Aftershock

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An **aftershock** is a smaller earthquake that occurs after a previous large earthquake, in the same area of the main shock. If an aftershock is larger than the main shock, the aftershock is redesignated as the main shock and the original main shock is redesignated as a foreshock. Aftershocks are formed as the crust around the displaced fault plane adjusts to the effects of the main shock.

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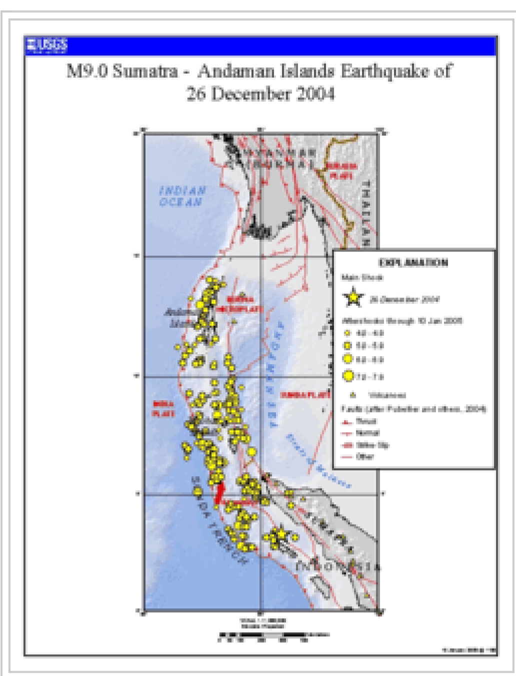
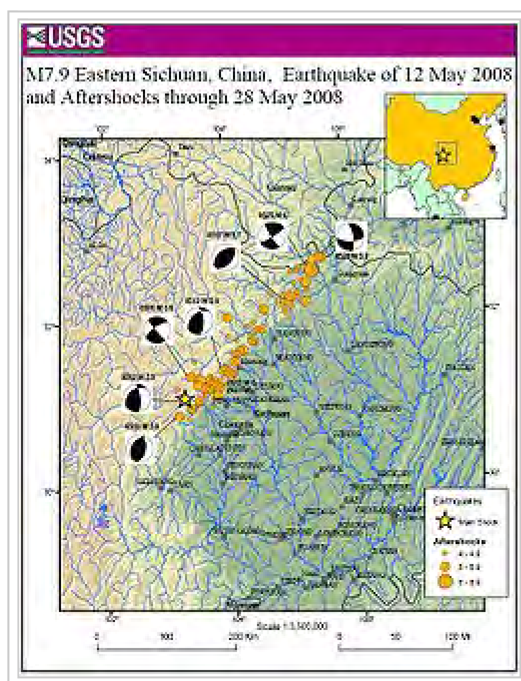
Distribution of aftershocks



Most aftershocks are located over the full area of fault rupture and either occur along the fault plane itself or along other faults within the volume affected by the strain associated with the main shock. Typically, aftershocks are found up to a



distance equal to the rupture length away from the fault plane.

The pattern of aftershocks helps confirm the size of area that slipped during the main shock. In the case of the 2004 Indian Ocean earthquake and the 2008 Sichuan earthquake the aftershock distribution shows in both cases that the epicenter (where the rupture initiated) lies to one end of the final area of slip, implying strongly asymmetric rupture propagation.

Aftershock size and frequency with time

Aftershocks rates and magnitudes follow several well-established empirical laws.

Omori's Law

The frequency of aftershocks decreases roughly with the reciprocal of time after the main shock. This empirical relation was first described by Fusakichi Omori in 1894 and is known as Omori's law.[1] It is expressed as

$$n(t) = \frac{k}{(c+t)}$$

where k and c are constants, which vary between earthquake sequences. A modified version of Omori's law, now commonly used, was proposed by Utsu in 1961.[2][3]

$$n(t) = \frac{k}{(c+t)^p}$$

where p is a third constant which modifies the decay rate and typically falls in the range 0.7–1.5.

According to these equations, the rate of aftershocks decreases quickly with time. The rate of aftershocks is proportional to the inverse of time since the mainshock and this relationship can be used to estimate the probability of future aftershock occurrence.[4] Thus whatever the probability of an aftershock are on the first day, the second day will have 1/2 the probability of the first day and the tenth day will have approximately 1/10 the probability of the first day (when p is equal to 1). These patterns describe only the statistical behavior of aftershocks; the actual times, numbers and locations of the aftershocks are stochastic, while tending to follow these patterns. As this is an empirical law, values of the parameters are obtained by fitting to data after a mainshock has occurred, and they imply no specific physical mechanism in any given case.

Båth's Law

The other main law describing aftershocks is known as Båth's Law[5][6] and this states that the difference in magnitude between a main shock and its largest aftershock is approximately constant, independent of the main shock magnitude, typically 1.1–1.2 on the Moment magnitude scale.

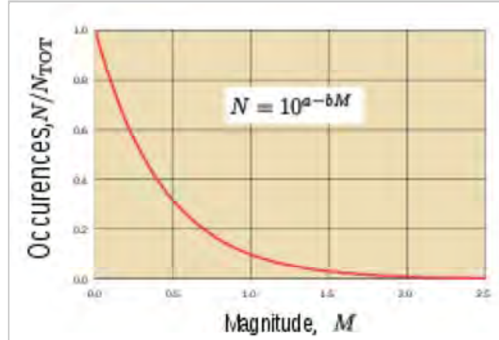
Gutenberg–Richter law

Aftershock sequences also typically follow the Gutenberg–Richter law of size scaling, which refers to the relationship between the magnitude and total number of earthquakes in a region in a given time period.

$$N = 10^{a-bM}$$

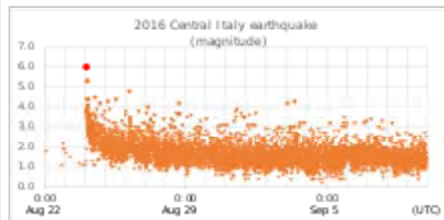
Where:

- N is the number of events greater or equal to M
- M is magnitude
- a and b are constants



Gutenberg–Richter law for $b = 1$

In summary, there are more small aftershocks and fewer large aftershocks.



Magnitude of the Central Italy earthquake of August 2016 (red dot) and aftershocks (which continued to occur after the period shown here)

Effect of aftershocks

Aftershocks are dangerous because they are usually unpredictable, can be of a large magnitude, and can collapse buildings that are damaged from the main shock. Bigger earthquakes have more and larger aftershocks and the sequences can last for years or even longer especially when a large event occurs in a seismically quiet area; see, for example, the New Madrid Seismic Zone, where events still follow Omori's law from the main shocks of 1811–1812. An aftershock sequence is deemed to have ended when the rate of seismicity drops back to a background level; i.e., no further decay in the number of events with time can be detected.

Land movement around the New Madrid is reported to be no more than 0.2 mm (0.0079 in) a year,[7] in contrast to the San Andreas Fault which averages up to 37 mm (1.5 in) a year across California.[8] Aftershocks on the San Andreas are now believed to top out at 10 years while earthquakes in New Madrid are considered aftershocks nearly 200 years after the 1812 New Madrid earthquake.[9]

Foreshocks

Some scientists have tried to use foreshocks to help predict upcoming earthquakes, having one of their few successes with the 1975 Haicheng earthquake in China. On the East Pacific Rise however, transform faults show quite predictable foreshock behaviour before the main seismic event. Reviews of data of past events and their foreshocks showed that they have a low number of aftershocks and high foreshock rates compared to continental strike-slip faults.[10]

Modeling

Seismologists use tools such as the Epidemic-Type Aftershock Sequence model (ETAS) to study cascading aftershocks.[11]

Psychology

Following a large earthquake and aftershocks, many people have reported feeling "phantom earthquakes" when in fact no earthquake was taking place. This condition, known as "earthquake sickness" is thought to be related to motion sickness, and usually goes away as seismic activity tails off.[12][13]

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External links

- Earthquake Aftershocks Not What They Seemed (http://www.livescience.com/environment/060607_quake_aftershocks.html) at Live Science

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