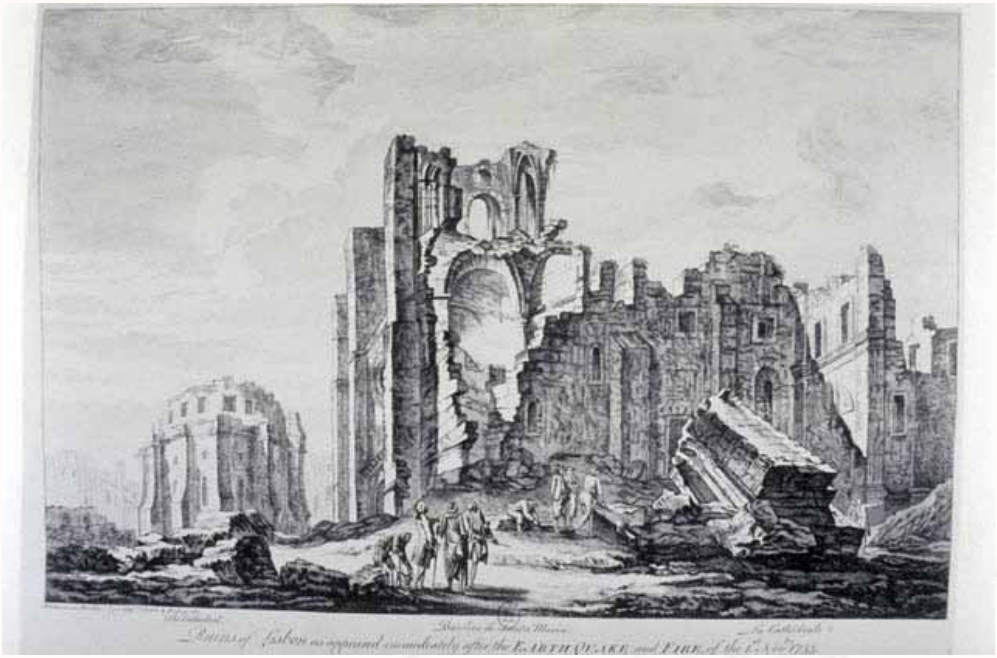
What is an earthquake ?

In ancient times earthquakes were thought to be caused by restless gods or giant creatures slumbering beneath the Earth.



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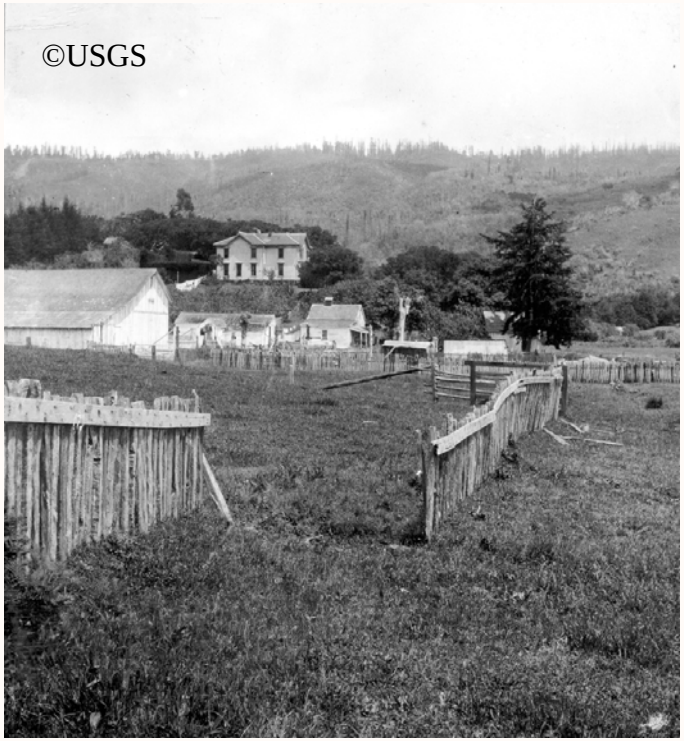
In Japan earthquakes were thought to be caused by a monster catfish (Namazu) that lived under Japan. In this picture people are punishing the catfish for causing a large earthquake in 1855.

The great Lisbon earthquake and subsequent tsunami of 1755 caused massive destruction and had a huge effect on European scientific and philosophical development.

The early Greek philosophers developed a theory that earthquakes were caused by movements of gases trying to escape from underground. Up until the 18th century western scientists (including Newton) thought they were caused by explosions of flammable material deep underground.

In 1760 Rev J.Mitchell proposed that earthquakes were caused by rock movements and related the shaking to the propagation of elastic waves within the earth.



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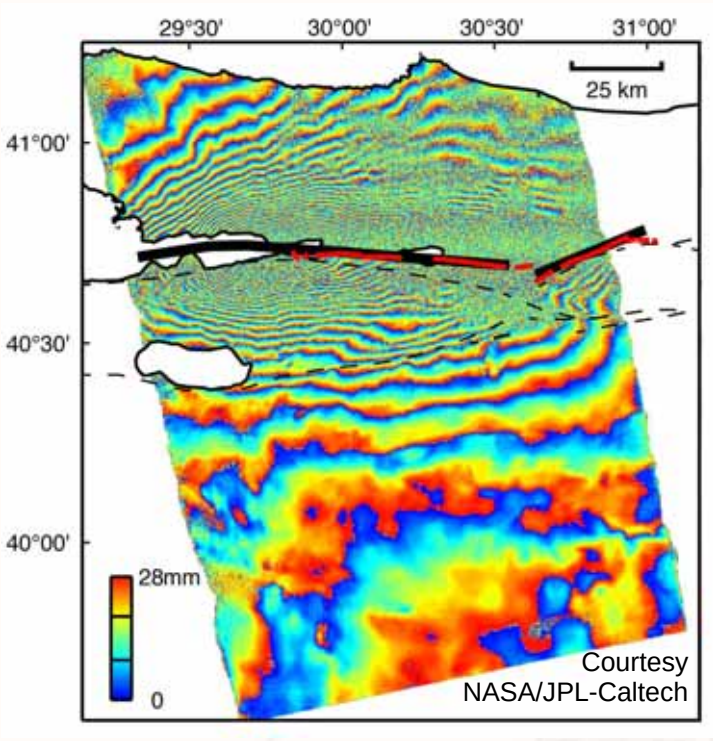
By examination of the displacement of the ground surface caused by the 1906 San Francisco earthquake, (photo shows a fence offset by 2.5 m by the earthquake) Henry Fielding Reid, Professor of Geology at Johns Hopkins University, concluded that the earthquake must have involved an 'elastic rebound' of previously stored elastic stress.



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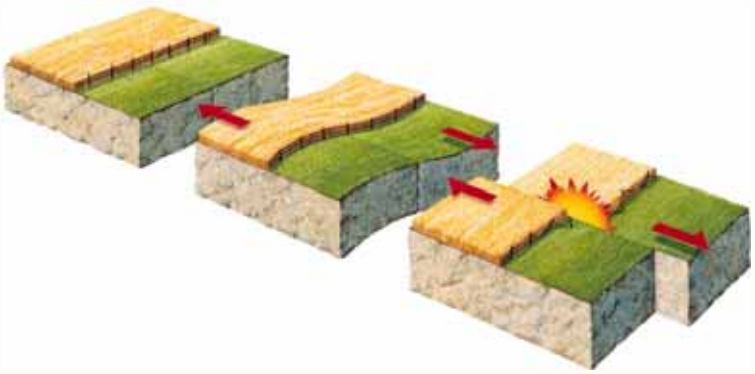
Scientists can now measure how the movement caused by an earthquake is distributed in space. By comparing two radar satellite images before and after a large earthquake we can determine how much each pixel has moved. In this interferogram of the area around the 1999 M7.3 earthquake in Izmit, Turkey, each colour band (red-blue) represents a movement of 28 mm (one radar wavelength).

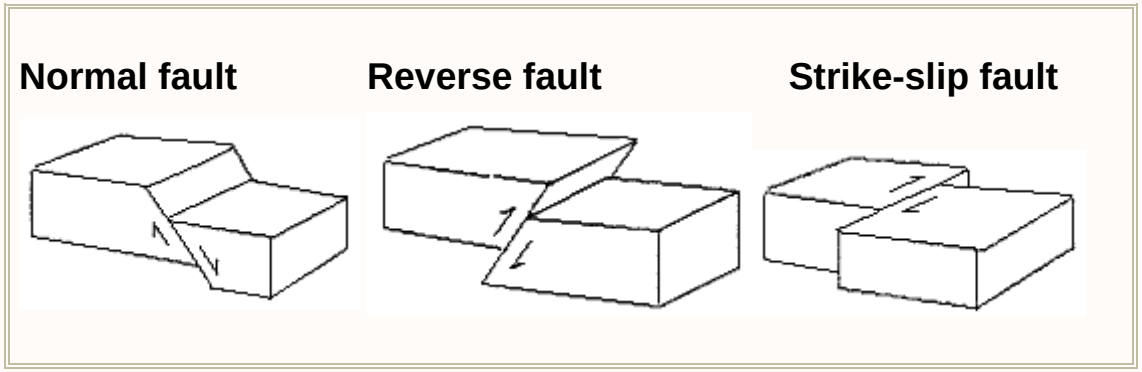
Elastic rebound

The mechanisms and processes involved when earthquakes occur are extremely complex. However some of the characteristics of earthquakes can be explained by using a simple elastic rebound theory.



Over time stresses in the Earth build up (often caused by the slow movements of tectonic plates)

At some point the stresses become so great that the Earth breaks … an earthquake rupture occurs and relieves some of the stresses (but generally not all)

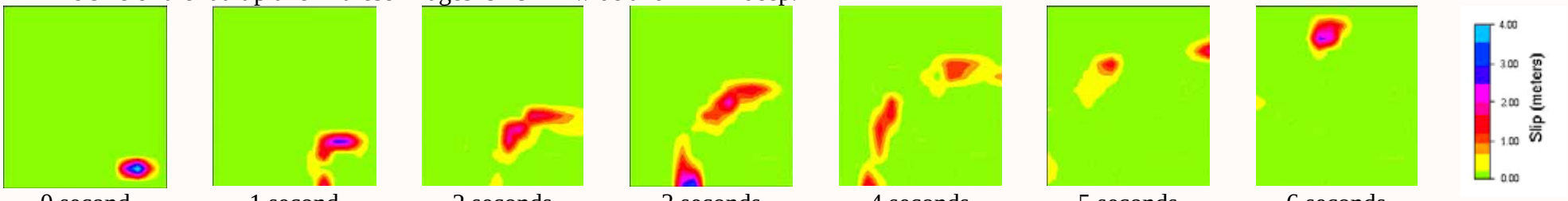


In earthquakes these ruptures generally happen along fault planes, or lines of weakness in the Earth's crust. There are three basic types of fault.

Earthquake rupture occurs in three stages:
1) initiation of sliding along a small portion of the fault,
2) growth of the slip surface and
3) termination of the slip.

The amount of slip will vary in different places along the fault, and will grow with time.

This sequence of images shows the growth of an earthquake rupture, modelled using data from the 1994 M6.7 Northridge earthquake in California (a movie of this process can be found at www.data.scec.org/Module/links/northrup.html images used with permission of David Wald) The size of the fault plane in these images is 18 km wide and 14 km deep.



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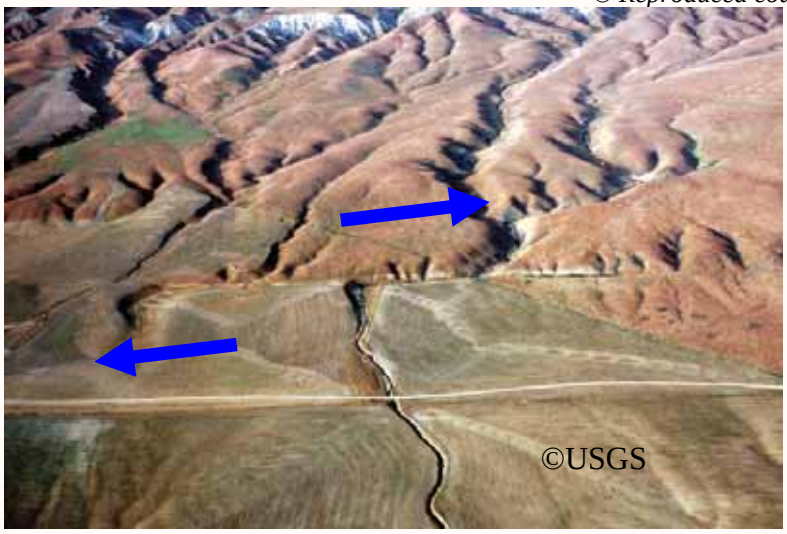

Aerial view of offset streams along the San Andreas Fault, caused by many earthquakes (the average movement along this boundary is ~3 cm per year)

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Small offset from a single earthquake in California (M6.9 strike slip event in 1979)

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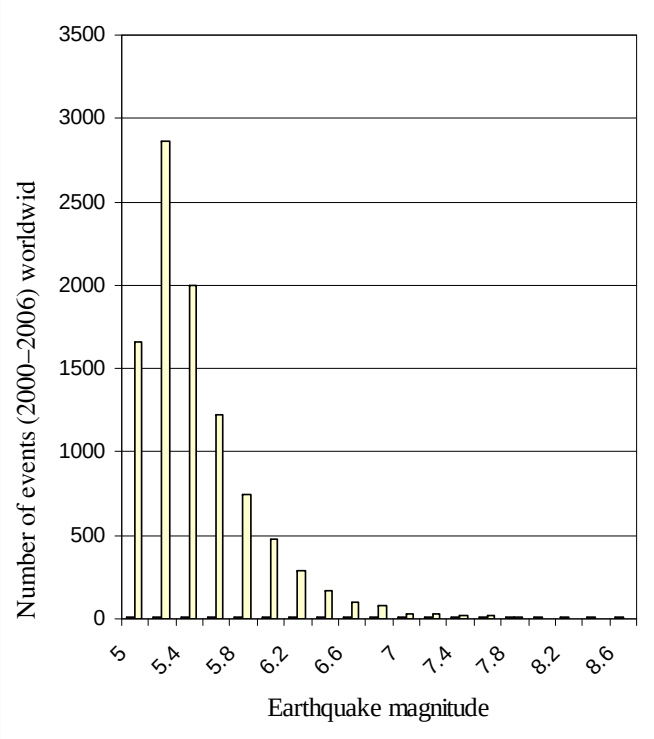
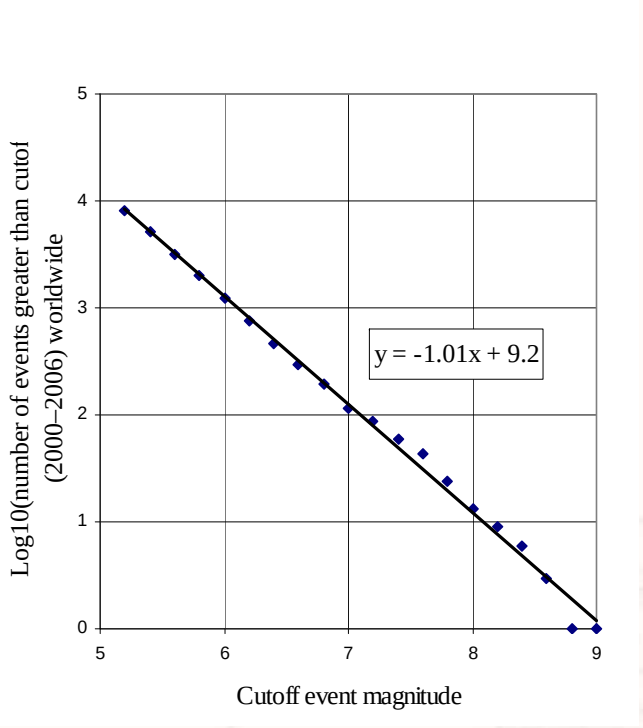
Usually with earthquakes the movement on these faults does not intersect the surface. However when it does the results are easy to see.

A histogram of all the earthquakes measured worldwide over a 6 year period shows large events are far less frequent than smaller ones.



This is more usually plotted as a cumulative plot on a log axis. This way the data plots as a straight line. Y= ax +b



This is referred to as the Gutenberg-Richter relationship after Charles Richter (1900–1985) and Beno Gutenberg (1889–1960) who both worked at the California Institute of Technology (CALTECH). The slope of the line is approximately -1 for all earthquakes (Because this is a Log 10 graph that means that for each increase in magnitude there are 10 x fewer events). This relationship holds true even when you consider earthquakes in smaller areas.