USGS science for a changing world

Natural Hazards

# Can we cause earthquakes? Is there any way to prevent earthquakes?

Earthquakes induced by human activity have been documented at many locations in the United States and in many other countries around the world. Earthquakes can be induced by a wide range of causes including impoundment of reservoirs, surface and underground mining, withdrawal of fluids and gas from the subsurface, and injection of fluids into underground formations. While most induced earthquakes are small and present little hazard, larger and potentially damaging manmade earthquakes have occurred in the past.

The hazard posed by manmade earthquakes can be mitigated by minimizing or in some cases stopping the activity that is causing the earthquakes to occur. For example, earthquakes linked to wastewater disposal in deep wells in Colorado, Ohio and Arkansas stopped occurring after injection was halted.

We cannot prevent natural earthquakes from occurring but we can significantly mitigate their effects by identifying hazards, building safer structures, and providing education on earthquake safety. By preparing for natural earthquakes we can also reduce the risk from human induced earthquakes.

## Explore More Science

earthquakes
induced seismicity
Hydraulic Fracturing
Natural Hazards

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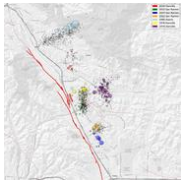


### What is the difference between aftershocks and swarms?

Aftershocks are a sequence of earthquakes that happen after a larger mainshock on a fault. Aftershocks occur near the fault zone where the mainshock rupture occurred and are part of the "readjustment process" after the main slip on the fault. Aftershocks become less frequent with time, although they can continue for days, weeks, months, or even...

### Do earthquakes occur in Antarctica?

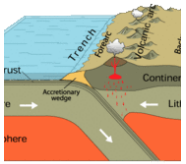
Earthquakes do occur in Antarctica, but not very often. There have been some big earthquakes--including one magnitude 8 --in the Balleny Islands (between Antarctica and New Zealand). The boundary between the Scotia Plate and the Antarctic Plate just grazes the north tip of the Antarctic Peninsula (look "northwest" from the Pole toward South...

## Where can I find earthquake educational materials?

Start with our Earthquake Hazards Education site. That includes: Earthquakes for Kids Cool Earthquake Facts Earthquake Science for Everyone Other good starting points include: State Geological Surveys for states in earthquake-prone regions The Great ShakeOut Earthquake Drills website IRIS (Incorporated Research Institutions for Seismology), which...

## What is surface faulting or surface rupture in an earthquake?

Surface rupture occurs when movement on a fault deep within the earth breaks through to the surface. NOT ALL earthquakes result in surface rupture.




## At what depth do earthquakes occur? What is the significance of the depth?

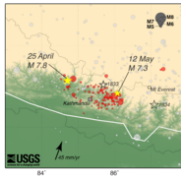
Earthquakes occur in the crust or upper mantle , which ranges from the earth's surface to about 800 kilometers deep (about 500 miles). The strength of shaking from an earthquake diminishes with increasing distance from the earthquake's source, so the strength of shaking at the surface from an earthquake that occurs at 500km deep is considerably...

## Why are there so many earthquakes in the Geysers area in Northern California?

The Geysers Geothermal Field is located in a tectonically active region of Northern California. The major seismic hazards in the region are from large earthquakes occurring along regional faults that are located miles away from the geothermal field, such as the San Andreas and Healdsburg-Rodgers Creek faults. However, activities associated with...

## What is an earthquake and what causes them to happen?

An earthquake is caused by a sudden slip on a fault . The tectonic plates are always slowly moving, but they get stuck at their edges due to friction. When the stress on the edge overcomes the friction, there is an earthquake that releases energy in waves that travel through the earth's crust and cause the shaking that we feel. In California there...




## Foreshocks, aftershocks - what's the difference?

"Foreshock" and "aftershock" are relative terms. Foreshocks are earthquakes that precede larger earthquakes in the same location. An earthquake cannot be identified as a foreshock until after a larger earthquake in the same area occurs. Aftershocks are smaller earthquakes that occur in the same general area during the days to years following a...

## Can the position of the moon or the planets affect seismicity? Are there more earthquakes in the morning/in the evening/at a certain time of the month?

Earthquakes are equally as likely to occur in the morning or the evening. Many studies in the past have shown no significant correlations between the rate of earthquake occurrence and the semi-diurnal tides when using large earthquake catalogs. Several recent studies, however, have found a correlation between earth tides (caused by the position of...


Year Published: 2016

## Potentially induced earthquakes during the early twentieth century in the Los Angeles Basin

Recent studies have presented evidence that early to mid-twentieth-century earthquakes in Oklahoma and Texas were likely induced by fossil fuel production and/or injection of wastewater (Hough and Page, 2015; Frohlich et al., 2016). Considering seismicity from 1935 onward, Hauksson et al. (2015) concluded...

Hough, Susan E.; Page, Morgan T.
*Attribution:* , Earthquake Science Center, Natural Hazards, Earthquake Hazards Program

View Citation


Year Published: 2015

## Myths and facts on wastewater injection, hydraulic fracturing, enhanced oil recovery, and induced seismicity

The central United States has undergone a dramatic increase in seismicity over the past 6 years (Fig. 1), rising from an average of 24 M≥3 earthquakes per year in the years 1973–2008 to an average of 193 M≥3 earthquakes in 2009–2014, with 688 occurring in 2014 alone. Multiple damaging earthquakes have occurred during this...

Rubinstein, Justin L.; Mahani, Alireza Babaie
*Attribution:* Natural Hazards, Earthquake Science Center, Natural Hazards, Earthquake Hazards Program, United States of America

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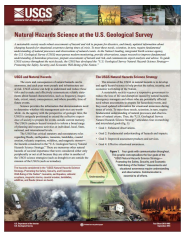



Year Published: 2013

## Natural Hazards Science at the U.S. Geological Survey

The mission of the USGS in natural hazards is to develop and apply hazard science to help protect the safety, security, and economic well-being of the Nation. The costs and consequences of natural hazards can be enormous, and each year more people and infrastructure are at risk. The USGS conducts hazard research and works closely with stakeholders...

Perry, Suzanne C.; Jones, Lucile M.; Holmes, Robert R.
*Attribution:* Natural Hazards, Geologic Hazards Science Center, Natural Hazards, Earthquake Hazards Program, , Region 7: Upper Colorado Basin, United States of America

View Citation


Year Published: 2013

## Potentially induced earthquakes in Oklahoma, USA: links between wastewater injection and the 2011 Mw 5.7 earthquake sequence

Significant earthquakes are increasingly occurring within the continental interior of the United States, including five of moment magnitude (Mw) ≥ 5.0 in 2011 alone. Concurrently, the volume of fluid injected into the subsurface related to the production of unconventional resources continues to rise. Here we identify the largest earthquake...

Keranen, Katie M.; Savage, Heather M.; Abers, Geoffrey A.; Cochran, Elizabeth S.
*Attribution:* Natural Hazards, Earthquake Science Center, Natural Hazards, Earthquake Hazards Program, Oklahoma, United States of America

View Citation


Year Published: 2010

## Passive seismic monitoring of natural and induced earthquakes: case studies, future directions and socio-economic relevance

An important discovery in crustal mechanics has been that the Earth's crust is commonly stressed close to failure, even in tectonically quiet areas. As a result, small natural or man-made perturbations to the local stress field may trigger earthquakes. To understand these processes, Passive Seismic Monitoring (PSM) with seismometer arrays is...

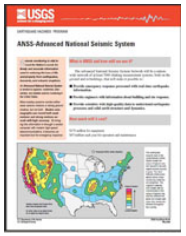
Cloetingh, Sierd; Negendank, Jörg; Bohnhoff, Marco; Dresen, Georg; Ellsworth, William L.; Ito, Hisao
*Attribution:* , Earthquake Science Center, Natural Hazards, Earthquake Hazards Program


Year Published: 2003

## The USGS Earthquake Hazards Program - investing in a safer future

Filson, John R.; McCarthy, Jill; Ellsworth, William L.; Zoback, Mary Lou; Stauffer, Peter H.; Hendley, James W.

View Citation




Year Published: 2000

## ANSS-Advanced National Seismic System

Benz, Harley M.; Filson, John; Arabasz, Walter; Gee, Lind; Wald, Lisa

View Citation


Year Published: 1984

## Understand earthquake hazards

[none]

Spall, Henry

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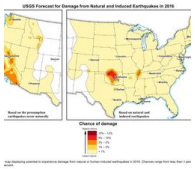


OCTOBER 28, 2016

## USGS Forecast for Damage from Natural and Induced Earthquakes in 2016

USGS map displaying potential to experience damage from a natural or human-induced earthquake in 2016. Chances range from less than one percent to 12 percent.

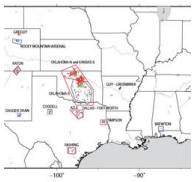
*Attribution: Natural Hazards, Earthquake Hazards Program*

DECEMBER 31, 2013

## Earthquake damage to chimney

House damage from earthquake.

*Attribution: Natural Hazards*



## Research has identified 17 areas in the central and eastern United States with increased rates of induced seismicity.

Research has identified 17 areas in the central and eastern United States with increased rates of induced seismicity. Since 2000, several of these areas have experienced high levels of seismicity, with substantial increases since 2009 that continue today.

## Installation of seismometers to monitor induced seismicity

Bryant Platt digs a hole to install seismometers at a home in southern Kansas. Seismometers are in the foreground.

*Attribution: Earthquake Hazards Program*