

Geothermal Energy

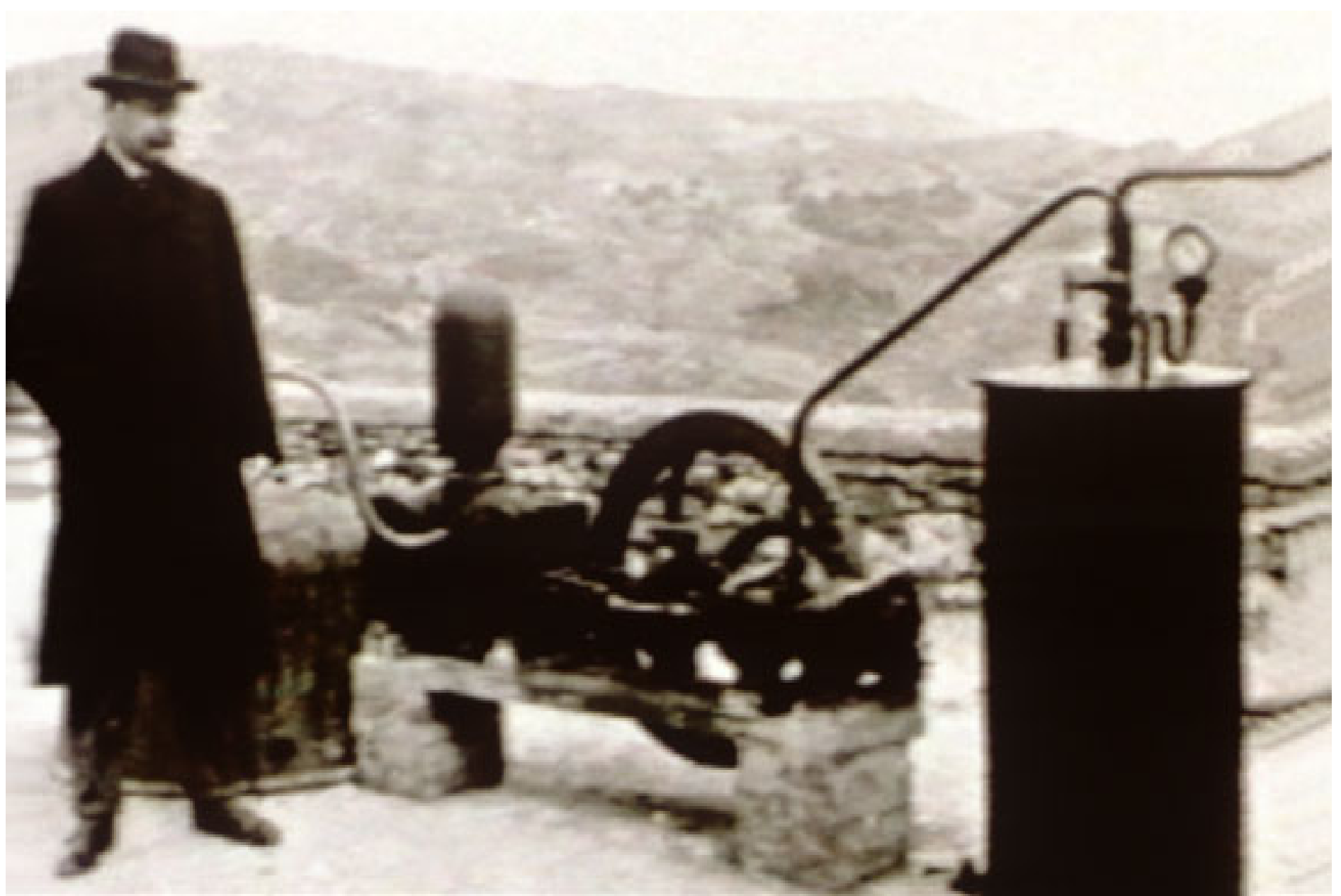
Presented by
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Geothermal energy

- Geo-earth
- Thermal-heat
- heat is continuously produced inside the earth and the water is replenished by rainfall.
- clean and sustainable

- <http://iga.igg.cnr.it/geoworld/galleria/puyehueluna.jpg>





First Geothermal Power Plant, 1904, Larderello, Italy

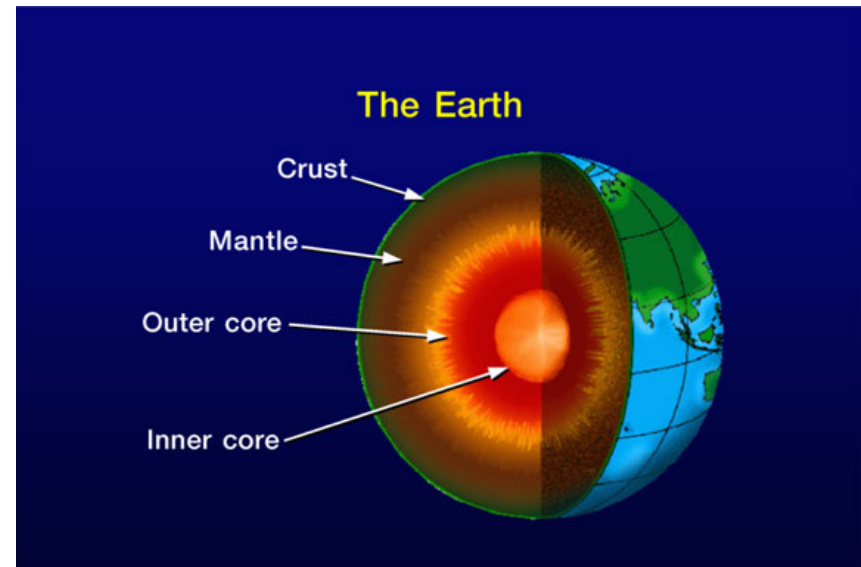
Energy inside the earth

Inner core-solid iron

Outer core-magma

Mantle-magma and rock

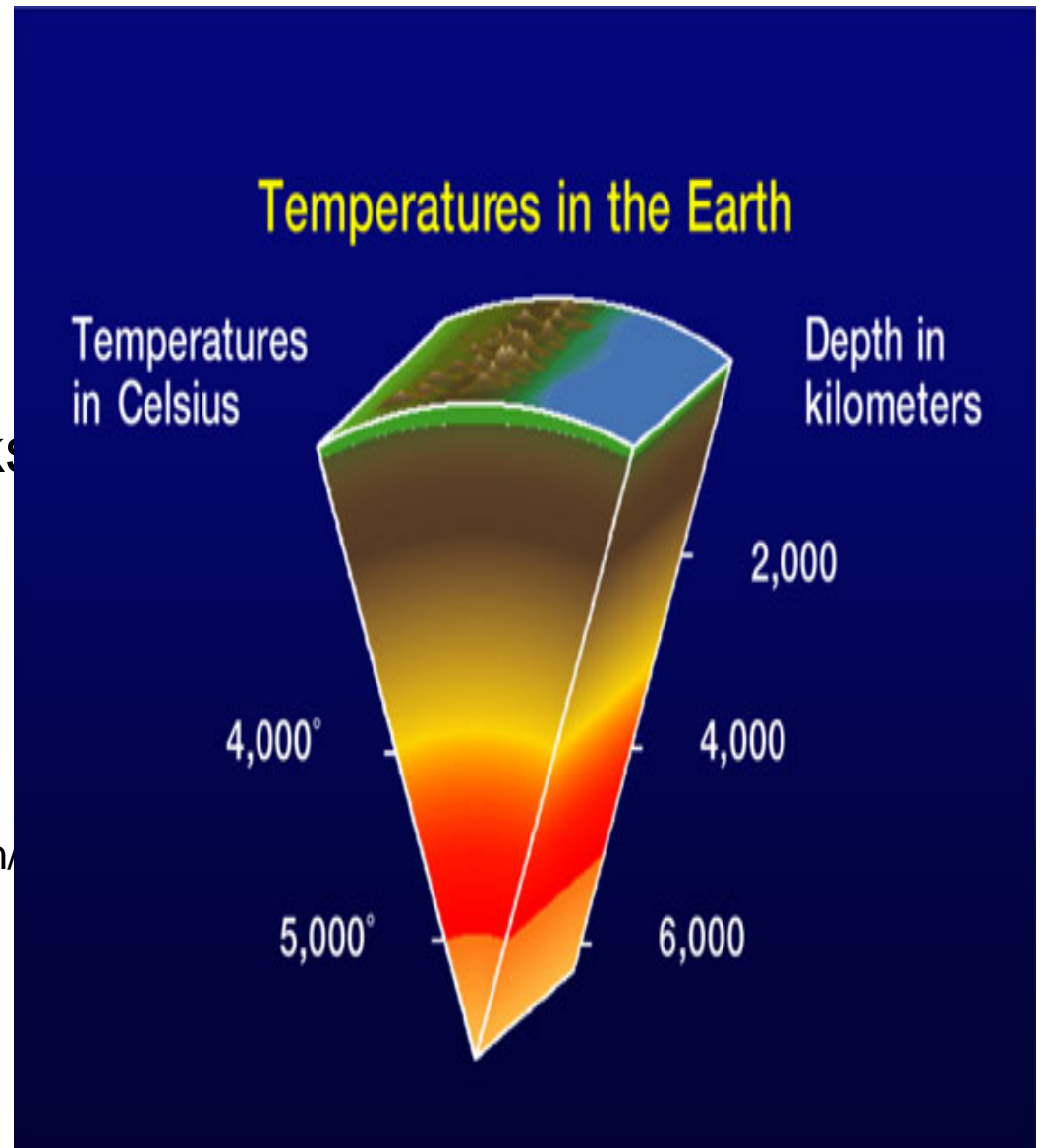
The heat flows outward towards from the earth's interior. The crust insulates the earth from the interior heat.



Temperature inside the earth

- Crust is broken into pieces called plates
- Magma erupts through the edges of plates
- Deep underground the rocks and water absorb the heat from this magma.

<http://geothermal.marin.org/GEOpresentation/d004.htm>



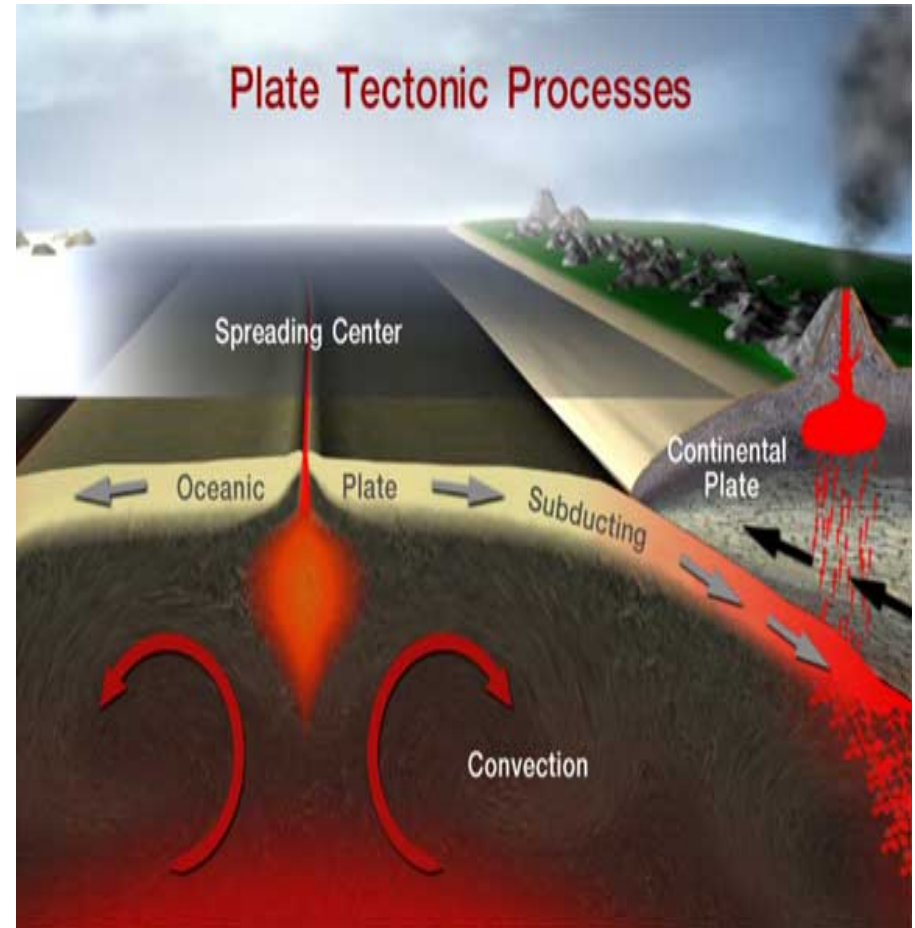
Where is geothermal energy found



- The most active geothermal resources are usually found along the major plate boundaries where most volcanoes and earthquakes are concentrated.
- Ring of fire is concentrated around the Pacific Ocean.
- <http://www.eia.doe.gov/kids/energyfacts/sources/renewable/geothermal.html>

Plate tectonic processes

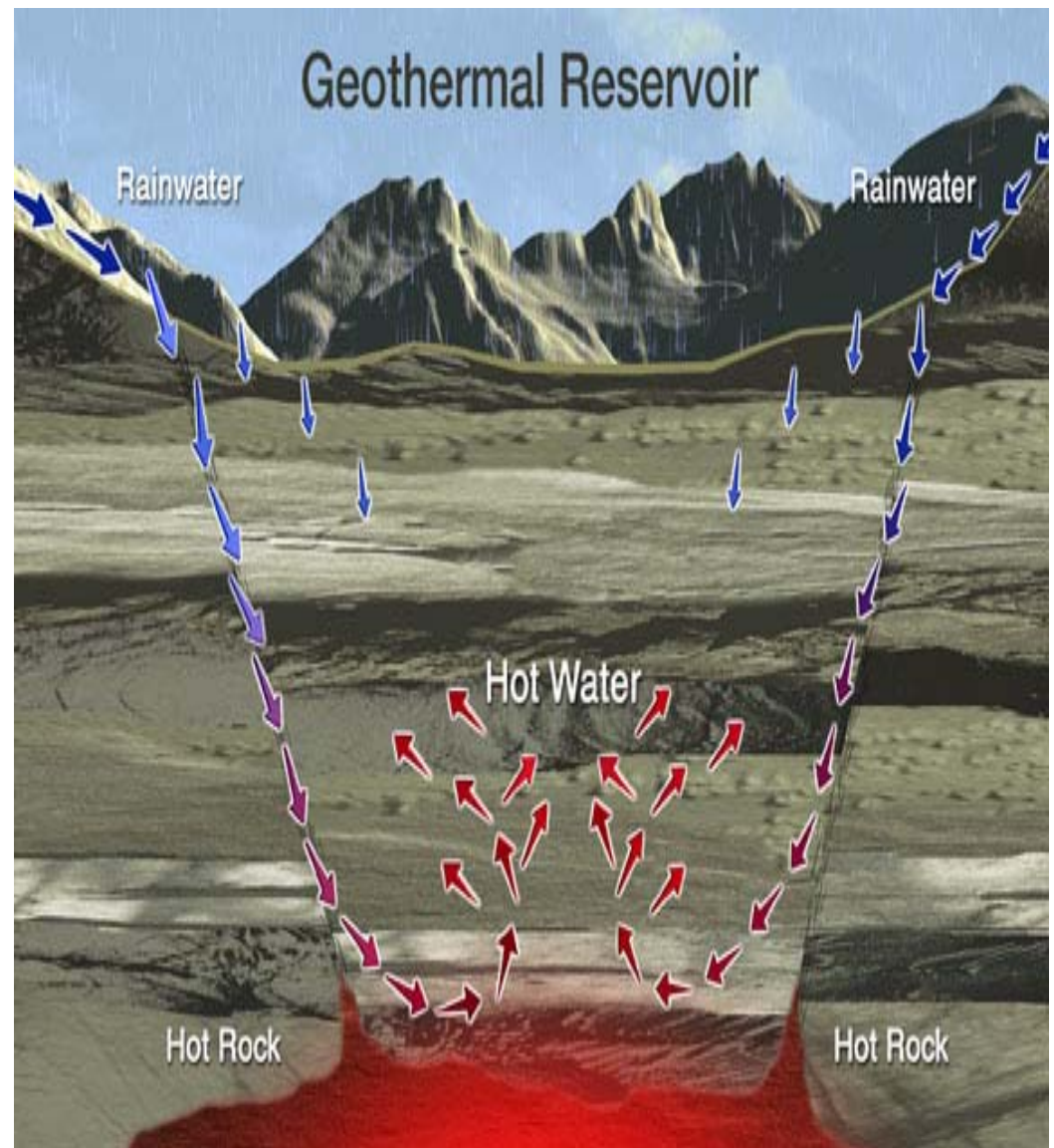
- In the middle of the ocean new crust is formed. When the plates meet they slide over one another and large amount of magma rises from the edge of sinking plates most magma does not reach the surface but causes the large regions of underground rock to heat up.



Geothermal reservoir

- The rising hot water and steam is trapped in the permeable and porous rocks under a layer of impermeable rock, a geothermal reservoir is formed.

- <http://geothermal.marin.org/GEOpresentation/sld012.htm>

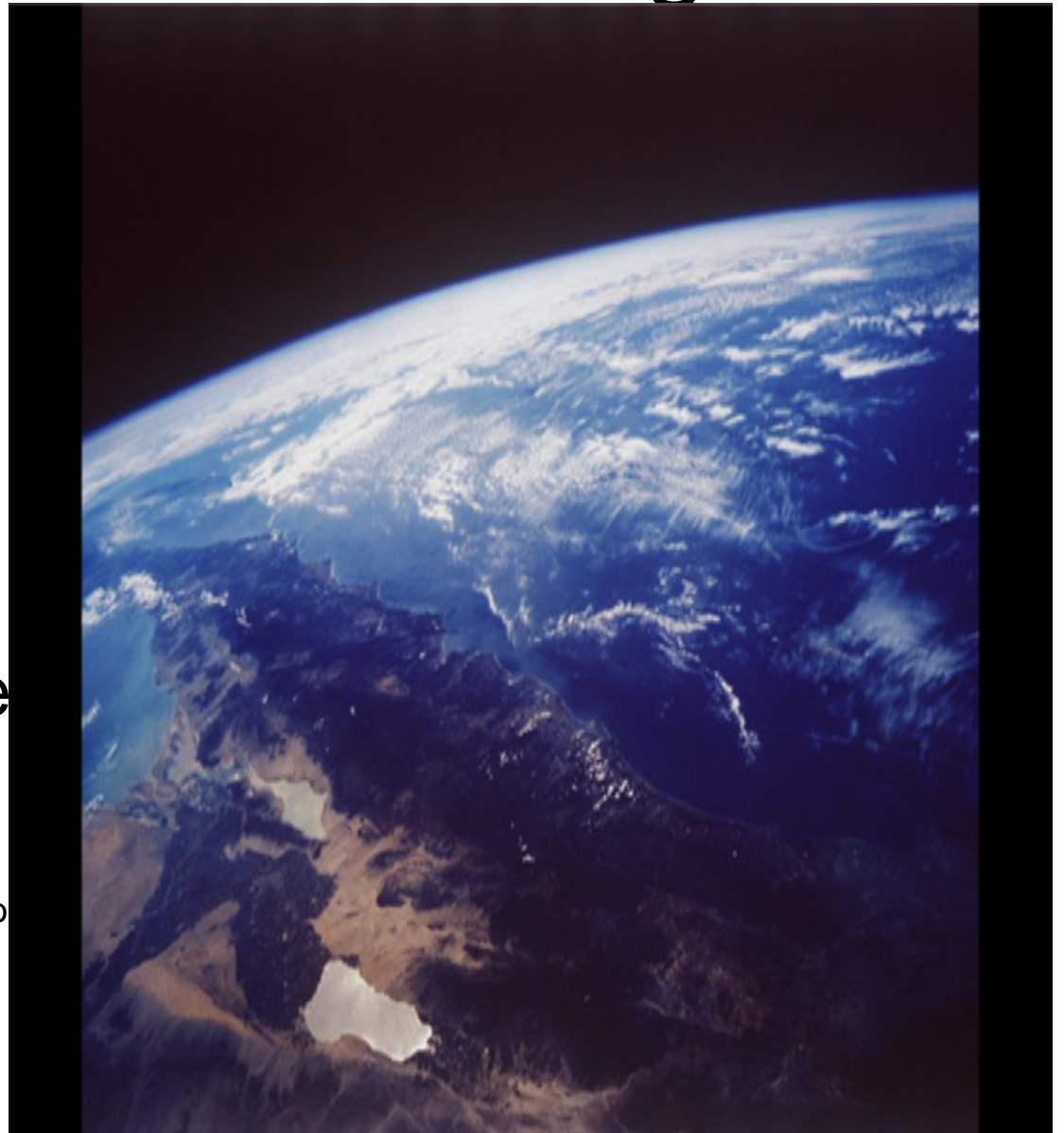


The rainwater can seep through the faults and cracks and get heated up it may return to the surface of water as springs ,geyser, mud pots or fumaroles (holes where the volcanic gases are released)



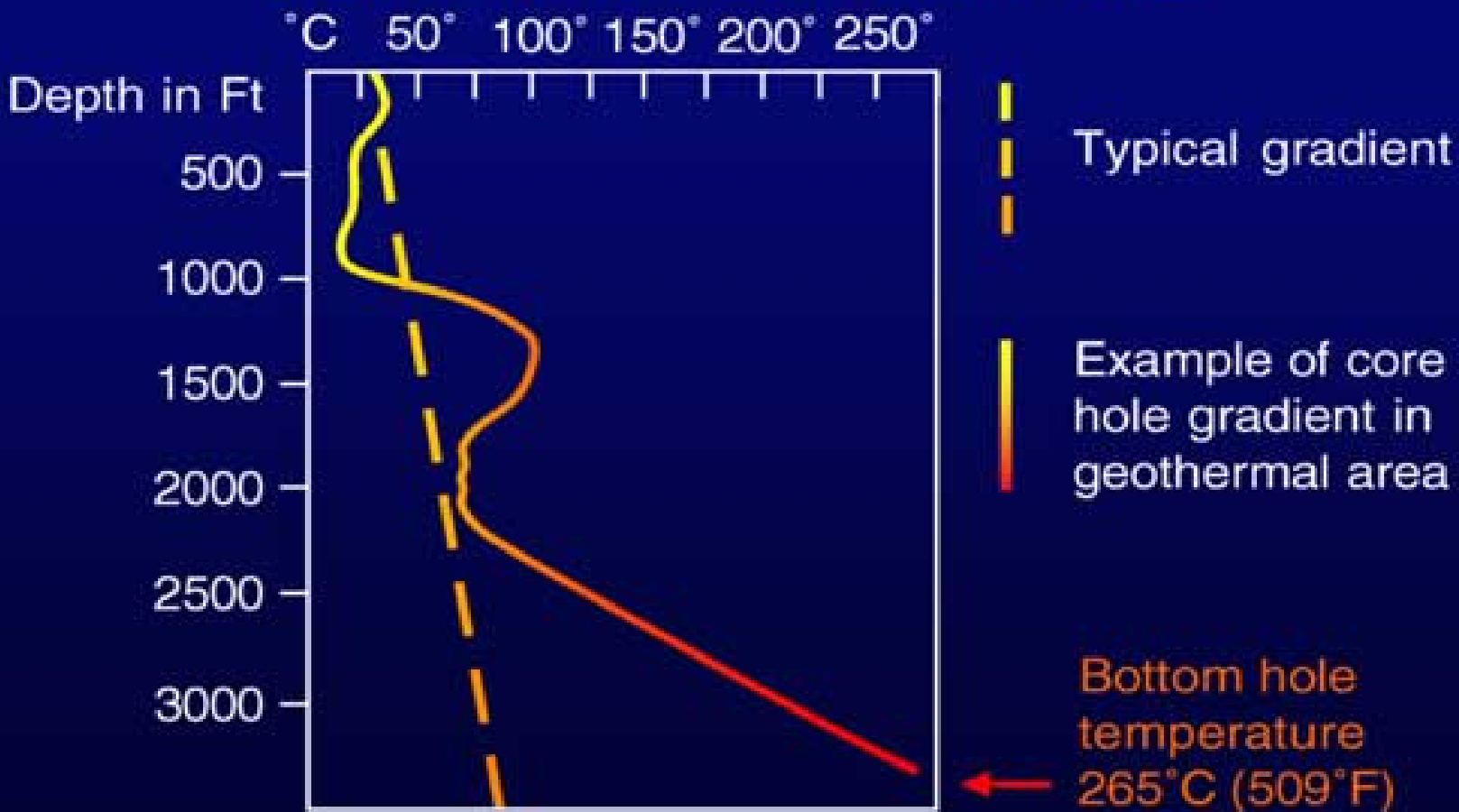
Exploration and drilling

- Satellite imagery and aerial photography-a number of satellite images are taken through artificial satellites
- Volcanological studies-volcanoes are natural indicator of underground heat
- <http://geothermal.marin.org/GEOpresentation/sld017.htm>



Rocks are carefully examined and the temperature gradient data is collected

Temperature Gradient Data

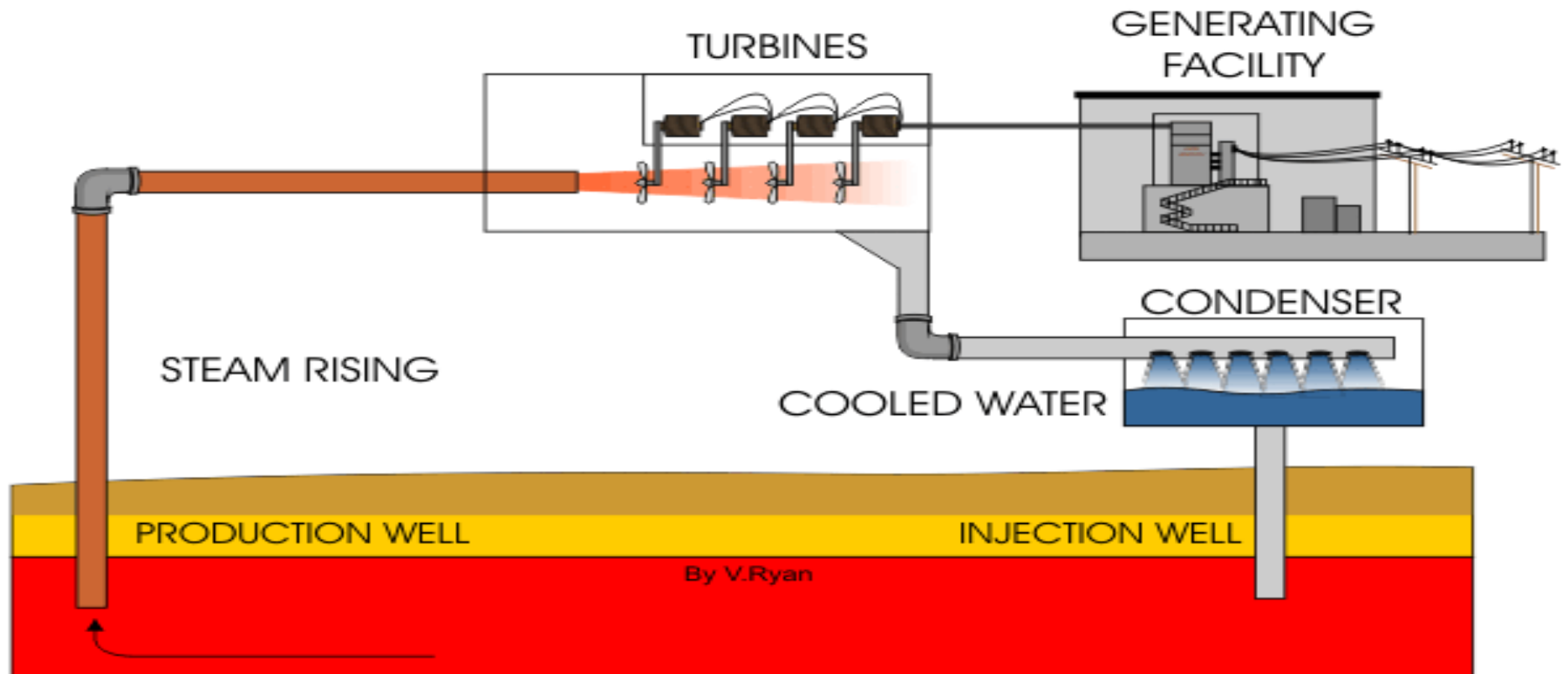


Power plants

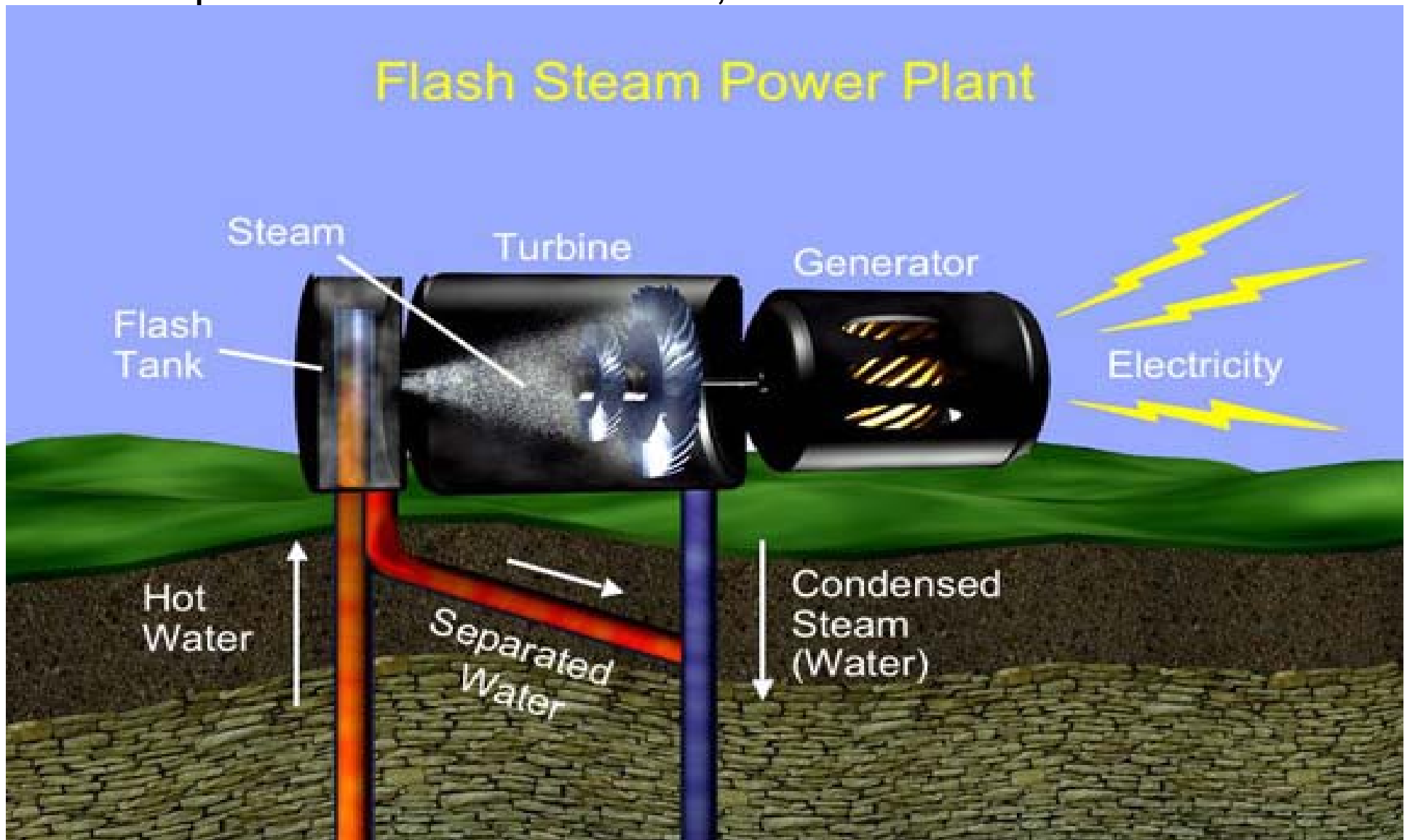
- Dry steam
- Flash steam
- Binary type

Dry Steam Power Plant

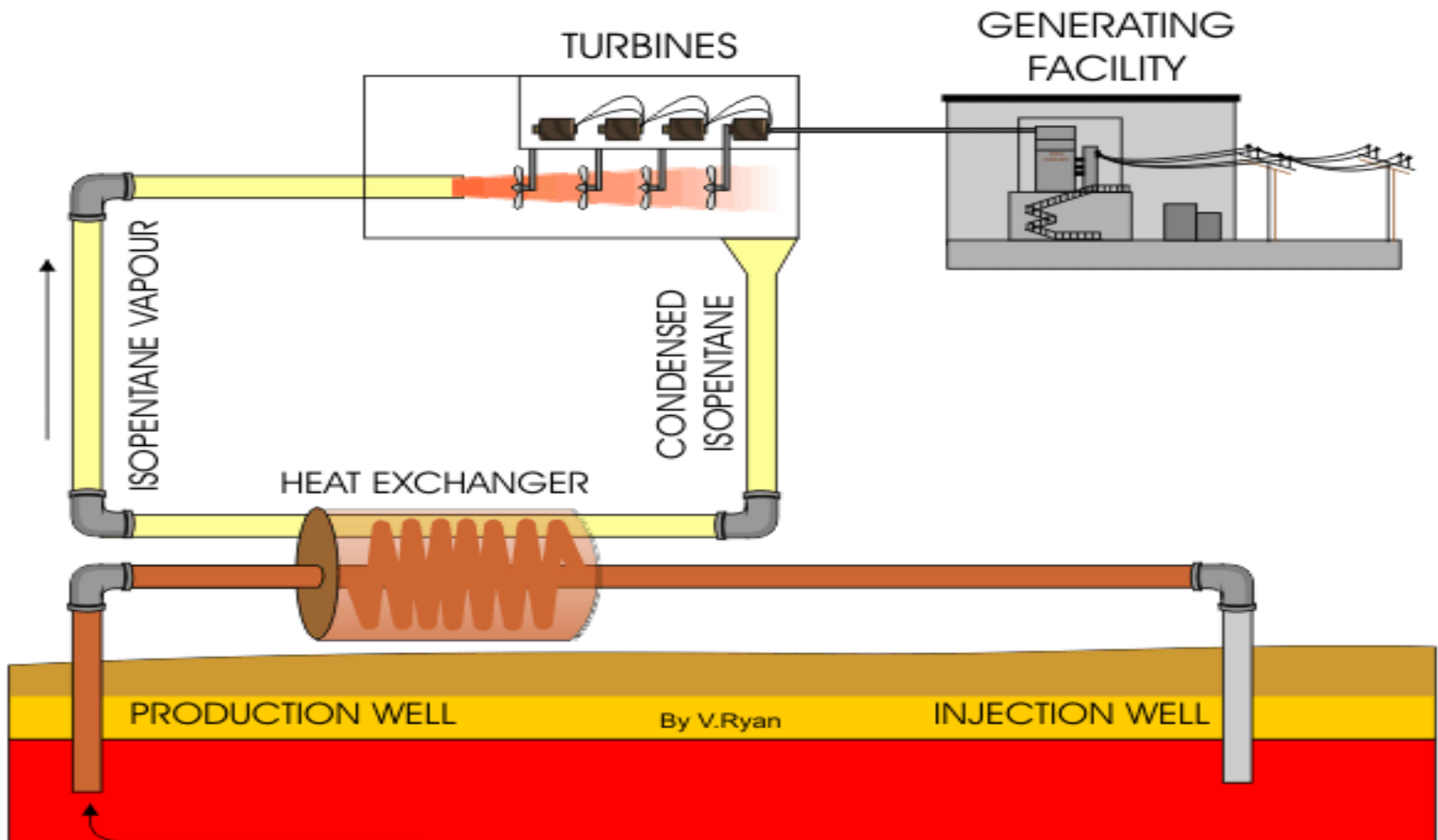
- The steam (and no water) shoots up the wells and is passed through a rock catcher (not shown) and then directly into the turbine. Dry steam fields are rare.



Flash steam power plants use hot water reservoirs. In flash plants, as hot water is released from the pressure of the deep reservoir in a flash tank, some of it flashes to steam.

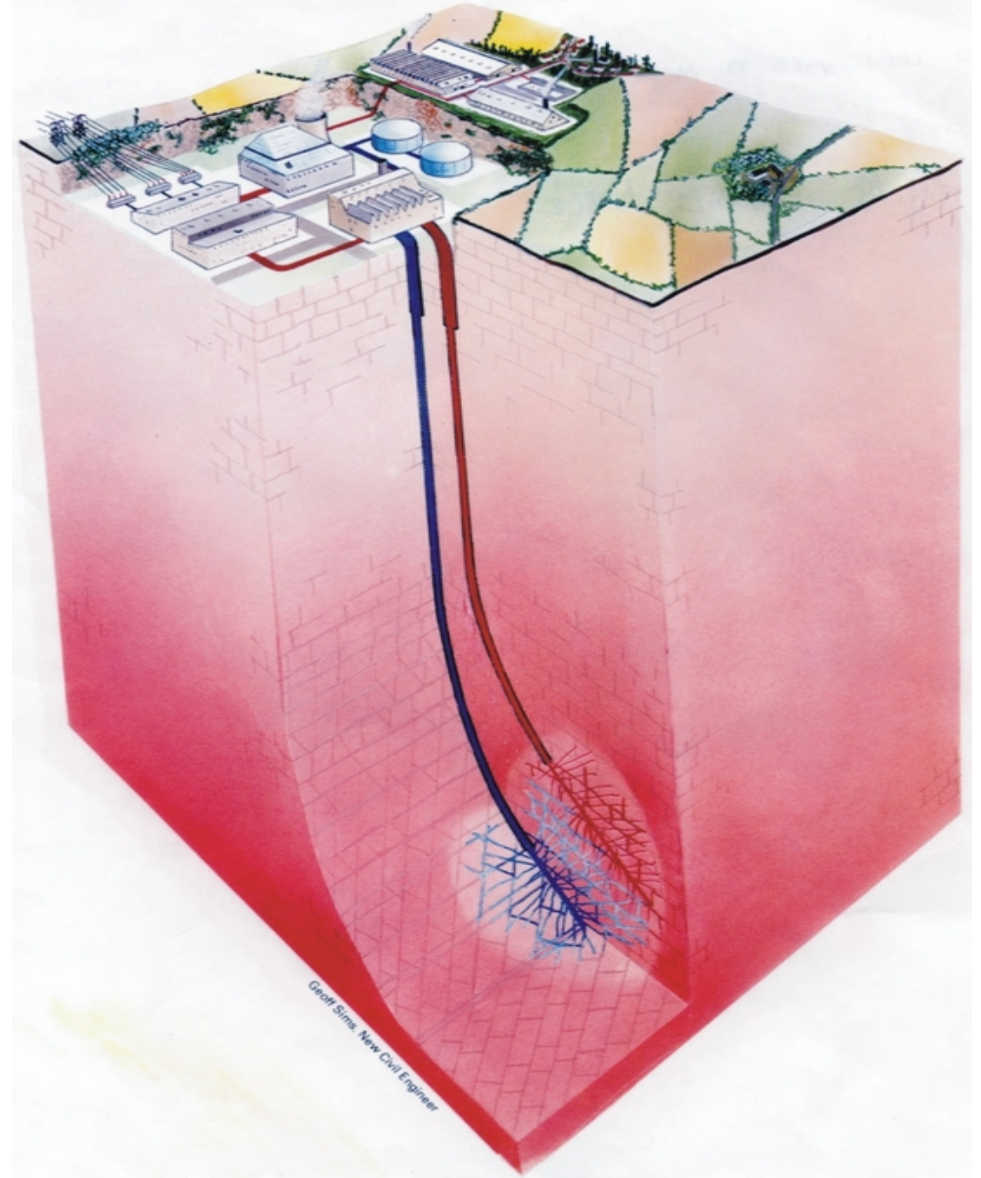


In the binary type power plant, the heat from geothermal water is used to vaporize a "working fluid" in separate adjacent pipes. The vapor, like steam, powers the turbine generator.



Enhanced Geothermal Systems (EGS) Hot Dry Rock Geothermal System

- Water is pumped through the injection well and superheated steam is returned through the production well
- Useful heat is extracted and water can be recirculated.
- Can cause earthquakes. The HDR project in Basel, Switzerland was suspended after causing an earthquake. On 8, December, 2006, only 8 days after water injection started, a quake occurred measuring 3.4 on the Richter scale with the epicenter at the bottom of the HDR borehole
- <http://www.lanl.gov/orgs/ees/ees11/geophysics/other/hdr.shtml>



The MIT report calculated the world's total EGS resources to be over 13,000ZJ, of which over 200 ZJ would be extractable, with the potential to increase this to over 2,000 ZJ with technology improvements - sufficient to provide all the world's energy needs for several millennia.

Advantages

The processed waste water can be used

It can be used anywhere as compared to tectonically active areas

Disadvantages

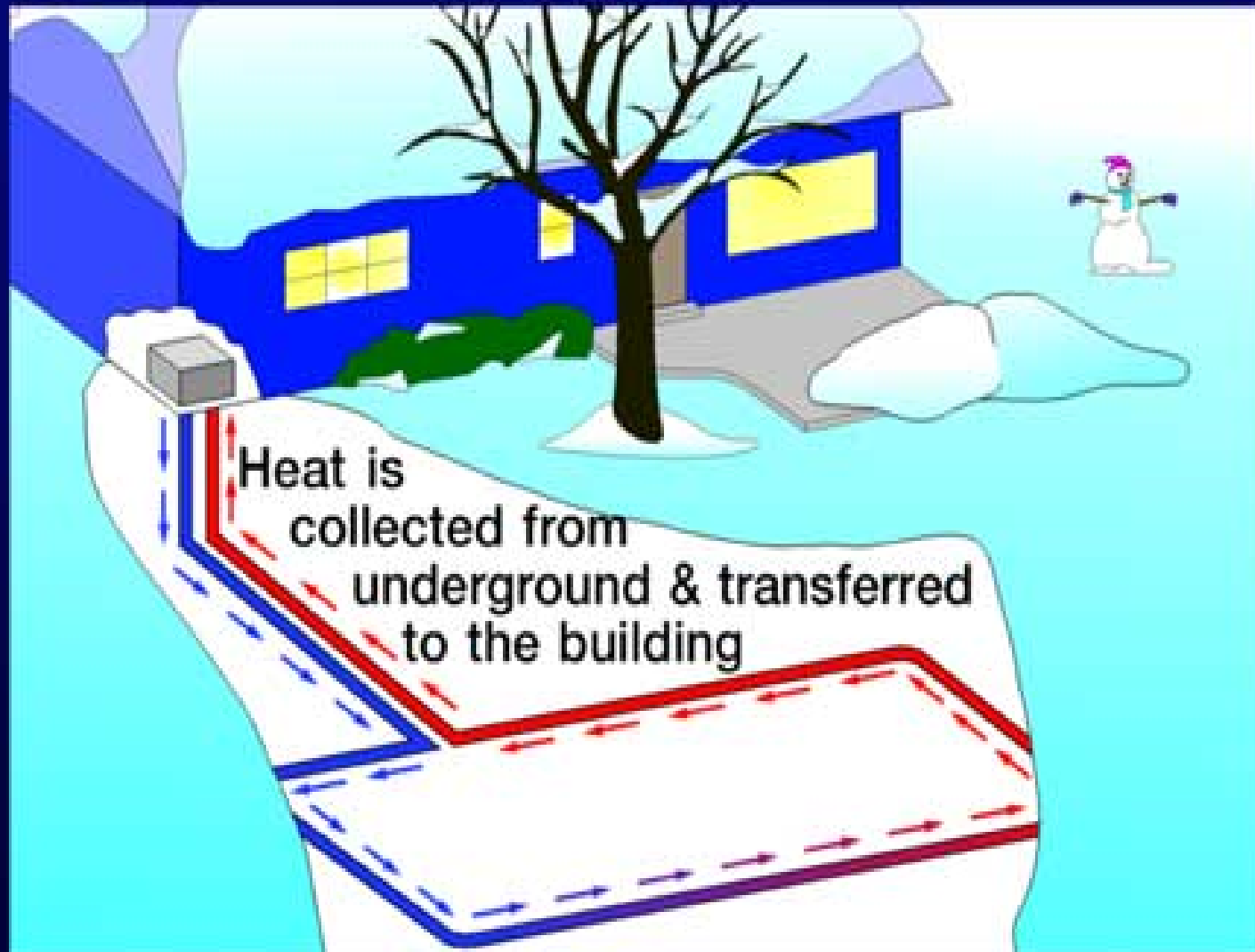
-Requires deeper drilling.

-Can cause earthquakes.

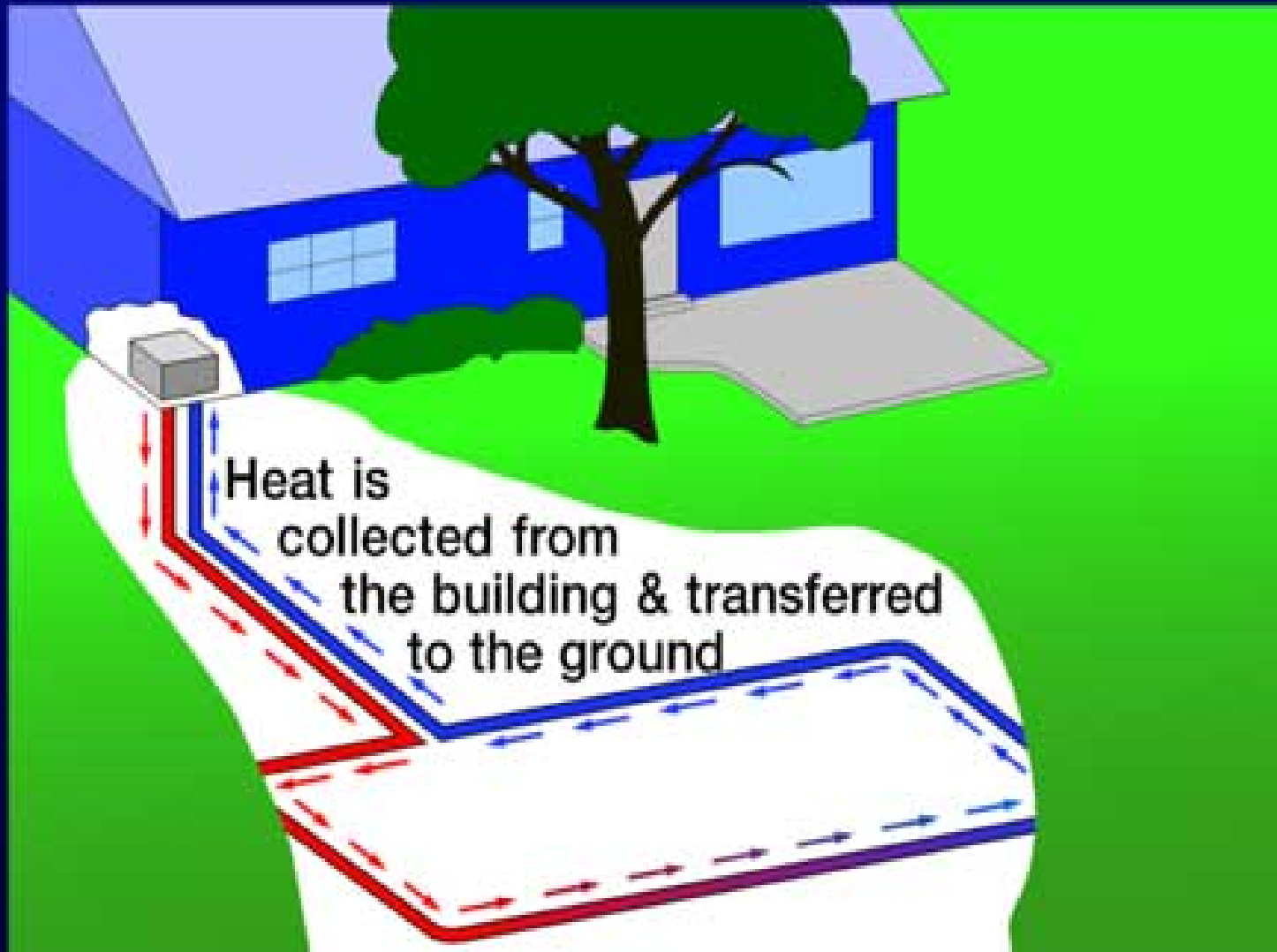
Geothermal heat pumps (geo exchange systems)

- Residential and commercial heating and cooling without a geothermal reservoir.....

Heat Pump in Winter



Heat Pump in Summer



Benefits of geothermal heat pump

- Can be used anywhere in the world
- Extremely cost and energy efficient
- No emission of harmful gases from the burning of fossil fuels
- Conservation of fossil fuel.

Worldwide geothermal power generation in early 2005

Country	Annual energy produced in GWh /year	Number of units	Percent of national energy
USA	17,917	209	0.5
China	96	13	30% of Tibet
El Salvador	967	5	22
France	102	2	9
Guatemala	212	8	3
Iceland	1483	19	17.2
Indonesia	6085	15	6.7
Italy	5340	32	1.9
Japan	3467	19	0.3
Kenya	1088	9	19.2
Mexico	6282	36	3.1
New Zealand	2774	33	7.1
Nicaragua	271	3	9.8
Philippines	9253	57	19.1

Geothermal energy Potential in the US

U.S. Geothermal Potential



● Power Plants and Direct Uses

● Direct Uses

Geothermal energy in Iceland

- In Iceland, there are five major geothermal power plants which produce about 26% (2006) of the country's electricity
- . Geothermal heating meets the heating and hot water requirements for around 87% of the nation's housing.
- Iceland is located on the mid Atlantic ridge, which makes it one of the most tectonically active places in the world

Uses

- Balneology (hot spring and spa bathing)- major tourist attraction
- Agriculture (green house and soil warming)
- Aquaculture (fish/prawn and alligator farming)
- Industrial uses (product dying and warming)
- Residential and district heating

Advantages of using GE

- Energy harnessed is clean and safe for the surrounding environment.
- Sustainable as the hot water used in the GE plant can be re injected into the ground to produce more steam. In EGS the treated waste water can be re injected into the ground.
- Geothermal power plants are unaffected by changing weather conditions.
- Extremely price competitive.
- Reduces reliance on fossil fuels
- Great scalability

Disadvantages of GE

- Highly localized resource. it is greatest along fault lines and around volcanic regions
- Construction of power plant can adversely affect the land stability in the surrounding region.
- The initial cost to build a geothermal power plant is expensive.

References

- The future of geothermal energy, Idaho National Laboratory
- Bertani Ruggero (2005) world geothermal power generation in the period 2001-2005 geothermics, volume 34,651-690
- Geothermal education office, US department of energy
- Geothermal power, wikipedia
- Hurter S and Schell Schmidt R, fuels and energy abstracts, geothermics, 2003, 32, (4-6), 779-787
- Dickson H and Fanelli M Institute di Geoscienze e Georisorse, international geothermal association.
- Environmental and Energy Study Institute (EESI). 2006. Geothermal Energy: Tapping the Energy in the Earth's Core. Online at