

Induced Seismicity: Man-Made Earthquakes Educator Guide

A resource for using QUEST video in the classroom

Watch it online <http://science.kqed.org/quest/video/induced-seismicity-man-made-earthquakes/> | 10:39 minutes

QUEST SUBJECTS

Life Science **Biology**
Health
Environment

Earth Science **Geology**
Climate
Weather
Astronomy

Physical Science **Physics**
Chemistry
Engineering

CA SCIENCE STANDARDS

Grade 6

Plate Tectonics and Earth's Structure (Focus on Earth Sciences)

1. (d) Earthquakes are sudden motions along breaks in the crust called faults; volcanoes and fissures are locations where magma reaches the surface.

Heat (Thermal Energy) (Physical Sciences)

3. (c) Heat flows in solids by conduction (which involves no flow of matter) and in fluids by conduction and by convection (which involves flow of matter).

Energy in the Earth System

4. (c) Heat from Earth's interior reaches the surface primarily through convection.

Grades 9-12

Dynamic Earth Processes (Earth Sciences)

3. (d) Why and how earthquakes occur and the scales used to measure their intensity and magnitude.

PROGRAM NOTES

Can humans create natural disasters? Located just north of San Francisco, The Geysers is the world's largest geothermal field. It produces enough electricity to power all of San Francisco. However, human activity at the steam fields is also linked to earthquake activity, and the number of such incidents is increasing.



In this segment you'll find...

- ⊗ the historic connection between energy mining and earthquakes.
- ⊗ an explanation of the hydrofracture and enhanced geothermal system processes.
- ⊗ the earthquake risk at The Geysers and local effects of human-generated earthquakes.

TOPIC BACKGROUND

Geothermal energy begins deep inside the planet. Hot molten rock, or magma, found below Earth's surface constantly generates temperatures higher than those found on the Sun. Rocks and water inside Earth absorb this heat. Geothermal reservoirs are underground areas that contain hot rock and hot water trapped in the cracks between rocks. We can't see most geothermal reservoirs because they're deep underground. But some geothermal energy comes to the surface through steam, hot gases and hot water generated by volcanoes, hot springs, fumaroles (holes in the crust where volcanic gases escape) and surface geysers.

Most geothermal reservoirs occur around tectonic plate boundaries and fault lines, where volcanoes and earthquakes are most frequent. The Ring of Fire in the Pacific Ocean contains most of all the known geothermal resources. Most U.S. geothermal resources occur in California and Hawaii. The dry steam geothermal reservoir at The Geysers near San Francisco is the largest known geothermal resource of its kind anywhere in the world. It has been used to generate electricity since the 1960s. Underground geothermal energy is recoverable through steam or hot water, which is used to create electricity or to heat and cool structures. Wells are drilled into a geothermal reservoir to reach the subsurface geothermal energy. In some cases, steam from the trapped water comes up through these holes. It's used to turn the turbines that drive electrical generators to produce electricity. In other cases, hot water found close to Earth's surface is piped directly into buildings and used as a source of heat.

Traditionally, geothermal energy has been collected from shallow, naturally occurring geothermal reservoirs, but new, enhanced geothermal systems (EGS) are collecting geothermal energy from deeper areas that contain hotter rocks but less water. In EGS, water is injected into permeable rock below Earth's surface to create a subsurface system of cracks and fractures. The injected water heats up when it comes in contact with the rock and then travels through the fractures to the surface through production wells, almost like a natural geyser or hot spring.

VOCABULARY

Convection

the transfer of heat by the circulation or movement of the heated parts of a liquid or gas

Earthquake

sudden movement of Earth's crust caused by the release of stress accumulated along geologic faults or by volcanic activity

Fault

fracture in the continuity of a rock formation caused by a shifting or dislodging of Earth's crust

Geothermal

of, relating to or produced by the internal heat of Earth

Magnitude

intensity of an earthquake represented by a number on an arbitrary scale

Seismic

of, subject to or caused by an earthquake or earth vibration

Tectonic

of or relating to the structure of Earth's crust and the large-scale processes that take place within it

PRE-VIEWING

- Where and why do earthquakes occur?
- What are some drawbacks associated with different forms of alternative energy?

VIEWING FOCUS

NOTE: You may choose to watch the television segment twice with your students: once to get an overview of the topic and again to focus on facts and draw out opinions.

- What is geothermal energy? What are the benefits of geothermal energy?
- What is induced seismicity? How does geothermal energy production create seismic activity?
- How does an enhanced geothermal system differ from a traditional geothermal system? What are the benefits of enhanced geothermal production?
- Do you think the risks and challenges of an enhanced geothermal system are worth the benefits? Why or why not?

For all media see:

- Segment Summary Student Sheet
http://www.kqed.org/quest/downloads/QUEST_SegSum_StudentSheet.pdf
- Personal Response Student Sheet
http://www.kqed.org/quest/downloads/QUEST_PersResp_StudentSheet.pdf

LESSON PLANS and RESOURCES from QUEST, PBS and NPR

Full Steam Ahead for California Geothermal Plans? NPR

<http://www.npr.org/templates/story/story.php?storyId=129282183>

How do we best access geothermal energy? This August 19, 2010, broadcast from NPR's **Morning Edition**, in combination with KQED, examines the prospect of enhanced geothermal activities at The Geysers.

Harvesting Geothermal Energy NPR

<http://www.npr.org/templates/story/story.php?storyId=93636624>

NPR's **Talk of the Nation** takes a look at ways to harvest geothermal energy from beneath Earth's surface in this story from August 15, 2008.

Earthquakes PBS LearningMedia

http://www.pbslearningmedia.org/content/ess05.sci.ess.earthsys.lp_earthquakes/

In this lesson, students explore the causes of earthquakes as well as their impacts on geology and human societies.

Earthquakes: San Francisco PBS LearningMedia

<http://www.pbslearningmedia.org/content/ess05.sci.ess.earthsys.sanfranthreat/>

In this video segment adapted from **NOVA**, a seismologist interprets earthquake data from the San Francisco Bay Area and shows how such information is used to predict area earthquakes.

Geothermal Power PBS LearningMedia

<http://www.pbslearningmedia.org/content/klvx09.vid.klvxgeoth/>

This video segment from Vegas PBS examines a geothermal energy system as it is being installed in a new green building in Las Vegas.

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www.ebparks.org

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www.exploratorium.edu

Girl Scouts of Northern California
www.girlscoutsnorcal.org

Golden Gate National Parks Conservancy
www.parksconservancy.org

The J. David Gladstone Institutes
www.gladstone.ucsf.edu

Lawrence Berkeley National Laboratory
www.lbl.gov

Lawrence Hall of Science
www.lawrencehallofscience.org

Monterey Bay Aquarium
www.mbayaq.org

Monterey Bay Aquarium Research Institute
www.mbari.org

Oakland Zoo
www.oaklandzoo.org

Stanford University's Woods Institute for the Environment
<http://woods.stanford.edu>

The Tech Museum of Innovation
www.thetech.org

UC Berkeley Natural History Museums
<http://bnhm.berkeley.edu/>

MORE EDUCATIONAL RESOURCES FOR USING QUEST MULTIMEDIA TO ENHANCE 21st CENTURY SKILLS IN TEACHING AND LEARNING

Why Use Multimedia in Science Education?

<http://science.kqed.org/quest/files/downloads/2011/06/QUESTWhyMedia.pdf>

- Read about the importance of using multimedia in the 21st century science classroom.

How to Use Science Media for Teaching and Learning

<http://science.kqed.org/quest/files/downloads/2011/06/QUESTMediaTips.pdf>

- A collection of tips, activities and handouts to actively engage students with multimedia.

Science Multimedia Analysis

<http://science.kqed.org/quest/files/downloads/2011/06/QUESTMediaAnalysis.pdf>

- Give your students the tools to recognize the purposes and messages of science multimedia.

Create Online Science Hikes with Google Maps

http://science.kqed.org/quest/files/downloads/2011/06/QUEST_ExplorationCreation.pdf

- Do you like the science hike Explorations on the QUEST site? Use this place-based educational guide to create similar science-based maps with youth.

Media-Making Toolkit for Science Education

<http://science.kqed.org/quest/education/media-making-toolkit/>

- Are you interested in integrating media making into your classroom or science education program? Find instructions, worksheets and rubrics for implementing simple media-making projects with students.

OTHER WAYS TO PARTICIPATE IN QUEST

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