Geology of the Hawaiian Islands

Class 28
22 April 2004

Any Questions?

HW #7 last chance to turn in
- Please do Virtual field Trip Quizzes – turn in before next Thursday

Geothermal Resources
What is geothermal energy?
Geo = earth
Thermal = heat
Geothermal energy is energy derived from the earth's heat

Geothermal Energy Use
- Hot water from geothermal areas was used by the early Romans for their public baths, and for bathing, cooking, and heating
- Geothermal heat still used for these purposes, and for agricultural and industrial processes, worldwide
- Today worldwide 10,000 MW of installed geothermal capacity

Problems with Geothermal Energy
- Geographically restricted
- Where would we expect to find Geothermal Resources?

The amount of geothermal energy stored within the interior of the earth is enormous
If we could easily exploit it, we could solve most of our energy problems for the next thousand years
The areas most favorable for finding and using geothermal energy are characterized by volcanism.

But most segments of the mid-ocean ridge system are > 2000 m below sea level.
Major elements of a Geothermal Resource:

1. Heat source
2. Porous layer
3. Fractures
4. Recharge

Geothermal Energy Use:
- High temperature water/steam used to generate electricity
- Low temperature water used directly for heating

Hydrothermal energy is used to generate electricity

Binary cycle power plant uses hot water to heat a volatile liquid, which then vaporizes and turns a turbine.
Flash steam power plant -- hot water rises to surface and flashes to steam, which turns a turbine.

Another use of hot water is to heat water, which is then used to heat a building.

In Iceland and Japan, hot water is used to keep streets free of snow and ice.

Geothermal Heat Pump brings hot water from reservoir to heat a building directly.
Subsidiary use of geothermal energy: Warm water feeding into prawn farm in New Zealand

Subsidiary use of geothermal energy: Warm water used for swimming in Iceland

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Click on the Country Name to retrieve information about geothermal developments in that country.
Geothermal energy first produced in Italy in 1904. This area is still producing today.

30% of Iceland’s total energy demand is met from geothermal energy. Most of Iceland’s homes and businesses are heated with geothermal energy.
**INDONESIA**
- 100 geothermal fields
- Geothermal development started in 1920s
- Kamojang Field -- 140 MW/day
- Natural steam and hot water also used locally for cooking and bathing

**THE PHILIPPINES**
- Geothermal fields are large (average 220 MW/day) and development is active
- Geothermal resources are most developed on Luzon and Leyte
- Subsea cables may soon be used to carry power between islands
- Electrical capacity > 1500 MW/day

**U.S. use of Geothermal Energy**
- U.S. is the world leader in geothermal energy development with plant capacity > 2,800 MW
- BUT, only 4 states produce geothermal energy:
  - Hawaii, California, Utah and Nevada
- Equivalent to 60 M barrels oil per yr
- Overall use of oil is > 7.3 Billion b.o./yr
- Geothermal saves only 3 days’ oil use per year
- Geothermal use < 1% of oil use

World’s largest geothermal electrical complex is in “The Geysers” area of northern Calif. 1990 production > 1000 MW/day Today > 2000 MW/day
Geothermal plant at The Geysers, northern California

> 500 MW/day produced in Salton Sea area of southern California

Geothermal plant, Coso, California

Geothermal power plant, Mammoth California
Geothermal Resources in Hawai`i
- Maui and the Big Island appear to have exploitable resources
- Maui: most likely place to find high temperatures is along the SW rift of Haleakala -- remember that this region has had an historic flow
- May be hot water at depths of less than 3 km below the surface

Geothermal Resources in Hawai`i
- Big Island: Most likely place to find hot temperatures near surface
- May be near-surface high T on flanks of Kohala volcano near Kawaihae
- Summit of Hualalai also likely place to find high T
- Mauna Loa surprisingly poor for near-surface high T

Geothermal Resources in Hawai`i
- Best area for geothermal development is around Kilauea
- Many areas where steam comes out at the surface, so there must be hot rocks near surface
- Southwest rift zone very likely place to find hot rocks
- East rift zone is currently being produced
Geothermal Resources in Hawai`i

- Assessments of the Kilauea E and SW Rift zones: Might be able to supply 2800 MW/day of energy
- Current plant at Poho Iki currently produces ~1 % of that -- about 30 MW/day
- Intrusives along the rift zones are about 1100-1200° C
- Very good fracture permeability and lots of water

Sufficient heat has been reached at depths between 1000 and 2000 m beneath the surface
- The region being produced has water that is >360° C (among world’s highest T production).
- The pressure is also very high -- about 200 psi

The geothermal resource is steam
- Steam flows up pipe from depth to surface where it is used to turn turbine to generate electricity
- Steam then condensed into a liquid and pumped back into the reservoir

Puna Geothermal Ventures’ plant in Poho Iki -- Flash steam power plant
Advantages of Geothermal Energy

- Can be used instead of fossil fuels to produce electricity
- Replacing fossil fuels will reduce the amount of air pollutants which can cause acid rain and contribute to global warming

Advantages of Geothermal Energy

- Geothermal plant emits ~ 0.3 lb of carbon per MWhr electricity produced
- Natural gas electric plant emits ~ 280 lb per MWhr
- Fuel oil plant emits ~420 lbs/MWhr
- Coal plant emits ~500 lbs/MWhr

It is very reliable
### Advantages of Geothermal Energy

- Reducing the amount of oil shipped for electrical generation lessens the possibility of oil spills
- Geothermal energy exists in large amounts in Hawai`i, so shipping is not necessary

A 30-megawatt geothermal power plant on the Big Island displaces the need to burn about 500,000 barrels of fuel oil every year.

Eliminates > 220,000 tons of CO$_2$ that an oil-fired plant would have emitted.

### Disadvantages of Geothermal Energy

- Geothermal fluids are corrosive -- they eat away at pipes and equipment, so maintenance costs are high
- Fluids can get into groundwater and contaminate it. -- need to be careful with waste water

Steam contains toxic gases

Hydrogen sulfide is the worst
Disadvantages of Geothermal Energy

- Hydrogen sulfide emissions monitored by the State
  - PGV allowed 8.5 lbs/hr
    - = 200 lbs/day = 0.1 Ton/day
  - Pu`u `O`o vent currently outputs 8-80 Ton/day
  - = 80-800 times as much as PGV plant is allowed to output

- Some residents may not want geothermal activities to occur in certain areas (such as rain forests)

- Some native Hawaiians oppose the development of geothermal power because it interferes with their worship of Pele

- Geothermal wells are sometimes vented for a few hours to clear the well and pipe lines resulting in a temporary release of steam and other gases
  - Such events can be noisy
  - Some continuous low-level noise is also generated during normal power plant operations

Questions?
Tuesday

- Local Environmental issues
- Read Chapter 15