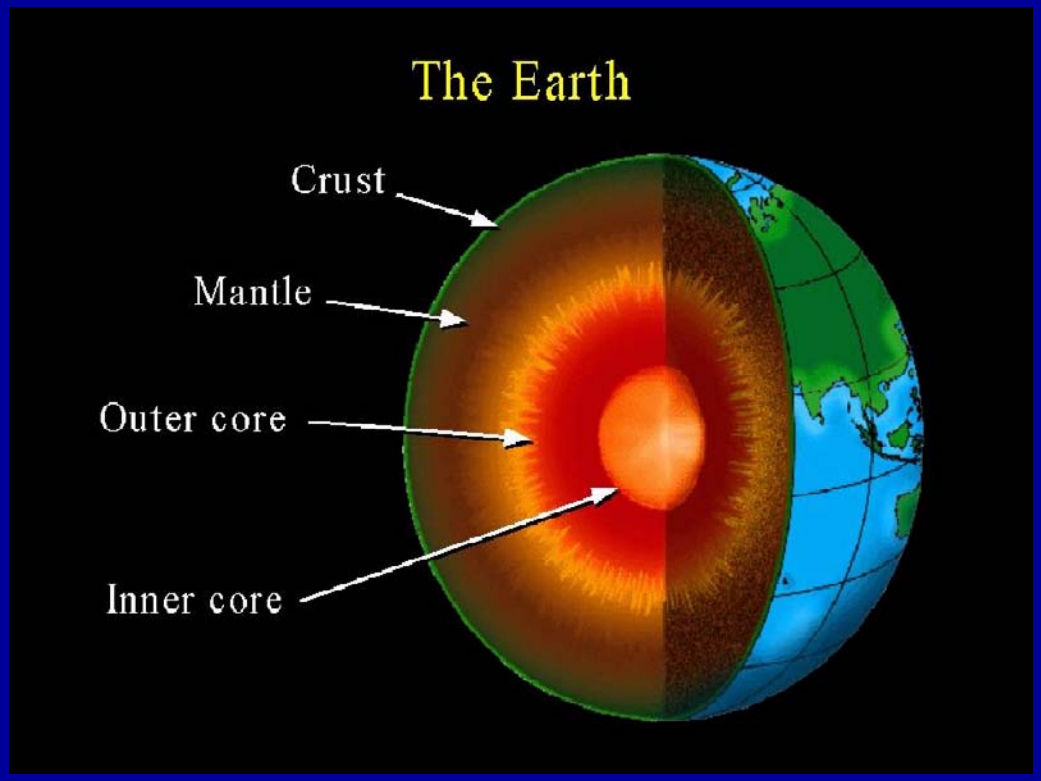
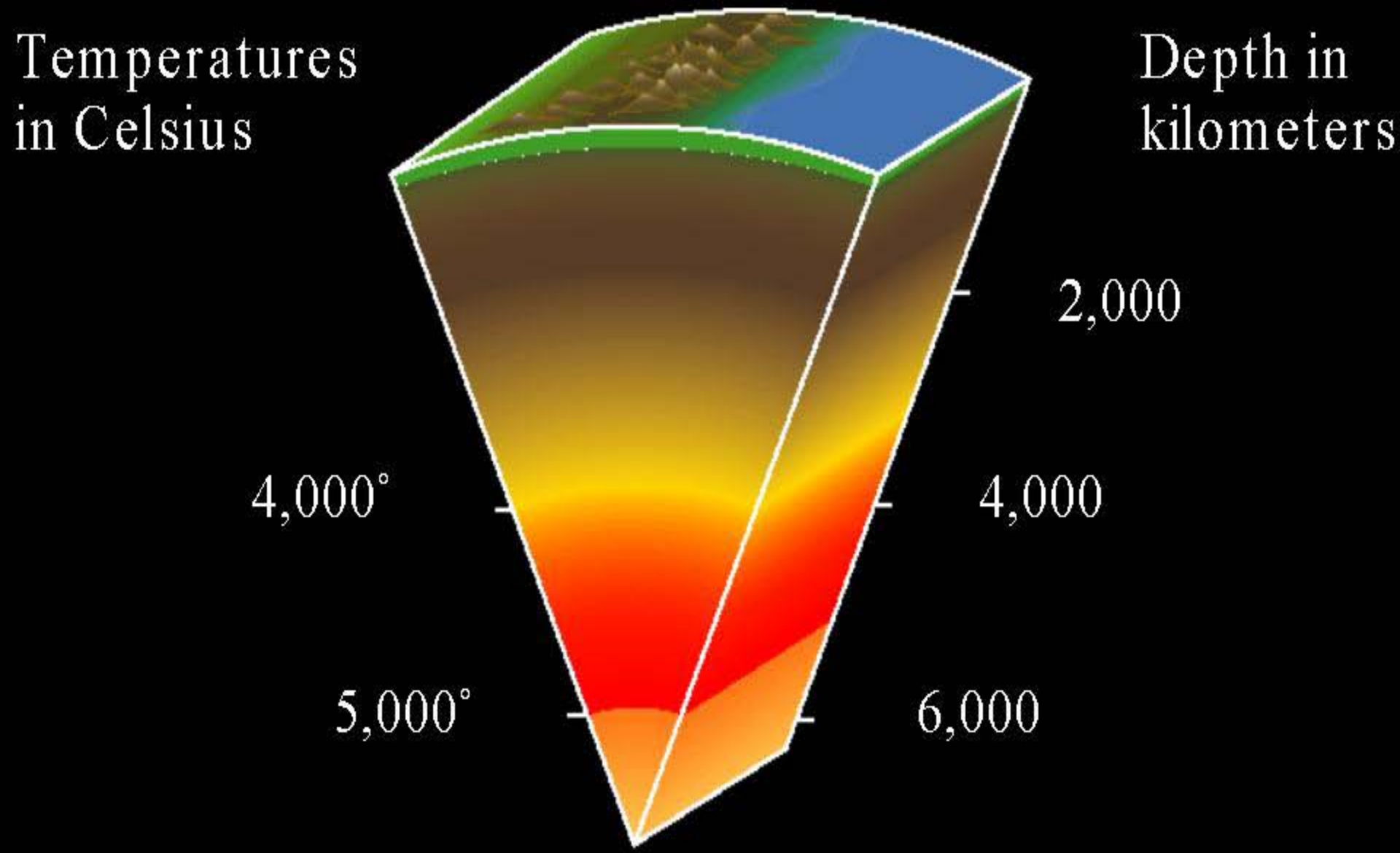
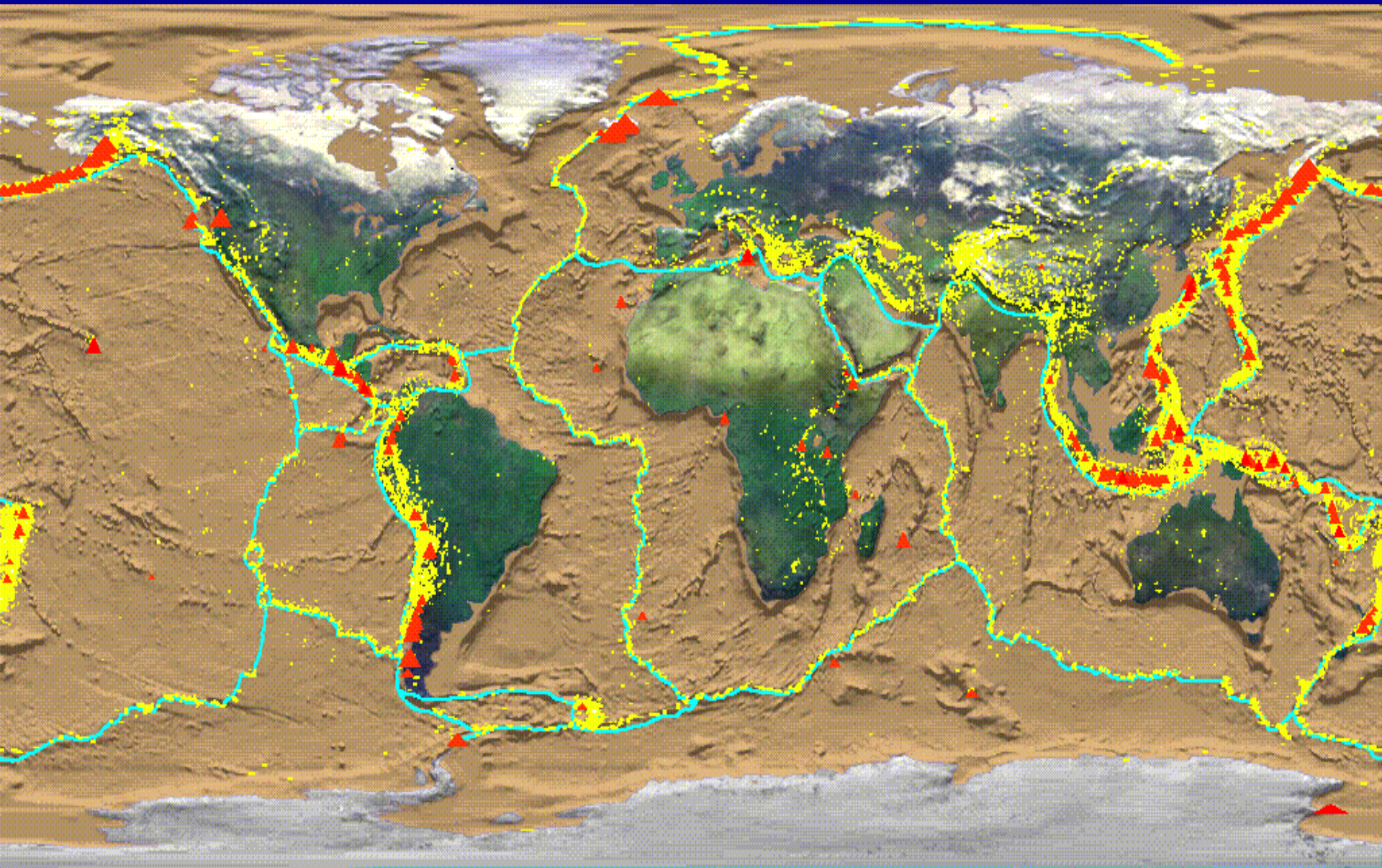
Geothermal Energy – Beneficial Uses of Heat from the Earth

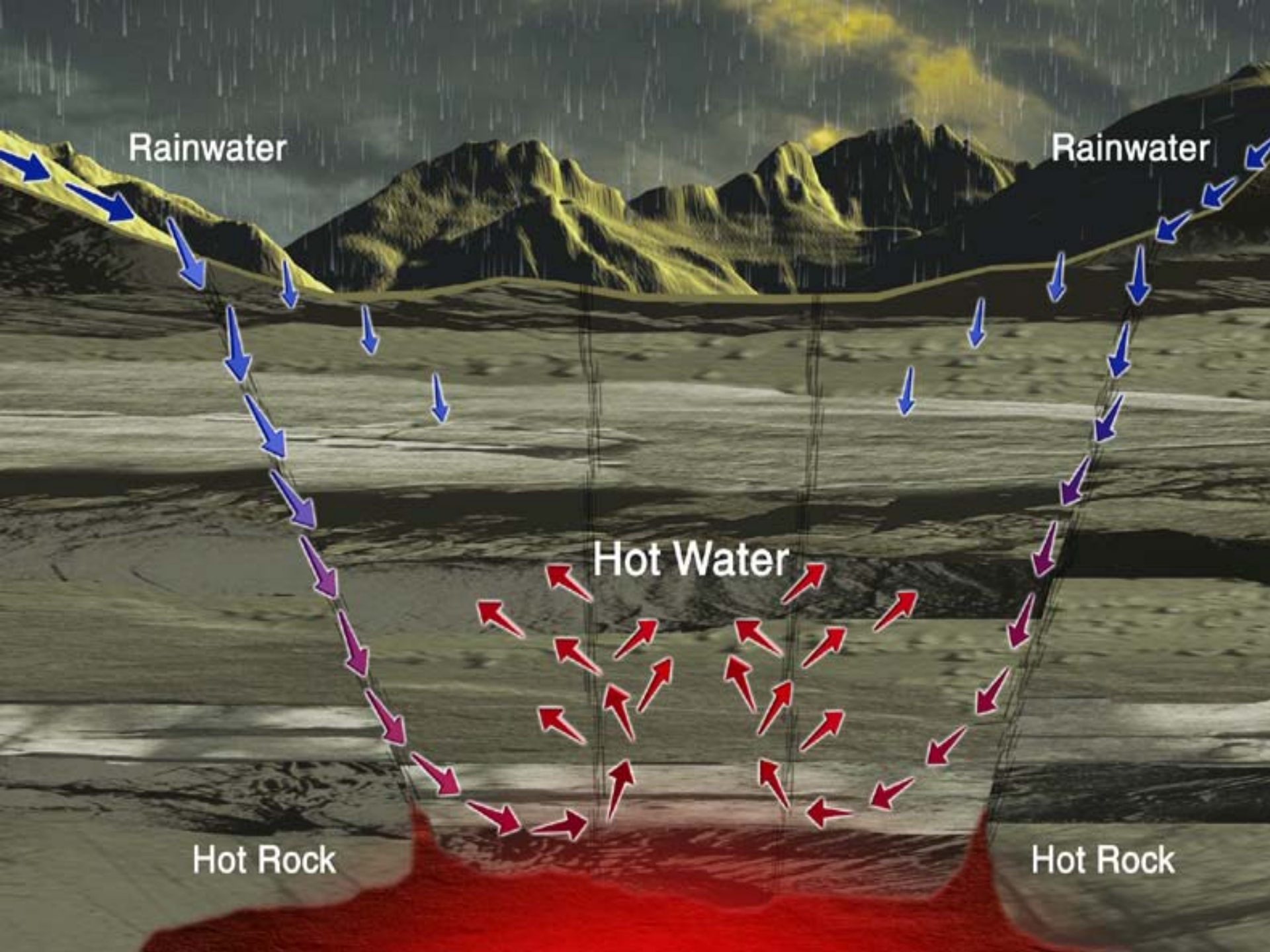


Temperatures in the Earth



Tectonic Plate Boundaries



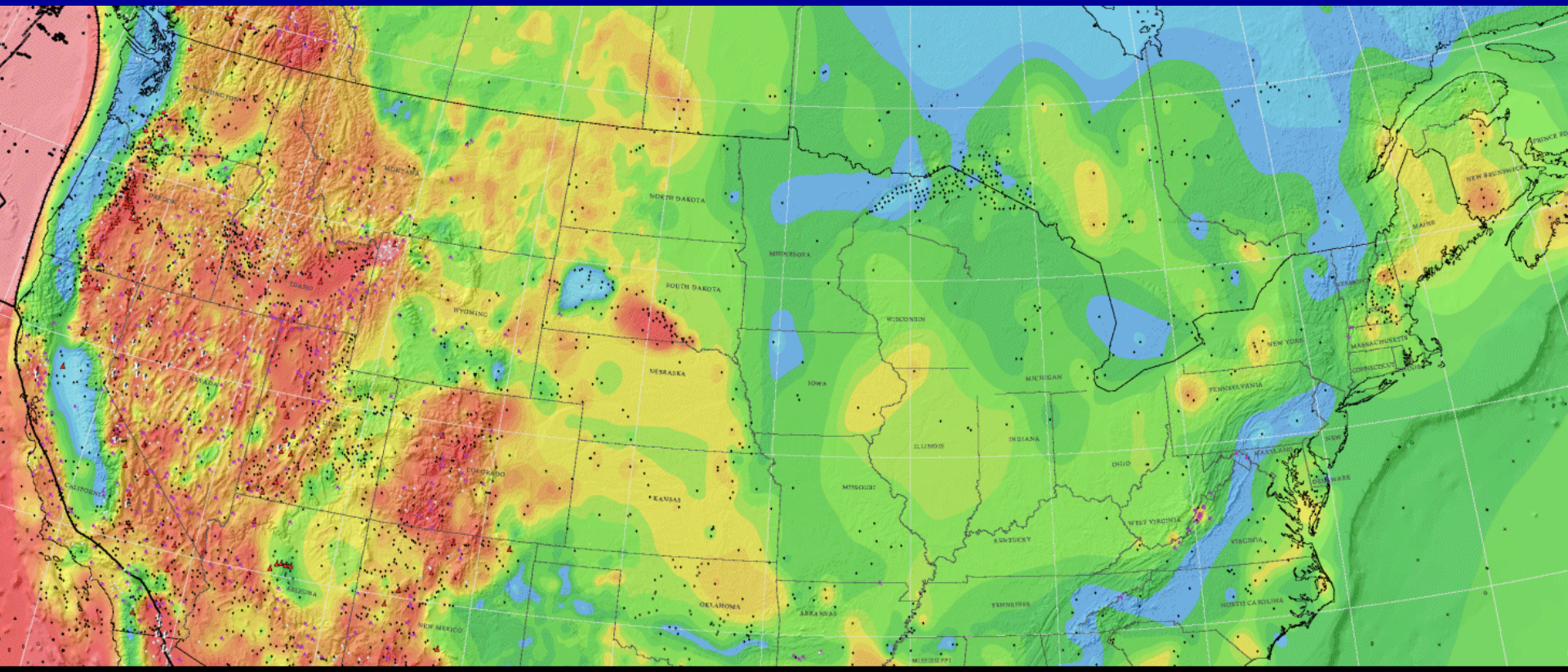

Rainwater
Rainwater
Hot Water
Hot Rock
Hot Rock

Introduction

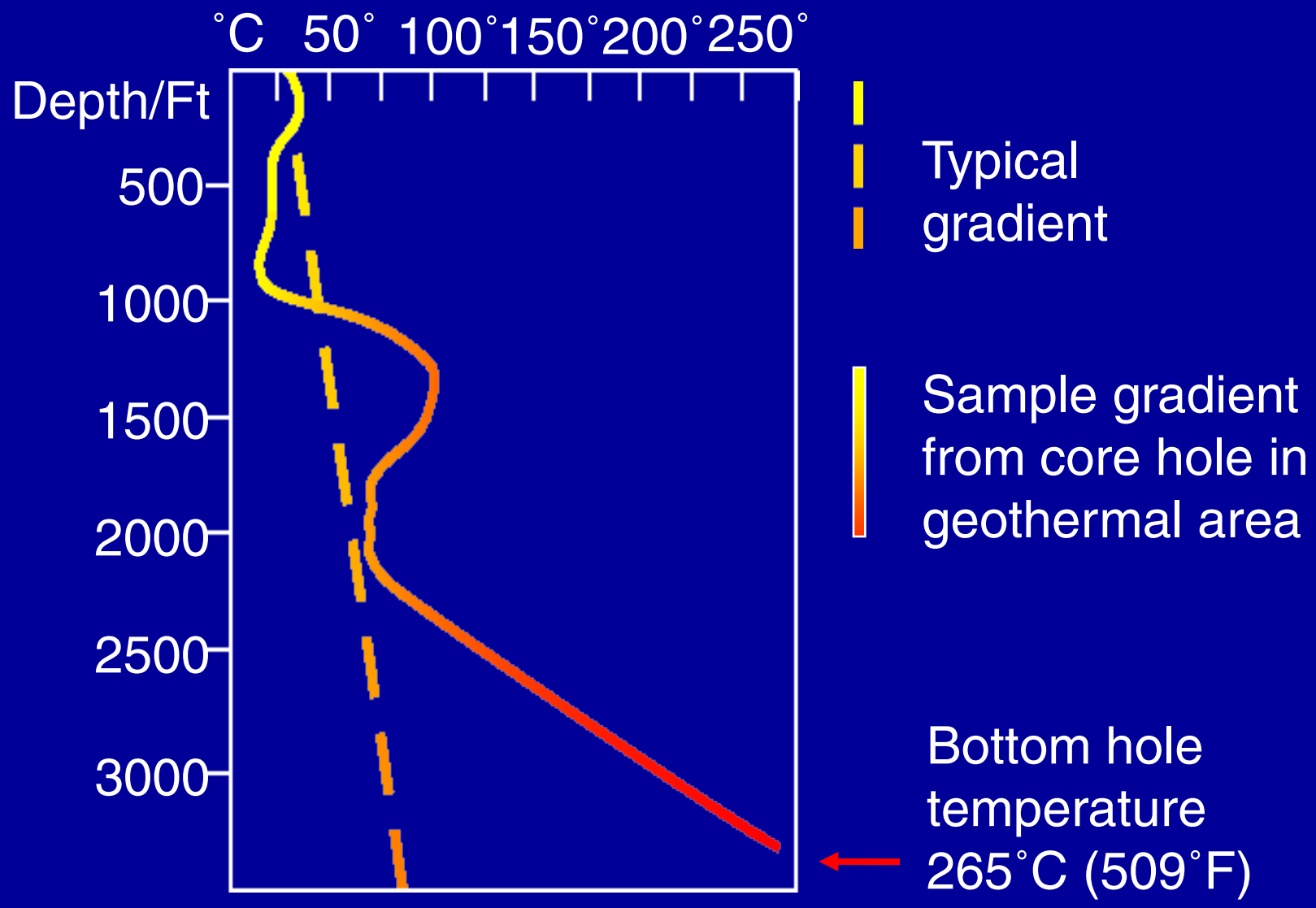
- **Four types of Geothermal Resources**
  - **Hydrothermal – our discussion today**
  - **Geo-pressured**
  - **Hot Dry Rock**
  - **Magma**

- **Greater than 120° C (250ºF) - produce electricity**
- **Greater than 40°C (105ºF) - direct thermal use**
- **Everywhere, can use geothermal heat pumps (GHPs) for heating and cooling.**

Geothermal Resource Potential

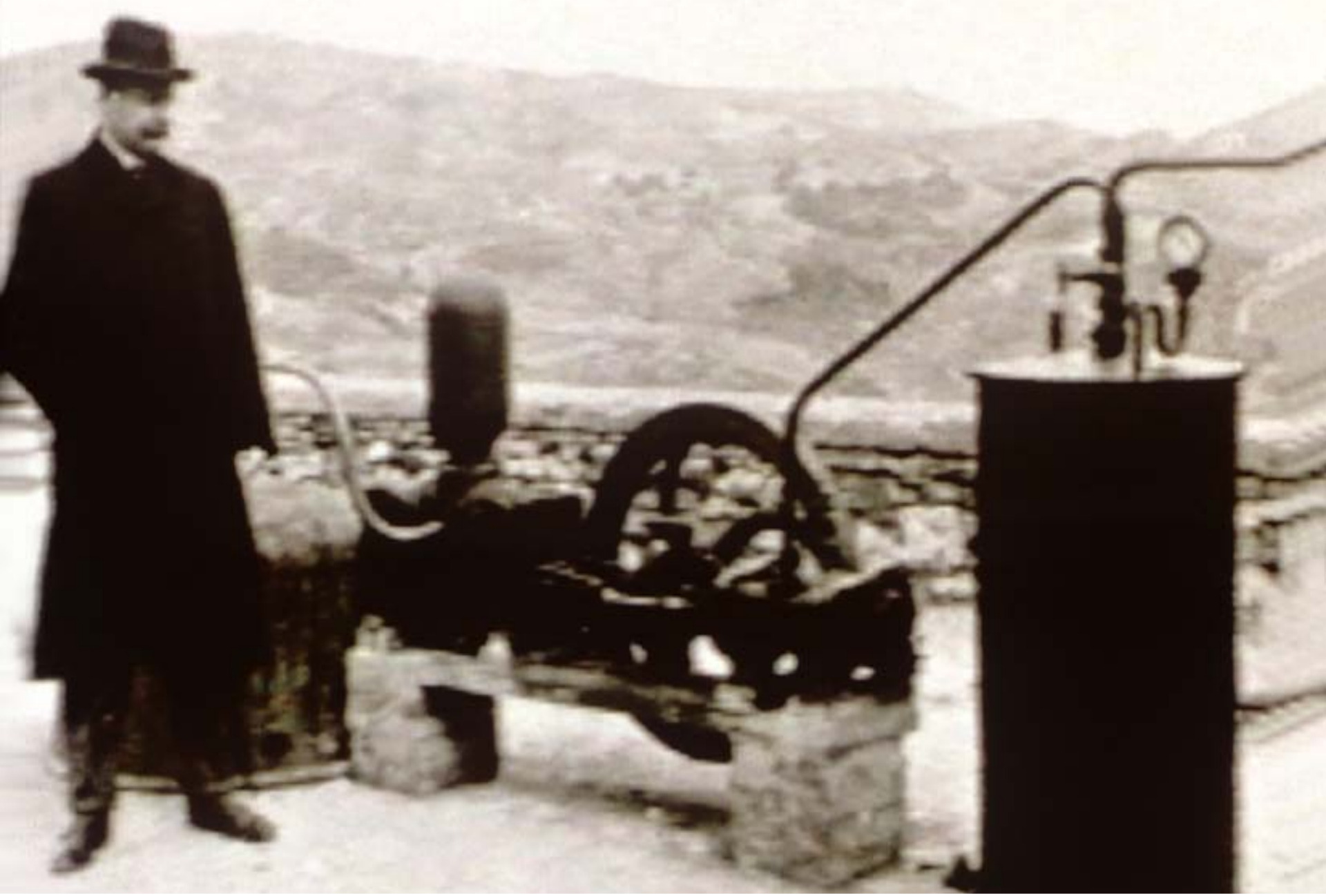


Sample Temperature Gradient Data



History of Geothermal Electricity

- Experiments began in Lardarello, Italy in 1904
- First U.S. plant at The Geysers in 1920s; first commercial plant in 1960

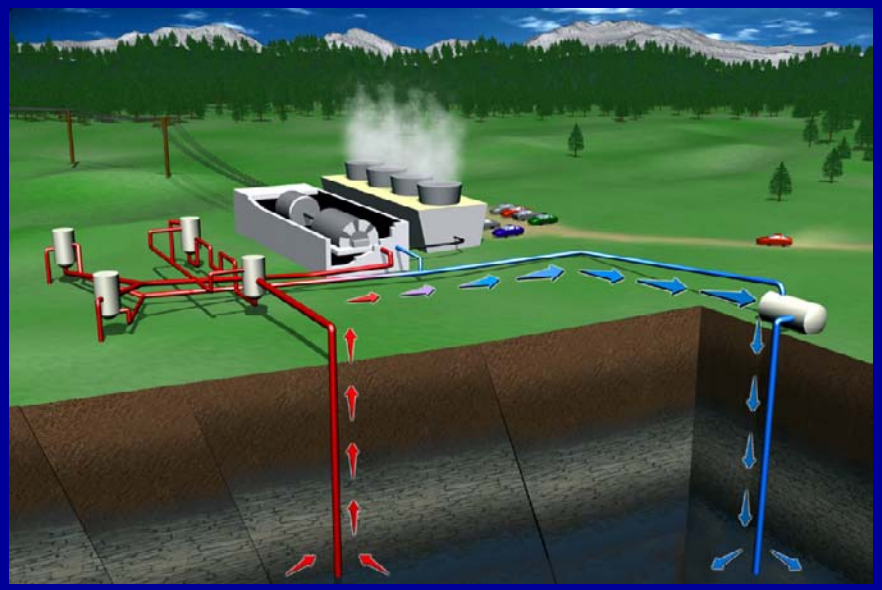


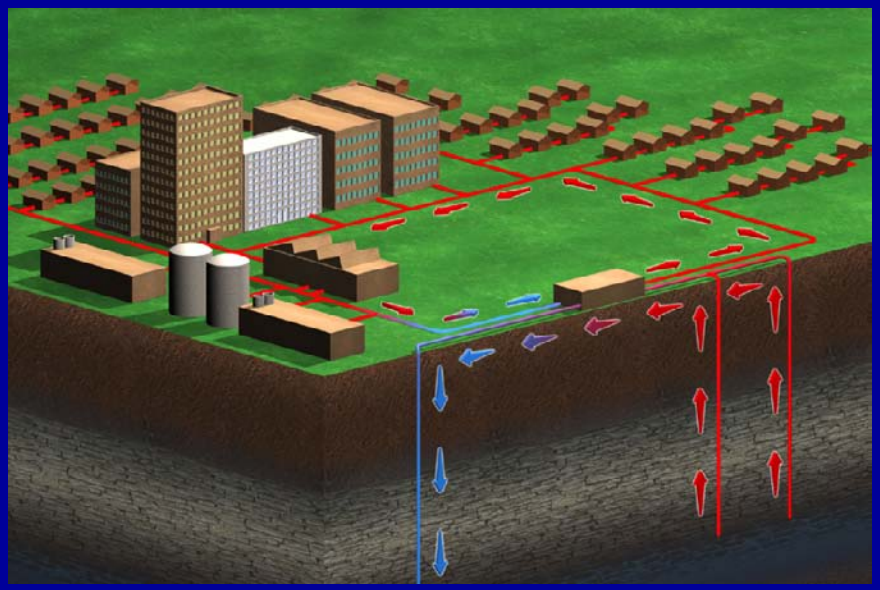
First Geothermal Power Plant, 1904, Larderello, Italy

Advantages of Geothermal Electricity

- Large and widespread resource
- Both supply- and demand-side applications
- Environmentally sound
- Virtually inexhaustible with good management practices
- High plant availability (>95%)
- Steady base-load power
- Relatively low cost (~4 – 8 cents/kWh)
- Worldwide market

Geothermal Energy Technologies – Using the Earth's Heat





Electricity Generation

- Distributed Power
- Central Station Power

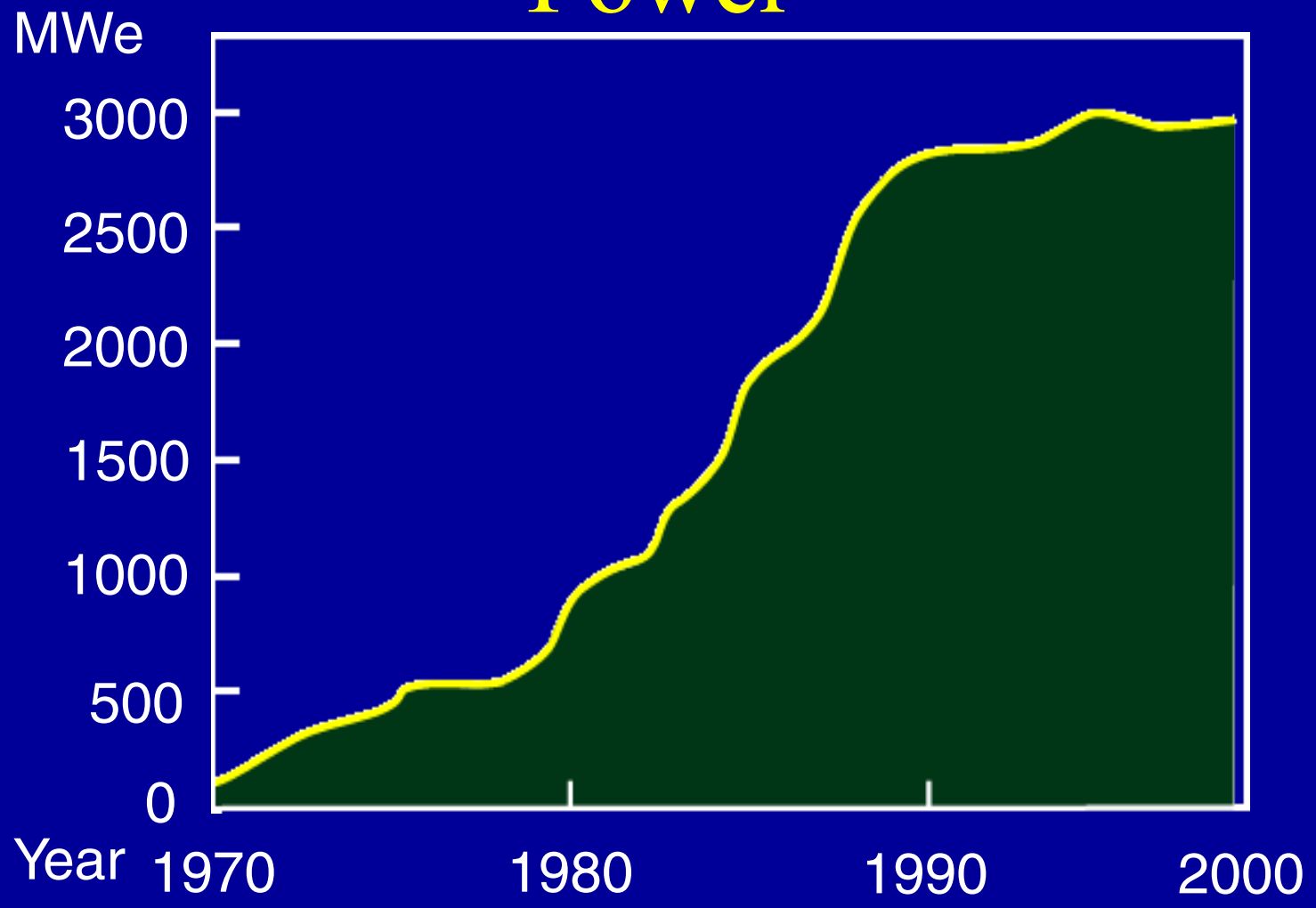
Heat Production

- District Heating
- Process Heat
- Agriculture
- Aquaculture

Today's Plants

- 8,000 MWe being generated in 21 countries
- 22 plants in U.S. (mostly California and Nevada) providing 2,200 MWe
- Hydrothermal resources could provide additional 20,000 MWe in U.S., 75,000 MWe in developing nations

Growth in U.S. Geothermal Power



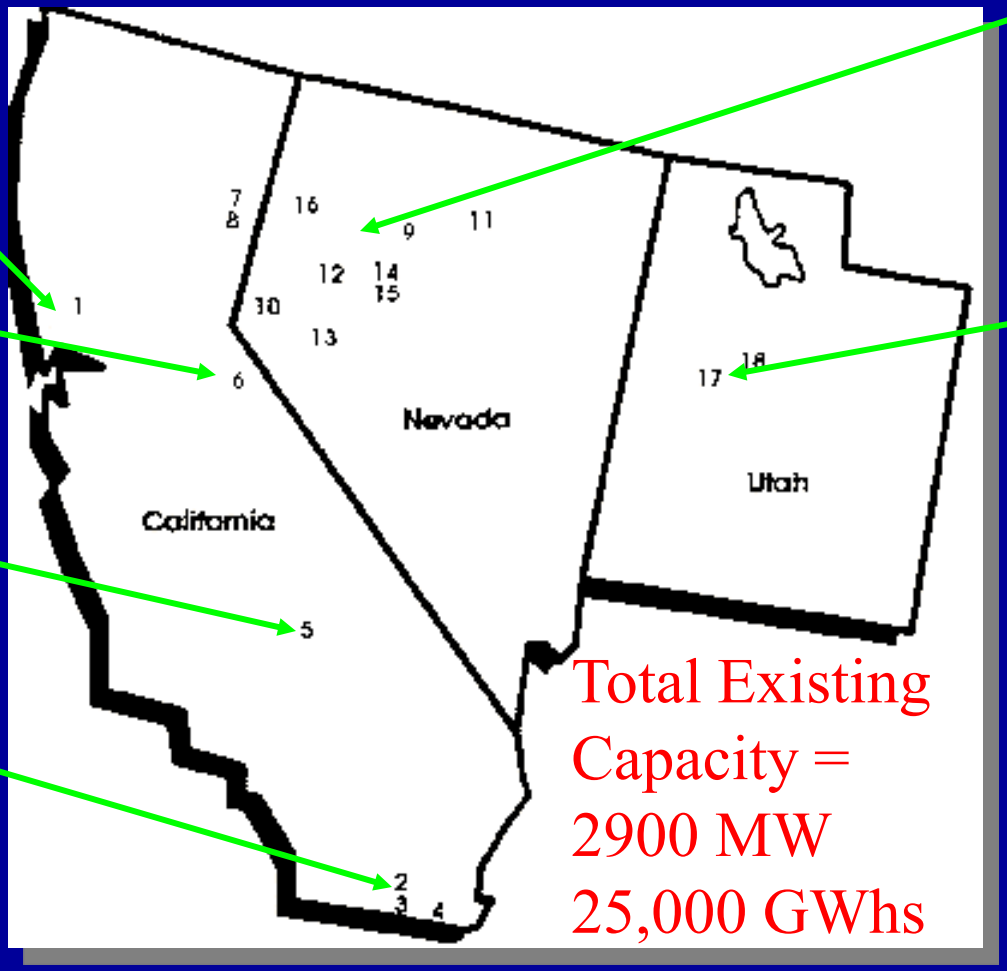
Current U.S. Geothermal Power Production

Geysers
2070 MW

Mammoth
40 MW

COSO
240 MW

Imperial
Valley
403 MW

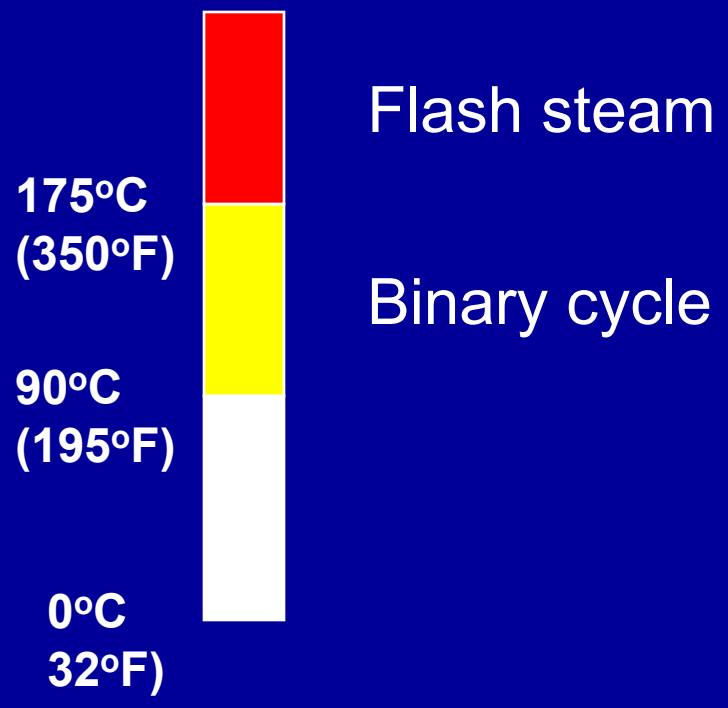


Nevada
Production
196 MW

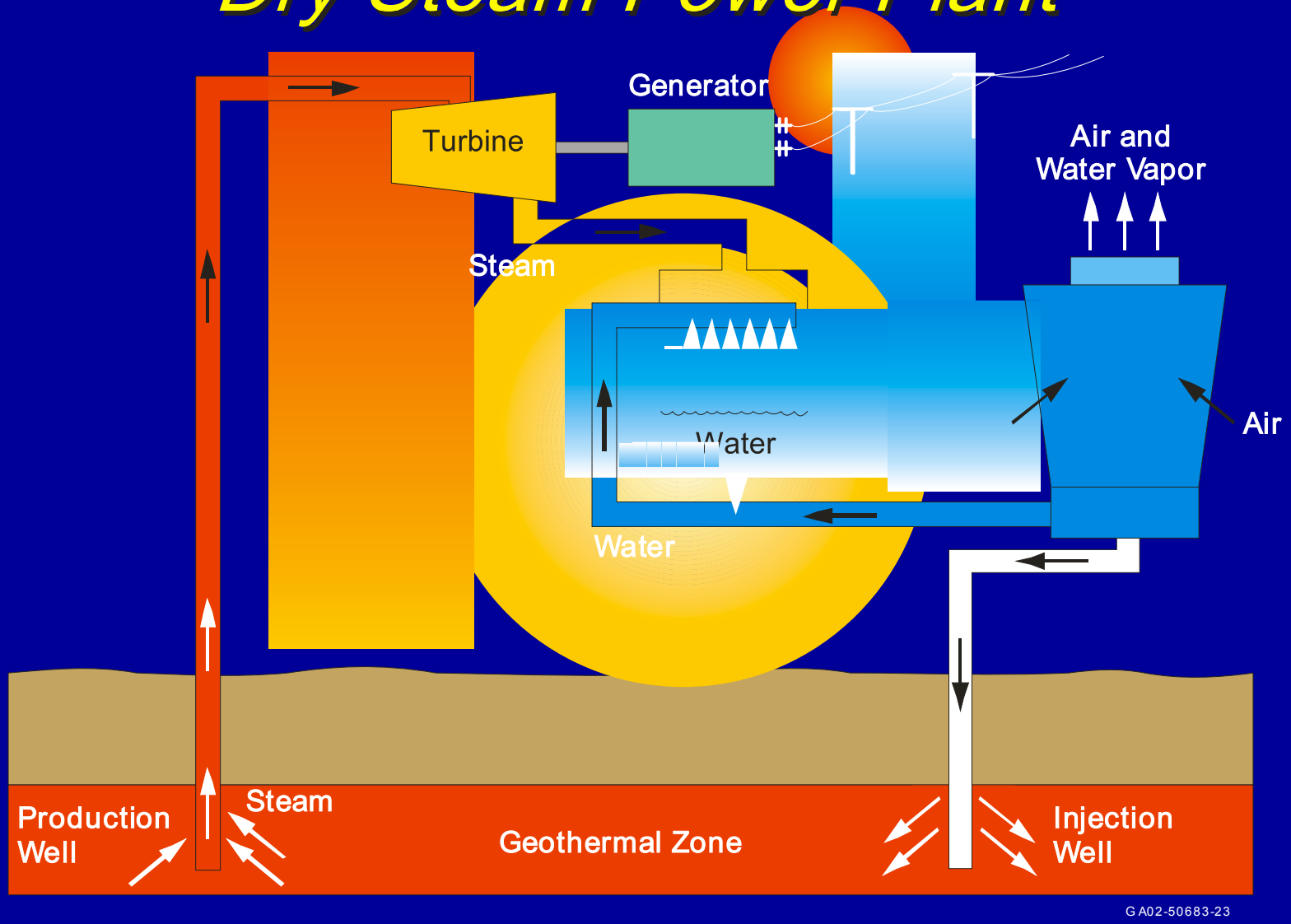
Utah
Production
33 MW

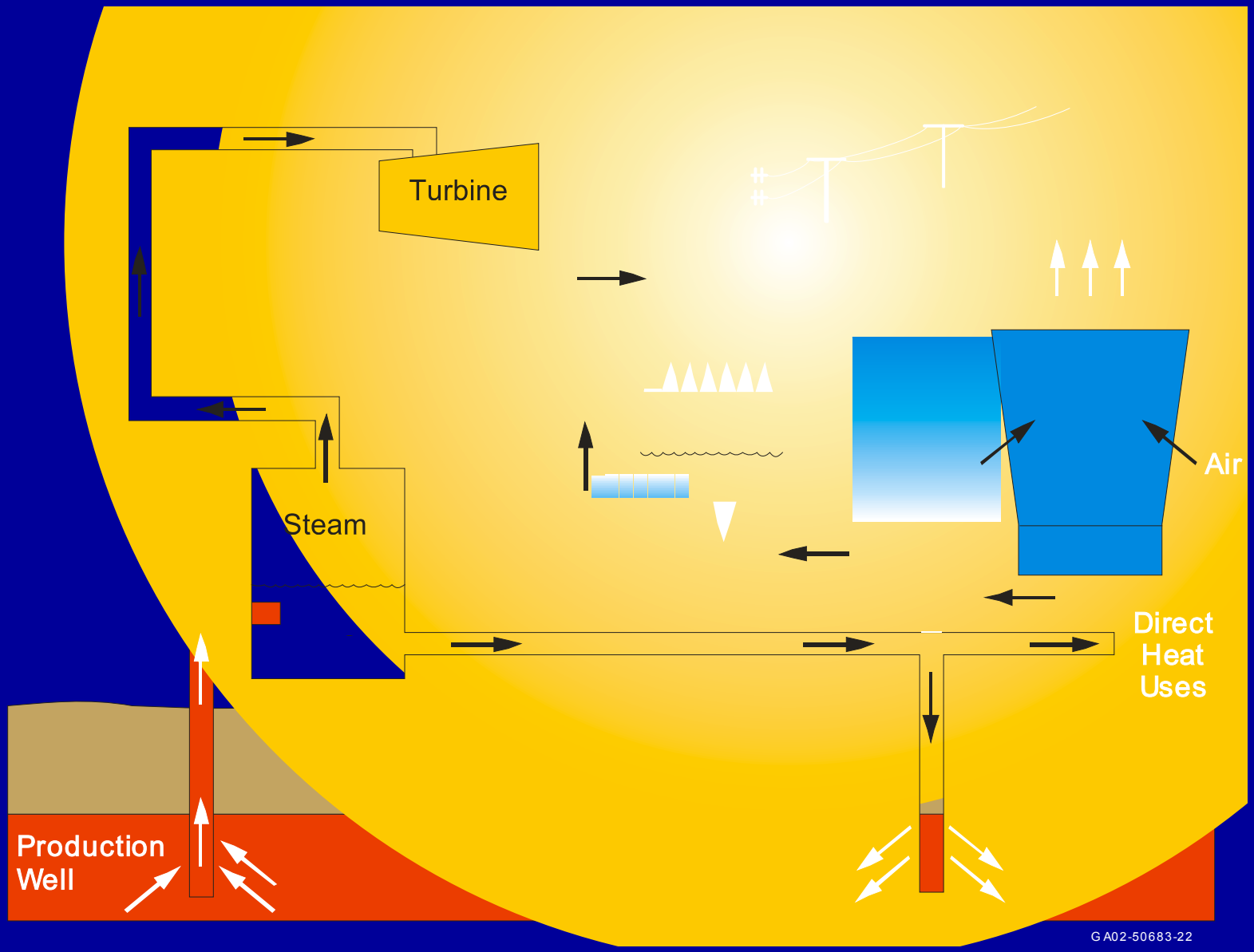
Total Existing
Capacity =
2900 MW
25,000 GWhs

Plant Type vs. Temperature

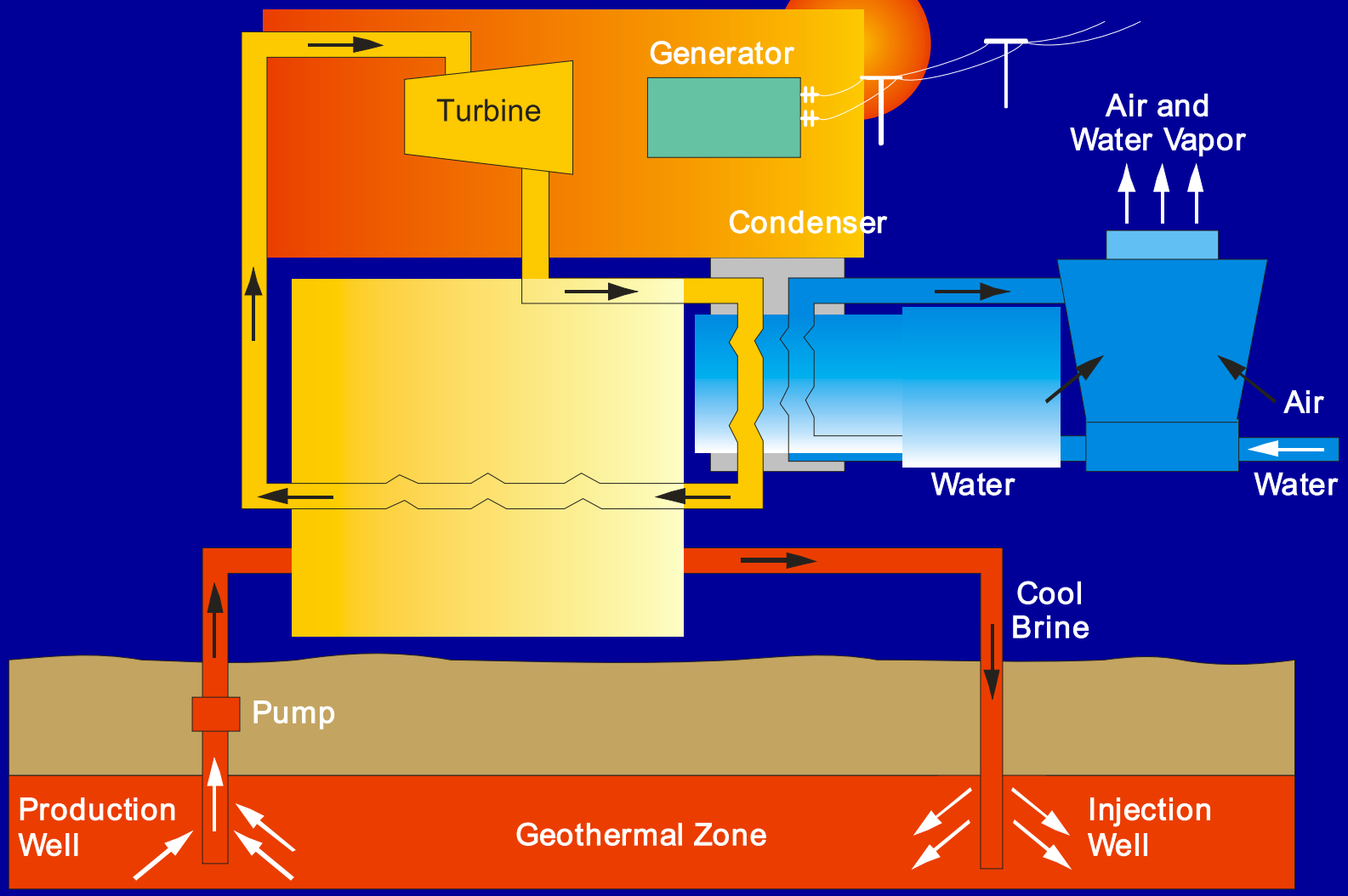


Dry Steam Power Plant




Turbine
Steam
Air
Direct
Heat
Uses
Production
Well
G A02-50683-22

Binary Cycle Power Plant



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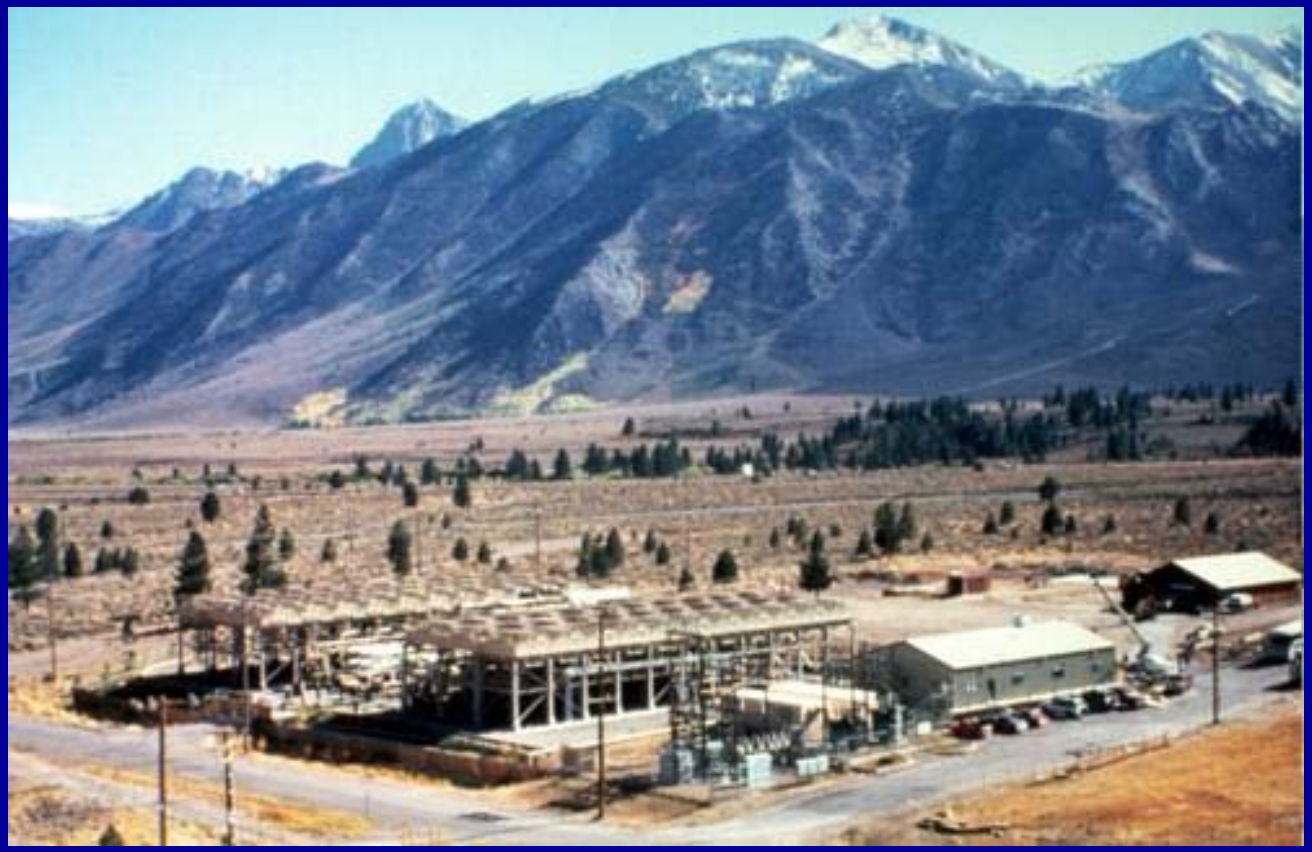

The Mammoth geothermal plant -- Located in the eastern Sierra Nevada mountain range in California, showcases the environmentally friendly nature of geothermal power. Three air-cooled binary units generate a total of 28 megawatts of electricity, and release essentially no emissions into the atmosphere or land surface.

Plant Costs

	Flash ($/kW)	Binary ($/kW)
Exp./drilling	700	500
Equip.	750	1600
TOTAL	1,450	2,100