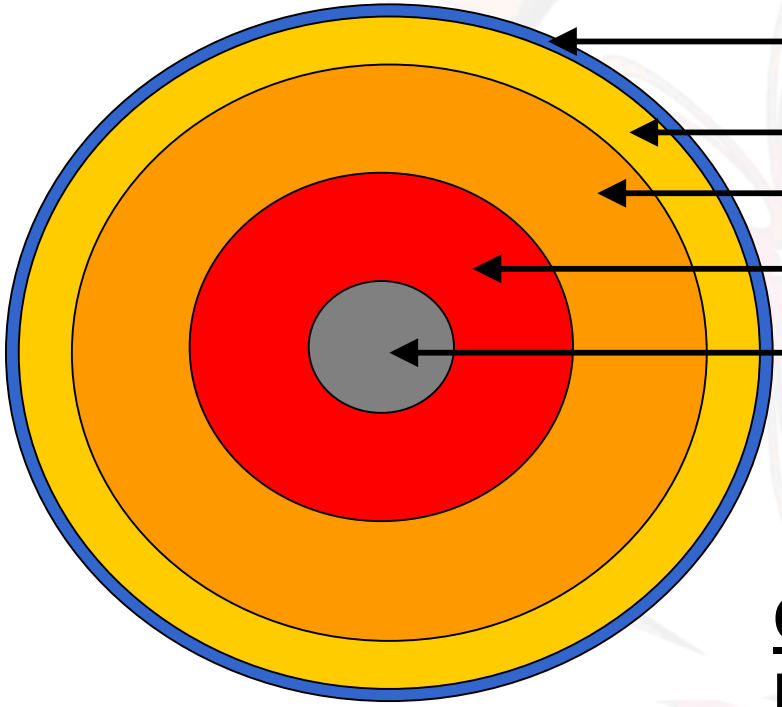
Geothermal Energy

Learning objectives:

1) To describe the principle behind tapping of Geothermal energy
2) To indicate limits and challenges with Geothermal energy usage

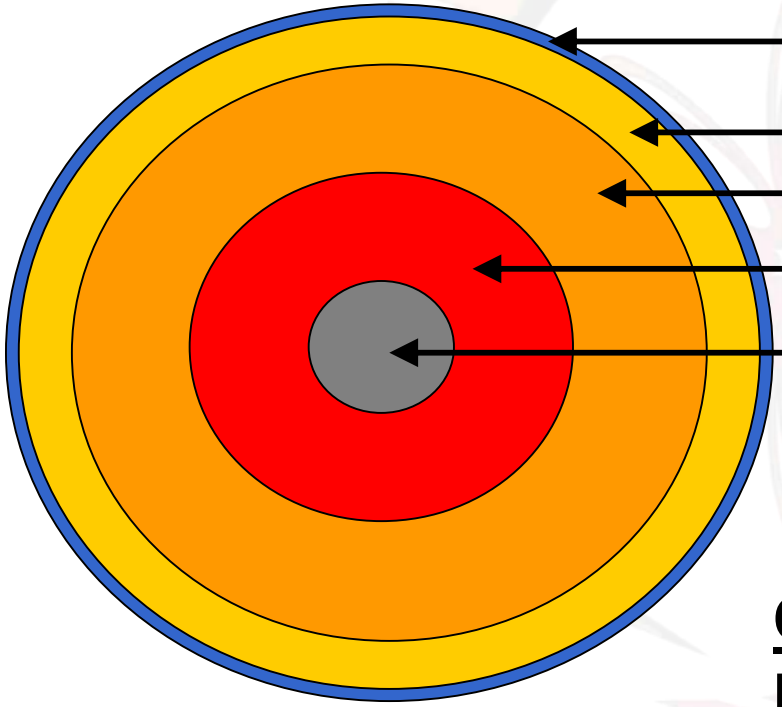
Cross-section of the Earth



	Thickness (km)
Crust	30
Upper Mantle	720
Lower Mantle	2170
Outer Core	2260
Inner Core	1220

Core: Iron, Nickel, noble metals
Mantle: Sulphide and Oxide rich
Crust: Oxides

Cross-section of the Earth



	Depth (km)
Crust	30
Upper Mantle	750
Lower Mantle	2920
Outer Core	5180
Inner Core	6400

Core: Iron, Nickel, noble metals
Mantle: Sulphide and Oxide rich
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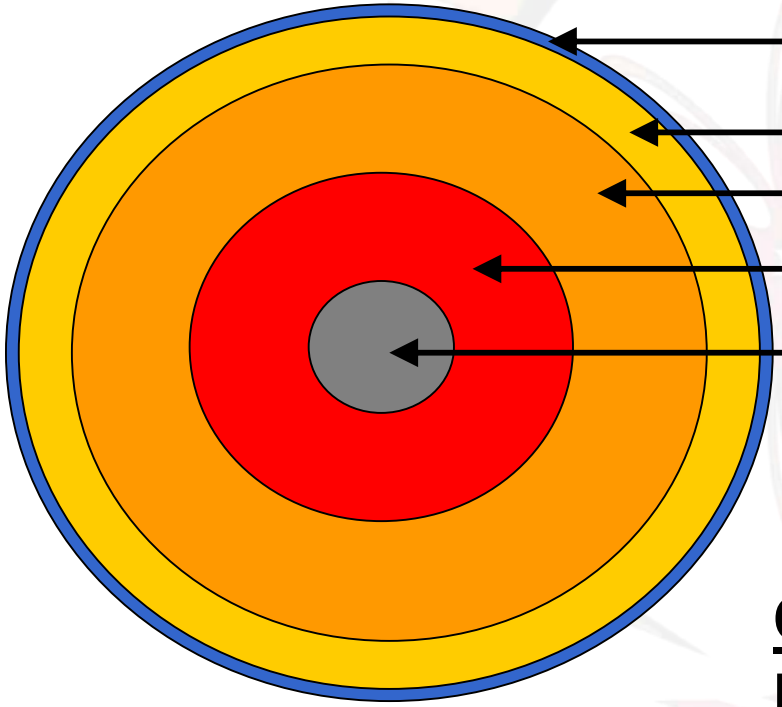
Cross-section of the Earth



	Temperature (ºC)
Crust	0-700
Upper Mantle	1000
Lower Mantle	3500
Outer Core	4000
Inner Core	7000

Core: Iron, Nickel, noble metals
Mantle: Sulphide and Oxide rich
Crust: Oxides

Deepest spot in the oceans:

The Challenger Deep / Mariana's Trench: 11 Km deep
(In the Pacific Ocean, near Japan)
Deeper than the height of Mt Everest 8.9 Km

Deepest spot in the lands:

Drill hole in Soviet peninsula of Kola: 12 Km deep

Composition of Earth determined from:

1) Flow of heat from inside earth

2) Experiments on surface minerals and rocks under high P, T

3) Gravity and magnetic fields of earth

4) Path of earth quake waves travelling through the earth

Principle of Geothermal energy usage:

- Temperature gradient is of the order of 25 ^{o}C to 30 ^{o}C per km
- 20 ^{o}C per km in northern latitudes
- 40 ^{o}C per km closer to equator

Principle of Geothermal energy usage:

- Temperature gradient is of the order of 25 ^{o}C to 30 ^{o}C per km
- Common usage 150 m to 200 m with temperature increase of less than 10 ^{o}C
- Oil industry drills 5,000 to 10,000 m, temperature greater than 350 ^{o}C. Electronics will struggle
- Faults will enable access to higher temperatures

Principle of Geothermal energy usage:

- Deep Water Horizon (US, Transocean, 2010): 10.5 km deep
- Sakahlin-1 (Russia, Exxon, 2012): 12.3 km deep

Principle of Geothermal energy usage:

- Anticipated lifetime: approximately 30 years

Conclusions:

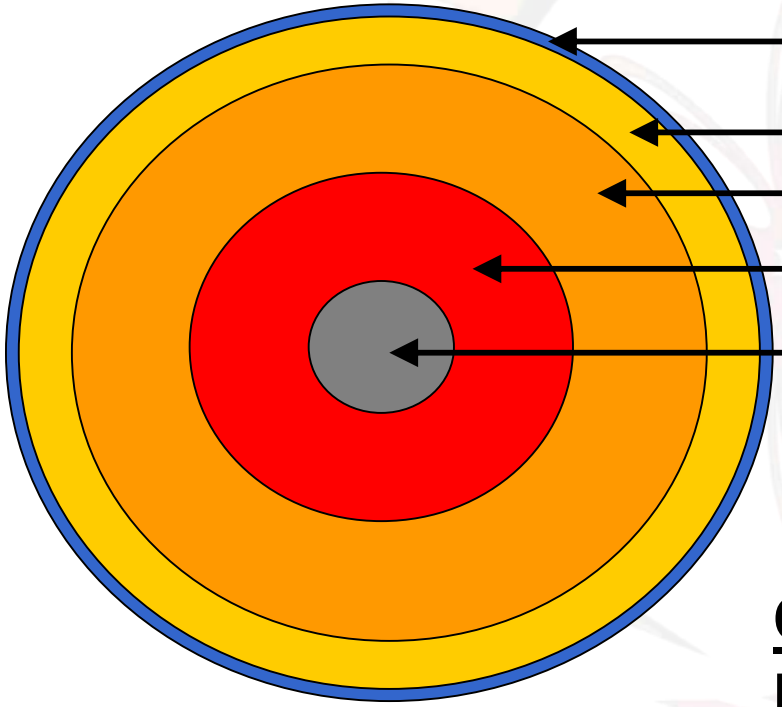
1) Geothermal energy preferably tapped near faults
2) Deep drills already being made for oil industry

Geothermal Energy
Technological aspects

Learning objectives:

1) To describe the different conditions relevant to Geothermal energy availability
2) To describe variations in Geothermal plant design

Cross-section of the Earth



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Prospecting

To enable identification of better locations for plant

Temperature as a function of depth

Tattapani, Balrampur District, Chhattisgarh

Prospecting

Helps identify low density regions for drilling

Nearly 40% of cost of geothermal energy associated with exploration

Large plants

Geysers geothermal complex California (1500 MW)

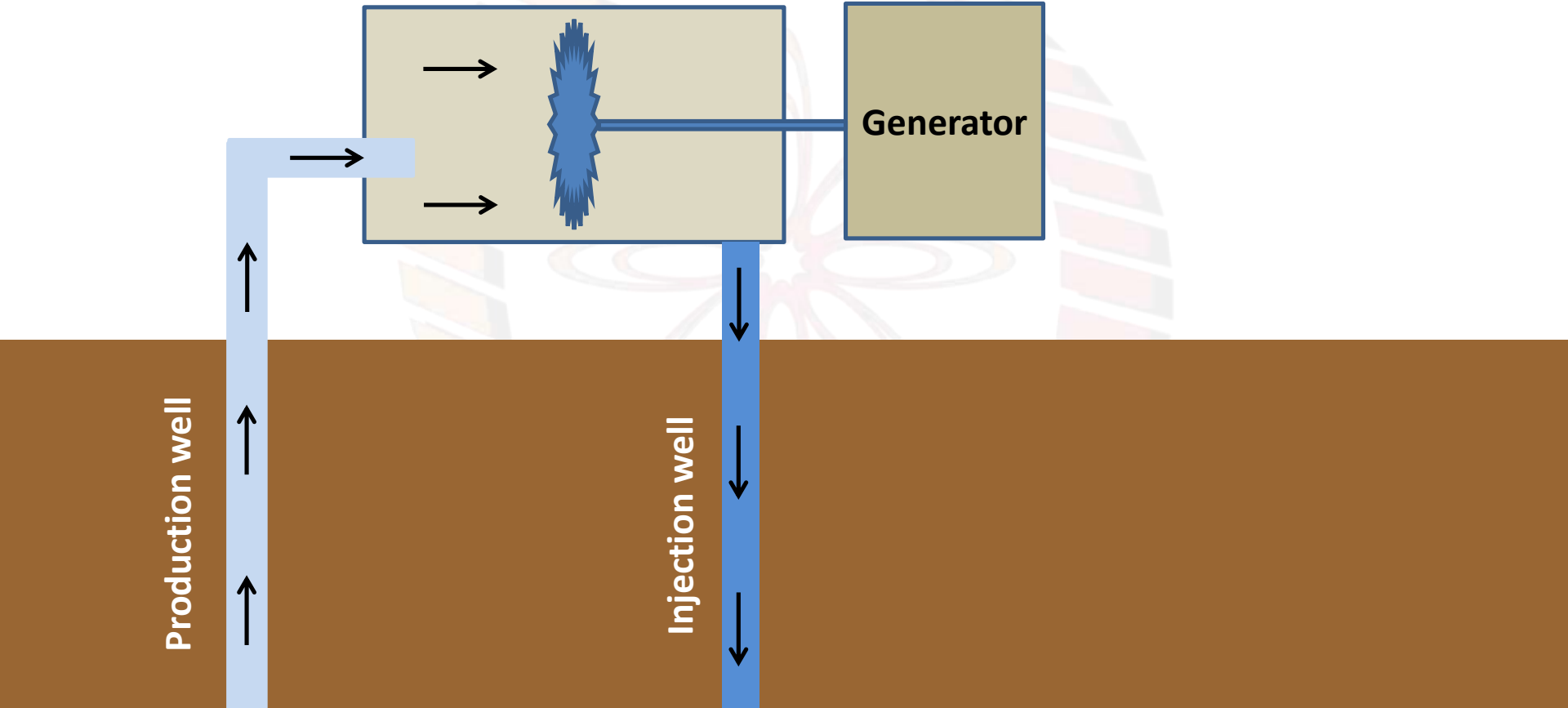
Philippines (3); US, Indonesia (2); Mexico, Italy, Iceland (1)

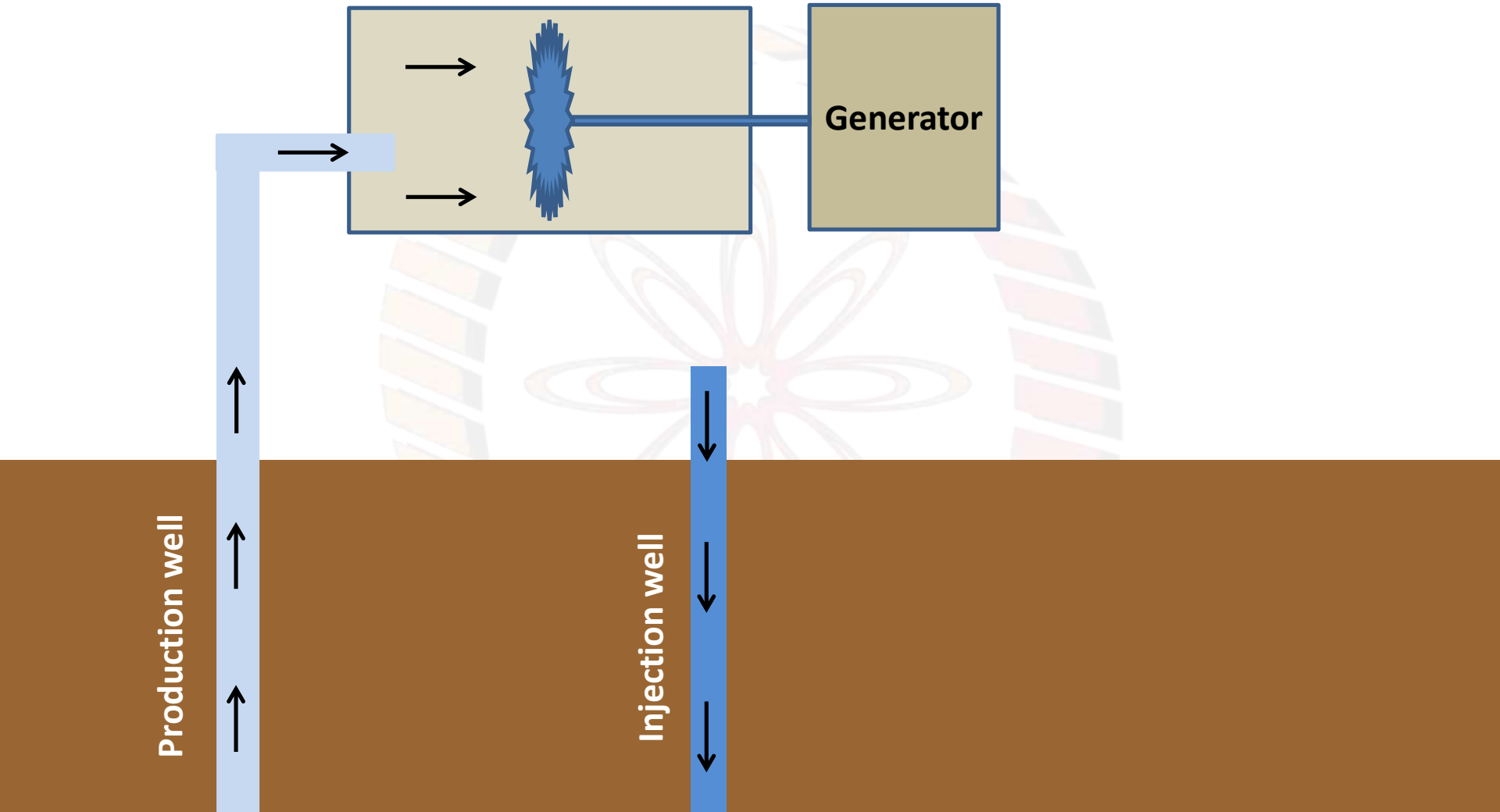
Super heated steam

Rare to find

Run a turbine. Should be corrosion resistant

Follow up with a condenser. Replenish the water


Generator
Production well
Injection well


Generator
Production well
Injection well

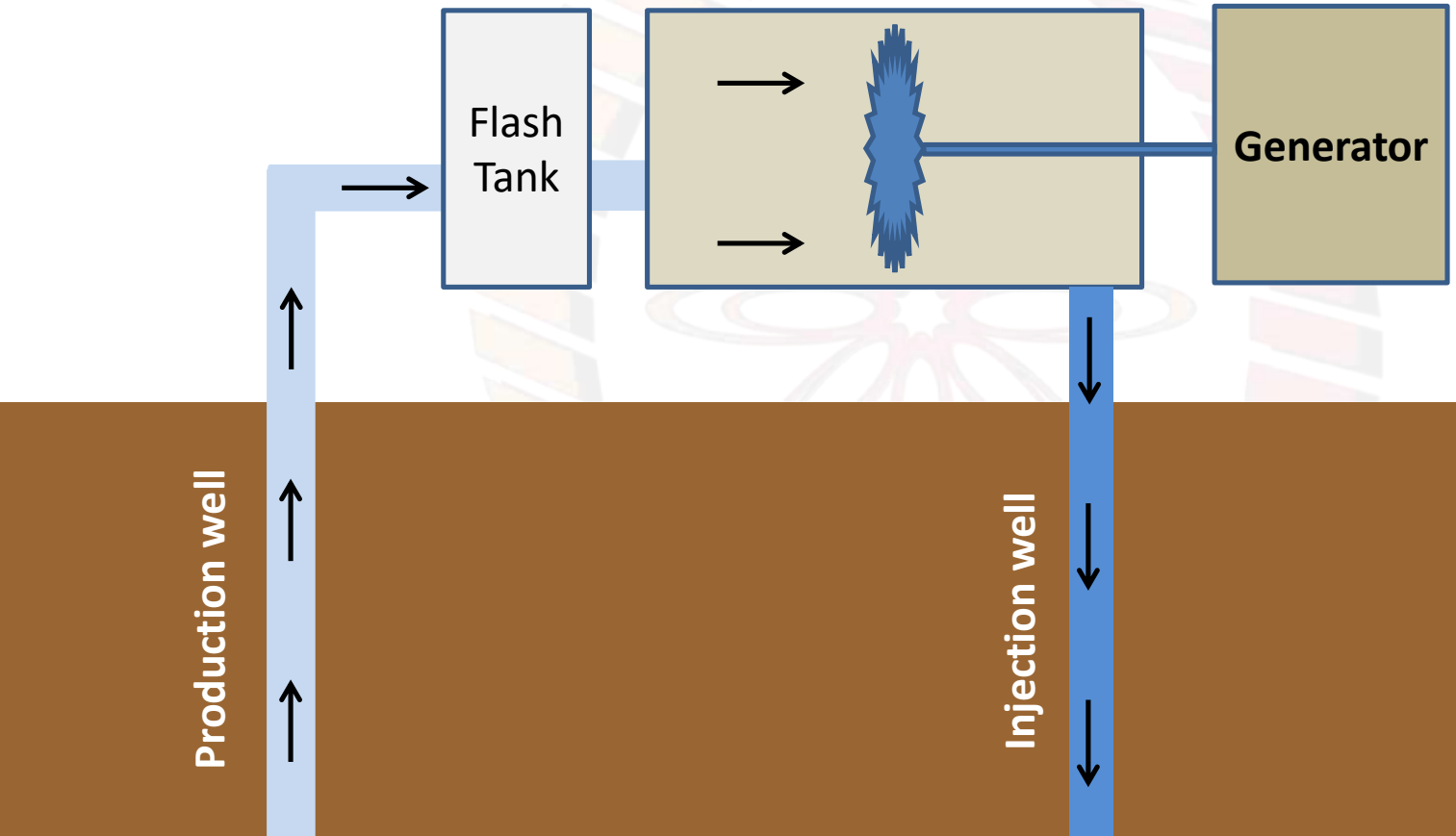
Saturated steam

Found relatively more often

Cannot be used directly since it can damage the turbines

Heating? Pressure?

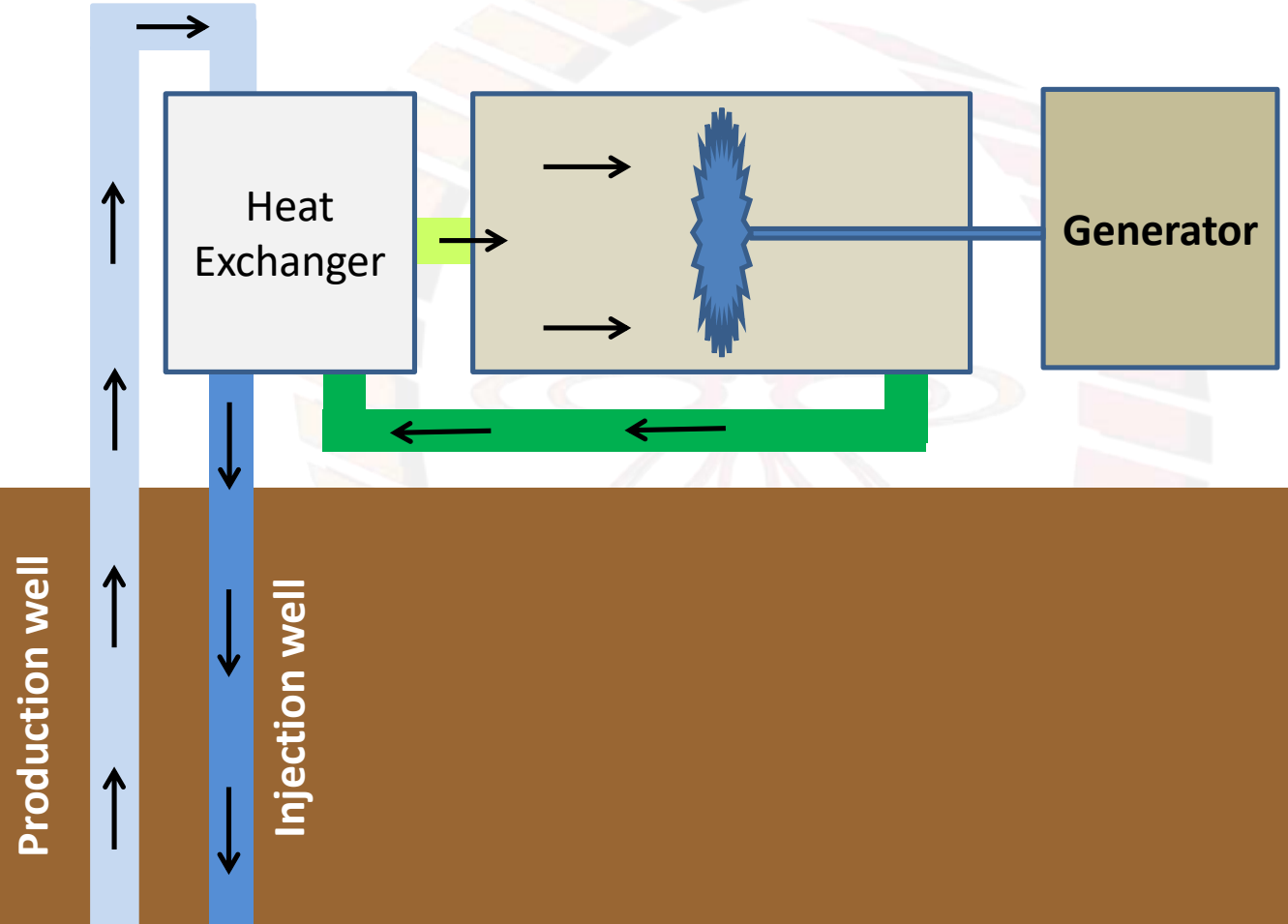
Flashing


Flash
Tank
Generator
Production well
Injection well

Hot water

Found in many places

Binary fluid cycle: Butane (-1 ^{o}C), Isobutane (-11.7 ^{o}C) or Pentane (36.1 ^{o}C)


Heat
Exchanger
Generator
Production well
Injection well

Conclusions:

1) Geothermal energy is available with differing levels of heat
2) Geothermal plants have to be designed to account for the different prevalant conditions