

Richter scale essay sample

[Science](#)



**ASSIGN
BUSTER**

SIZING UP

How do we measure earthquakes? By the early 20th century, geologists knew that some earthquakes create visible rips across the earth's surface, which gives some indication of their force. But since most fault ruptures are entirely underground, we need other methods to size up and compare earthquakes. The earliest scales were called intensity scales, which typically assign Roman numerals to the severity of shaking at a given location. Intensity scales remain in use today: well-calibrated intensity values determined from accounts of earthquake effects help us study historical earthquakes and their effects within densely populated areas, for example. Following an earthquake in Virginia in 2011, over 140, 000 people reported their accounts to the US Geological Survey's " Did You Feel It?" website. To size up an earthquake directly, one needs to record and dissect the waves it generates.

Today, this is done with seismometers employing digital recording, but it wasn't always so. The first compact instrument capable of faithfully recording small local earthquakes was called a Wood-Anderson seismometer. When the ground shook, a mass suspended on a tense wire would rotate, directing a light onto photosensitive film. The image " drawn" by the light reflected the severity of the seismic waves passing through. In the early 1930s, Charles Francis Richter used these seismometers to develop the first magnitude scale – borrowing the word " magnitude" from astronomy. Richter's scale uses a logarithm to produce magnitude values that are easily tractable: each one unit increase in magnitude corresponds to a 30-fold

increase in energy release. A magnitude 7 earthquake thus releases almost 1000 times more energy than a magnitude 5 earthquake.

Magnitude values are relative: no physical units are attached. Richter tuned the scale so that magnitude 0 (M0) was the smallest earthquake that he estimated could be recorded by a surface seismometer under ordinary conditions. Earthquakes with negative magnitudes are possible but thus unlikely to be recorded. The scale is open-ended, but Richter might have had an upper limit of M10 in mind: he also tuned the scale so that the largest recorded earthquakes in California/Nevada were around M7, and surmised that the 1906 San Francisco earthquake was probably around M8. (The largest earthquake recorded since then was in Chile in 1960, with an estimated magnitude of 9.5.) Relationships have been developed since to relate the energy released by earthquakes to magnitude. In the 1960s, Keiiti Aki introduced a fundamentally different quantity: the " seismic moment".

This provides a full characterisation of the overall size of an earthquake and is the measure generally used in scientific analyses. The so-called moment-magnitude scale was introduced to convert the seismic moment to an equivalent Richter magnitude. This figure is the one usually reported in the media. Strictly speaking this reported value is not " on the Richter scale", because it is calculated differently to Richter's formulation. Still, following Richter's approach, moment-magnitude values have no physical units, and are useful for comparing earthquakes. " Strictly speaking, earthquake magnitudes reported in the media are not on the Richterscale" What is an earthquake? We have always been aware of the planet's rumblings, but it has taken us centuries to grasp the true causes. And as for sizing them up, <https://assignbuster.com/richter-scale-essay-sample/>

seismologists only settled on a reliable scale of measurement in the 1930s

WHAT AND WHERE

Our awareness of earthquakes dates back to our earliest days as a sentient species, but for most of human history we have not understood their causes. It's only in the past century that scientists have been able to answer the question: what exactly is an earthquake? Earthquakes in the ancient world, including in the Mediterranean region and Middle East, occurred frequently enough to have been part of the cultural fabric of early civilisations. Legends ascribing geophysical unrest to the whims and fancies of spiritual beings are a recurring theme in early cultures. In more recent history, people began to seek physical explanations. The ancient Greeks in the shape of Aristotle and Pliny the Elder, for example, proposed that earthquakes were the result of underground winds.

The earliest scientific studies of earthquakes date back to the 18th century, sparked by an unusual series of five strong earthquakes in England in 1750 followed by the great Lisbon earthquake of 1755 in Portugal. Early investigations included cataloguing past earthquakes and trying to understand the seismic waves of energy generated during the events. These waves, which radiate from the earthquake's source and cause the ground to heave, remained the focus of scientific efforts until the end of the 19th century. Indeed, the word " earthquake" is derived from the ancient Greek word for " shaking", although when modern scientists say " earthquake" they are generally referring to the source, not the ground motion. Following the 1891 Mino-Owari earthquake in Japan and the 1906 San Francisco

earthquake, attention shifted to the mechanisms that give rise to these events.

Using data from triangulation surveys - an early forerunner to GPS - conducted before and after the 1906 earthquake, geophysicist Harry Fielding Reid developed one of the basic tenets of earthquake science, the theory of "elastic rebound". This describes how earthquakes occur due to the abrupt release of stored stress along a fault line (see diagram, below left). Another half-century elapsed before the plate tectonics revolution of the mid-20th century provided an explanation for the more fundamental question: what drives earthquakes? We now know that most earthquakes are caused by the build-up of stress along the planet's active plate boundaries, where tectonic plates converge or slide past each other.

Other earthquake causes have also been identified, such as post-glacial rebound, when the crust returns to its non-depressed state over timescales of tens of thousands of years following the retreat of large ice sheets. Such processes, however, make up only a tiny percentage of the overall energy released by earthquakes due to plate tectonics. Thus has modern science established the basic framework to understand where, how and why earthquakes happen. The devil continues to lurk in the details. Instant Expert: Earthquakes

Charles Richter (left) borrowed the term "magnitude" from astronomy. San Francisco was destroyed by an earthquake in 1906 (right) GROUND MOTION STRONGEST LINKS

Earthquakes are often related to one another - one can lead to another - but

there are common misconceptions about what drives them and the ways that they are linked. It is an enduring misperception that a large earthquake is associated with a sudden lurching of an entire tectonic plate. If one corner of the Pacific plate moves, shouldn't it be the case that other parts of the plate will follow suit? The idea might be intuitive, but it is wrong. The Earth's tectonic plates are always moving, typically about as fast as human fingernails grow. What actually happens is that adjacent plates lock up, causing warping of the crust and storing energy, but only over a narrow zone along the boundary. So when an earthquake happens, this kink is catching up with the rest of the plate.

Earthquake statistics do tell us, however, that the risk of aftershocks can be substantial: on average, the largest aftershock will be about one magnitude unit smaller than the mainshock. Aftershocks cluster around the fault break, but can also occur on close neighbouring faults. As the citizens of Christchurch, New Zealand, learned in 2011, a typical largest aftershock (M6.1) had far worse consequences than the significantly bigger mainshock (M7), because the aftershock occurred closer to a population centre. In addition to aftershock hazard, there is always a chance that a big earthquake can beget another big earthquake nearby, typically within tens of kilometres, on a timescale of minutes to decades. For example, the 23 April 1992 M6.1 Joshua Tree earthquake in southern California was followed by the 28 June 1992 M7.3 Landers earthquake, approximately 35 kilometres to the north. Such triggering is understood as a consequence of the stress changes caused by the movements of the rocks.

Basically, motion on one fault will mechanically nudge adjacent faults, which can push them over the edge, so to speak, following delays ranging from seconds to years. An additional mechanism is now recognised as giving rise to triggering: the stress changes associated with seismic waves. Remote triggering occurs commonly – but not exclusively – in active volcanic and geothermal areas, where underground magmatic fluid systems can be disrupted by passing seismic waves. Overwhelmingly, remotely triggered earthquakes are expected to be small. Here again, recent advances in earthquake science as well as centuries of experience tell us that earthquakes do not occur in great apocalyptic cascades.

However, in recent decades scientists have learned that faults and earthquakes communicate with one another in far more diverse and interesting ways than the classic foreshock-mainshock-aftershock taxonomy suggests. Understanding the shaking caused by earthquakes is crucial if we are to prepare for these events – but the impact of an earthquake on people and cities depends on more than magnitude alone. The Earth's crust can amplify or dampen the severity of shaking. The tsunami that hit Japan in 2011 caused more damage and deaths than the shaking TSUNAMI!

Undersea earthquakes can generate a potentially lethal cascade: a fault break can cause movement of the seafloor, which displaces the water above to form a tsunami wave. Tsunamis can also be generated when earthquakes trigger undersea slumping of sediments, although these waves are generally more modest in size. Tsunami waves spread out through the ocean in all directions, travelling in the open ocean about as fast as a jet airplane. They have a very long wavelength and low amplitude at sea, but grow to

<https://assignbuster.com/richter-scale-essay-sample/>

enormous heights as the wave energy piles up against the shore. Seismic waves cause perceptible ground motion if they are strong enough. For seismic hazard assessment, the study of ground motion is where the rubber meets the road. If we understand the shaking, we can design structures and infrastructures to withstand it.

The severity of earthquake shaking is fundamentally controlled by three factors: earthquake magnitude, the attenuation of energy as waves move through the crust and the modification of shaking due to the local geological structure. Bigger earthquakes generally create stronger shaking, but not all earthquakes of a given magnitude are created equal. Shaking can depend significantly on factors such as the depth of the earthquake, the orientation of a fault, whether or not the fault break reaches the surface and whether the earthquake rupture is relatively faster or slower than average.

Attenuation of seismic waves varies considerably in different regions. In a place like California or Turkey, where the crust is highly fractured and relatively hot, waves dissipate – or attenuate – quickly. Following the 1906 San Francisco earthquake, pioneering geologist G. K. Gilbert observed: “ At a distance of twenty miles [from the fault] only an occasional chimney was overturned and not all sleepers were wakened.”

In regions that are far from active plate boundaries, such as peninsular India or the central and eastern US, waves travel far more efficiently. The three principal mainshocks of the 1811-1812 New Madrid earthquake sequence in the central US damaged chimneys and woke most sleepers in Louisville, Kentucky, some 400 kilometres away. In 2011, the magnitude 5.8 Virginia earthquake was felt in Wisconsin and Minnesota, over 1500 km away. Local

<https://assignbuster.com/richter-scale-essay-sample/>

geological structures such as soft sediment layers can amplify wave amplitudes. For example, the M8 earthquake along the west coast of Mexico in 1985 generated a ringing resonance in the lake-bed sediments that underlie Mexico City. And in Port-au-Prince, some of the most dramatic damage in the 2010 Haiti earthquake was associated with amplification by small-scale topographic features such as hills and ridges.

Characterisation of the full range and nature of site response remains a prime target for ground motion studies, in part because of the potential to map out the variability of hazard throughout an urban region, called “microzonation”. This offers the opportunity to identify those parts of urban areas that are relatively more and less hazardous, which can guide land-use planning and appropriate building codes. Rubber, meet road. “Earthquakes far from major plate boundaries can often be felt over 1000 kilometres away” To prevent building collapse, geologists must map out hazards due to local geology WHY SO DIFFICULT?

In the 1970s and 1980s, leading scientists were quoted in the media expressing optimism that reliable short-term prediction of earthquakes was around the corner. This was fuelled by promising results from the Soviet Union, and the apparently successful prediction of the 1975 earthquake in Haicheng, China. Since then, this optimism has given way to varying degrees of pessimism. Why are earthquakes so hard to predict? Any number of possible precursors to earthquakes have been explored: small earthquake patterns, electromagnetic signals and radon or hydrogeochemical changes. Many seemed promising, but none have stood up to rigorous examination. Consider this example. In March 2009, Italian laboratory technician <https://assignbuster.com/richter-scale-essay-sample/>

Giampaolo Giuliani made a public prediction that a large earthquake would occur in the Abruzzo region of central Italy. His evidence? An observed radon anomaly.

The prediction was denounced by local seismologists. The M6.3 L'Aquila earthquake struck the area on 6 April, killing 308 people. This gets to the issue of reliable precursors. It is possible that radon was released due to the series of small earthquakes, or foreshocks, that preceded the main earthquake. It is also possible it was coincidence. Scientists explored radon as a precursor in the 1970s and quickly discovered how unreliable it is. Once in a while radon fluctuations might be associated with an impending earthquake, but usually they are not. Meanwhile big earthquakes hit regions where anomalies were absent. The same story has played out with many other proposed precursors. That's not to say that seismologists have neglected to investigate precursors - on the contrary they are examining them with increasingly sophisticated methods and data.

However, a common bugaboo of prediction research is the difficulty of truly prospective testing. To develop a prediction method based on a particular precursor, researchers compare past earthquakes with available recorded data. One might, for example, identify an apparent pattern of small earthquakes that preceded the last 10 large earthquakes in a given region. Such retrospective analyses are plagued by subtle data selection biases. That is, given the known time of a big earthquake, one can often look back and pick out apparently significant signals or patterns. This effect is illustrated by the enduring myth that animals can sense impending earthquakes. It is possible that animals respond to weak initial shaking that

<https://assignbuster.com/richter-scale-essay-sample/>

humans miss, but any pet owner knows that animals behave unusually all the time - and it's soon forgotten.

People only ascribe significance with hindsight. At present most seismologists are pessimistic that prediction will ever be possible. But the jury is still out. One of the big unanswered questions in seismology is: what happens in the earth to set an earthquake in motion? It is possible that some sort of slow nucleation process is involved, and therefore possible that earthquake precursors exist. For this as well as all earthquake prediction research, the challenge is to move beyond the retrospective and the anecdotal, into the realm of statistically rigorous science. Many avenues for earthquake forecasting have been explored, from prior changes in animal behaviour to electromagnetic signals. Yet predicting exactly when an earthquake will happen remains impossible today. Still, there is a great deal we do know about the Earth's shaking in the future " Shake tables" test how buildings will act in an earthquake

FORECASTING: WHAT WE KNOW

When seismologists are asked whether earthquakes can be predicted, they tend to be quick to answer no. Sometimes even we geologists can forget that, in the ways that matter, earthquakes are too predictable. We know where in the world they are likely to happen. For most of these zones, we have quite good estimates of the expected long-term rates of earthquakes (see map, right). And while we often cannot say that the next Big One will strike in a human lifetime, we can say it is very likely to occur within the lifetime of a building. We know the largest earthquakes occur along subduction zones, where a tectonic plate dives beneath another into the

<https://assignbuster.com/richter-scale-essay-sample/>

Earth's mantle, with rupture lengths of more than 1000 kilometres and an average slip along a fault of tens of metres. But any active plate boundary is fair game for a big earthquake, at any time.

For example, two years before the 2010 earthquake in Haiti, geophysicist Eric Calais and his colleagues published results of GPS data from the region, noting that "the Enriquillo fault is capable of a M7.2 earthquake if the entire elastic strain accumulated since the last major earthquake was released in a single event". While this exact scenario did not play out in 2010, it wasn't far off. We can say for sure that people living on plate boundaries will always face risk. Future large earthquakes are expected in California. Research by James Lienkaemper and his colleagues estimates that sufficient strain is stored on the Hayward fault in the east San Francisco Bay area to produce a M7 earthquake. An earthquake this size is expected, on average, every 150 years.

The last one was in 1868. Local anxieties inevitably mount knowing such information, but earthquakes occur by irregular clockwork: if the average repeat time is 150 years, it could vary between 80 to 220 years. So we are left with the same vexing uncertainty: an "overdue" earthquake might not occur for another 50 years, or it could happen tomorrow. On a geological timescale there is not much difference between sooner versus later. On a human timescale, sooner versus later seems like all the difference in the world. Earth scientists have made great strides in forecasting the expected average rates of damaging earthquakes. The far more challenging problem remains finding the political will and resources to prepare for the inevitable.

MEGAQUAKE MYTHS

<https://assignbuster.com/richter-scale-essay-sample/>

Since the M9.1 Sumatra-Andaman earthquake struck on Boxing Day in 2004, another four earthquakes with magnitudes of 8.5 or greater have occurred on the planet, including the Tohoku, Japan, earthquake in 2011 (see diagram, below). This apparent spate has led some to wonder if earthquake frequency is increasing. Careful statistical analysis reveals that it is not. The recent rate of very large earthquakes is unusual, but not a statistically significant increase relative to expected variability. And the overall energy release by earthquakes in the past eight years is still below the combined energy release of the two largest recorded earthquakes: the 1960 Chilean quake and Alaska's 1964 quake on Good Friday.

Anthropogenic climate change could conceivably influence earthquake rates in certain areas in the future: the process of post-glacial rebound associated with the retreat of large glaciers provides a source of stress that can drive earthquakes. Such earthquakes could have a significant local impact, but their overall energy release will continue to be dwarfed by that of earthquakes caused by plate tectonics. While there is no reason to believe that megaquakes are on the rise, there is little doubt that more and worse megadisasters due to earthquakes lie ahead in our future - they are the inevitable consequence of explosive population growth and concomitant construction of vulnerable dwellings in the developing world. "Climate change could influence the frequency of earthquakes in the future"

Geologists use hazard maps to illustrate earthquake risk in a region.

This one essentially shows the peak shaking that policymakers should prepare for in the next 50 years California schoolchildren perform earthquake practice drills Susan Hough Susan Hough is a senior seismologist <https://assignbuster.com/richter-scale-essay-sample/>

with the Southern California Earthquake Center and a Fellow of the American Geophysical Union. She led the Earthquake Disaster Assistance Team effort to deploy seismometers in Haiti following the January 2010 earthquake. Derk-Jan Dijk Raphaëlle Winsky-Sommerer sleep 4 February

WHITHER EARTHQUAKE SCIENCE

In the 1970s, during the heyday of earthquake prediction research, Charles Richter remained an ardent and vocal sceptic, a stance that drove a wedge between him and more optimistic colleagues. Overwhelmingly, the lessons of subsequent decades have vindicated Richter's views. Yet asked in 1979 if he thought earthquake prediction would ever be possible, he replied: " Nothing is less predictable than the development of an active scientific field." Indeed, the 25 years since Richter's death have witnessed developments he could not have imagined, including the recent recognition that many subduction zones generate a kind of seismic chatter, dubbed non-volcanic tremor, and that patches along subduction zones can slip slowly without releasing seismic waves. Non-volcanic tremor, which is thought to occur along the deep extension of faults into layers that are too hot to remain fully brittle, has also been identified along a few faults outside subduction zones.

Could the processes at play in the deeper layers be the key to understanding the occurrence of large earthquakes? Other intriguing but controversial ideas have been proposed, including the theory that electromagnetic precursors are generated before faults rupture. Scientific discourse about such research is couched within polarised debates about proposed prediction methods.

Some scientists now wonder if the pessimism about the feasibility of reliable earthquake prediction has led the field to shy away from investigations that

<https://assignbuster.com/richter-scale-essay-sample/>

could help us understand earthquake processes. Some fairly basic questions still beg for answers: why does an earthquake start at a particular time and place? Why does an earthquake stop? As a big earthquake starts, does it “know” it will be a big earthquake? Or is it merely a small one that gets out of hand? As seismologists work to develop a more complete understanding of earthquakes, and to refine hazard assessments, one sobering lesson has emerged: expect the unexpected.

While hazard maps characterise the expected long-term rates of earthquakes in many regions, an “overdue” earthquake might not strike for another 100 years. Moreover, even in well studied areas, the historical record is too short to understand fully the variability of the earthquake cycle associated with a given plate boundary. Geological investigations of prehistoric earthquakes can start to extend our knowledge to more geologically meaningful timescales, but such results are limited and typically characterised by high uncertainties. Our understanding of both the variability of earthquake repeat times and the largest possible earthquake in a given area is limited at best. Our expectations for the largest possible earthquakes are often too strongly shaped by the events in the historical record only. We should know better. further

READING

Predicting the Unpredictable: The tumultuous science of earthquake prediction by Susan Hough, Princeton University Press, 2009 Earthshaking Science: What we know (and don't know) about earthquakes by Susan Hough, Princeton University Press, 2002 Introduction to Seismology by Peter

Shearer, Cambridge University Press, 1999 Earthquakes 5th edition by Bruce Bolt, W. H. Freeman, 2003

Websites

US Geological Survey Earthquake Hazards Program earthquake. usgs. gov

European-Mediterranean Seismological Centre emsc-csem. org

Global Seismic Hazard Assessment Program www. seismo. ethz.

ch/static/GSHAP The Great ShakeOut US earthquake drills shakeout. org

© 2012, New Scientist, Reed Business Information UK, Ltd., a division of Reed Elsevier, Inc. All Rights Reserved. Copyright of New Scientist is the property of Reed Business Information and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.