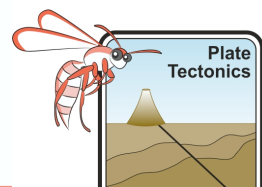


Basel's Fault – Teacher Notes



During the natural breakdown of unstable radioactive elements within our planet, new elements are created and heat is the by-product. Rock, being a solid, holds this heat better than liquids or gasses.

The deeper you go the hotter it gets. At only five kilometres depth rock can be well over 40°C.

Groundwater (or meteoric water) can be held within pores and cracks in this rock. Hot water can be pumped from underground aquifers and used directly.

This **passive geothermal energy** is already used to heat water in swimming pools at Beatty Park and Bicton Baths in Perth. It can also be passed through heat inverters to supply energy for air conditioning as at the Chemistry Centre at Curtin University and at the University of Western Australia.



A three year program tapping into geothermal experts across the world finished in 2012. Perth has good supplies of water at about 230°C at depths of only 50 to 120 metres.

Tourists and local people enjoy hot water bubbling from underground at natural upwellings such as at Zebedee Springs near El Questro in the Kimberley. This use of geothermal energy causes minimal pollution and does not require the use of precious fossil fuels. Warm water also rises to the surface from underground pressure at the edge of artesian basins and along openings such as fault-lines.

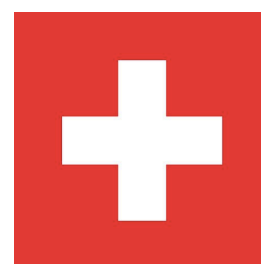
Active geothermal energy can be obtained by pumping cold water from the surface down through drill holes into “hot rocks” such as granites at depths of up to five kilometres. Drilling costs limit depth. Water is the medium that carries heat back up to the surface to power turbines and create electricity for domestic and industrial use. (<http://www.ga.gov.au/energy/geothermal-energy-resources.html>)

Granite has a high thermal capacity (holds heat well) but is not permeable as it is crystalline. Drilling and fracturing (**stimulation or fracking**) creates small cracks that allow the cool water to pass down through the granite, be heated up and be pumped back to the surface. Sand is usually used as a proppant to hold the artificial pores open.

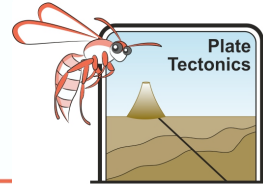
Rocks at depth are under stress from the burden of overlying strata and from tectonic plate movement. If they host pre-existing faults and are at sub-critical stress levels adding water can trigger a seismic event. Those wishing to undertake stimulation for geothermal energy must ensure that:

1. Geological and geophysical surveys have established if there are any major faults prior to drilling.
2. The history of seismicity of the area and present seismic data is available to establish the natural patterns of seismic background.
3. Using the data above, engineers establish “trip points” when it is considered that future stimulation should decrease or cease.
4. During stimulation surrounding holes are monitored for seismicity and fluid leakage
5. Safe engineering practices are followed including double casing and good well closure.

In cold countries with poor reserves of fossil fuel such as Switzerland, finding alternative energy sources is an economic necessity. Basel is major town in Switzerland that was trying to decrease its dependence on nuclear and fossil fuels. Nuclear energy was seen as a viable alternative until the Three Mile



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Island incident, the Chernobyl incident and most recently the catastrophic result of a tsunami at Fukushima in Japan. Switzerland's nuclear power stations will have come to the end of their functioning lives by 2034. A program of drilling was established to tap into geothermal water from hot granites under a nearby valley.

Basel lies on a major fault and was almost destroyed by an earthquake in 1356. A major series of earthquakes were felt in Basel during stimulation of rocks to release geothermal energy. Stimulation ceased as a result of good engineering protocol and has not continued. The earthquakes however continued for some time.

Of course there are always conflicting opinions such as:

1. Without stimulation the earthquake would have happened anyway as the area has a history of instability.
2. The stimulation merely triggered faulting of pre-stressed rock and released a lesser earthquake before even greater stress had built up. The earthquakes would have happened anyway.
3. Stimulation should be required for faults near built up areas (such as the San Andreas Fault that is statistically overdue for a quake) before stress builds up. Many minor earthquakes are better than a major one.

Materials per student or group

- Access to Internet or a print of the article (Induced seismicity in Basel) at:

http://en.wikipedia.org/wiki/Induced_seismicity_in_Basel

Method

Read the article and answer the questions provided. Please explain your answers as in some cases more than one answer is possible.

Where was the geothermal project situated?

Basel is a large city in Switzerland.

(Switzerland is a small high country in the center of Europe. It has few fossil fuel energy sources of its own and relies on nuclear generated electricity and hydro-electric power supplemented by expensive oil imports from other countries. The last of its five nuclear power plants will be shut down in 2034 after parliament voted to wind down the countries' dependence on nuclear energy and seek alternatives)

What was the established problem?

Basel is built on a major fault.

How did the engineers know that there was an established problem?

The city was almost destroyed by an earthquake in 1356.

What was the trip point that caused the injection to be reduced?

Seismic events rising to Richter Magnitude ML 2.9

What was the trip point that caused the project to be suspended?

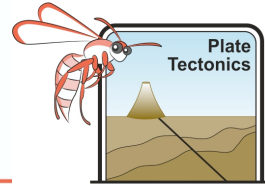
Seismic events reaching Richter Magnitude ML 4.4

Why were six borehole seismometers installed near the stimulation/injection well?

To monitor for any change in background seismicity

An initiative supported by Woodside and ESWA

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What was the damage claim by Swiss citizens as a result of the events?

7-9 million Swiss francs or 6.5 to 8.3 million US dollars

Why was the project cancelled?

It was considered too dangerous to continue

Has there been any direct benefit from this event?

The USA reacted to produce new regulations to govern deep geothermal energy projects



There are arguments for and against using geothermal power in Australia. List some of them and write your opinion below