

Historical Development of Global Seismology

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Zhang Heng (78-139 AD)



Around 132 AD, Chinese scientist Chang Heng invented the first seismoscope, an instrument that could register the occurrence of an earthquake. Heng's invention was called the dragon jar. The dragon jar was a cylindrical jar with eight dragonheads arranged around its brim; each dragon had a ball in its mouth.



Around the foot of the jar were eight frogs, each directly under a dragonhead. When an earthquake happened a ball dropped from a dragon's mouth and was caught by the frog's mouth.

John William Strutt (Lord Rayleigh)



Baron Rayleigh, was born on November 12, 1842 at Langford Grove, Maldon, Essex. In 1887Lord Rayleigh demonstrated the existence of additional solutions of elastic equations of motion for bodies with free surfaces. These are Rayleigh waves, involving wave motions confined to and propagating along the surface of the body.

Richard Dixon Oldham (1858-1936)



In 1897, a discovery by the Irish scientist Richard Dixon Oldham provided early clues about the nature of Earth's interior.In 1906, Oldham recognized the existence of the Earth's core and made a preliminary, but incorrect, estimate of its size. He also noted a seismic "shadow zone," on the side of the Earth opposite the earthquake, where no P waves were recorded. Oldham's work, which included partially successful attempts to determine the existence of a thin outer crust and an inner core, helped other scientists accurately map the Earth's different layers.

John August Anderson (1876-1959)



The Seismo Lab was established by Harry Wood in 1921 under the auspices of the Carnegie Institution of Washington. In the early 1920s, Wood and John Anderson developed the Wood-Anderson torsion seismometer that became the standard for local earthquake recording. Hundreds of these instruments are still in regular use today.

Keiti Aki (1930-2006)



Keiti Aki was born on March 3, 1930, in Yokohama. Keiti Aki defines seismic moment, which is a physical measure of the magnitude of an earthquake in 1966. He was co-author (together with Paul Richards) of the seismologist's bible: **"Quantitative Seismology"**.

Robert Hook's (1635-1703)



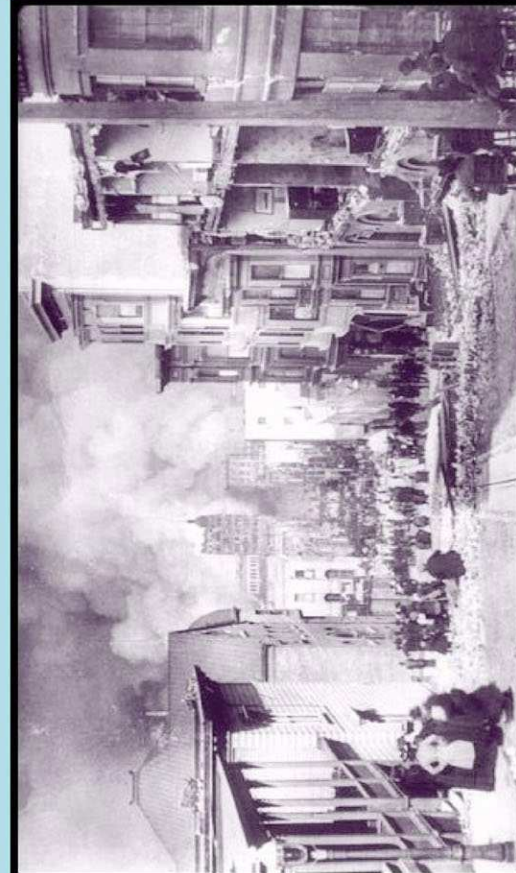
He was born on 18 July 1635 in Freshwater, Isle of Wight, England In 1660 he discovered an instance of Hooke's law while working on designs for the balance springs of clocks. However he only announced the general law of elasticity in his lecture Of Spring given in 1678. This law indicate a proportionality between stress and strain , to the development of equations for elasticity theory by Navier and Cauchy in 1821-1822,our understanding of the behavior of solid materials evolved rapidly.

Augustus Edward Hough Love (1863-1940)



In 1911 a second type of surface wave motion, produced in a bounded body with layered material properties, was characterized by Love and is hence called a Love wave. Rayleigh and Love waves are surface waves and result from the interaction of P and S waves with the boundary conditions on the body.

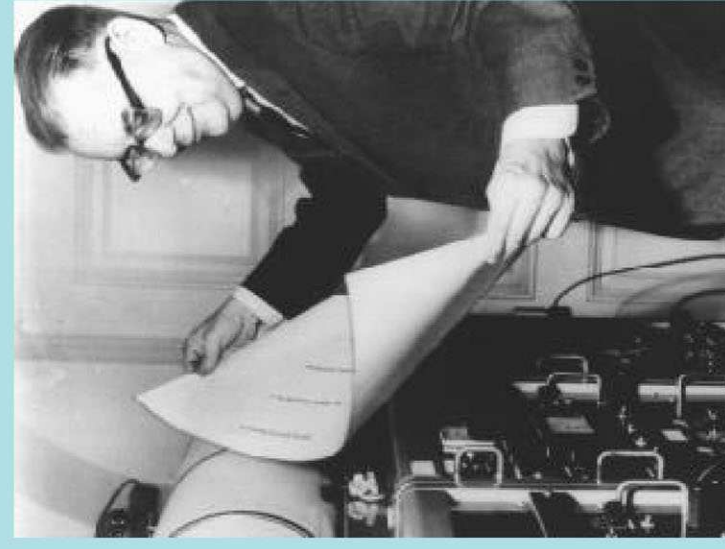
San Francisco earthquake 1906



The 1906 earthquake in San Francisco is one of the most famous earthquakes in history - although not the largest recorded nor the most killed, it was one of the first major earthquakes to be comprehensively studied, reported and photographed.

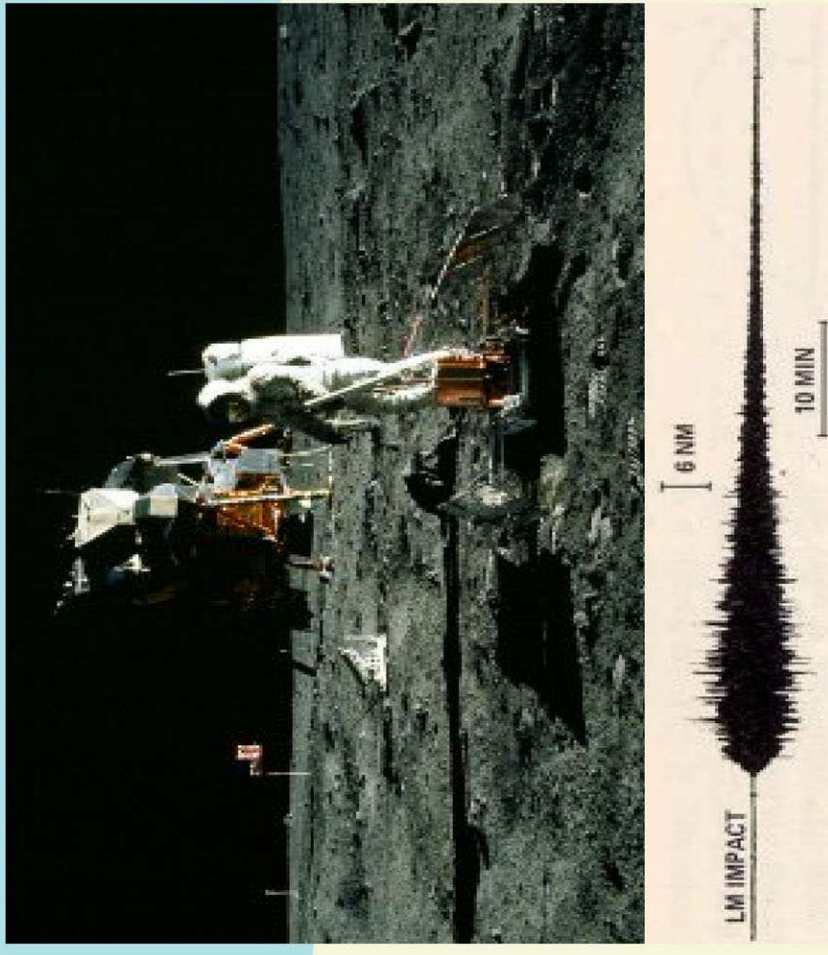
The first shocks occurred at 05:12 am local time on April 18th 1906. These were large enough to be felt around the city of San Francisco but were followed some 25 seconds later by the main earthquake with violent shocks and strong shaking for some 60 seconds. Some 7,000 people were estimated to have died in the earthquake, although the true figure for the earthquake and the subsequent fires is likely to have been far larger.

Charles Francis Richter (1900-1985)



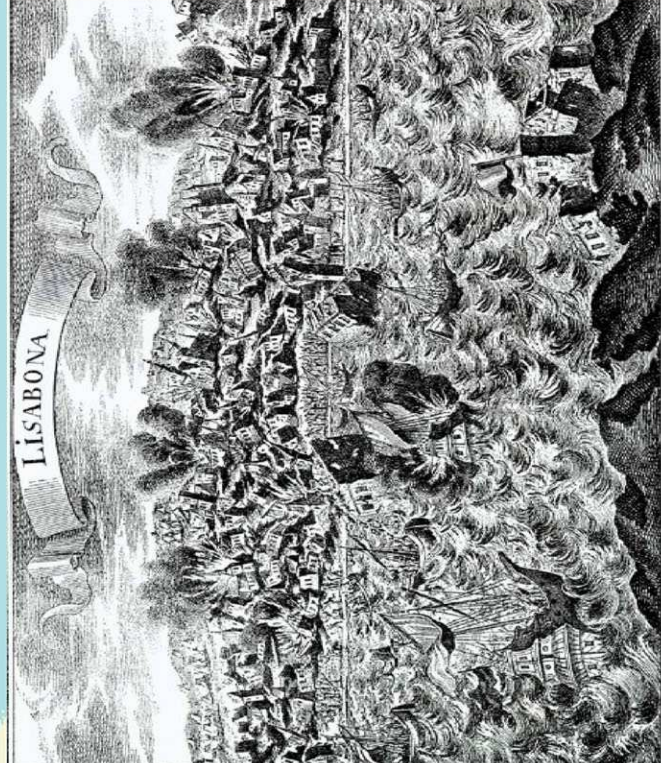
Born in Hamilton, Ohio,Richter developed his scale to measure the strength of earthquakes in 1935. Earlier scales had been developed by de Rossi in the 1880s and by Giuseppe Mercalli in 1902 but both used a descriptive scale defined in terms of damage to buildings and the behavior and response of the population. Richter's scale is an absolute one, based on the amplitude of the waves produced by the earthquake. He defined the magnitude of an earthquake as the logarithm to the base 10 of the maximum amplitude of the waves, measured in microns.In 1954 Richter and Gutenberg produced one of the basic textbooks on seismology. Seismicity of the Earth.

Moonquake (1969-1972)



Apollo astronauts place a seismometer on the Moon, and the first "moonquakes" are registered.

Lisbon earthquake (1755)



The 1755 Lisbon earthquake took place on November 1, 1755, at 9:20 in the morning. It was one of the most destructive and deadly earthquakes in history, killing between 60,000 and 100,000 people.The quake was followed by a tsunami and fire, resulting in the near total destruction of Lisbon. The earthquake accentuated political tensions in Portugal and profoundly disrupted the country's 18th century colonial ambitions.

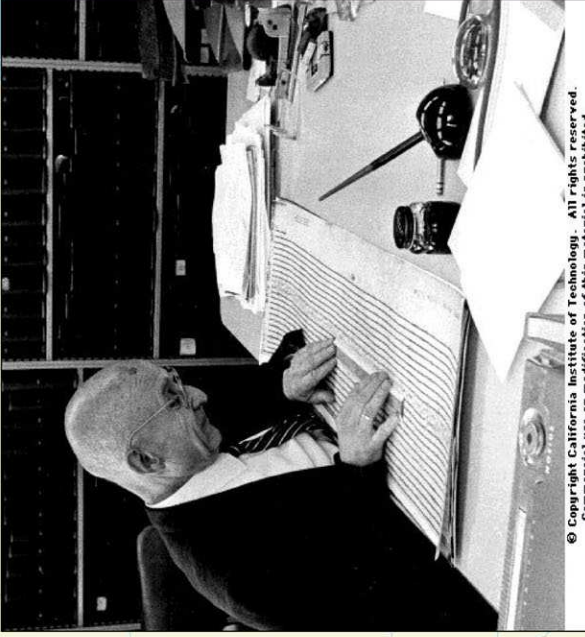
As the first earthquake studied scientifically for its effects over a large area, it signalled the birth of modern seismology. Geologists today estimate the Lisbon earthquake approached magnitude 9 on the Richter scale, with an epicenter in the Atlantic Ocean about 200 km west-southwest of Cape St. Vincent.

Filippo Cecchi (1822-1887)



A Scapolian father, born in Ponte Buggianese in Valdintevole (Tuscany), Cecchi was an accomplished physicist and an able maker of scientific instruments. The first seismometer is invented by Filippo Cecchi in Italy in 1875.

Beno Gutenberg (1889-1960)



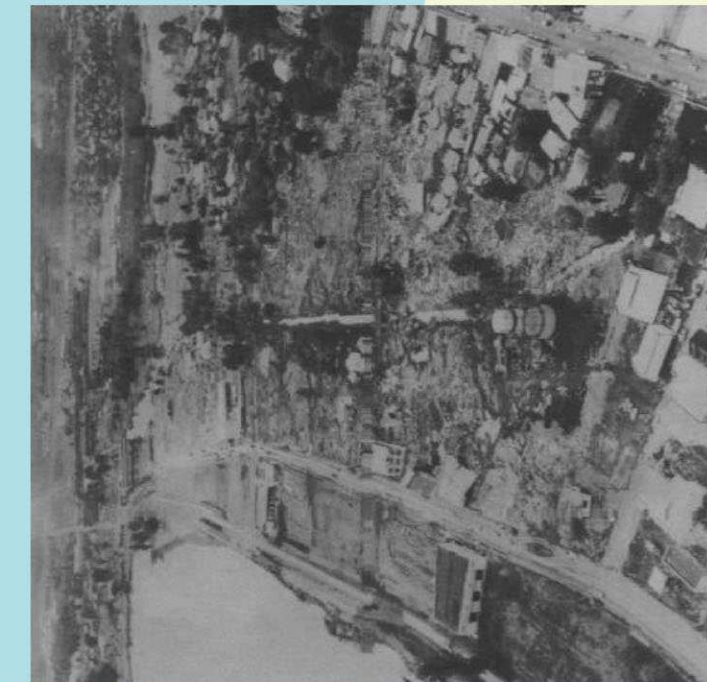
Beno Gutenberg was born in Darmstadt, Germany, on June 4, 1889. Gutenberg turned his attention to the Earth's interior, basing his early research on the seismographic material that Wiechert had assembled for studying the Earth's deep structure. In the best known of his early work he made the first correct determination of the radius of the Earth's core, a study completed in 1913. With Charles Richter, he published a series of papers titled "On seismic waves" between 1931 and 1939. Gutenberg and Richter also collaborated on the development of various magnitude scales using seismic waves of different types so that observers could assign magnitudes to earthquakes that have both shallow and deep foci and occur at various epicentral distances.

Keith Edward Bullen (1906-1976)



Keith Edward Bullen was born at Auckland, New Zealand, on 29 June 1906.Jeffreys was working on the revision of the travel time of the seismic waves from earthquakes and Bullen worked with Jeffreys on this project throughout his years in Cambridge.

1960 Chilean Tsunami



On May 22, 1960, at 19:11 GMT, an earthquake occurred off the coast of South Central Chile. A Pacific-wide tsunami was triggered by the earthquake, which had a surface-wave magnitude of 8.6 and Mw=9.5, an epicenter of 39.5 S, 74.5 W, and a focal depth of 33 km. The number of fatalities associated with both the tsunami and the earthquake has been estimated to be between 490 to 2,290. Damage cost estimates were over a half billion dollars.

Navier (1785-1836)



Claude-Louis Navier (February 10, 1785 in Dijon - August 21, 1836 in Paris) born Claude Louis Marie Henri Navier, was a French engineer and physicist who specialized in mechanics. Navier formulated the general theory of elasticity in a mathematically usable form (1821). His major contribution however remain the Navier-Stokes equations (1822), central to fluid mechanics. Cauchy was born on August 21, 1789 in Paris, France. Cauchy is known for his work with permutation groups, differential equations, determinants, probability, mathematical physics, wave propagation and optics, and fluid flow. Cauchy founded theories of elasticity, functions of complex variables, and substitution groups.He formulated and developed the general theory of stress.

Von Rebeur Paschwitz (1861-1895)



A distant earthquake is recorded instrumentally for the first time in 1889. The recording is made in Potsdam, Germany of a Japanese earthquake.

Simeon Denis Poisson (1781-1840)



He was born on 21 June 1781 in Pithiviers, France In 1830 Poisson used the equation s of motion and elastic constitutive laws to show that two (and only two) fundamental type of waves propagate throuth the interior of homogenous of solids: P waves and s waves. These two types of motion are called body waves, because they traverse the interior of the medium.

John Milne (1850-1913)



John Milne was, perhaps, the greatest individual contributor to observational earthquake investigations of all time. In 1889, a moderate earthquake did damage in Yokohama. This led him to initiate the founding of the first seismological society in the world, the Seismological Society of Japan. He enlisted the help of two English colleagues Alfred Ewing, a mechanical engineering professor, and Thomas Gray, an electrical engineering professor, to invent a revolutionary new seismograph, simple yet sensitive. After modifications, it was widely used for many years as the Milne-Shaw seismograph. Milne's instruments permitted him to detect different types of earthquake waves, and estimate velocities.

Sir Harold Jeffreys (1891-1989)



Harold Jeffreys was born on April 22, 1891, in Durham, England. Jeffreys, in 1926, gave the first quantitative estimate of the rigidity of the earth's core and established that most of the core is probably molten. He was the senior author of tables produced during 1930-1940, giving the travel times of earthquake waves through the interior of the earth. Since 1940 these tables have been used as the standard in calculating the epicenters and origin times of the world's earthquakes for the International Seismological Summary. Jeffreys also contributed notably to theories of seismic wave propagation, of mutations of the earth's axis, on mountain building, on convection currents inside the earth, on tidal problems, on the figure of the earth and the moon, and a theory on the internal structures of other terrestrial planets.

Hugo Benioff (1899-1968)



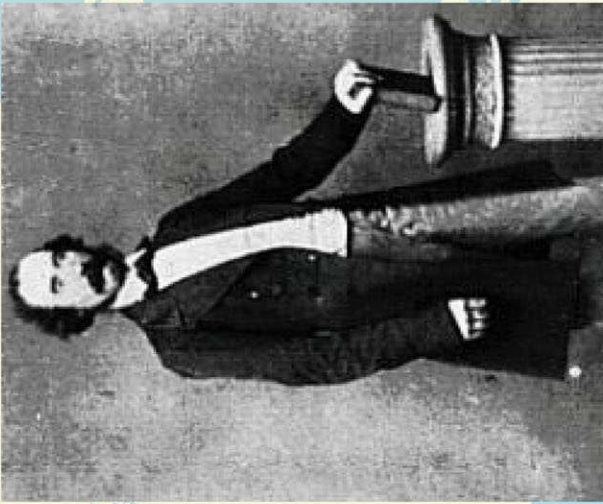
Seismologist and inventor, born in Los Angeles, California, USA. He was a physicist at the Carnegie Institution, before joining the California Institute of Technology. He devised and developed many seismic detection instruments, including a seismograph for measuring travel-time curves of earthquake waves that became the basis for the Geneva Conference nuclear detection system.

He was the first to describe the plane of earthquake foci extending from Pacific Ocean trenches to the earth's shallower mantle, now known as the Benioff zone.

2004 Indonesian Tsunami

The earthquake measuring 9.0 magnitude struck the western end of Indonesia's Sumatra Island at 6:58 a.m. local time, flattening buildings and sending a wall of water higher than the tops of coconut palms into the towns and villages in the province of Aceh. The epicenter was located 155 miles southeast of the provincial capital of Banda Aceh and 200 miles west of Medan, Sumatra. The 9.0 magnitude quake was the strongest in 40 years and the fourth-most-powerful since 1900, according to the U.S. Geological Survey. The tsunamis also left thousands injured, thousands missing and hundreds of thousands homeless in Indonesia, India, Sri Lanka and Thailand. It is the fourth-largest earthquake since such measurements began in 1899, according to the NEIC, lying with a 1952 quake in Kamchatka, Russia.

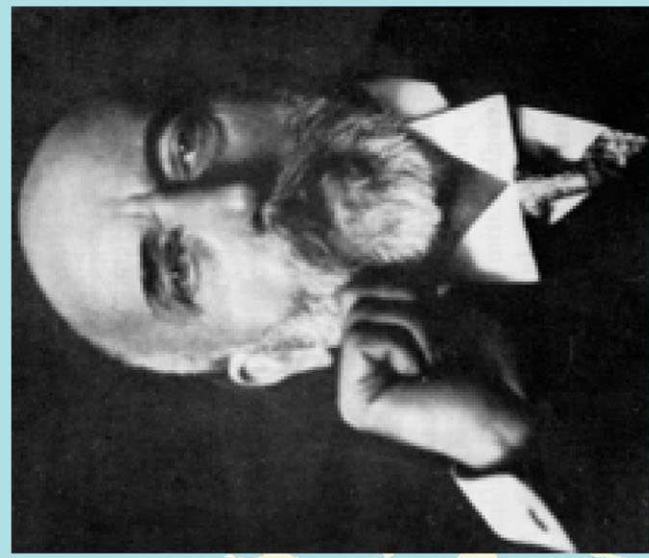
Robert Mallet (1810-1881)



Born in Dublin on June 3, 1810. He wrote the important treatise on the dynamics of earthquakes, he carried out blasting experiments for determining the propagation speed in sand and in solid rock and wrote detailed reports about the facts and phenomena of earthquakes for the British Association. Until 1852 MALLETT did not experience an earthquake himself, as Ireland is a typically aseismic area. He only witnessed the earthquake on November 2, 1852 in Great Britain.

But MALLETT could have a direct experience of the – destructive force of earthquakes only after the earthquake in Naples on December 16, 1857 when he visited this area a few months later with financial support by the Royal Society. After his return he moved to London in 1861. During the last seven years of his life he was totally blind. He died on November 5, 1881.

Andrija Mohorovicic (1857-1936)



January 23, 1857 – December 18, 1936 was a notable Croatian meteorologist and seismologist born in Volosko, Istria. Mohorovicic concluded that the Earth consists of surface layers above an internal core. He was first in the world to establish, (based seismic waves), surface and velocity discontinuity that separates the crust of the planet Earth from the mantle. There are depths where seismic waves do change speed and also there is change in chemical composition.

We know today that the crust is 5-9 km deep beneath the ocean floor and 25-60 km beneath the continents carried on tectonic plates. This layer is called the Mohorovicic Discontinuity or Moho.

Reid and Elastic Rebound Theory



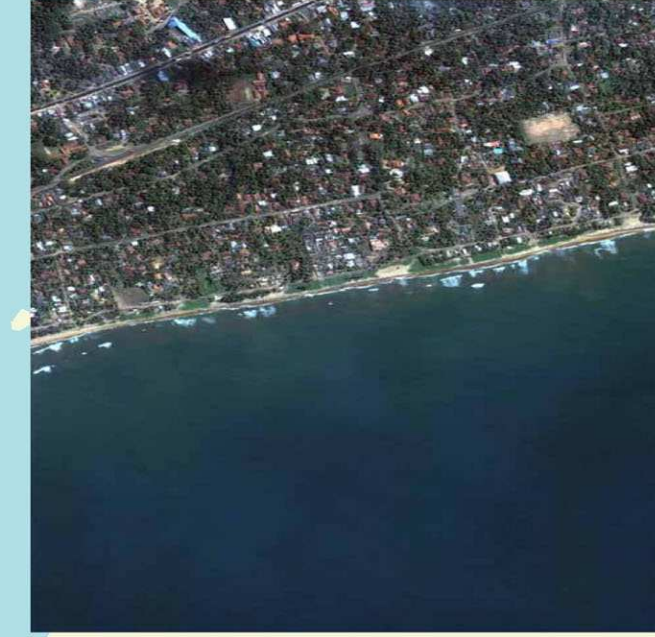
From an examination of the displacement of the ground surface which accompanied the 1906 earthquake, Henry Fielding Reid, Professor of Geology at Johns Hopkins University, concluded that the earthquake must have involved an "elastic rebound" of previously stored elastic stress. If a stretched rubber band is broken or cut, elastic energy stored in the rubber band during the stretching will suddenly be released. Similarly, the crust of the earth can gradually store elastic stress that is released suddenly during an earthquake. This gradual accumulation and release of stress and strain is now referred to as the **"Elastic Rebound Theory"** of earthquakes. Most earthquakes are the result of the sudden elastic rebound of previously stored energy.

Hiroo Kanamori and Mw



Hiroo Kanamori was born on October 17, 1936 is a seismologist who has made fundamental contributions to understanding the physics of earthquakes and the tectonic processes that cause them. His most visible public contribution is the moment magnitude scale for measuring the relative strength of earthquakes In 1977 Hiroo Kanamori establishes the moment magnitude scale, which is a measure of earthquake magnitude based on seismic moment. The moment magnitude scale is used by most seismologists today.

Before Tsunami



After Tsunami



This poster is prepared by Mahesh Devarwar, Bannam (Devarwar@kcl.ac.uk), at Seismology Department in center of National Earthquake Prediction with using the Generic Mapping Tools (GMT) version 4.3.