of scholars, but with little or no primary documentation to support it. For example, Phyllis Forsyth claims that "in the sixteenth and seventeenth centuries belief in Atlantis continued to spread as exploration of the Americas became more extensive," but she does not indicate from what sources she draws her conclusion. Forsyth, 2.

[55]Francesco López de Gómara, *Hispania Victrix. Primera y segunda parte de la historia general de las Indias co[n] todo el descubrimiento, y cosas notables que han acaescido dende que se ganaron hasta el año 1551. Con la conquista de Mexico, y de la nueua España*. Medina del Campo: Guillermo de Millis, 1553. Chapter entitled "De la isla que Platon illama Atlantide."

[56]Romm, 408.

[57]Much ink has been spilt debating the veracity of Plato's account. See discussion in Chapter 1.

Americas would not be visible at all, let alone comprise another continent. Thus, Ortelius supposed that Plato actually meant that the "lost" portion of Atlantis had not sunk into the sea but instead had separated from what remained of the island. Such a scenario better accounted for the jigsaw-puzzle fit of the continents.[58]

Until the 1990s, Ortelius' observations about the physical relationship between continents remained unnoticed, because scientists were more concerned with addressing current issues related to continental drift theory, rather than with looking back into history for possible precursors to it. From the 1930s, just twenty years after Wegener first introduced the theory of continental drift, scholars had credited the more well known Englishman Francis Bacon with having formulated the earliest iteration of the theory of continental drift in his work *Novum Organum (New Organon)*, published in 1620. Interestingly, for several decades this conclusion was either taken on faith, or ignored, but it was not examined. The only source cited for the early identification of Bacon as a forerunner of continental drift is Alexander L. du Toit's 1937 work *Our Wandering Continents: An Hypothesis of Continental Drifting*.[59] Du Toit, a South African geologist, was a strong supporter of Wegener's theory, and in fact made significant contributions to

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[58]Romm, 408.

[59]Alexander L. du Toit, *Our Wandering Continents: An Hypothesis of Continental Drifting* (Edinburgh and London: Oliver and Boyd, 1937). For an analysis of this book in the 1940s context of geological science, see T. W. Gevers, *The Life and Work of Dr. Alex. L. du Toit* (Johannesburg: Geological Society of South Africa, 1949). This small book is the printed version of the first-ever Alexander L. du Toit Memorial Lecture, which was given by Gevers, a professor of geology at the University of the Witwatersrand-Johannesburg. The lecture series was founded by the Geological Society of South Africa, in cooperation with the South African Geographical Society and the South African Association for the Advancement of Science, following du Toit's death in 1948.

its development.[60] At the beginning of du Toit's chapter on the history of ideas about the theory, he provides only a short list of individual last names and dates of works published by them, persons he considered to have been precursors of Wegener—Bacon (1620) among them—without offering any explanation of each person's specific thoughts or contributions to the theory of continental drift.[61] In this list, Bacon was an early exception, as most theory forerunners whom du Toit identified after Bacon did not arrive on the scene until the second half of the eighteenth century—Buffon (ca. 1780)[62]—and in most cases well into the nineteenth century: Young (ca. 1810); [63] R. Owen (1857);[64] A.

[60]After having done extensive mapping of the geology of South Africa (*The Geology of South Africa* (Edinburgh and London: Oliver and Boyd, 1926), still considered a must-read for any geologist studying South Africa), du Toit traveled to the southern section of South America. He noticed geological characteristics strikingly similar to those he had found in South Africa, making it seem increasingly obvious to him that the two continents had once been joined. Du Toit's extensive research, published with F. R. C. Reed as *A Geological Comparison of South America with South Africa* (Washington, DC: Carnegie Institute of Washington, 1927), provided tangible and significant evidence for Wegener's theory.

Although du Toit's contributions to the development of continental drift theory are, in recent times, less known than Wegener's, his work was widely recognized by scientists in the throes of discussions about the theory in the 1960s. In the introduction to the published papers of a symposium on continental drift held by The Royal Society on 19-20 March 1964, P. M. S. Blackett makes explicit that it was not until the second half of the twentieth century that the theory "became the subject of detailed scientific study, chiefly due to the work of Taylor in the U.S.A., Wegener in Germany, and du Toit in South Africa." *A Symposium on Continental Drift*, organized for The Royal Society by P. M. S. Blackett, Sir Edward Bullard, and S. K. Runcorn (London: The Royal Society, 1965), vii.

[61]du Toit, *Our Wandering Continents*, 11. Neither does du Toit include these individuals in his otherwise-extensive bibliography.

[62]Georges-Louis Leclerc (1707-1788), Comte De Buffon, best known for his work in natural history, which heavily influenced many of the well known naturalists of the next generation such as Jean Léopold Nicolas Frédéric Cuvier (1769-1832), also known as Georges Cuvier. The date cited by du Toit, ca. 1780, seems to refer to Buffon's 1778 work *Les Époques de la Nature (The Epochs of Nature)*, though it also corresponds to Buffon's *Histoire naturelle, génerale et particulière* (*Natural History, General and Particular*) which was published in thirty-six volumes from 1749 to 1788.

[63]Thomas Young (1773-1829) was an English polymath most well known for his deciphering of Egyptian hieroglyphics, especially the Rosetta Stone. He published in 1807 the two-volume work *A Course of Lectures on Natural Philosophy and the Mechanical Arts*.

Snider (1859);[65] H. Wettstein (1880);[66] O. Fisher (1882);[67] C. B. Warring (1887);[68] and W. H. Pickering (1907).[69] Indeed, du Toit considered such matters more "of interest to the historian than to the scientist," and devoted the rest of his chapter to an extended discussion of the theory's development in the 1910s and 1920s.

Little was said about Bacon, du Toit, or du Toit's list of continental drift theory precursors until after mid-century, when new data gathered from oceanographic explorations in the 1950s and 1960s, along with parallel developments in paleomagnetism, provided solid evidence that Wegener's previously-rejected theory had been correct. More scientists began to pay attention to Wegener's possible historical predecessors, in many cases relying on du Toit's list as a starting point, and the "search for the germ of the vital concept of continent drift" came to the fore in a way that it had

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[64]Richard Owen was professor of geology and chemistry at the University of Nashville, and wrote *Key to the Geology of the Globe*, published in 1857.

[65]Antonio Snider-Pelligrini (1802-1855) was a French geographer and scientist, who published in Paris in 1858 *La Création et ses Mystères Dévoilés* (*Creation and its Mysteries Unveiled*). He is frequently cited in more recent literature as a true forerunner to Wegener. To be discussed further below.

[66]A Swiss schoolteacher whose work Wegener cited, Heinrich Wettstein published in Zurich in 1880 *Die Strömungen der Festen, Flüssingen und Gasförmingen und ihre Bedeutung für Geologie, Astronomie, Klimatologie und Meteorologie*.

[67]Oswald Fisher, 1882. Untitled article in volume 25 of the journal *Nature*.

[68]Charles B. Warring, "The Evolution of Continents," *Transactions of the Vassar Brothers Institute and Its Scientific Section* (Poughkeepsie, NY), Vol. IV, Part II (1885-1887): 256-274.

[69]William Henry Pickering (1858-1938) was an American astronomer who followed in the footsteps of George Howard Darwin (1845-1912) and argued that the moon had originally been attached to the earth but broke off, leaving an oceanic gap in the earth's surface. Pickering advocated a connection between this dramatic event and continental drift, a view sustained by others into the first half of the twentieth century. William H. Pickering, "The Place of Origin of the Moon – The Volcani Problems," *Popular Astronomy* 15 (1907): 274-287.

not done previously.[70] Within this new context, both the research itself and the findings it produced were of a decidedly different texture from what du Toit had presented and also included considerably more detail and documentation. Writing during a time when Wegener's theory continued to provoke controversy, du Toit was understandably more concerned with discussing contemporary scientific matters than with exploring and proving historical precedent, something the content of his book reflects. Once Wegener's ideas began shifting into the mainstream, it became less necessary to defend the theory itself and instead provided an opportunity for scientists to consider in more detail whose proverbial shoulders Wegener might have stood upon.

The basic criteria for evaluating whether or not an individual demonstrated an understanding of ideas similar to Wegener's are the two components fundamental to continental drift theory: (1) the congruence of continents once joined in a single land mass; and (2) the separation and physical movement of individual continental units. Embedded within these criteria is the issue of identifying the mechanism or mechanisms for what caused the separation and also created the individual continents. In modern scientific theory, the answer to both issues is one-and-the-same. Relatively slow-moving "convection currents in the earth's mantle" are responsible for continental migration.[71]

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[70]du Toit, 11. The opening line of his chapter on the theory's history. No doubt following in du Toit's footsteps, see also the similarly titled article by Paul Tasch, "Search for the Germ of Wegener's Concept of Continental Drift," *Osiris* 11 (1954): 157-167.

[71]Naomi Oreskes, ed., *Plate Tectonics: An Insider's History of the Modern Theory of the Earth* (Cambridge, MA: Westview Press, 2001), 7. Oreskes says the "spirited and rigorous debate over the possible mechanisms of continental migration" following the introduction of Wegener's theory "ultimately

Before the twentieth century, however, the causal explanation was less clear cut and also more dramatic.

For centuries following the encounter with the Americas, two ancient stories heavily influenced the way Europeans discussed the new continents and how they came to be where they were: Plato's tale of Atlantis and the flood of Noah. Both stories had already been in circulation for at least two millennia by the time of Columbus, ensuring their solid entrenchment in the European imagination, whether or not everyone believed the veracity of either tale.

At the heart of both stories is enormous catastrophe. A significant portion of Plato's island of Atlantis and its inhabitants suffer extraordinary earthquakes and floods, then sink into oblivion, never to be heard from again. Similarly, Noah, his family, and enough creatures to fill a large vessel are the only survivors of a world-wide flood sent to destroy all living things. In both cases there is great drama, not only for the humans involved, but also for the earth itself. Earthquakes and/or floods powerful enough to obliterate large landmasses are indeed remarkable demonstrations of force, and provided ready-made explanations for Europeans seeking to explain the existence and placement of previously unknown continents such the Americas.

As fantastic as the stories of Atlantis and Noah's flood might be to a twentieth- or twenty-first-century scientist, there is no way to get around them if one is to go in search

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settled on the same explanation generally accepted today for plate tectonics: convection currents in the earth's mantle."

Even with a causal mechanism identified, one wonders about the moment when the mechanism began working to facilitate continental drift. In other words, at what point did convection currents actually start?

of precursors to Wegener's theory. In a 1954 article, for example, geologist Paul Tasch makes plain that one cannot "attempt to divorce [the question of continental drift] from historical antecedents fabulous or otherwise," and he demonstrates several historical links between Europeans' arrival to America, Plato's Atlantis, and the theory of continental drift.[72] Given the importance of the two stories to individuals in the centuries leading up to Wegener, scientists evaluating potential early iterations of the theory therefore tend to stay focused on a person's demonstrated understanding of the two basic criteria of continental drift, as well as on the kind of argument the individual uses to make his case.

In a number of instances, a closer examination of individuals said to have been early proponents of continental drift proved that those individuals' ideas did not in fact anticipate Wegener's. First to be critiqued was Francis Bacon, the seventeenth-century Englishman at the top of du Toit's list of Wegener's predecessors. In separate articles published in 1969 and 1970, geologists Albert V. Carozzi[73] and N. A. Rupke[74] each take

[72]Tasch, 158. Tasch was interested in topics beyond the hard sciences, as attested by the content of this article, which he published during his first teaching assignment after completing his Ph.D. in 1952. His obituary speaks to his intellectual diversity, and refers to him as a "scientist, scholar, philosopher, and historian." Daniel F. Merriam, "Memorial to Paul Tasch, 1910-2001," *Geological Society of America* Memorials 32 (2002): 23-25.

[73]Albert Victor Carozzi, Swiss-born geologist and mineralogist, is Emeritus Professor of Geology from the University of Illinois, where he taught from 1957 to 1989. He has published profusely. In addition to his own geological studies, such as Microscopic Sedimentary Petrography (New York: Wiley, 1960) and Carbonate Rock Depositional Models: A Microfacies Approach (Englewood Cliffs, NJ: Prentice-Hall, 1989), his translations of others' works from the seventeenth, eighteenth, and nineteenth centuries, as well as his studies of them, have contributed significantly to the history of geology. A few examples include: Benoît de Maillet (156-1738), *Telliamed; or, Conversations between an Indian Philosopher and a French Missionary on the diminution of the sea*, translated and edited by Albert V. Carozzi (Urbana: University of Illinois Press, 1968); Carozzi, *Histoire de Sciences de la terre entre 1790 et 1815 vue à travers les documents inédits de la Société de Physique et d'Histoire Naturelle de Genève: Trois grands protaganistes: Marc-Auguste Pictet, Guillaume-Antoine Deluc et Jean Tollot* (Geneva: Société de Physique et d'Histoire Naturelle de Genève, 1990); and Émile Argand (1879-1940), *Tectonics of Asia*, translated and

issue with Bacon as one of the first to note the complementarity between continents. [75] Both Carozzi and Rupke are clear to point out that what Bacon had noticed was not the continents' congruence, but rather their symmetry.[76] Bacon commented about how both

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edited by Albert V. Carozzi (New York: Hafner Press; London: Collier Macmillan, 1977); and Carozzi, *Horace-Bénédict de Saussure (1740-1799): Un pionnier des sciences de la Terre* (Geneva: Éditions Slatkine, 2005). Regarding the latter work, Carozzi is identified as a specialist on Saussure, and has published several other texts by or about him, including: *Manuscripts and Publications of Horace-Bénédict de Saussure on the Origin of Basalt (1772-1797)* (Geneva: Éditions Zoé, 2000), and, along with Gerda Bouvier, *The Scientific Library of Horace-Bénédict de Saussure (1797): Annotated Catalog of an 18th-Century Bibliographic and Historic Treasure* (Genève: Société de Physique et d'Histoire naturelle, 1994).

Carozzi's contributions to the history of geology also extend into the library arena. In 1984 he co-edited with Dederick C. Ward *Geology Emerging: A Catalogue Illustrating the History of Geology (1500-1850) from a Collection in the Library of the University of Illinois at Urbana-Champaign* (Urbana-Champaign, IL: University of Illinois Graduate School of Library and Information Science, 1984).

[74]The name N. A. Rupke applies to several scholars within the history of science. This N. A. Rupke was formerly of the Geological Institute of the State University of Groningen in The Netherlands, then at Princeton University's Department of Geological and Geophysical Sciences. In addition to the article discussed here, he is the author of only two other pieces: "Aspects of Bed Thickness in Some Eocene Turbidite Sequences, Spanish Pyrenees," *The Journal of Geology* 77 (1969): 482-484; and "Sedimentary Evidence for the Allochthonous Origin of *Stigmaria*, Carboniferous, Nova Scotia," *Geological Society of America Bulletin* 80 (1969): 2109-2114.

The second of Rupke's articles has been invoked by some creationists as scientific evidence for their belief in a young earth (i.e. thousands of years old versus the billions of years suggested by modern scientists). See, for example, Joe Deweese and Bert Thompson, "Polystrate Fossils and the Creation/Evolution Controversy," *Reason and Revelation* 20 (2000): 93-95.) A key element in the debate between creationists and scientists is whether the organic deposits which form coal did so because they accumulated in their native area for millions of years (*autochthonous*) or because they were from diverse regions and amassed in one place after having been brought there by flood conditions (*allochthononous*). Rupke's work offers evidence of the allochthonous position, at least in the small section of Nova Scotia he studied. Rupke himself is a creationist. See his essay "Prolegomena to a Study of Catacylsmal Sedimentation," in *Why Not Creation?*, ed. Walter E. Lammerts (Grand Rapids, MI: Baker Book House, 1970).

[75]Albert V. Carozzi, "A propos de l'origine de la théorie des dérives continentales: Francis Bacon (1620), François Plaçet (1668), A. von Humboldt (1801) and A. Snider (1858)," *Compte rendu de séances de la Société de physique et d'histoire naturelle de Genève* 4 (1969): 171-179; and N. A. Rupke, "Continental Drift before 1900," *Nature* 227 (1970): 349-350.

[76]The passage to which these and other scientists refer in talking about Bacon and continental drift comes from Book 2, Part XXVII of the *New Organon*, in which Bacon talks about "instances of resemblance or conformity" or "physical similarities." His discussion runs the gamut, from the similarities between the eye and a mirror to the roots and branches of plants, and from the scrotum in males and the womb in females, to the configurations of Africa and the region of Perú. Related to the latter, the brief passage is as follows: "These things aside, instances of resemblance should not be ignored in bigger matters, even in the actual

Africa and South America were more bulbous on top and narrower at the bottom, not how they might have fit together conjoined.[77] Bacon also noticed the resemblance between the parallel coasts of Africa and the region of Perú on the west coast of South America, not the coasts on opposite sides of the Atlantic. Further, he made no suggestion as to how or why the continents drifted apart. According to the two scientists, all of these factors clearly demonstrate that Bacon was not a forerunner of Wegener.[78]

Although Bacon's ideas about the continents may not reflect those found in a twentieth-century theory, he does take an approach to understanding the physical world that is worth noting. Bacon is the only possible precursor to Wegener not to invoke either the Atlantis tale or the biblical flood narrative in his writings. In the same work from which modern scholars extricate his views about the continents, Bacon is clear about where he stands with regard to America and Atlantis. He writes,

> But we rely on the evidence of things, and reject even the suspicion of fiction and imposture. We do not think it is any more relevant to the

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configuration of the earth; such as Africa and the Peruvian region with the coastline extending to the Strait of Magellan. For both regions have similar isthmuses and similar promontories, and that does not happen without a reason. Likewise, the New World and the Old World: in the fact that both worlds are immensely wide towards the North and narrow and pointed towards the South." Bacon, *The New Organon*, 147.

[77]Carozzi, 171-172; Rupke, 349.

[78]Most scientists agree with this assessment. That is not to say, however, Bacon was incorrect about what he did observe. Scientists' study of the mid-Atlantic ridge revealed an even more striking similarity both between and in-between the African and South American continents. As P. M. S. Blackett notes in 1965: "The last vestige of doubt that Francis Bacon was right when, over 300 years ago, he concluded that the similarity of the shapes of the two opposing coasts of the Atlantic could not be an accident, was removed when it was noted that the mid-Atlantic Ridge has the same shape as, and was equidistant from, both opposing coast lines." *A Symposium on Continental Drift*, ix.

> present subject whether the discoveries to come were once known to the ancients, and have been dying and recurring in the revolutions of things through the centuries, than it should matter to men whether the New World is the famous island Atlantis which the ancient world knew or a new land now discovered for the first time. For the discovery of things is to be taken from the light of nature, not recovered from the shadows of antiquity.[79]

For Bacon, ancient knowledge of any kind is irrelevant and not to be relied upon when learning new things about the physical world. One should take nature as it is and allow it to speak for itself, rather than interpret it in the context of what was previously known about it.

Bacon explores this idea more fully in a novel he published in Latin in 1624 and in English in 1627, which describes his utopian vision for a future in which human discovery and knowledge revolve around finding the new rather than recovering the old. Ironically, however, he chose to title this fictional work after a well-known ancient story, naming the book *New Atlantis*. For all of his emphasis on discovering things as they are, Bacon's choice of a title indicates his recognition of the importance of an existing knowledge base for understanding and appreciating something new. Practically speaking, he was no doubt counting on the possibility that familiarity with Plato's

[79] Francis Bacon, *The New Organon* (1620), eds. Lisa Jardine and Michael Silverthorne (Cambridge: Cambridge University Press, 2000), 94.

Atlantis might help the sales of his book, but Bacon's invocation of ancient knowledge communicates a more profound message. To borrow his terminology, "the light of nature" is perhaps better appreciated when seen against "the shadows of antiquity." Said another way, "the discovery of things" does not happen in a vacuum and is always contextual to one degree or another.

Scientists in search of "the germ" of continental drift theory are well aware of this reality. If they were to dismiss out-of-hand every individual who relied upon ancient knowledge in his exploration of ideas about the continents, then there would be no one for them to study. Instead, scientists identify individuals who express ideas akin to the theory of continental drift, then work to disentangle those ideas from any preconceived notions the individuals seem to have, as seen in the example of Ortelius. Such an endeavor is hard enough, but the fact that scientists bring their own set of assumptions to the process makes it even more difficult.

Returning to the case of Bacon and continental drift as an example, not all scientists draw the same conclusion about Bacon as do Carozzi and Rupke. In a new and fully revised edition of *Principles of Geology*, which was published several years before Carozzi's and Rupke's articles, esteemed British geologist Arthur Holmes credits Bacon with having been "sufficiently impressed by the parallelism of the opposing shores of the Atlantic to speculate as to its meaning."[80] Appearing the same year as Holmes' book were the published papers from a symposium on continental drift hosted by The Royal

[80]Holmes, 1197.

Society in London in 1964. In the introduction to the collection, P. M. S. Blackett, an experimental physicist and one of the organizers of the symposium, considers Bacon to have been vindicated by recent scientific discoveries. Blackett declares: "The last vestige of doubt that Francis Bacon was right when, over 300 years ago, he concluded that the similarity of the shapes of the two opposing coasts of the Atlantic could not be an accident, was removed when it was noted that the mid-Atlantic Ridge has the same shape as, and was equidistant from, both opposing coast lines."[81] Writing more than a decade after Carozzi and Rupke, mineralogist A. C. Bishop continued to perpetuate the notion that Bacon had recognized the continental symmetry across the Atlantic by noting, "the configuration of the opposing coasts of the Atlantic were sufficiently well known for Bacon (1620) to comment on the similarity of the coastlines of Africa and South America."[82] All of these examples demonstrate a bias towards a particular interpretation of Bacon's ideas, one that reflects more the twentieth-century scientists' understanding of continents rather than Bacon's. Although there is disagreement between the two camps of scientists about Bacon's place in the lineage of continental drift theory, both camps make the similar black-and-white assumption that how they define continent drift will either be present on Bacon's writings, or not. There is no middle ground.

Such an approach is paradoxical. By definition, scientific theories must evolve and change as they account for and incorporate the newest data available, which implies

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[81] *A Symposium on Continental Drift*, ix.

[82] A. C. Bishop, "The development of the concept of continental drift," in *The Evolving Earth*, ed. L. R. M. Cocks (Cambridge: British Museum of Natural History and Cambridge University Press, 1981), 155.

that no theory is ever fixed, but is always open to being modified or supplanted. At the same time, the rigorous process through which scientific theories must go to gain acceptance, and the protracted controversies sometimes involved in that process, demonstrate the reluctance with which scientists relinquish attachment to their theories. Looking back into the annals of history, either to refute or to find evidence for the "germ" of continental drift theory or any other theory, serves a particular agenda in the present. Du Toit invoked Bacon as a precursor to Wegener during a controversial time when evidence to support the validity of continental drift theory was most needed. Once the theory was generally accepted within the scientific community, scientists were free to look back with a more critical eye and evaluate whether or not Bacon had demonstrated an understanding of continental drift. Carozzi's and Rupke's conclusion that Bacon had not anticipated any aspect of the theory offered an implicit validation of the unique character of the theory's current iteration, while other scientists' contention that Bacon's ideas resembled continental drift further authenticated the theory's efficacy. Given this divergence of opinion and the impermanence of scientific theories, one wonders what long-term value there is in such an exercise.

Indeed, it was not long before the theory of continental drift was replaced by a new theory that is still in vogue, the theory of plate tectonics. Although continental drift theory laid the foundation for an understanding of plate tectonics, it was the study of earthquakes, which happen in more places than just along continental boundaries, which helped scientists make the intellectual leap to the broader theory of plate tectonics.

According to plate tectonic theory, earthquakes result from the shifting of giant, movable, and puzzle-like plates which make up the surface of the earth. Only readily accepted since the 1970s, plate tectonics is a fairly young theory, especially when considered within the context of millennia of theories that have come and gone since people first started formulating their understanding of earthquakes in this way. Yet, the average person is often surprised to find out how new the theory is; the fervor with which people have been indoctrinated into accepting it has created an aura of permanence about it.

Despite its relative youth, the theory of plate tectonics holds a place of profound significance, and for more reasons than because it reflects the current scientific view. To begin with, it is a global theory, that is, it takes into account the physical make-up of the entire earth, not just certain parts of it. In the current climate of the World-Wide Web, hand-held Global Positioning System (GPS) devices, and airline partnerships that allow travelers to fly virtually anywhere in the world, a global theory may seem an obvious creation, but even the global luxuries of the twenty-first century have only become available within the last few decades. It is easy to forget that what one considers global has evolved as new information became available, much like scientific theories. Before 1492, a European understanding of the geographical world included only the three continents of Europe, Asia, and Africa. Not only Europeans but also peoples in other parts of the world did not have confirmed knowledge of the existence of the major continents before the fifteenth century, making Columbus' encounter with the New World the first time in recorded history that a global theory became possible.

The significance of plate tectonic theory also lies in its being "the first global theory ever to be generally accepted in the entire history of earth science."[83] In addition to the theory itself encompassing the entire globe, its general acceptance is also global. Within the scientific community, seismologists from virtually every continent use plate tectonics in their study of earthquakes, a noteworthy detail given the scrutiny that scientific theories must undergo to gain acceptance. Plate tectonic theory is also remarkable when considered within the history of earth science. If one uses the traditional timeline espoused by most scientists that earth science began no earlier than the mid-eighteenth century, then one is struck by the incongruence between the relatively short period within which plate tectonic theory was adopted and the profundity of the theory itself.

The incongruence is even more striking, given that the possibility of a global theory existed for at least 250 years before earth science is said to have first developed. During those 250 years—in other words, from the time of Columbus until the mid-eighteenth century—Europeans, especially Spaniards, explored, studied, and mapped the New World, acquiring foundational data about a previously unknown part of the globe. That knowledge base made possible all later discussions about the earth as a physical unit. Moreover, Europeans' opening of passageways to the American continents helped facilitate the migration of peoples and knowledge around the globe from the fifteenth century into the present. Considering this broader context, the global theory of plate

[83]Oreskes, ed., *Plate Tectonics*, xvi.

tectonics and its general acceptance in very recent times are noteworthy indeed, having been in the making for more than four-and-a-half centuries.

It is important to remember, however, that plate tectonic theory is as subject to being revised or superseded as any other scientific theory. Even Isaac Newton's laws of gravity, which were highly revered and remained steadfast for two centuries, did not escape this fate. Every scientific theory, plate tectonics included, represents a boundary of knowledge about the physical world that is destined to be crossed. There is always more to be learned and understood, and sometimes in worldview-altering ways, as Europeans found out after 1492. One can only hope that when the next major intellectual earthquake strikes, the first scientists on the proverbial scene will respond with flexibility, creativity, and innovation similar to what the Spaniards practiced in their physical investigation of the Americas in the sixteenth century. That unpredictable, though inevitable, future historical moment will perhaps be better confronted by incorporating now one of the lessons learned from the Spaniards, that detailed and valuable knowledge about the physical world, firsthand experience in particular, can be gathered from a variety of individual sources, if one is open to the possibility. Not only physical earthquakes, but also intellectual ones are regular and not-so-gentle reminders of the limits of knowledge and scientific enterprise.

CHAPTER 4

Deep Seismic Events and Views of Spain's Earthshaking Empire

One of the great ironies of scientific theories is that they present a view of the world that is both stable and predictable, while they themselves are neither completely stable nor always predictable. They will, by definition, eventually be modified or replaced, and there are always exceptions to the rule. This instability and unpredictability becomes most apparent in the face of physical phenomena like earthquakes, which continue to defy human understanding. From the perspective of the physical world, earthquakes likely operate as they ought. Their failure to align with a particular type of explanatory model like a scientific theory is not a matter of defiance, but rather is an indicator of the deficiency of the model. The global theory of plate tectonics accounts for much of what is known about earthquakes, but it does not explain everything. Falling outside its purview, for example, are the New Madrid earthquakes of 1811-1812, which did not occur along a plate boundary but instead shook the interior of the North American continent.[1] Accounting for exceptions like the New Madrid earthquakes is one of the greatest challenges of science. Indeed, one could argue that these exceptions are what provide fuel for further scientific research.

[1]See, for example: Arch C. Johnston and Eugene S. Schweig, "The Enigma of the New Madrid Earthquakes of 1811-1812," *Annual Review of Earth and Planetary Sciences* 24 (1996), 339-384; and Susan E. Hough, "Scientific Overview and Historical Context of the 1811-1812 New Madrid Earthquake Sequence," *Annals of Geophysics* 47 (2004): 523-537.

An avenue of earthquake research ignored by many scientists and little known to the general population is the study of deep earthquakes, which make up approximately one-quarter of all instrumentally-recorded earthquakes.[2] Most simply defined, deep earthquakes are those with a focal depth of greater than 60 km below the surface of the earth. Two sub-groups of deep earthquakes are those that occur at intermediate depths of between 60 km and 300 km, and deep-focus earthquakes, whose depths extend 300 km and greater.[3] As a point of contrast, almost all of the earthquakes occurring in the highly seismic region of California occur at shallow depths of between 5 and 15 km,[4] while the

[2]Although scientists have been studying deep earthquakes since the 1920s, the first full-length monograph on the subject was not published until 2006: Cliff Frohlich, *Deep Earthquakes* (Cambridge: Cambridge University Press, 2006). Frohlich, a seismologist, senior research scientist, and associate director at The University of Texas Institute of Geophysics, is the ideal scientist to author such a book, as he has "maintained a steadfast and passionate interest in deep earthquakes" for over three decades (xiii). Alhough technical in many places, particularly the middle chapters about the properties and mechanisms of deep earthquake, *Deep Earthquakes* is nevertheless accessible, as Frohlich communicates his substantial knowledge about and research on the subject in a conversational tone. Individual bibliographies included at the end of each chapter capture well the state of the field of deep earthquake research. A comprehensive bibliography, a more complete index, and a glossary of terms would have been helpful.

Frohlich calls attention to scientists' continued indifference about deep earthquakes, see section 2.6, "Previous reviews of deep earthquake literature, pp. 47-49, and section 9.2.3, "Deep earthquakes and the history of science," pp. 357-361. For a quick overview of the institutions that are engaged in deep earthquake research, see section 9.2.2, "Who studies deep earthquakes, and why?", pp. 352-357.

[3]There continues to be some disagreement among scientists as to whether the cut-off between deep and shallow earthquakes is 60 km or 70 km, and whether the designation "deep" refers to all earthquakes occurring below 60/70 km or only to those with a focal point greater than 300 km, in which case all earthquakes between 60/70 km and 300 km are considered "intermediate depth." Frohlich is careful to specify his nomenclature, which is followed here. See section 2.1, "What are deep-focus and intermediate-focus earthquakes?" for his discussion of these matters, pp. 30-34.

[4]Frohlich, 38. Interestingly, the authors of a recent article on "California earthquake history" do not address focal depth at all. Tousson Toppozada and David Branum, "California earthquake history," *Annals of Geophysics* 47 (2004): 509-522.

five deep earthquakes that have struck Fiji since 1932 had focal depths between 436 km and 699 km.[5]

Depth, however, is only one of four observational and mechanical features that distinguish deep earthquakes from shallow ones.[6] Deep earthquakes generate waves on seismograms distinct from those produced by shallow quakes, a characteristic first noticed in 1925 by Kiyoo Wadati, a young Japanese physicist whose observation prompted him to investigate the phenomenon further.[7] Many deep earthquakes also "generate far fewer aftershocks" than shallow ones, even when their magnitudes exceed

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[5]Ibid., 5. See Table 1.2.

[6]This paragraph follows Frohlich's section 2.3, "How are deep and shallow earthquakes different?", pp. 36-38.

[7]Wadati is one of the founders of deep earthquake research. Wadati is credited, along with Hugo Benioff, for identifying the deep active seismic areas near subduction zones, now known as Wadati-Benioff zones. Wadati's first article, "Existence and study of deep earthquakes," was written in Japanese, and so was accessible only to a small portion of the scientific community. However, his 1928 paper "Shallow and deep earthquakes," was published in English and remains a classic in the field. Wadati, "Existence and study of deep earthquakes (in Japanese)," *Journal of the Meteorological Society of Japan*, Series 2, 5 (1927): 119-145; "Shallow and deep earthquakes," *Geophysical Magazine* 1 (1928): 161-202. Wadati continued his work through the 1930s, but his studies on deep earthquakes, along with those of other Japanese scientists, were stunted until after World War II and its aftermath. Wadati gives a wonderful personal account of his career and researches in, Kiyoo Wadati, "Born in a Country of Earthquakes," *Annual Review of the Earth Planetary Sciences* 17 (1989): 1-12. Frohlich evaluates Wadati's contributions to the general field of geophysics, as well as to the more specific study of deep earthquakes in: "Kiyoo Wadait and early research on deep focus earthquakes: introduction to the special section on deep and intermediate focus earthquakes," *Journal of Geophysical Research* 92 (1987): 13,777-13,788, an article that was reprinted in *History of Geophysics* 4 (1990): 166-177.

Scientists had long credited the British seismologist H. H. Turner for having "discovered" deep earthquakes. See, H. H. Turner, "On the arrival of earthquake waves at the antipodes, and on the measurement of the focal depth of an earthquake," *Monthly Notices of the Royal Astronomical Society, Geophysial Supplement* 1 (1922): 1-13. However, Frohlich considers the deep earthquake aspects of Turner's otherwise significant 1922 paper "high-focus hocus pocus." Frohlich, 55-56. In his discussion of Turner, Frohlich notes the Monthly Notices' Geophysical Supplement eventually became the highly respected *Geophysical Journal International*.

7.5.[8] Finally, "one remarkable feature of deep earthquakes is that they appear to occur at temperatures" and pressures so high as to make impossible the ordinary fracturing of rocks, as happens with earthquakes occurring at lower temperatures in shallower depths.[9] This latter point is especially noteworthy because it calls into question the mechanism by which the majority of earthquakes are understood to operate. Even after almost a century of research, scientists still do not know how deep earthquakes work. Applying "Occam's Razor" that the most simple explanation is usually the correct one, scientists assume that the operations of all types of earthquakes are the same. However, the marked difference between the environment of high temperature and extreme pressure in which deep earthquakes function, in comparison to the lower pressure, rock-breaking conditions of shallow earthquakes has so far kept the answer to the riddle of earthquakes' mechanism out of reach.

In the first book exclusively devoted to deep earthquakes, which was published in 2006, seismologist Cliff Frohlich unconsciously introduces a potentially fruitful area of future earthquake research.[10] Frohlich opens with a chapter entitled "The big, the bad, and the curious," so named for three categories of twentieth-century case studies he chose to illustrate the complex and exceptional nature of deep earthquakes. The three types of deep earthquakes are represented by a total of four individual events: "the big" is the

[8]Scientists do not agree about what defines an aftershock, an issue Frohlich addresses briefly in his short discussion of deep earthquakes and aftershocks, pp. 162-172.

[9]Frohlich, 36-38.

[10]Frohlich, op. cit.

earthquake that struck Bolivia on 9 June 1994; "the bad" includes the earthquakes of 4 March 1977 in Romania and of 25 January 1939 in Chile; and "the curious" is the Spanish deep earthquake of 29 March 1954. Perhaps geographically unremarkable to a twenty-first century conception of political boundaries and nation-states, this list is striking if the historical point-of-view is reframed. Had they happened during the sixteenth, seventeenth, or eighteenth centuries, three of the four earthquake events that Frohlich selects – Bolivia, Chile, and Spain – would have occurred within the domain of the Spanish Empire.

This seeming coincidence appears less-so when one considers how much of Spain's extensive empire was frequented by large and destructive earthquakes: for example, the Americas, numerous islands in the Caribbean, the Philippines, and parts of Italy. The geographical extent of Spain's territories across many seismic regions of the globe characterizes the Spanish Empire as an earthshaking one. This geopolitical configuration is unusual, indeed "curious," to borrow Frohlich's term, and it suggests the existence of a particular culture, a culture of earthquakes. Somehow linked to this culture is the Black Legend, the perception of all things Spanish as wicked and corrupt. Although a precise connection between the Black Legend and Spain's earthshaking empire remains elusive, Spain's detailed and well documented administration of so many earthquake-prone areas presents an extraordinarily rich research opportunity for scholars and scientists interested in earthquakes. The unconventional, earthshaking framework of the Spanish Empire serves both to challenge and to broaden traditional ways of thinking

about the historical study of earthquakes, much as deep earthquake research is doing within the earth sciences. An exploration of these issues begins with Frohlich's twentieth-century case studies.

Frohlich begins with "the big" earthquake of 9 June 1994 in Bolivia.[11] With a focal depth of 647 km and a magnitude of 8.2, this earthquake was indeed big. "When it occurred it was the largest earthquake of any depth the world experienced in the 17 years since the Sumbawa earthquake of 1977," and "it is also the largest earthquakes ever recorded with a focal depth greater than 300 km."[12] Despite its enormous size, the earthquake inflicted only minor damage relative to what one might expect. There were broken windows and some structural damage in towns within about a 500 km radius of the epicenter, as well as four deaths and numerous injuries in southern Perú resulting from landslides triggered by the quake.[13] Such results were not inconsequential, but they are certainly remarkable for their relative leniency. These reasons alone would have

[11]Frohlich neglects to note that just three days earlier, a shallow earthquake of 10 km and a 6.0 magnitude struck Colombia, triggering a landslide that destroyed the small town of Paez and killed 1,100 people. Eclipsed by the scientific interest in the 1994 Bolivia earthquake, the Columbia event has attracted little scholarly attention. One article in which it is briefly discussed is: Cristina Dimaté, Luis Rivera, and Armando Cisternas, "Re-visiting large historical earthquakes in the Colombian Eastern Cordillera," *Journal of Seismology* 9 (2005): 1-22.

[12]Frohlich, 4. The Sumbawa (Indonesia) earthquake occurred 19 August 1977. That 8.3 magnitude quake, which was also felt in Australia, generated a tsunami. According to a recent article in the *Bulletin of the Seismological Society of America*, "The combined number of victims from both the earthquake and tsunami in Indonesia was 107 people." Aditya R. Gusman, Yuichiro Tanioka, Hiroyuki Matsumoto, and Sin-Iti Iwasaki, "Analysis of the Tsunami Generated by the Great 1977 Sumba Earthquake that Occurred in Indonesia," *Bulletin of the Seismological Society of America*99 (2009): 2169-2179.

[13]Ibid.

given scientists pause, but this earthquake did not "follow the textbook pattern."[14] There were two other aspects of the 1994 Bolivia quake that sent scientists scurrying for answers.[15]

First, in addition to the tremors experienced across South America, the 1994 earthquake was felt in North American cities as far away as Minneapolis. 'Felt reports' of such distances from an earthquake's epicenter are typical for very large shallow earthquakes, such as the 28 March 1964 quake in Alaska, but not so for deep earthquakes. In fact, "the 1994 Bolivia earthquake is the only earthquake event of 300 km or greater to generate felt reports at such distances."[16] After studying the time delays between the earthquake's initial rupture and the recording of felt reports elsewhere, scientists deduced that it was not the earthquake's secondary surface (S) waves that traveled so far from the quake's epicenter, as is the case with shallow earthquakes, but rather its higher velocity primary (P) waves, which were generated from the earthquake's great focal depth.[17] In this way, the 1994 Bolivia earthquake challenges long-held assumptions not only about how earthquakes operate, but also about how felt reports are understood. Rather than reflecting a shallow earthquake occurring within a short-term radius, historical reports of

[14]Richard A. Kerr, "Bolivian Quake Deepens a Mystery," *Science* 264 (1994): 1659.

[15]As articulated by Frohlich, 4-7.

[16]Ibid., 5.

[17]Ibid., 5-7.

earth-shaking may tell, for example, of a deep earthquake event originating at a great distance.

The second "peculiar feature of the Bolivian earthquake was its location beneath a part of South America where few deep-focus earthquakes had occurred previously."[18] In particular, Frohlich notes, this earthquake "lies within a distinct gap" between two deep earthquake regions of South America.[19] Even with recorded data of the earthquake's 89 aftershocks, which occurred over a period of 20 days, scientists have yet to come up with a satisfactory model that explains what took place at 647 km below Bolivia, and research efforts continue. As Frohlich points out, "more research papers have been published concerning the 1994 Bolivia earthquake than any other deep earthquake, ever."[20]

The "big" earthquake in Bolivia may have caused little damage and minimal loss of life, but the "bad" earthquakes of 4 March 1977 in Romania and of 25 January 1939 in Chile were deadly. The magnitude of the Romanian earthquake was 7.5, while that in Chile was calculated to be around 7.8, and both earthquakes were at an intermediate depth of approximately 80 to 100 km. Despite their similarity in size, the damage inflicted by each earthquake was quantitatively different. The earthquake in Romania "killed more than 1,500 people, mostly in the city of Bucharest . . . about 150 km south of the epicenter," left around 200,000 people homeless, and "destroyed or seriously

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[18]Ibid., 7.

[19]Ibid.

[20]Ibid., 12.

damaged some 33,000 housing units," as well as almost 400 schools, a dozen hospitals, and one orphanage.[21] The earthquake in Chile, by contrast, killed 28,000 people and razed hundreds of blocks of buildings in the city of Chillán, in addition to reported casualties and damage "in numerous towns and cities within a region that extended about 200 km along the Chilean coast."[22] Frohlich presents the examples of Romania and Chile together because the severe hazard of intermediate-depth earthquakes in Romania are well known, well documented, and well studied, while most scientists are much less aware of the much-deadlier intermediate-depth earthquakes in Chile. If Frohlich is correct that the 1939 Chilean earthquake is "the most deadly earthquake of any depth in Chilean history,"[23] "the most deadly deep earthquake anywhere,"[24] and "the second most deadly earthquake in South America in the twentieth century,"[25] then it would seem that earthquakes in Chile should merit more attention from scientists.

Not only Chile, but South America more generally, invites interest from researchers of deep earthquakes. In their study and extensive monitoring of deep earthquakes over the past one hundred years, scientists have discerned twenty-seven

[21]Ibid., 13.

[22]Ibid., 19.

[23]Ibid., 493.

[24]Ibid.

[25]Ibid., 18.

regions on the globe in which deep earthquakes routinely occur.[26] These regions are identified geographically rather than politically, though national boundaries also apply in several instances. Following an eastward trail that begins in the southeastern Pacific Ocean, travels around the globe, and ends in the Indian Ocean, the twenty-seven deep earthquake regions with their own distinct characteristics are: (1) the Hjort Trench, an oceanic trench southwest of New Zealand; (2) New Zealand; (3) the Tonga-Kermadec Subduction Zone, where the Pacific Plate and Indo-Australian Plates converge; (4) the Vitiaz Cluster and South Fiji Basin, which is adjacent to Tonga-Kermadec; (5) the nation of Vanuatu, a series of islands known as the New Hebrides in colonial times; (6) the band of islands stretching from New Guinea to the Solomon Islands; (7) Indonesia; (8) the Philippines; (9) the Ryukyu Islands (Japan) and Taiwan (China); (10) the 3000 kilometer-long archipelago of Mariana-Bonin, known as the Izu-Bonin-Mariana Arc system; (11) Japan; (12) the Kuril Islands (Russia) and neighboring Hokkaido Island (Japan); (13) Alaska and the Aleutian Islands; (14) Western North America; (15) Central America, extending from southern Mexico to Costa Rica; (16) the Caribbean; (17) the region comprising Colombia, Venezuela, and the isthmus of Panamá; (18) South America, primarily the western region along the Andes Mountains; (19) the South Shetland Islands, off the coast of Antarctica; (20) the Scotia Arc, including the South Sandwich Islands, which are southeast of the tip of South America; (21) southern Spain and northern Africa; (22) Italy and the Tyrrhenian Sea; (23) Greece and Turkey; (24) the region of Vrancea in

[26]There are twenty-eight regions if one counts the category "Other," which Frohlich includes as a catch-all for small or rare occurrences outside of the twenty-seven explicitly named zones.

Romania, located at the meeting place of the Southern and Eastern Carpathian Mountains; (25) the Middle East, more precisely identified by deep earthquake activity in southeastern Iran/western Pakistan and beneath the Central Caspian Sea; (26) the Pamir-Hindu Kush mountain ranges in Central Asia; and (27) Burma, also known as the Union of Myanmar.[27] Of these twenty-seven regions, the Tonga-Kermadec Subduction Zone experiences more deep earthquakes than any other region, and "there are more deep-focus earthquakes here than in all the remaining regions combined."[28] However, "a remarkable feature of South America is that it possesses a disproportionate fraction of the world's large very deep earthquakes."[29] According to data acquired over the past one hundred years, South America lays claim to the world's three largest deep-focus earthquakes – Bolivia, 1994; Colombia, 1970; and northern Perú, 1922 – as well as four of the remaining top eighteen largest, all of which occurred along the border of Perú and Bolivia in August 1963, November 1963, 1961, and 1958.[30] As Frohlich notes, "why such large earthquakes occur here and not elsewhere is a significant question," one without an obvious answer.[31] He asks, "What then, is special about South America?"[32]

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[27]One of the most useful aspects of Frohlich's book is chapter 10, "A geographic summary of deep earthquakes," which has twenty-nine separate sections each with a short discussion and individual bibliography of the twenty-seven deep earthquake regions named here, the "Other" category, and "Deep moonquakes."

[28]Frohlich, 384.

[29]Ibid., 4.

[30]Ibid.

[31]Ibid.

A similar question about South America was posed by Europeans in the New World in the sixteenth, seventeenth, and eighteenth centuries, although their query was framed in geographical terms understood during the period. Following the arrival of Spaniards in the Americas, the Spanish crown established two colonial administrative districts, known as "Viceroyalties," to make easier the governing of its faraway lands. Founded in 1535, the first of these was the Viceroyalty of New Spain, whose capital was Mexico City and whose jurisdiction eventually encompassed what is modern-day Mexico, Central America excluding Panamá, Florida, parts of Texas and New Mexico, and California, and also extended to Spanish holdings in the Pacific, including the Philippines, the Mariana Islands, and parts of Taiwan. Seven years later, in 1542, the Viceroyalty of Perú was established with Lima as its capital in order to manage Spanish holdings in South America. On paper, all of South America except Brazil belonged to the Spanish crown, but the challenges of terrain prevented expansion into some of this territory, and the growing responsibilities of an ever-increasing empire made impossible effective governance of remote regions in which Spaniards achieved only a toe-hold, such as Paraguay. Thus, the functional geographical domain of the Viceroyalty of Perú comprised the Isthmus of Panamá; the west coast of South America from Colombia to Chile; and portions of the continent's interior, including Bolivia and Argentina. For ease of management, this large region was further divided into smaller administrative units called *audiencias*, sometimes translated as "kingdoms," such as those of Chile and Quito.

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[32]Ibid.

When Europeans during the early modern period wondered about the unusual region of South America, they used terminology defined by this Spanish administrative organization.

An early reference to the strangeness of South America, in particular the region of Perú as distinct from the other audiencias, was made by the sixteenth-century Spaniard José de Acosta. In his *Historia*, Acosta declares, "This piece of the world called Perú is most worthy of study because it has very strange properties and is almost the exception to the general rule among the lands of the Indies."[33] Acosta attributes his five "strange properties" to Perú's exceedingly variegated terrain, "which is divided into three long and narrow zones...the plains are on the seacoast; the sierras are all inclines, with some valleys; and the Andes are extremely high peaks."[34] Acosta begins his discussion by discussing the property of wind. Unlike other regions in the Torrid Zone, which experience multiple winds, most notably ones blowing from the north, the coast of Perú experiences only one wind, and it comes from the south or southwest. Second, Acosta considers the typically stormy and troublesome south wind to be "wonderfully gentle, health giving, and pleasant" on the Peruvian coast, in part because it makes bearable the extreme heat there. Third, Acosta notes how remarkable it is that there is never rain, thunder, sleet, or snow along the entire coast of Perú. Fourth, although there may never be precipitation on the coast, just a short distance away, Acosta marvels, "it snows and

[33]José de Acosta, *Historia Natural y Moral de las Indias, en que se tratan de las cosas notables del dielo, y elementos, metales, plantas, y animales dellas: Y los ritos, y ceremonias, leyes, y gobierno de los Indios, compuesto por el Padre Joseph de Acosta* (1590), Book III, chapter 20.

[34]Acosta, Book III, chapter 20.

storms terribly." This stark difference in conditions Acosta makes explicit in the last item on his short list of Perú's strange properties by comparing the "two mountain ranges [that] run alongside each other and at the same distance from the pole." Despite their close proximity, these ranges differ markedly. While on "one there are many trees and it rains most of the year and . . . is very hot, the other, on the contrary, is barren and very cold and the year is divided between winter and summer into a rainy season and a calm season."[35]

The calm and dry weather experienced along the Peruvian coast is balanced out, Acosta declares, by the frequent earthquakes there.[36] "For," he says, "although on the

[35]Ibid. Many of these unusual characteristics of Perú described by Acosta, in particular the absence of rain on the coast, are reiterated well into the eighteenth century by European writers who had either visited South America firsthand or heard similar stories from others. A classic example is the report of Frenchman Amédée-François Frézier, who traveled throughout South America from 1712 to 1713. In the *Relation* of his trip, which was first published in French in 1714, and in English three years later, Frézier wonders about Perú, "[How is it] that it never rains along the Coast, tho' it rains 15 or 20 Leagues from the Sea, up the Country?" Quotation taken from English edition, but verified against 1716 French version, with page citations provided for both. Frézier, *Relation du Voyage de la Mer du Sud aux Côtes du Chily et du Perou, Fait pendant les années 1712, 1713 & 1714, Dediée à S. A. R. Monseigneur Le Duc D'Orleans, Regen du Royaume. Par M. Frezier, Ingenieur Ordinaire du Roy. Ouvrage enrichi de quantité de Planches en Taille-douce*. (A Paris, Chez: Jean-Geoffroy Nyon, Quay de Conti, au coin de la rue Guenegaud, au Nom de Jesus. Etienne Ganeau, rue Saint Jacques, aux Armes de Dombes, vis-à-vis la Fontaine de S. Severin. Jacque Quillau, Imprimeur-Juré-Libraire, rue Galande, aux Armes de l'Université, 1716), 191; *A Voyage to the South-Sea, And along the Coasts of Chili and Perú, In the Years 1712, 1713, and 1714. Particularly describing The Genius and Constitution of the Inhabitants, as well Indians as Spaniards: Their Customs and Manners; their Natural History, Mines, Commodities, Traffick with Europe, &c. By Monsieur Frezier, Engineer in Ordinary to the French King. Illustrated with 37 Copper-Cutts of the Coasts, Harbours, Cities, Plants, and other Curiosities: Printed from the Author's Original Plates, inserted in the Paris Edition. With a Postscript by Dr. Edmund Hally, Savilian Professor of Geometry in the University of Oxford. And an Account of the Settlement, Commerce, and Riches of the Jesuites in Paraguay* (London: Printed for Jonah Bowyer, at the Rose in Ludgate-street, 1717), 214.

[36]Interestingly, in 1989 the noted Japanese seismologist Kiyoo Wadati said something similar about his home country: "My country, Japan, is favored with a mild climate and with sufficient precipitation. We enjoy this gift of nature heartily, even though we also suffer from violent natural phenomena: earthquakes, typhoons, and volcanic eruptions. I was born in 1902 in Nagoya, during a raging typhoon. I think I was fortunate to have been born in this wonderful country that exhibits such a wide range of natural

plains of Perú they do not suffer the persecution of the heavens in the form of thunder and lightning, yet they are not without fear from the earth."[37] Indeed, Acosta points out how earthquake-prone coastal lands like Perú seem to be, and includes a list of several earthquakes that struck different places along the South American coast in the 1580s. Acosta in fact considers these earthquakes to have occurred as a sequence, noting: "In Perú it has been a remarkable thing, and worthy of notice, that from Chile to Quito, a distance of more than 500 leagues, earthquakes have occurred in a series (I mean the large and famous ones, for there have been lesser tremors)."[38] Even without seismograms or an understanding of deep earthquakes, Acosta was very aware of the distinctiveness of earthquakes in Perú and its neighboring regions.

Of all the South American cities shaken by earthquakes in the centuries following Spaniards' arrival there, none probably received more attention than Lima, the Viceroyalty of Perú's capital. As the primary seat of Spanish governance in South America, Lima's welfare was certainly a matter of concern whenever an earthquake struck, and tremors of all sizes were felt frequently. Acosta mentions a large earthquake that occurred in Lima on 9 July 1586, an event which he describes as follows:

> [A]ccording to the viceroy's report [the earthquake] had run in length 170 leagues along the coast and in breadth 50 leagues into the sierra. By the

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phenomena." Kiyoo Wadati, "Born in a Country of Earthquakes," *Annual Review of Earth and Planetary Sciences* 17 (1989), 1.

[37]Acosta, Book III, chapter 26.

[38]Ibid.

> great mercy of the Lord, in this earthquake the people were alerted by a loud noise, which they heard a short time before the tremor, and since in those parts they are forewarned by experience they quickly saved themselves by going out to the streets or squares or fields, in a word, out of doors. And so, although it devastated that city and demolished or badly damaged the principal buildings, they say that among its inhabitants only some fourteen to twenty persons died. Also at the same time the sea made the same movement as [what followed another earthquake] in Chile, which was shortly after the tremor was over; it rushed furiously away from the beaches and then swept inland for almost 2 leagues, for it rose more than 14 fathoms and covered that whole coastal region with the beams and lumber that were floating in the water there.[39]

This earthquake in Lima has gone largely unnoticed by scholars, but one that happened a century later has received more attention.

On 20 October 1687 at just past 4:15 in the morning, an earthquake shook Lima. According to modern author Domingo Angulo, "The earth began to vibrate so violently that it was almost impossible to maintain one's footing. The intensity of the phenomenon grew by the minute, and darkness contributed to the terror because the meager light of the

[39]Ibid.

dawn was almost dissipated by the dense clouds of dust raised by the falling buildings."[40] The tremors continued intermittently for over an hour, when a larger quake, estimated to have had a magnitude of 8.2, struck at 5:30 AM.[41] Aftershocks persisted until around 6:30 AM.[42] Not surprisingly, the effects were devastating. The city of Lima was destroyed and virtually no buildings were left standing, forcing citizens and government officials alike to live in canvas shelters in the plaza and other places in the city.[43] Numerous people died, including hundreds of victims of a tsunami that followed the second earthquake and flooded the nearby port city of Callao.[44] An official body count

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[40]Domingo Angulo, "La Metropolitana de la Ciudad de los Reyes, 1535-1825," in *Monografias historicas sobre la Ciudad de Lima*, vol 2 (Lima: Librería e imprenta Gil, s.a., 1935), 65-66: "cuando comenzó a trepidar la tierra tan violentamente, que casi era imposible mantenerse en pie: crecía por momentos la intensidad del fenómeno, y la oscuridad contribuía a propagar el terror, porque la escasa luz del alba casi se diluía entre las densas nubes de polva que la caída de los edificios iba levantando."

[41]Enrique Silgado Ferro, "Historia de los sismos más notables ocurridos en el Perú (1513-1974)," published in *Bulletin No. 3, Serie C. Geodinámica e Ingeniería Geológica* (Lima: Instituto de Geología y Minería, Enero 1978), 25 and 127. Silgado notes on page 127 regarding estimating magnitude strength before the existence of seismic instruments, "la magnitud instrumental, un concepto que se utiliza hoy en día para determinar el tamaño o grando de un terremoto lo establece en base de las relaciones empíricas que ha encontrado entre la magnitud, intensidad y extensión areal de los sismos ocurridos en el Perú durante los últimtos treinticinco años."

There is also an unpublished English translation available of Silgado's work: "History of the Most Noteworthy Earthquakes in Perú (1513-1970)," translated for the U. S. Geological Survey by Dorothy B. Vitaliano (Reston, VA: U. S. Geological Survey, 1978, typed and bound manuscript). However, care must be taken when using the English version, because it is neither a complete nor an accurate translation. The translation must be checked against the original Spanish text to ensure correct data.

[42]Angulo, footnote 149, page 65.

[43]Cited by Maria Antonia Durán Montero in *Lima en el siglo XVII. Arquitectura, urbanismo, y vida cotidiana* (Sevilla, 1994), 40. From the "Relación del temblor de Lima en 1687" (Biblioteca Nacional, Madrid, Mss. 18.760/36).

[44]There is some disagreement about the exact number of victims in Callao. Citing a seventeenth-century source, Silgado claims there were 300 deaths (p. 25), but the English translation of his work records that there were 500 (p. 19). Waldemar Espinoza Soriano concurs with the 500-person estimate (*Virreinato Peruano: Vida cotidiana, Instituciones y Cultura* (Lima: Biblioteca Nacional del Perú, 1997), 157, while

for the region, including Lima and its surrounding areas, has not surfaced, but one eighteenth-century author claims that it was more than 5,000 people.[45]

Despite the devastation wrought by the 1687 earthquake, it has not been the single subject of a scholarly or scientific study.[46] Instead, it is either mentioned only in passing or used as a minor point of reference by geological, anthropological, and historical works. Numerous scholars have employed different methodologies and have highlighted various aspects of earthquakes and other natural disasters in Perú. A brief look at these scholarly efforts gives a broader historical and geological context for appreciating the 1687 earthquake, introduces the sources upon which these secondary studies rely, and offers a point of departure for a broader discussion of earthquakes in Perú.

The most obvious field of interest with which to begin is geology. Enrique Silgado Ferro's "Historia de los sismos más notables occurridos en el Perú (1513-1974)," which was edited and published by the Institute of Geology and Mining in Lima, is a work intended for a geological audience.[47] In his introduction he discusses physiography,

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Ruben Vargas Ugarte prefers 300 ("Virreinato," vol 3 (1596-1689) of *Historia General del Perú*, ed. Carlos Milla Batres (Lima, 1966), 382).

[45]*A true and particular relation of the dreadful earthquake which happen'd at Lima, the capital of Perú, and the neighboring port of Callao on the 28th of October, 1746*, translated from the original Spanish by an unnamed person (London, 1758), 107.

[46]This is not so for the Lima earthquake of 28 October 1746. See Pablo Emilio Pérez-Mallaina Bueno, *Retrato de una ciudad en crisis: La sociedad limeña ante el moviemiento sísmico de 1746* (Sevilla: Consejo Superior de Investigaciones Científicas y Pontifícia Universidad Católica del Perú, 2001), and the more recent book by Charles F. Walker, *Colonialism: The 1746 Earthquake-Tsunami in Lima, Perú, and its Long Aftermath* (Durham and London: Duke University Press, 2008).

[47]Silgado, *Historia*, 7.

tectonics, geo-history, seismology, and seismic energy release, placing Perú in its geological context of frequent and intense seismic activity. He calls attention to the work of historian José Toribio Polo, who, in 1904, estimated that Perú had experienced more than 2,500 tremors from the early sixteenth century through the eighteenth century.[48] The bulk of Silgado's text is a journal-style account of basic details, such as date, time, location, buildings damaged, number of casualties, and geologic effects of over 200 earthquakes recorded in Perú from the early sixteenth to the late twentieth century. Except for a brief note about the architectural restructuring that occurred after the tremors, his entry for the 1687 earthquake is straightforward.[49]

> 20 October. Two earthquakes occurred in Lima, one at 04:15 and the other at 5:30. The first movement shook and broke up the buildings and towers of the city and the second, more prolonged in duration, finished razing them, causing 100 deaths; "the bells tolled by themselves and the noise was great," said Father Álvarez de Toledo. Old adobe structures, with thick walls, did not withstand the violent oscillations of the ground. The damage was great in the harbor of el Callao and vicinity, the ruination extending about seven hundred kilometers to the south of Lima . . . . As secondary effects of these shocks, large cracks many kilometers long were formed between Ica and Cañete . . . . According to Padre López y

[48]Ibid. Toribio Polo's work is an important source: *Sinopsis de los Temblores y Volcanes del Perú* (Lima: Bol. Soc. Geog. de Lima, 1904).

[49]Ibid.

> Martínez, the second earthquake caused a tsunami, killing about 300 persons in the port [of Callao] . . . . The earthquakes were felt over the whole extent of the realm. In Trujillo they were perceived as noises without motion. The earth kept trembling in Lima until 2 December of that year.[50]

Silgado's sources are largely historical, especially for the earlier centuries when instrumental data were not available. As he notes about the textual sources, "The data that are available are incomplete and are scattered in various unpublished or little known works, in the chronicles of the religious orders, or in the narratives of famous travelers who visited [Perú]."[51] Noteworthy are references to four primary sources specific to the 1687 earthquake, which are located in different archives, but for which Silgado unfortunately does not provide complete archival citations: a letter written in Lima in October 1687 by Fray Domingo Álvarez de Toledo;[52] an account of the earthquake sent from Lima in December 1687 by the Viceroy of Perú, Don Melchor Navarra y Rocafull,

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[50]Silgado, "Historia," 25-26. My translation from the Spanish. As noted above, the unpublished English translation does not include every detail.

[51]Silgado, "History," 2. Spanish text from Silgado, *Historia*, 7: "Los datos de que se dispone son incompletos y se encuentran esparcidos en diversas obras inéditas o poco conocidas, en la crónicas de los religiosos, o en las narraciones de los viajeros ilustres que visitaron esta parte del continente."

[52]Fray Domingo Álvarez de Toledo, "Carta escrita desde Lima al R[e]v[eren]do Padre General de la Orden de San Francisco" (Lima, October 1687), en manuscritos "Papeles de Flandes," Biblioteca de Madrid. Regarding the archive, Silgado likely means the Biblioteca Nacional (Madrid).

the Duke of la Palata;[53] Padre Francisco López Martinez's "An account of the exemplary punishment sent by God to the city of Lima;"[54] and the published anonymous account, "The earthquake of 20 October 1687."[55] Another important, but later, work cited by Silgado is Manuel Odriózola's "Colección de relaciones de los más notables terremotos que ha sufrido esta capital y la han arruinado," which was published in 1863.[56] Within a few years after publishing his *Historia*, Silgado reproduced verbatim much of his research in a new text, *Terremotos en el Perú*, which he co-authored with Alberto Giesecke, Director of the Regional Center of Seismology for South America.[57] Unfortunately, in *Terremotos* Silgado and Giesecke do not footnote sources and they limit the bibliography to geologic works. This makes Silgado's earlier study even more important for acquiring helpful source citations.

Although anthropological studies, which rely heavily upon secondary sources, do not provide new data or sources specific to the 1687 earthquake, they do present an alternate framework for viewing and contextualizing it and earthquakes in Perú more

[53]Don Melchor Navarra y Rocafull (el Duque de la Palata), "Relación del Terremoto de 1687 dirigida a S. M. Carta" (Lima, Diciembre 1687) en manuscritos "Papeles de Flandes," Biblioteca de Madrid. Also likely the Biblioteca Nacional (Madrid).

[54]Padre Francisco López Martínez, "Relación del ejemplar castigo que envió Dios a la ciudad de Lima, cabeza del Perú y a su costa de barlovento con los espantosos temblores del día 20 de Octobre de 1687," en Lima por Joseph de Contreras (1687).

[55]P. Domingo Angulo, "El Terremoto del 20 de Octubre de 1687," *Revista del Archivo Nacional del Perú*, Tomo XII (1939).

[56]Manuel Odriozola, "Colección de Relaciones de los más notables terremotos que ha sufrido esta capital y la han arruinado" (Lima, 1863).

[57]Alberto Giesecke and Enrique Silgado, *Terremotos en el Perú* (Lima: Ediciones Rikchay, 1981).

generally. In the introduction to their collected volume, *The Angry Earth: Disaster in Anthropological Perspective*, Anthony Oliver-Smith and Susanna M. Hoffman provide a helpful overview of historiographical trends in social scientific studies of disasters. Beginning in the early twentieth century and continuing until the late 1970s, "social scientists approached disasters as unpredictable and extreme happenings that dismayingly fell upon human communities."[58] Early on, these studies focused on the external aspects of the event, most notably the physical agents of change.[59] "The behavior of individuals and organizations in the warning, impact, and immediate aftermath stages of disaster" became the new focus throughout the mid-twentieth century, although without much attention to historical perspective or sociocultural patterns.[60] This began to change, however, in the early 1980s, when "disasters, and the hazards leading to them, were reevaluated and redefined as basic, often chronic elements of environments and, more significantly, as happenings humans themselves to some degree construct."[61] This new approach to disaster studies has provided a niche for anthropologists, who study "social

[58]Anthony Oliver-Smith and Susanna M. Hoffman, eds., *The Angry Earth: Disaster in Anthropological Perspective* (New York: Routledge, 1999), 1.

[59]Oliver-Smith and Hoffman, 1.

[60]Ibid.

[61]Ibid., 2.

and cultural continuity and change."[62] Their contribution to the field of disaster studies has been significant in recent years.[63]

The high frequency of natural disasters, especially earthquakes, in Perú provides an excellent topic of research for anthropologists interested in these new trends in disaster study. Oliver-Smith notes:

> As regions linked by climatological and geological processes, the Peruvian coast and highlands are characterized by a series of natural forces and phenomena with enormous potential for destructive power when combined with human populations in vulnerable configurations. As these complex and unstable environments have been the home to human inhabitants for over 10,000 years and the site of major cultural complexity for the last 4,000 years, the nature of human cultural adaptation to these environments becomes a compelling issue.[64]

While concerned with the general topic of disasters,[65] Oliver-Smith, an anthropologist at the University of Florida, Gainesville, has devoted much of his career to the study of earthquakes in Perú. His work epitomizes the shift in social scientific studies of disasters.

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[62]Ibid., 3.

[63]Oliver-Smith and Hoffman outline these contributions in terms of four trends: archaeological/historical, political ecology, sociocultural/behavioral, and applied/practicing. Ibid., 4-12.

[64]Anthony Oliver-Smith, "Perú's Five Hundred Year Earthquake: Vulnerability in Historical Context," in *Disasters, Development and Environment*, ed. Ann Varley (Chichester, UK: John Wiley & Sons, 1994), 34.

[65]See, for example, his essay, "'What is a Disaster?': Anthropological Perspectives on a Persistent Question," in *The Angry Earth*.

In his 1986 book, he describes the 31 May 1970 earthquake in Yanguay, but also examines "those processes of reconstruction of material, social, and psychological life which enable people to recover from major losses of family, community, and culture."[66]

Oliver-Smith's essay, "Perú's Five Hundred Year Earthquake: Vulnerability in Historical Context," provides a broader context for understanding the 1687 earthquake. Although his emphasis is the 1970 earthquake, he sets it up within a larger temporal picture of natural hazards in Perú.[67] Like Silgado, Oliver-Smith first places Perú within its earthquake-prone geological context. He also connects, as Acosta did, its climatological and oceanographic elements, which make the region "extremely sensitive to any anomalies in the ocean-to-energy transfer system with implications for global weather patterns."[68] However, the main thrust of his argument is rooted in historical precedent.

Oliver-Smith organizes his discussion in two parts: "Adaptations to Hazards in the Pre-Columbian Andes" and "Peruvian History and the Subversion of Indigenous Adaptations." Before the conquest, the native inhabitants employed five basic patterns in their adaptation to natural phenomena: control of multiple ecological tiers, dispersed settlement patterns, environmentally appropriate building materials and techniques,

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[66]Anthony Oliver-Smith, *The Martyred City: Death and Rebirth in the Andes* (Albuquerque: University of New Mexico Press, 1986), viii-ix.

[67]Oliver-Smith, "Perú's Five Hundred."

[68]Ibid., 32.

preparedness, and ideology and modes of explanation.[69] Changes wrought by the sixteenth-century arrival of the Spaniards—socio-economic reorganization, the introduction of Spanish building techniques and settlement, indigenous demographic collapse, and changes in methods of production—undermined a native system designed to accommodate natural disasters.[70] This transformation made Perú even more susceptible to future disasters, such as the 31 May 1970 earthquake. Although Oliver-Smith is entirely dependent upon secondary sources, his approach of engaging with natural disasters as an important component of the historical context is compelling. He makes it seem strange to discuss the disaster-prone Peruvian context without addressing issues related to disaster and adaptation, which many scholars neglect. It is difficult to think that residents of this area who suffered continually at the hands of earthquakes and other natural disasters would not have been influenced at least in part by these events.

In his narrower geographical study, "Lima, Perú: Underdevelopment and Vulnerability to Hazards in the City of the Kings," Oliver-Smith continues with his approach that vulnerability "to natural and technological hazards has been deeply influenced by historical processes of development and underdevelopment."[71] As with his other works, he discusses Lima's physical environment. He follows his previous essay

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[69]Ibid., 34.

[70]Ibid., 36-40.

[71]Anthony Oliver-Smith, "Lima, Perú: Underdevelopment and Vulnerability to Hazards in the City of the Kings," in *Crucibles of Hazard: Mega-Cities and Disasters in Transition*, ed. James K. Mitchell (Tokyo: United Nations University Press, 1999), 249.

about Perú by briefly touching on the pre-Colombian role of natives in adapting to natural disasters and the Spanish conquest of Perú, but he also devotes several pages to discussing "the colonial model of development" specific to Lima. With the goal of establishing Lima's importance as a mega-city, he traces its history from its founding as the capital of the Spanish viceroyalty of Perú to the present. The remainder of the essay is his discussion of "Hazards and Vulnerability," in which he talks more generally about the natural phenomena of earthquakes, tsunamis, huaycos [flash floods] and other floods, and water shortages, as well as other hazards such as biological epidemics and fires. He includes much evidence about the physical layout of the city of Lima, especially regarding civil engineering and architecture. Of particular interest in this essay is a table of "Disasters in Lima," which lists 21 earthquakes dating from 1552 to 1974, including the 1687 earthquake.[72]

While anthropologists such as Oliver-Smith are engaged with disaster studies and Perú's place within them, historians of colonial Spanish America are less concerned with these issues. This is especially true with regard to the 1687 earthquake. Historians have approached this earthquake in a variety of ways, but almost all have only offered a cursory consideration of it. In his essay, "Rural Economy and Society in South America," Magnus Mörner makes only one reference to the 1687 earthquake.[73] He claims, "The earthquakes of 1687 are said to have produced widespread sterility of the

[72]Oliver-Smith, "Lima," 270-271.

[73]Magnus Mörner, "Rural Economy and Society in South America," in *Colonial Spanish America,* ed. Leslie Bethell (Cambridge: Cambridge University Press, 1987).

earth, thus bringing about a severe agricultural crisis. The destruction appears to have been limited to the environs of Lima, however, and the effects were probably only temporary."[74] Unfortunately, Mörner provides neither a citation nor a reference in his bibliographic essay that would assist the reader in learning more about this earthquake or its sources.

In *Virreinato peruano: Vida cotidiana, instituciones y cultura*, Waldemar Espinoza Soriano makes a passing reference to the 1687 earthquake and briefly addresses earthquakes in general.[75] In the section about the port city of Callao, which is located just west of Lima, Espinoza Soriano links Callao to Lima, because they are both affected by the same earthquakes, such as those in 1586, 1609, 1687, and 1746.[76] In the chapter about science and technology, there is approximately one page devoted specifically to "geology and earthquakes."[77] Without providing documentation, Espinoza Soriano comments that, "The total population of the viceroyalty believed . . . that the cataclysms were determined by the anger of God as correctives to the many sins that the people committed day to day."[78] Espinoza Soriano interprets the Peruvian religious

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[74]Mörner, 303.

[75]Waldemar Espinoza Soriano, *Virreinato peruano: Vida cotidiana, instituciones y cultura* (Lima: Biblioteca Nacional del Perú, 1997).

[76]Espinoza Soriano, 157.

[77]Ibid., 410-411.

[78]"Es que la población total del virreinato creía a puño cerrado que los cataclismos estaban determinados por la ira de Dios, como correctivos a tantos pecados que la gente cometía día a día." Espinoza Soriano, 410.

understanding about earthquakes as one reason the viceroyalty failed to adopt the rational science that was developing in Europe.[79]

Peter Findell Klarén follows Espinoza Soriano's idea about religious belief in *Perú: Society and Nationhood in the Andes*.[80] He claims that the high incidence of hazards, such as earthquakes, poor sanitation, disease and epidemics, and crime, helps to explain the powerful place of religion in society. Klarén acknowledges the centrality of the church to Spanish colonial society, but he comments that given the "perilous state of affairs" in Perú, "it is no wonder that the population sought the spiritual protection and comfort offered by religion (although this of course is not the only explanation), expressed in a variety of ways."[81] Here Klarén offers one explanation for how Peruvians manage their disaster-prone context, but his conclusion, like those of Mörner and Espinoza Soriano, are not based on solid sources.

While some historians have discussed earthquakes in a broader historical context, authors such as Ruben Vargas Ugarte are only interested in how the disaster affects their main topic of study. In his article on "Viceroyalty" in volume 3 (1596-1689) of *Historia General del Perú*, Vargas Ugarte spends some time discussing the government of Viceroy Don Melchor de Navarra y Rocafull, the Duke of la Palata, who governed Perú

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[79]Ibid., 411.

[80]Peter Findell Klarén, *Perú: Society and Nationhood in the Andes* (Oxford: Oxford University Press, 2000).

[81]Klarén, 91.

from 1681 to 1689.[82] In his chapter's final section, "Residencia del Duque," Vargas Ugarte places the 1687 earthquake in the first place among the events that occurred during the duke's tenure, although he devotes less than a page to it.[83] His emphasis is on the role of the duke in dealing with the earthquake's immediate aftermath.[84] As with other authors, Vargas Ugarte's bibliography is minimal, as are citations for his discussion of the 1687 earthquake, which has only one footnote.[85]

In his essay, "La Metropolitana de la Ciudad de los Reyes, 1535-1825," Domingo Angulo frames his short look at the 1687 earthquake in terms of architecture and structural damage.[86] Angulo views this earthquake as a "furious cataclysm" that reduced to useless rubble "the legendary opulence of the elegant city of the viceroys."[87] He also briefly discusses the buildings—especially churches—that were affected by the quake. An important note about Angulo's work is that he cites similar secondary sources to those

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[82]Ruben Vargas Ugarte, "Virreinato," Vol 3 (1596-1689), *Historia General del Perú*, ed. Carlos Milla Batres (Lima, 1966).

[83]"Entre los sucesos de su época el terremoto de Lima del 20 de Octubre de 1687, ocupa el primer lugar." Vargas Ugarte, 381.

[84]While the Duke of la Palata began the recovery and reconstruction process immediately following the earthquake, his successor, Don Melchor Portocarrero Lasso de la Vega, the Count of la Monclova, who assumed his office in August 1689, had to deal extensively with the aftereffects.

[85]It is a December 1687 letter housed at the Archivo de Indias. Archivo de Indias. Lima, 304. Carta fha. en Late, el 3 de Diciember de 1687.

[86]Domingo Angulo, "La Metropolitana de la Ciudad de los Reyes, 1535-1825," in *Monografias historicas sobre la Ciudad de Lima*, vol 2 (Lima: Librería e imprenta Gil, s.a., 1935).

[87]Angulo, 65. "Desgraciademente, la recia envergadura de su fábrica no pudo eludir los efectos del furioso cataclismo, que en 20 de Octubre de 1687 acabó por convertir en un enorme acervo de inútiles escombros la legendaria opulencia de la gentil ciudad de los Virreyes."

found in Silgado's 1978 study, such as Odriózola and Polo, as well as a few primary materials that he does not clearly identify.[88]

Primary source citations about the 1687 earthquake are a strength of María Antonia Durán Montero's discussion of architecture, urbanism, and daily life in seventeenth-century Lima.[89] She provides approximately a dozen helpful citations for government correspondence located in Spanish and Peruvian archives.[90] With a decided focus on urban social structures and buildings, Durán Montero presents the earthquake as an agent of historical change in seventeenth-century Lima.

In comparison to the historical texts examined thus far, Kenneth J. Andrien's *Crisis and Decline: The Viceroyalty of Perú in the Seventeenth Century* deals more directly with the 1687 earthquake and its socio-economic effects.[91] The work is one voice in the larger historiographical debate about the nature of the seventeenth-century crisis in Spanish America. Andrien seeks to examine "the impact of certain key political and economic changes during the seventeenth century in the rich Spanish possessions in the Viceroyalty of Perú."[92] The significant transition that took place toward the end of

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[88]Vasquez, "Corónica continuada desta Provincia del Perú," de N. P. San Agustín, etc., Liv. V.,cap II; Mugaburu, "Diario de Lima," tomo I.

[89]Maria Antonia Durán Montero, *Lima en el siglo XVII. Arquitectura, urbanismo, y vida cotidiana* (Sevilla, 1994).

[90]Montero, 40-45; see her footnotes 43 to 54.

[91]Kenneth J. Andrien, *Crisis and Decline: The Viceroyalty of Perú in the Seventeenth Century* (Albuquerque: University of New Mexico Press, 1985).

[92]Andrien, *Crisis and Decline*, 1.

the seventeenth century was that Lima's place as the commercial and economic hub of Spanish Perú began to decline, gradually being replaced by merchants in other South American cities, most notably Buenos Aires and Santiago. One contributor to this change was the 1687 earthquake, whose economic effects were felt in both the city and the countryside. The agricultural valleys of the central coast, an important supplier of foodstuffs, suffered damage, resulting in lower crop yields.[93] The decrease in food supply led to government control of bread sales and distribution, which was followed by outbreaks of disease.[94] Andrien does not provide details about the earthquake, but rather notes it as a contributor to economic decline in seventeenth-century Perú.

This overview of geological, anthropological, and historical works related to the 1687 earthquake illustrates several salient points about earthquakes in Perú. First, as Silgado's and Durán Montero's studies attest, there is rich textual evidence for studying Peruvian earthquakes before the advent of scientific instruments to measure them. This includes both firsthand accounts, like reports from the Viceroy of Perú, as well as secondary literature such as Polo's 1904 synopsis of earthquakes that have occurred in Perú since the early sixteenth century. Second, the work of anthropologist Oliver-Smith calls attention to a feature of Perú that Acosta also noted in the sixteenth-century: the seeming link between the climatology and geology of Perú's variegated landscape of contrasting plains and highlands. Although current mainstream science tends to study

[93]Ibid., 27.

[94]Ibid.

these two aspects of the physical world separately, perhaps the unusual case of Perú offers an opportunity to rethink such a division. Third, all of the authors reviewed here make clear both the frequency and impact of earthquakes in Perú. The region's high seismicity matters to its inhabitants, and so it should also matter to scientists.

All three of these issues related to earthquakes in Perú are also applicable to other parts of the Spanish Empire. Spain's extensive government bureaucracy generated a wealth of documentation about all of its holdings, accounts of earthquakes included. The manual catalogue of state papers in Spain's Archivo General de Simancas, for example, has a separate listing for earthquakes (*terremotos*).[95] This feature has been carried over to Spain's electronic archive catalog—the Portal de Archivos Españoles, or PARES—although only a small portion of the documents themselves are accessible remotely through the internet. Earthquakes were clearly relevant to the Spanish government. It is easy to see why, for most of the regions under Spanish control at different points in its history were and still are hot earthquake zones. Besides South America, Spain ruled parts of the west coast of North America, Mexico, Central America, the Caribbean Islands, the Philippines, Sicily, and Naples—all regions that appear in Frohlich's list of active deep earthquake zones.

[95]Several examples of individual catalogs with earthquake listings are: Catalog XVI, Secretaría de Estado, *Papeles de Estado de la correspondencia y negociación de Nápoles. Virreinato*, by Ricardo Magdaleno Redonod (Valladolid, 1942); Catalog XIX, Secretaría de Estado, *Papeles de Estado. Sicilia. Virreinato Español*, by Ricardo Magdaleno (Valladolid, 1951); and Catalog XXI, Secretaría de Estado, *Reino de las Dos Sicilias* (Siglo XVIII), by Ricardo Magdaleno Redondo (Valladolid, 1951).

The majority of Spain's earth-shaking territories may have experienced, and indeed continue to experience, frequent and destructive earthquakes, but this is less true for Spain itself. Spain has certainly had its share of earthquakes over the centuries, on an average of about one or two per year, but the majority of them have been relatively small. A region of moderate seismicity, Spain is estimated to experience a large earthquake only every century or two.[96] For the past several centuries, there have only been a handful of large earthquakes that inflicted significant damage and loss of life, and all of these occurred in southern Spain, including earthquakes in Málaga on 26 January 1494 and 9 October 1680,[97] and the broader Andalusian earthquake of 25 December 1884.[98] This is markedly different than in South America, where Chile, for example, is shaken every twelve years by magnitude 8 earthquake events like the "bad" one in 1939.[99] Such a distinction explains, in part, why sixteenth-century Spaniards like Acosta and Oviedo were so struck by the frequency of earthquakes in the Americas.

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[96]Scientists base this estimate on the study of the numerous earthquake catalogs published since the 1 November 1755 Lisbon earthquake, as well as further research of the individual earthquake events listed in the catalogs. David Muñoz and Agustín Udías, "Historical Development of Spain's Catalogs of Earthquakes," *Bulletin of the Seismological Society of America* 72 (1982): 1039-1042. See also the more recent article by Antoni Roca, Aranch Izuierdo, Carlos Sousa-Oliveira, and Jose-Manuel Martínez-Solares, "An Outline of Earthquake Catalogues, Databases and Studies of Historical Seismicity in the Iberian Peninsula," *Annals of Geophysics* 47 (2004): 561-570.

[97]T. Goded, E. Buforn, and D. Muñoz, "The 1494 and 1680 Málaga (Southern Spain) Earthquakes," *Seismological Research Letters* 79 (2008): 707-715. This article includes a useful bibliography of both archival and more recently published sources.

[98]C. G. Rockwood, "The Spanish Earthquakes," *Science* 5 (1885): 191-195; Agustín Udías and David Muñoz, "The Andalusian Earthquake of 25 December 1994," *Tectonophysics* 53 (1979): 291-299.

[99]Sergio E. Barrientos, "Earthquakes in Chile," in *The Geology of Chile*, eds. Teresa Morena and Wes Gibbons (London: The Geological Society, 2007), 263.

The statistical contrast between earthquake zones in Spain and South America is particularly noticeable in the study of deep earthquakes. Of the top eighteen largest deep earthquakes occurring in the century between 1906 and 2004, seven were in South America and only one was in Spain. Nevertheless, earthquake events from both regions made Frohlich's short list of representative deep earthquakes. The 9 June 1994 earthquake in Bolivia was "big" and the Chilean earthquake of 25 January 1939 was "bad," but the deep earthquake that rattled Spain on 29 March 1954 was "curious."

What prompted Frohlich to label Spain's 7.9 magnitude, 627 km-deep earthquake curious was that it defies most of what scientists understand about deep earthquakes. Frohlich succinctly summarizes:

> It is arguable that no deep earthquake in the twentieth century is more peculiar than this event. It is remarkable for its large size, for its location far distant from any ordinary [deep earthquake] zone, and for the near absence [of] any subsequent seismic activity near its focus. It produced property damage in Granada and Málaga, Spain, and when it occurred it was the second largest deep-focus earthquake known (after the 17 January 1922 Perú earthquake [which was 664 km]) . . . . In spite of its size it produced no aftershocks. And as of 2004 there have been exactly three earthquakes reported nearby, all with epicenters within 30 kilometers of the 1954 focus [and all with a 4.5 magnitude or less].[100]

[100]Frohlich, 523.

Even with the developments in scientific thought and practice spurred by plate tectonic theory, scientists continue to find the 1954 Spanish deep earthquake bewildering. In hindsight, seismologist Charles Richter's statement that the 1954 earthquake was "one of the most important earthquakes ever recorded" seems rather prophetic.[101]

Experiencing a deep earthquake deemed "curious" and something of a mystery is fitting for a country that has itself been considered enigmatic. In the mid-twentieth century a literary debate raged within Spanish scholarship about Spain's status as "a historical enigma." The core issue was the determination of what constitutes the essential nature of Spaniards. On one side of the debate was Américo Castro, who claimed that the true nature of Spaniards was formed by centuries of *convivencia* (roughly translated as "coexistence") among Christians, Muslims, and Jews.[102] To Castro, this convivencia meant more than merely inhabiting the same space. It constituted an interdependence and interaction that made "unity in diversity" a distinct attribute of Spain and Spanish culture. On the other side of the debate was Claudio Sánchez-Albornoz y Menduiña, whose two-volume work, *España: Un enigmo histórico* (*Spain: A Historical Enigma*) was written in

[101]Frohlich, 22, citing Charles Richter, *Elementary Seismology* (San Francisco: W. H. Freeman, 1958). No page number provided.

[102]Américo Castro, *España en su historia: Cristianos, moros y judíos* (Buenos Aires, 1948). A more developed version of his theories was published as *La realidad histórica de España* (Mexico City, 1954), which was published in English as *The Structure of Spanish History* (Princeton, 1954). In 1971 *La realidad* was revised and re-translated as *The Spaniards: An Introduction to their History* (Berkeley: University of California Press, 1971).

response to Castro's ideas.[103] Sánchez-Albornoz argued vehemently for "one, eternal Spain" that had no internal regional, cultural, or religious divisions. For him, "the quest for unity"[104] epitomized in the single-minded *reconquista* (reconquest) and *repoblación* (repopulation) of previously Muslim lands by Spanish Christians, not convivencia, defines the essence of Spain.

The debate, which was never resolved and which continues to influence scholarly research on Spain, reflects a bit of the "curious" character that Frohlich assigns to the 1954 earthquake. Although they approached the issue from two different perspectives, Castro and Sánchez-Albornoz were both trying to provide an answer for Spain's paradoxical history. From the Muslim invasion of the Iberian Peninsula in the eighth century to the expulsion of the Jews in 1492, there was convivencia in Spain. At the same time, there was also a decided Catholic Spanish identity that persisted before, during, and after this period. Thus, Castro and Sánchez-Albornoz were both right. The essential nature of Spaniards was not defined wholly by either "unity in diversity" or "the quest for unity," but by a combination of the two, and understanding exactly how that works is indeed as perplexing as the 1954 Spanish earthquake.

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[103]Originally published in 1956, this work has gone through at least eight editions in Spanish, but the one to which most Anglophone scholars refer is the second edition, because the English translation was based on that edition: Claudio Sánchez-Albornoz, *España: Un enigma histórico* (Buenos Aires, 1962). The English version, *Spain, A Historical Enigma* (Madrid, 1975), translated by Colette Joly Dees and David Sven Reher, has been criticized by specialists in medieval Spain for the poor quality of its translation. See the review by J. N. Hillgarth in the *American Historical Review* 83 (1978), 455-456.

[104]This specific phrase comes from medieval historian Joseph O'Callaghan, who adheres to the Castilianist school of thought to which Sánchez-Albornoz also belonged. Joseph O'Callaghan, *A History of Medieval Spain* (Ithaca: Cornell University Press, 1975). According to O'Callaghan, "The quest for unity, whether achieved or not, is the characteristic theme of medieval Hispanic history." (p. 24)

While what constitutes the essence of Spain and Spaniards has been intensely debated by Spanish scholars and others who study Spanish history, there has been long-standing general agreement among everyone else that Spaniards are ignorant, superstitious, cruel, and rabidly Catholic bigots—an idea known as the "Black Legend." From this perspective, Spain is "curious" because it is "other" or different, just like the 1954 deep earthquake is distinct from all other deep earthquakes.

The seeds for the Black Legend were first planted in the late sixteenth century, when Spain was still enjoying the height of its power in Europe. Having observed Spain's many political and economic successes in the New World since 1492, several European nations, most notably the increasingly Protestant England, began taking concerted steps toward establishing their own lucrative colonies in the Americas, and creating their own political identity. An important part of their strategy was to denigrate everything that the Catholic Spaniards had been doing in the New World for almost a century. One avenue for accomplishing this was to translate into English and publish works by Spanish authors such as the Dominican Bartolomé de las Casas,[105] who were

[105]For example, Bartolomé de las Casas, *Brevísima relacioń de la destruccioń de las Indias* (Seville: Sebastian Trugillo, 1552), which was translated into English and published in 1583 as: *The Spanish colonie, or Briefe chronicle of the acts and gestes of the Spaniardes in the West Indies, called the Newe World, for the space of xl. yeeres / written in the Castilian tongue by the Reuerend Bishop Bartholomew de las Casas or Casaus, a friar of the order of S. Dominicke ; and nowe first translated into English, by M. M. S. which was published in Spain in 1552* (London: William Brome, 1583).

For a broader understanding of Las Casas, see the somewhat outdated but still classic work by Francis A. MacNutt, *Bartolomew de Las Casas: His Life, His Apostolate, and His Writings* (Cleveland, OH: Arthur H. Clark Company, 1909); Juan Friede and Benjamin Keen, eds., *Bartolomé de Las Casas in History: Toward an Understanding of the Man and His Work* (DeKalb: Northern Illinois University Press, 1971); the three separate studies by the noted Las Casas specialist Lewis Hanke, *Bartolomé de Las Casas: An Interpretation of His Life and Writings* (The Hague: Martinus Nijhoff, 1951), *Bartolomé de Las Casas: Bookman, Scholar*

critical of their countrymen's behavior in the Americas, particularly their poor treatment of the natives.[106] Following their initial English publication, the texts of Las Casas and other Spaniards were renamed, emended, and republished. In doing so, printers and publishers perpetuated for centuries the depiction of Spaniards as vile and corrupt, and, therefore, fundamentally different from everyone else, a notion that continues to color scholars' approaches to Spain.

Spain's being labeled "different" or "curious" applies to more than what constitutes its true nature or what particular type of earthquake the country has experienced. Of all the European empires that existed after 1492, Spain's was not only one of the largest, but also the only one with such an extensive network of earthquake territories. From Italian holdings on the European continent to the islands of the

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and Propagandist (Philadelphia: University of Pennsylvania Press, 1952), and *Bartolomé de Las Casas, Historian: An Essay in Spanish Historiography* (Gainesville: University Presses of Florida, 1952).

[106]Las Casas's staunch opposition to Spanish mistreatment of the Indians attracted both supporters and detractors. During his lifetime individuals and groups who believed in his cause as strongly as he surrounded him. Generally speaking, Dominicans were Las Casas's most trusted allies, especially after he joined the order in 1522. A variety of brethren, including Antonio de Montesínos, Rodrigo de Andrada, and Pedro de Angulo, accompanied Las Casas on his trips to and from Spain. In short, like-minded men surrounded him constantly. Pedro de Córdoba, an older friar and compatriot of Montesínos, was a strong, spiritual anchor for Las Casas in his work on behalf of the Indians. Likewise, a number of his contemporaries exerted considerable energy against his actions and writings. Franciscan missionary Fray Toribio de Benavente, known as Motolinía, Spanish historian Gonzalo Fernández de Oviedo, and Juan Ginés de Sepúlveda are three of Las Casas's better known detractors.

The same confrontation has characterized scholarly debates since Las Casas's death. Some historians praise him for his valiant service not only to New World natives but also to the study of historical, political, or theological thought. Others dismiss him as a substandard historian who is primarily responsible for the anti-Spanish attitudes that have persisted since the sixteenth century. This latter group generally consists of scholars who have studied and/or sought to combat the Black Legend of Spain, with Las Casas included only as one component of their discussion. Prominent examples are: Julián Juderías, op. cit. in chapter 3, footnote 42; Rómulo D. Carbia, *História de la leyenda negra hispano-americano* (Buenos Aires: Ediciones Oriéntaciones Española, 1943); Ramón Menéndez Pidal, *El padre Las Casas y la leyenda negra* (Madrid: Consejo Superior de Investigaciones Científicas, 1962); and William S. Maltby, op. cit. in chapter 3, footnote 42.

Caribbean, and from its vast territory in the Americas to the Philippines and other islands in the Pacific, Spain's empire was an earthshaking one. This exceptional geographical-political configuration could perhaps be better described as a geological-political one, and it prompts consideration of several earthquake-related issues.

First, one wonders if there is more than a coincidental connection between the Black Legend and the Spanish Empire's high incidence of earthquakes. An English account of the large and destructive 1746 Lima earthquake, for example, blames Spaniards' contemptible behavior for the earthquake. As the book's Preface notes, "there was not before the late great Calamity a more licentious Spot upon the Earth."[107] This approach is not unlike the one employed by evangelist Pat Robertson, who, following the 2010 earthquake in Haiti, declared that the Haitians were being punished for a "pact with the devil" they had supposedly made two centuries earlier. Another iteration of this same attitude is found when insurance companies refuse to cover loss incurred during an earthquake, because the injured party had failed to pre-purchase the precise coverage for "acts of God." Both in this instance and in the two examples of despicable moral behavior, blame for suffering is placed on the earthquake survivor, which prevents anyone else from having to take any responsibility. The Black Legend operates similarly, because the perception that Spaniards are wicked and flawed in character burdens them with the responsibility for all that is evil and wrong with the world, and allows others to

[107] *A true and particular relation*, 10.

evade accountability. In this way, earthquake survivors and Spaniards share in common the role of scapegoat, and serve as targets in the search for causes of earthshaking events.

A second issue worth noting is that Spain's predilection for earthshaking territories suggests an affinity for earthquake culture, as opposed to the culture of another physical phenomenon such as a volcano or flood. There is something "different" and "curious" about living in an earthquake zone, and how that is interpreted is a matter of perspective. California, for instance, is both the most populous state in the United States, and also one of the two most seismically active.[108] Over six decades ago, leaders in California cultivated the state's identity as an earthquake region and were successful in helping to build the state's reputation and its economy on, ironically enough, the region's geological instability.[109] There are certainly many people in other states who have no interest in living in earthquake-prone California, but instead choose to stay where they are, be that on the hurricane-frequented Gulf Coast, a flood plain of the Mississippi River, or somewhere along the corridor of the central U.S. known as Tornado Alley. Nonetheless, California remains appealing because of its mild climate and physical beauty, despite its vulnerability to earthquakes. In this contradiction are echoes of Acosta's sixteenth century statement about an equilibrium of phenomena in parts of South America, with frequent earthquakes providing balance to the calm and dry weather.

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[108]The other most earthquake-prone state is Alaska, which typically ranks in the bottom five of state populations in the United States.

[109]See Ted Steinberg's chapter on California, "Disaster as Archetype," in his book *Acts of God: The Unnatural History of Natural Disaster in America* (Oxford: Oxford University Press, 2000).

Every physical environment includes one kind of disruptive phenomena or another; where a person chooses to live reflects that person's preference for the culture of a particular physical environment.[110] Although it may be a mere historical coincidence, it is nevertheless remarkable that Spain's territorial expansion consistently resulted in the acquisition of not just earthquake-prone regions, but ones with a particularly high frequency of earthshaking events.

The distinction between an interest in highly seismic areas and in those with less frequent earthquakes also exists within seismology, the "official" field of earthquake study. At the end of his distinguished career, Japanese seismologist Kiyoo Wadati noted:

> Looking back at the development of seismology, it may be pointed out that there have been two major schools. One school developed in countries of high seismicity, and the other in countries of low seismicity. In the former, the subject of studies has been local earthquakes and studies related to the prevention of earthquake damage, focused on earthquake motions and related phenomena, and eventually on earthquake mechanisms. In the latter, along with studies of earthquakes, more

[110]The scope of study of *New Worlds, New Lives: Globalization and People of Japanese Descent in the Americas and from Latin America in Japan*, eds. Lane Ryo Hirabayashi, Akemi Kikumura-Yano, and James A. Hirabayashi (Stanford: Stanford University Press, 2002) seems relevant within the context of the current discussion about people having a preference for the culture of a particular phenomenon like earthquakes, as both Japan and Latin America are hot earthquake zones.

> emphasis has been placed on studies focused on the internal structure of the earth.[111]

One sees here a dichotomy of emphasis. On one side is a focus on pragmatic, local concerns about earthquakes, which are cultivated in and exceedingly relevant for a region of high seismicity. On the other side is a concern for more theoretical issues of a global perspective, which are perhaps easier to explore from a place of relative detachment in an environment not affected by frequent earthquakes. All too often scientists stay in these two separate camps and do not cross the divide to exchange knowledge that could prove useful to both sides. The study of deep earthquakes has been overlooked by most scientists because, in part, they have assumed that deep earthquakes are not destructive and therefore do not merit extensive study. This is a gross misconception, as Frohlich illustrates pointedly with the "bad" earthquakes of Romania and Chile. Looking at the question from the alternate perspective, scientists more concerned with theoretical matters can appear to be blasé about the tangible reality of earthquakes for people and the important place science holds in society for attending to that reality. As Frohlich quips about the field of seismology, "one of seismology's best-kept secrets is that understanding earthquakes isn't the principle objective of most earthquake research; rather, the goal is to understand the structure and dynamics of the Earth itself."[112] If this statement is true, then it dismisses the research of scientists interested in addressing

[111]Wadati, "Born in a Country of Earthquakes," 6.

[112]Frohlich, 342.

earthquakes' deleterious effects and the local, real-world concerns of earthquake survivors. No doubt it would be beneficial for both camps to find more points of connection between them.

Creating a research opportunity for negotiating the gap between these two competing perspectives is the pairing of the unusual geological-political configuration of Spain's earthshaking empire with understudied deep earthquakes and their exceptional nature in Spain and its former colonies. The abundant documentation of the highly seismic Spanish empire is a rich and largely untapped resource for historical data about earthquakes and their effects in many different parts of the world. These data would provide a broader framework within which to revisit and reevaluate historical earthquakes, which in turn would augment instrumental data acquired in more recent times, and perhaps influence a refinement or shift of current theories about earthquakes of all types.

Gathering historical earthquake data from parts of the Spanish empire that are known to have experienced deep earthquakes in the last hundred years, may provide some clues for the few scientists seeking to solve the riddle of how earthquakes operate at such deep focal depths. Because the heart of that riddle lies in the seeming incompatibility between the functioning of deep earthquakes and the operations of the more common and better studied shallow earthquakes, one suspects that uncovering the riddle's solution would facilitate a profound change in how all earthquakes are understood to work. Moreover, a greater number of scientists could give more attention

to the study of deep earthquakes, not only because it offers a striking theoretical challenge, but also because many deep earthquakes, “bad” ones in particular, have immediate and lasting significance for hundreds of thousands of people.

CONCLUSION

The unpredictable, indefinable, and potentially destructive character of earthquakes demands multiple perspectives in order to be understood. Despite the millennia-long legacy of ancient earthquake stories and their importance for people trying to make sense of the natural phenomenon, many scientists in countries like the United States continue to ignore or dismiss altogether this legacy in favor of a narrow approach to earthquake research. This lack of respect for alternate ways of understanding earthquakes could be better excused if current scientific theories about earthquakes were more complete in their explanations and more effective in combating or preventing altogether the destruction earthquakes inflict on a global society.

Much remains unknown about earthquakes, including specifically when and exactly where an earthquake will strike. The scientific community would do well to use the study of earthquakes both as an opportunity to remind itself of the limits of knowledge and as an impetus for stepping beyond those limits into fresh avenues of research. Physical scientists are unlikely to study folklore or religion for new knowledge about why earthquakes happen. Nevertheless, folkloric and religious views of earthquakes should be recognized as valuable for an understanding of history and society, precisely because they address human issues of meaning ignored by scientific perspectives. Likewise, those who study folkloric and religious perspectives on earthquakes must concede that their understanding is also limited. They should be respectful of others' attempts to understand the devastating phenomena of earthquakes

and thoughtful about the spirit in which they attribute meaning to specific earthquake events. So far, no single explanation of earthquakes—whether ancient or modern, religious or scientific—has provided humanity with a completely satisfying answer to the question of why the earth shakes. The best hope for approaching that answer lies in attention to a diversity of perspectives.

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more particular narrative, collected from several other authentic materials ; to which also is now added a genuine letter ..., purposing to describe the last great eruption, as well as a journey to the very summit of Mount Aetna, in the year 1766. London : Printed for J. Wilkie ... and E. Easton, at Salisbury, 1775.

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