Earthquake Mythology
adapted from the 2014 CUREE Calendar
illustrated essays by Robert Reitherman

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Cover photo: Namazu, the giant catfish who causes earthquakes, from Japanese mythology. (Jan Kozak Collection) - Courtesy of the National Information Service for Earthquake Engineering, PEER, University of California, Berkeley.

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The modern scientific understanding of earthquakes and the contemporaneous development of valid engineering techniques to deal with that hazard mostly evolved since the mid 1800s, with a growth spurt in the latter half of the twentieth century. That is a small fraction of the roughly 10,000 years that people have been living in settlements that have facilitated cultural continuity, and it has been 20,000 years since humans have constructed simple buildings. The past couple of centuries is an extremely small fraction of the 200,000-year timespan over which primates closely resembling us evolved into today’s homo sapiens.

In that majority of time that people have lived on Earth in the absence of engineering and science that came rather late, there were nonetheless attempts to understand and deal with earthquakes. It would actually be surprising if that were not the case, for homo sapiens, the knowing ape, has a strong urge to know about the world and penetrate its mysteries. It would only be surprising if the sudden shaking of the entire region in which people lived did not bring forth attempts at explaining that frightening and bewildering phenomenon. What could be more mysterious? more curious? more thought-provoking?

Consider earthquakes as compared to other natural hazards. In storms, for example, the wind starts to blow, then it blows harder. The sky darkens. There is some thunder and lightning, then more. The storm does not pounce on us all at once, unannounced. A flood is usually preceded by prolonged rainfall. The wildfire is understandable as a large-scale version of the fires humans built in their caves and campsites since Paleolithic time. But earthquakes, unless preceded by a number of small foreshocks (and more often, a small earthquake leads to nothing larger), come without warning and are easily conceptualized as something supernatural. How can the very earth be shaken as far as one can see, and what is big and strong enough to shake it? How could heavy buildings impervious to any person’s attempt to shove them sideways be shaken violently? What huge invisible force other than a supernatural one could cause the earth to shake? Go inside a building and you are sheltered from the storm. Go to higher ground and you are above the floodwaters. In an earthquake, everyone and everything is prey to that invisible attack, regardless of where they try to flee. It is not surprising that our forebears, with essentially the same brains as we have, tried to come up with explanations for this phenomenon, and even if they only came up with legends and tales, could we have done any better, if we were to be time-transported back to ancient times?

Lacking scientific stepladders on which to stand, people who lived from 200 years ago to 20,000 years ago could not yet accurately see the answers that any schoolchild today learns as a matter of course. Consider the fact that it was only very recently, in the 1960s and later, that earth scientists could actually explain where earthquakes came from, that plate tectonic movements of the earth’s crust, generated by convective forces of magma beneath, which in turn caused horizontal seafloor spreading, were the prime mover that shoved and pulled plates of crust and caused localized fracture lines, or faults, that slipped occasionally and caused earthquakes. The fact that many 10-year-olds can tell you that explanation today does not mean that the search for that answer was easy or that it could have been done centuries ago.

Consider the analogy of Abel Janszoon Tasman (1603–1659), who was the first to circumnavigate Australia, coming very close to its coastline but without sighting it. How can one sail around a piece of geography as large as Australia and never see it? To us, that huge area on the world map seems impossible to miss, but that is only because many who have gone before have drawn that world map for us. Science and engineering before the scientific revolution in Europe were a series of isolated explorations. Later scientists were able to develop knowledge rapidly by referring to the overall map of knowledge of earthquakes and their effects, a map that was steadily filled in, albeit slowly, in the nineteenth century, and more rapidly through the twentieth.

While appreciating the basic humanity we share with the ancient peoples, we need to avoid the pitfall of glorifying the ancient myths as being
Accurate insights that predated what civil engineers and earth scientists only understood centuries later. Care must be taken in examining the frequent claims that ancient societies precociously developed earthquake-resistant construction. For example, given the most common material for the biggest and most important structures of most ancient societies, unreinforced masonry, one of the best construction techniques to use in the absence of any engineering know-how is to build thick walls. Fractures still can occur in walls a meter thick, but fractured upper areas of such walls tend to sit in a stable manner on lower portions. However, thick masonry walls also provide greater security against the threat of attacking humans, and in ancient times towns were invaded many more times by armies and bandits than by earthquakes. An unreinforced masonry fortress wall is more likely to survive an earthquake than the thin one of a two-story dwelling, simply because it has thick walls. The massive brick-walled fort at Fort Point in San Francisco was the closest building in San Francisco to the San Andreas Fault that released the earthquake vibrations in 1906, and yet it survived without significant damage. Precocious earthquake engineering? No, just unusually thick walls, serving as protection against cannon fire. Thus, from the historian’s viewpoint, motive becomes an important question. The question of why people had particular beliefs about earthquakes is relevant, as well as whether those beliefs were valid from a scientific viewpoint.

As Karl Steinbrugge (1982, p.1) notes, “The supernatural in one form or another has dominated the explanations of earthquakes and their effects until the development of the science of seismology.” John Milne (1886, p.7), from his late nineteenth century perspective, made this conclusion:

Speaking generally, it may be said that the writings of the ancients, and those of the Middle Ages, down to the commencement of the nineteenth century, tended to the propagation of superstition and to theories based on speculations with few and imperfect facts for their foundation.

Guidoboni (1998 p.197) has reviewed pre-1600 theories about earthquakes, noting that there “was never a clear dividing line in the ancient world between religion and the observation of nature.” In the sciences today, the term “theories” is used to refer to explanations based on the evidence that must be proved (or withstand evidence that might disprove them) by recourse to scientific rather than divine laws. In the common usage of the term, however, there is no doubt that early peoples theorized about earthquakes: they were curious about them, wondered what caused them, and struggled to figure out how to mollify their destructiveness. We often call the earliest cultures primitive, but the minds of those primitive peoples were recognizably similar to ours.

There are four reasons why prescientific societies did not begin to accurately understand what caused earthquakes and how to create earthquake-resistant construction. Lack of technology was one reason, for example, the lack of seismographs that show us the global distribution of earthquakes and their size, and the lack of strong motion seismographs that record every lurch and jolt of the motion of the ground or of structures. Equally important was a second reason, a lack of a scientific frame of mind. The mythological explanations for earthquakes described in this chapter were often untestable beliefs rather than hypotheses. In some cases, premodern explanations were susceptible to proof or disproof with only ancient knowledge-gathering technologies at hand, such as identifying surface fault rupture and its association with ground shaking, but these explanations were not investigated in that critical way because the fundamental concept of scientific methods had yet to evolve.
Thirdly, the lack of earlier progress is partly due to the fact that in a given region, earthquakes do not happen often, compared to the lifespan of humans. With sketchy record-keeping – and record-keeping is one of the hallmarks of science – one could speculate about earthquakes generation after generation without getting closer to the truth. By contrast, the ad hoc observational technique worked well with experiments that could be frequently run. One could try several different fish hooks and compare results in a single season, but earthquakes do not provide frequent reproducibility of an experiment.

Why do biologists conduct so many genetic experiments using the fruit fly (Drosophila)? One desirable attribute is the large size of its chromosomes, but another is its rapid development through its life cycle, a fruit fly developing from egg to adult in as little as a week. To study evolution as it occurs in humans, one waits about a quarter of a century for offspring of one generation to develop to maturity; to study that genetic process in fruit flies, the biologist can study dozens of generations in one year.

Relying on ad hoc observations of damage or lack thereof to construction in earthquakes, even if the observations had been systematically recorded over the centuries, is an extremely slow process. And while ancient chronologies of earthquakes do exist in some places such as China, Japan, and the Middle East, as Ambraseys (1971) pointed out, the original sources are often frustratingly vague and usually only record very approximate intensity data. Today, engineers subject multiple specimens in the structures or geotechnical laboratory to tests, or run hundreds of computer analyses, which is analogous to studying dozens of generations of fruit flies. Today we also have the luxury of knowing almost instantly of the occurrence of earthquakes anywhere in the world and dispatching teams to study them, and their data are broadly disseminated and preserved. It is understandable why prescientific societies, especially those passing down knowledge via oral traditions, made so little progress toward today’s earthquake engineering.

There was a fourth reason for lack of progress. Part of the success of science and engineering in Europe from the Renaissance through the Enlightenment through the Industrial Revolution to today was the seemingly unheroic role of keeping good records and passing them on so that either truths or falsehoods, workable or unworkable technologies, would be documented for the next generation to build upon. That continuity of fact-recording over the past 500 years was not typical of previous history.

Consider this brief listing of accomplishments spanning from Copernicus to Newton. Isaac Newton (1643–1727) had the work of Galileo Galilei (1564–1642) to learn from concerning gravity and inertia. Galileo knew the work of his elder contemporary, Johannes Kepler (1571–1630) on celestial motions, and although the two differed on theories of orbits and tides, the competition between them helped stimulate that field of early astronomy and physics. Kepler studied under and built on the data accumulated by his senior mentor, Tycho Brahe (1546–1601), who organized an astronomy observatory that was to collect data for many years. Nicolaus Copernicus (1473–1543) produced De Revolutionibus, titled because it dealt with the revolutions of celestial objects, but it was also a revolution in the history of science and scientists. Between the publication of De Revolutionibus of Copernicus in 1543 and Principia by Newton in 1687 is a span of almost 150 years, over which there was an unbroken transmission of scientific work among Europeans working in what today are Italy, Austria, Germany, Czech Republic, Sweden, Denmark, and England. Individual brilliant accomplishments could have merely been short travels down culs-de-sac, without the highway of knowledge maintained for centuries that made the scientific revolution possible.

Going back to the premise stated earlier that we moderns share basic aspects of humanity with the ancients, let us ask the question: are we sophisticates today free of nonscientific ideas about earthquakes? Are there still earthquake myths? Ask the “person on the street” in the United States, and perhaps in other countries as well, to name one designer and one building that has something to do with earthquakes, and a very common answer is “Frank Lloyd Wright and the Imperial Hotel.” Why? The answer I have heard many times when I pose this question to audiences is “because it stood up in the great Tokyo earthquake while most of the rest of the buildings fell down,” and people will also say, in layman’s terms, that the building was seismically isolated. This myth, these two false statements, are often repeated. To quote the way the mass circulation newsstand edition of Great
Buildings of the World (Knauer 2010, p.52) by Time magazine states it: “the Imperial Hotel in Tokyo, whose ingenious system of structural supports kept the hotel intact during a devastating 1923 earthquake that flattened almost all the buildings around it.”

Back in the 1970s when I did research on the seismic design of the Imperial Hotel (Reitherman 1980a, 1980b), I found that other, larger buildings in Tokyo on average did as well or better in the earthquake, and that Tachu Naito and Riki Sano had by then developed the essence of the equivalent static lateral force method, which was the forward-looking technique of earthquake engineering. The feature Wright most promoted as the advanced seismic design feature of his building, the foundation, was in fact one of its greatest weaknesses, and it was not a seismically isolated structure, as the legend today has it. It was very conventionally rooted in the ground with a typical concrete spread footing on short piles.

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A sign of a successful myth is that it is a good story. People today love a good story as much as the ancient Mesopotamians, who after the death of Sargon the Great in the 23rd century BC kept alive for 2,000 years the myth of his magical upbringing by gods. The Greeks of Homer’s day in the eighth or ninth century BC also loved a good story, and many of them (for example the historian Herodotus, who came four centuries after Homer) believed in the supernatural as well as the historical aspects of the Homeric tales. A successful myth has some element of reality in it to make it more believable. Sargon the Great actually was a powerful king, Troy actually did exist, and Wright’s Imperial Hotel did in fact avoid collapse in the 1923 earthquake (though buildings several times as tall did so as well, with less damage.)

Ancient understanding about earthquakes was more often misunderstanding, as illustrated in the following examples, but if you had lived in one of those cultures and eras, (and keeping in mind that even today we sometimes believe in myths and rumors that turn out to be false), could you have done any better? And don’t you sense a kinship with these people who were motivated by a fundamental human trait still with us today, the urge to look beneath the surface of phenomena and seek out causes, to know how the world works?

References are located at the back of the calendar.

This essay is largely derived from Chapter 3, Ancient Understanding and Misunderstanding, in Earthquakes and Engineers: An International History (Robert Reitherman, ASCE Press, 2012), available through the American Society of Civil Engineers (ASCE) website at: www.asce.org
Zhang Heng deserves credit for engineering a device intended to measure an aspect of earthquakes, to determine the direction from the instrument where the ground motions of an earthquake originated. In all of the pre-scientific annals of history, he stands out for his original thought and inventiveness and his avoidance of supernatural speculation. However, the instrument could not have actually deconstructed the complex vibrations at a site to determine the direction of a distant source. Type in "seismograph" in a web browser, however, and you will find a multitude of misstatements that have kept this myth alive.

Zhang Heng (79-139 A.D.) was a noted Chinese astronomer, mathematician, poet, and scientist.

Especially for distant sources, the waves are affected by different paths and geology so that a predominant direction is difficult to predict. Also note that Zhang Heng's invention recorded only the first motion sufficient to dislodge a ball, not the peak motions.
In the Hindu tradition and also some Buddhist sects, the Nāgas are giant snakes, sometimes looked upon with reverence, but also thought to cause earthquakes by their subterranean movements. The great antagonist of the Nāgas is the bird-king Garuda, who serves Vishnu as his mount. The famous iron pillar of Delhi, in a courtyard of what is now the Quwwat-ul-Islam Mosque, was erected in pre-Islamic time about 400 AD in the reign of Chandragupta II. Some attribute the purpose of the pillar to be the symbolic anchoring of the underlying Nāga spirit, to restrain its motions and thereby prevent earthquakes.
According to Japanese legend, earthquakes were caused by the movements of a monster catfish that lived under Japan. Following the Ansei earthquake of October 2, 1855, woodblock prints called Namazu-e ("catfish pictures") appeared in Edo (now Tokyo). Here in a woodblock print, the people who suffered from the effects of the earthquake are trying to punish two Namazu.

Namazu, the logo of the 9th World Conference on Earthquake Engineering, held in Tokyo and Kyoto in 1988.

Namazu and Sambaso

When traveling in Japan, one may come upon a picture of a catfish in a poster in a subway or train station. It is not an advertisement about a fish restaurant, but rather an earthquake safety poster. Namazu in Japanese mythology is the giant catfish who occasionally wriggles and causes the earth to shake. If attending a Kabuki performance, the Sambaso dancer is the one you will see who enters at the beginning, hopping on one foot, the tradition being that it will prevent an earthquake from interrupting the performance.
Charles Tuarau with the tekoteko, a protective figure mounted on Maori buildings. Tuarau was the master carver at the national museum, Te Papa Tongarewa, whom Karl Steinbrugge commissioned to make the IAEE’s Rūaumoko icon.  (Evening Post 1959)

Karl Steinbrugge was a U. C. Berkeley professor and earthquake engineering expert who commissioned a carving of Rūaumoko for the IAEE. It was adopted as the association’s symbol and was displayed at each of following World Conferences on Earthquake Engineering (WCEE). In 2008 it was stolen during the 14th WCEE conference in Beijing, China, and has been replaced with a replica.

In 2009, a replica carving of Rūaumoko was officially welcomed to its new home at the University of Canterbury’s Engineering Library where it will reside between World Conferences on Earthquake Engineering. (Canterbury.ac.nz 2009)

The Māori belief concerning the origin of Rūaumoko has to do with his birth by an Earth mother god who rolled over on him, pressing him into the ground. This explains his association with the active geological signs such as earthquakes and hot springs that the Māori observed in New Zealand. Rūaumoko has become more well-known today in the earthquake engineering field than any other symbol discussed here with the exception of Japan’s catfish, Namazu, because of the adoption of Rūaumoko as the logo of the International Association for Earthquake Engineering and the New Zealand Society for Earthquake Engineering.

Rūaumoko

The original Rūaumoko statue of the International Association of Earthquake Engineering (IAEE).
Aristotle thought that "the earth is essentially dry, but rain fills it with moisture. Then the sun and its own fire warm it and give rise to a quantity of wind both outside and inside it..." (Barnes 1984, Bekker #365b22). Thus, the movement of air in underground caverns was the cause of earthquakes. Many later opinions were similar:

Athanasius Kircher (1601-1680): underground passageways were the sites of "subterrestrial combustions."


Robert Mallet (1810-1881) and John Milne (1850-1913): explosions under the seafloor, where water seeped into hot cavities, analogous to boiler explosions.

Greek Mythology

In Greek mythology, Poseidon was the god of the sea and was usually depicted carrying a trident or fish spear. One of his nicknames is Earthshaker. With his trident he could strike the ground, causing earthquakes. The areas inhabited by the ancient Greeks, including regions in what are today southern Italy and western Turkey, are seismically active. In the Iliad (book XX), Poseidon joins a battle in the Trojan War on the side of the Greeks (Achaians) as they attack the fortified city of Troy (Ilions): "Poseidon made the solid earth quake beneath, and the tall summits of the hills; Mount Ida shook from head to foot, and the citadel of Ilions trembled." (Rouse 1938, p. 237).
In Philippine mythology, a god named Panlinugun is the Ruler of the underworld and the god of earthquakes. Some say a giant named Bernardo Carpio is trapped between two great rocks in the Mountains of Montalban where he uses his enormous strength to either hold up the sky, keep the mountains from crashing together, or is simply trying to break free. It is his movements that causes earthquakes. In Oceania, different islands have different but related humanlike gods who cause earthquakes.

1. Samoa
Mafui’e was the god of earthquakes and also fire until Maui fought him and carried fire to humans.

2. New Guinea
Marruni was the god of earthquakes, with a human-like upper body and the tail of a snake.

3. Fiji
Negendei was the earth balancer; when he moved, earthquakes occurred.

4. Hawai’i
Kane-lulu-moku is called the god of earthquakes, but Pele is better known as the cause of volcanoes and also earthquakes.

In Fiji legends Negendei was the Earth-balancer, on whose head rested the surface of the earth. When he moved, earthquakes occurred. One need not visit Fiji to see an effigy of this god; one can be found outside the Enchanted Tiki Room at Disneyland.

His strength and his struggle to be free has gained Bernardo Carpio a folk hero status among the Philippine people, resulting in stamps, comic books, and movies.

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**Islands in the Pacific**

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Legends of Latin America

Much of what we know of early Mesoamerican civilization was found in codices. These folding books from the pre-Columbian Maya civilization, written in Maya hieroglyphic script, described both Aztec and Mayan earthquake gods. Some said the Mayan calendar can be matched to destructive earthquake events, with the last cycle of civilization to end December 21, 2012, a date that came and passed with no disaster.
The Thunderbird and the Whale

Preserved in the oral tradition of northwest coast native peoples is the story of a huge wave, a mythological account that has turned out to have a factual basis (Ludwin 2002). Three centuries ago, a massive subduction zone earthquake offshore of that coast caused dramatic tsunami effects locally and also sent tsunami waves to faraway Japan. Written records in Japan (there were none among the Native Americans then) along with geological evidence have pinpointed the date and time: 9 pm, January 26, 1700.

USGS geologist Brian Atwater was chiefly responsible for the geological detective work to relate coastal subsidence along the Washington and Oregon coasts caused by the subduction earthquake in 1700 that was recorded in the form of tsunami waves in Japan. Subsidence caused flooding of trees (allowing for tree-ring dating of their year of death).

Chief Maquinna, wearing a thunderbird headdress, welcomes British Columbia Lieutenant Governor Walter Nichol to Yuquot in 1924. On right, a Native American monument depicting Mount Conuma (home of the thunderbird) and thunderbird with whale.

In highly seismic British Columbia, the Haida Indians explained earthquakes as the conflicts between a thunderbird and a whale. The thunderbird dropped the whale in the water, causing earthquakes and tsunamis.

Image RBCM CPN14429 courtesy of Royal BC Museum, BC Archives
It is understandable that people look for signs and charms to ward off disaster. In 1989, during the Loma Prieta Earthquake that struck the San Francisco Bay Area, a section of the Bay Bridge collapsed. During repairs, the ironworkers welded a small metal troll figure to the Bay Bridge as a protective symbol (inset). When this span of the Bridge was replaced in 2013, a new troll was created and secured to the Bridge in an undisclosed location.

Omens and Superstitions

This sketch is of an oarfish (originally described as a sea serpent) that washed ashore on a Bermuda beach in 1860. In Japanese folklore the oarfish acts as a messenger of warning from the Sea God’s Palace. When they appear on the beaches of Japan, an earthquake is imminent.

Harper's Weekly, 3 March 1860

This oarfish, measuring 18 feet in length, was found off the coast of Southern California in October 2013.

Catalina Marine Institute

The new Bay Bridge troll, seen in front of the new East Span opened in 2013. The inset shows an earlier troll attached to the repaired original bridge sections after the 1989 Loma Prieta Earthquake.

Metropolitan Transportation Commission, Oakland, CA
Movie Myths About Earthquakes

Movies often over-dramatize reality, and earthquake movies are not exceptions. There are scenes of skyscrapers collapsing, (while usually low- and mid-rise buildings perform worse); people and buildings are swallowed up in huge surface cracks (instead, localized landslides and liquefaction are what can occur); earthquakes are predicted (earthquakes are still unpredictable); an earthquake is caused by a nuclear explosion, flooding a fault with water, or positions of the planets (rather than the strain from tectonic deformation).
Even today, earthquake myths live on. Frank Lloyd Wright’s Imperial Hotel in Japan was not seismically isolated, nor is the Pyramid Building in San Francisco. Good performance of timber pagodas in Japan "has been attributed to the pendulum action of the heavy central post, but this is not tenable, since in many cases the central column rests on a stone base (Muto 1930, p. 16)." Muto and Berg (1976) provide the less catchy but more accurate reason: these structures just happen to have very high damping and long periods of vibration.

Many people believe the Transamerica Pyramid building in San Francisco is seismically isolated by mounting it on ball bearings. Actually, with its three basement levels and nine-foot-thick reinforced concrete mat foundation, it is like a fencepost embedded in the ground.
Can Animals Predict Earthquakes?

This myth enjoys continued popularity, despite studies refuting it. The 1976 Haicheng Earthquake in China was said to have been successfully predicted, which may have been the case, but the primary reason the seismologists made a forecast was because of an increasingly intense earthquake swarm, and not animal behavior. Unfortunately for the effort to predict earthquakes, most small earthquakes are not foreshocks -- no large earthquake follows.

Endangered Bird Said To Predict Earthquakes

The Great Argus, a type of pheasant found in Sumatra, known locally as a Kuwau, is claimed to have the ability to predict earthquakes. Some say the bird was noted as acting strangely, singing often and loudly, prior to the Sumatra quake on Sept. 30, 2009.

Sandy Cole

A theory popularized in Santa Clara County, California in the 1980s asserted that when dogs ran away from home it was a premonitory sign of an earthquake. However, a study of 41,717 reports of missing pets and 224 earthquakes in the region (Schaal 1988) found that “the data show there is no correlation.”

Robert Reitherman

It will be a magnitude 6.6...no, make that 6.7. Epicenter 15 kilometers south-southwest. Tomorrow at 5:45 pm. Darn, that's going to interrupt my dinner.
References Cited


