Lecture 23: Geothermal Energy

Course: MECH -422 – Power Plants

Instructor: Kashif Liaqat

Term: Fall 2021

BUITEMS – DEPARTMENT OF MECHANICAL ENGINEERING

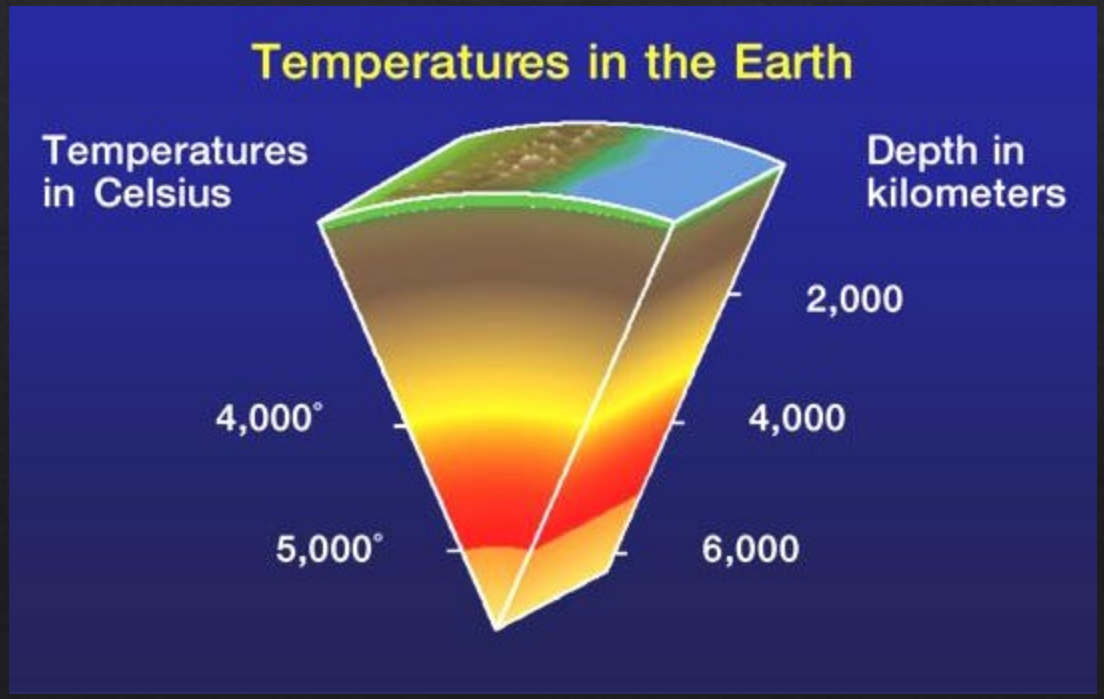
Geothermal Energy can be spectacular!

Photos of US Geological Survey

Geothermal Energy

Definition:

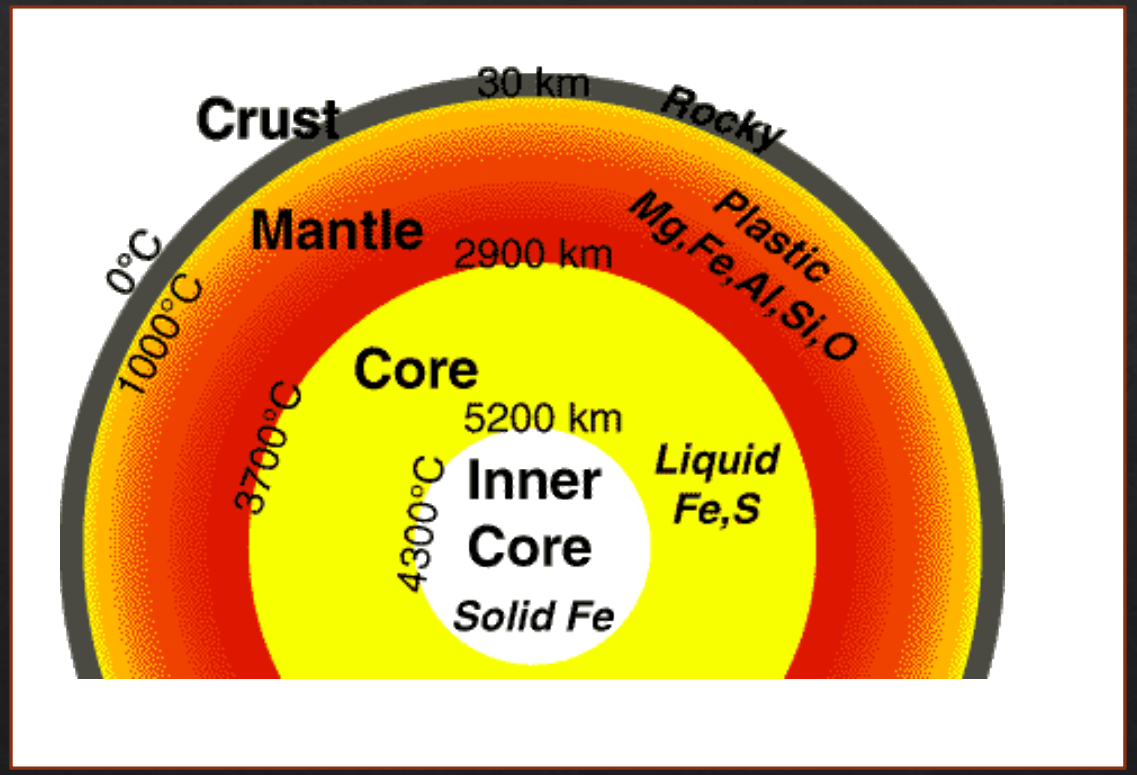
Geothermal Energy is energy stored in the form of heat beneath the surface of the solid earth



Graph from Geothermal Education Office, California

What is Geothermal Energy?

- Geo (Greek for earth) Thermal (heat)
- Temp. of Shallow Crust (upper 10 ft.) Constant 55-75°F (13-24°C)
- Up to 14,400°F (8,000°C) at Molten Core (approx. 4,000 mi. to center of core)



What is Geothermal Energy Cont'd?

- Basic Geothermal Systems Take Advantage of:
  - Heat Differential Between Ground and Indoor Air Temperatures – Heat Pump
  - Earth as a Natural Heat Source – Power Plants

Types of Geothermal Resources?

- Geothermal Sources are Classified Based on: (1) Temperature, (2) Physical State of H_20 (i.e. water or steam), and (3) Type of Energy Usage
- Primary Classification is Resource Temperature:
  - Low Temperature Reservoir: 50-200 °F (10-94 °C)
  - High Temperature Reservoir: >200 °F

A short glimpse at geothermal power

First experiment to produce geo-thermal power, done in Italy in 1904 by prince Ginori Conti

Photo courtesy of ENEL/ERGA, Italy

Photos: Lund

Modern geothermal power plants in Larderello, Italy

Brief History of Geothermal Energy

- Paleo-Indians Usage Dates Back 10,000 Years
- Use by Romans – Hot Spas; Hot Running Water, Etc.
- Early 1800s – Yellowstone Hot Springs and Hot Springs Arkansas
  - 1830 1st Commercial Use; Asa Thompson sold Bath in Wooden Tub for $1

History of Geothermal Energy Cont'd

- In 1852, the Geysers Resort Hotel in San Fran. CA opened
- 108 Years later, 1st Geothermal Electricity Plant Opened at the Same Location – "The Gysers"

Basic Types of Geothermal Reservoirs

- 3 General Classes of Geothermal Uses
  - Ground Source Heat Pump
  - Direct Source
  - Commercial Electricity Generation: Power Plants
    - Need High Capacity Geothermal Reservoir; Generally Water / Steam >200°F

The Geothermal Heat Pump

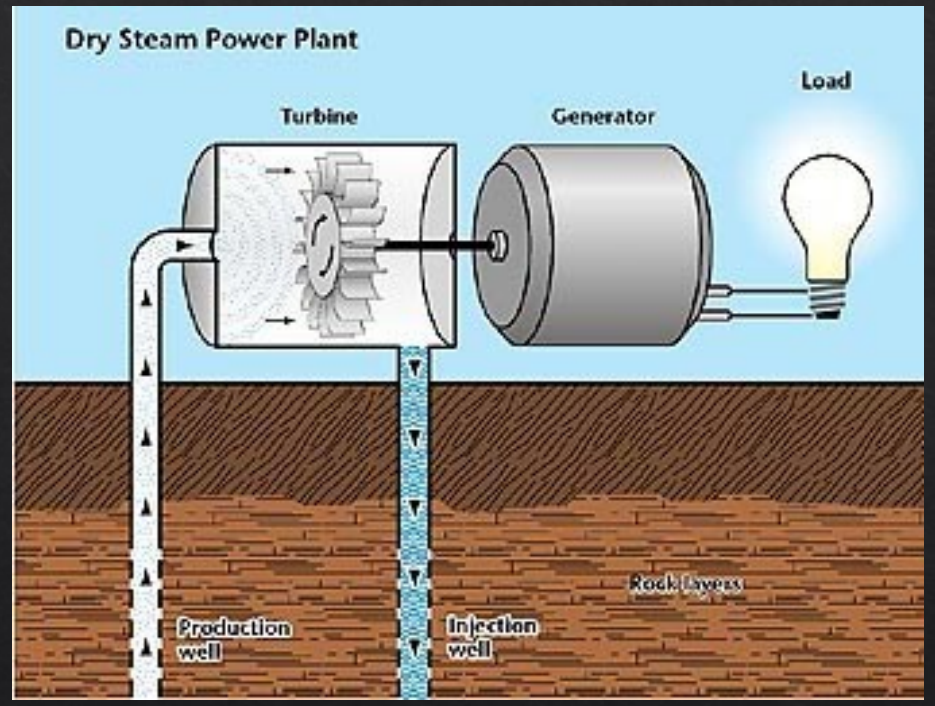
- Most Basic Form of Geothermal Usage
- What – takes advantage of stored heat of near surface soil / water (Const. temp of 55-75 °F)
  - Winter Months – uses ground as a “heat source”
    - Transfers heat from warm subsurface to facility
  - Summer Months – uses ground as a “heat sink”
    - Transfers heat from facility to ground

TYPES OF GEOTHERMAL POWER PLANTS

- Different Types of Plants are Required to Take Advantage of the Particular Characteristics of Each Specific Geothermal Site
- Main Types of Geothermal Power Plants:
  - Dry Steam
  - Flash Steam
  - Binary Cycle

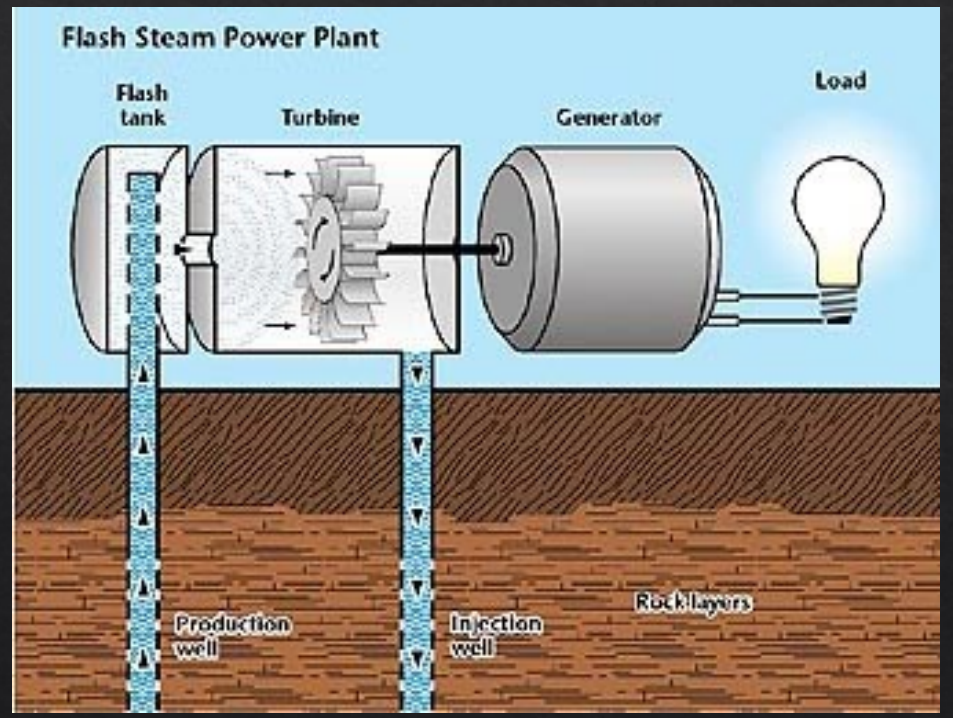
Dry Steam Geothermal Plants

- Uses Steam From Geothermal Reservoir Directly
- Only Requires Removal of Rock Fragments From Steam Prior to Entering Turbines
- Only Emissions Are Water Vapor



Flash Steam Geothermal Power Plants

- Injection of Deep, High-pressure Water Into Low-pressure Tanks; Water “Flashes” to Steam Used to Drive Turbines
- Excess Water Returned to Maintain Pressure in Reservoir

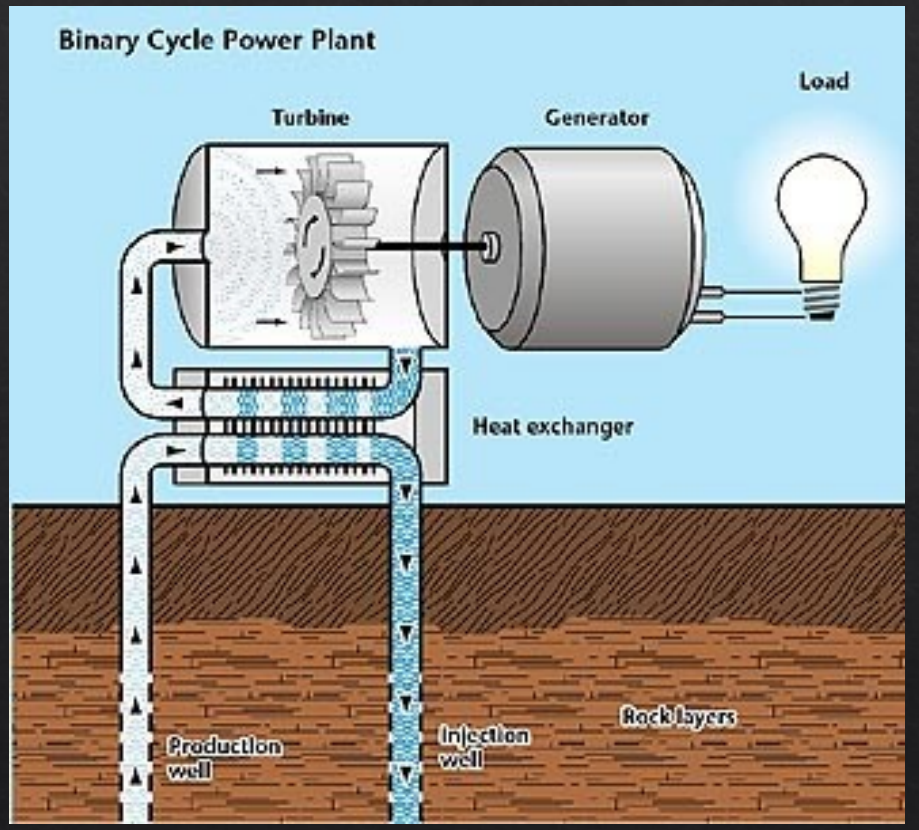


Flash Steam Plants Cont'd

- Steamboat Springs, NV Plant
- Initial Conditions – Liquid H_2O @ 240°C, Pressures of 24 MPa (hydrostatic pressure)

Binary Cycle Geothermal Power Plants

- Moderately Hot Water (<175 °C) Passed Through Heat Exchanger
- Heat Transferred to Secondary Fluid (Low B.P. Fluids (i.e., Propane or Isobutane) Which Is Vaporized (“Flashed”)



Binary Cycle Plants Cont'd

- Higher Capital Cost
  - Needs High Efficiency Equip.
- Water Never Contacts Turbine/generator Units
- Water Returned Directly to Reservoir
- No Plant Emissions!

The top five Geothermal Power Generation markets in 2021

Global geothermal power generation capacity stood at 15,854 MW at the year-end 2021.

Pakistan's Geothermal Resources

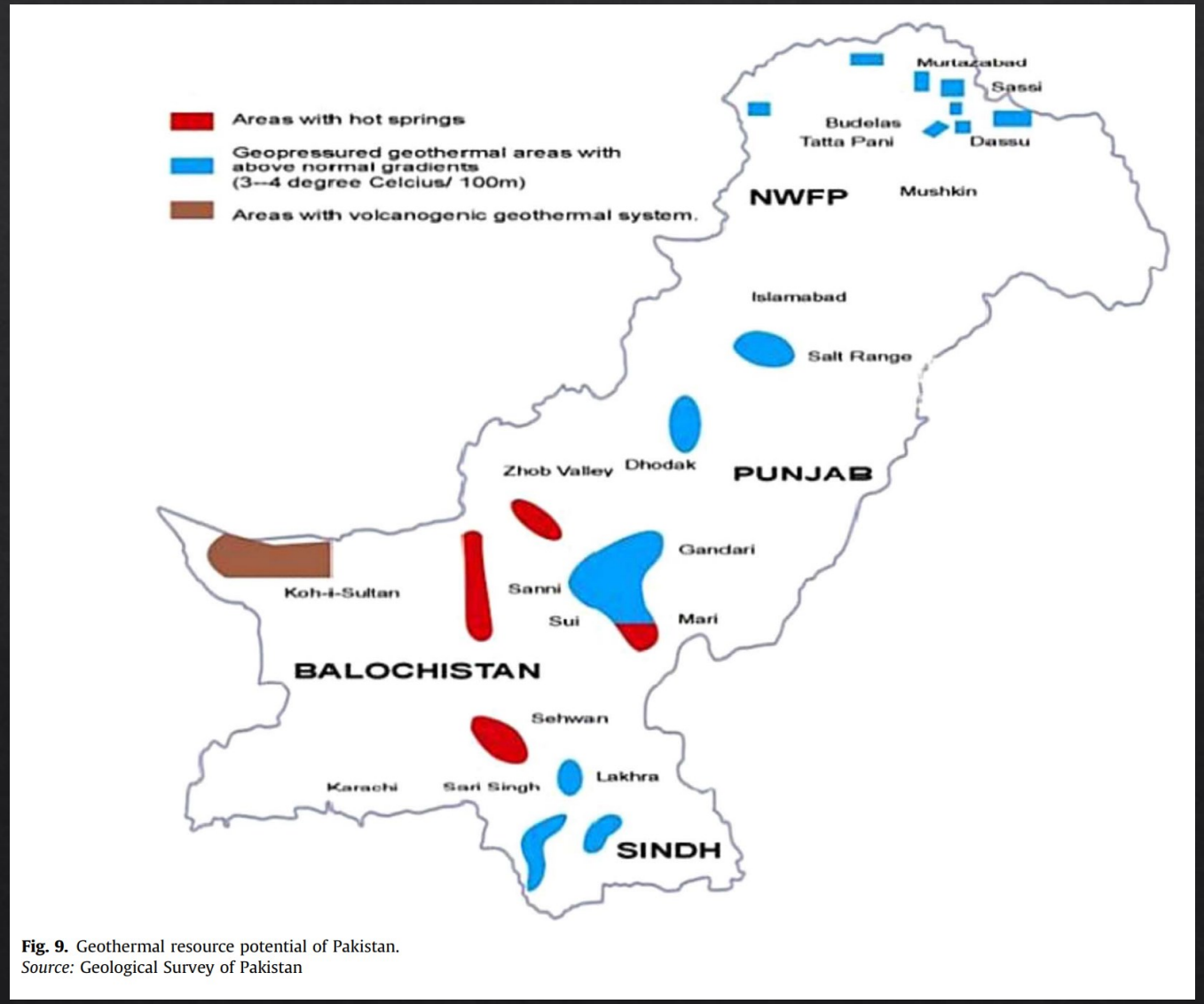
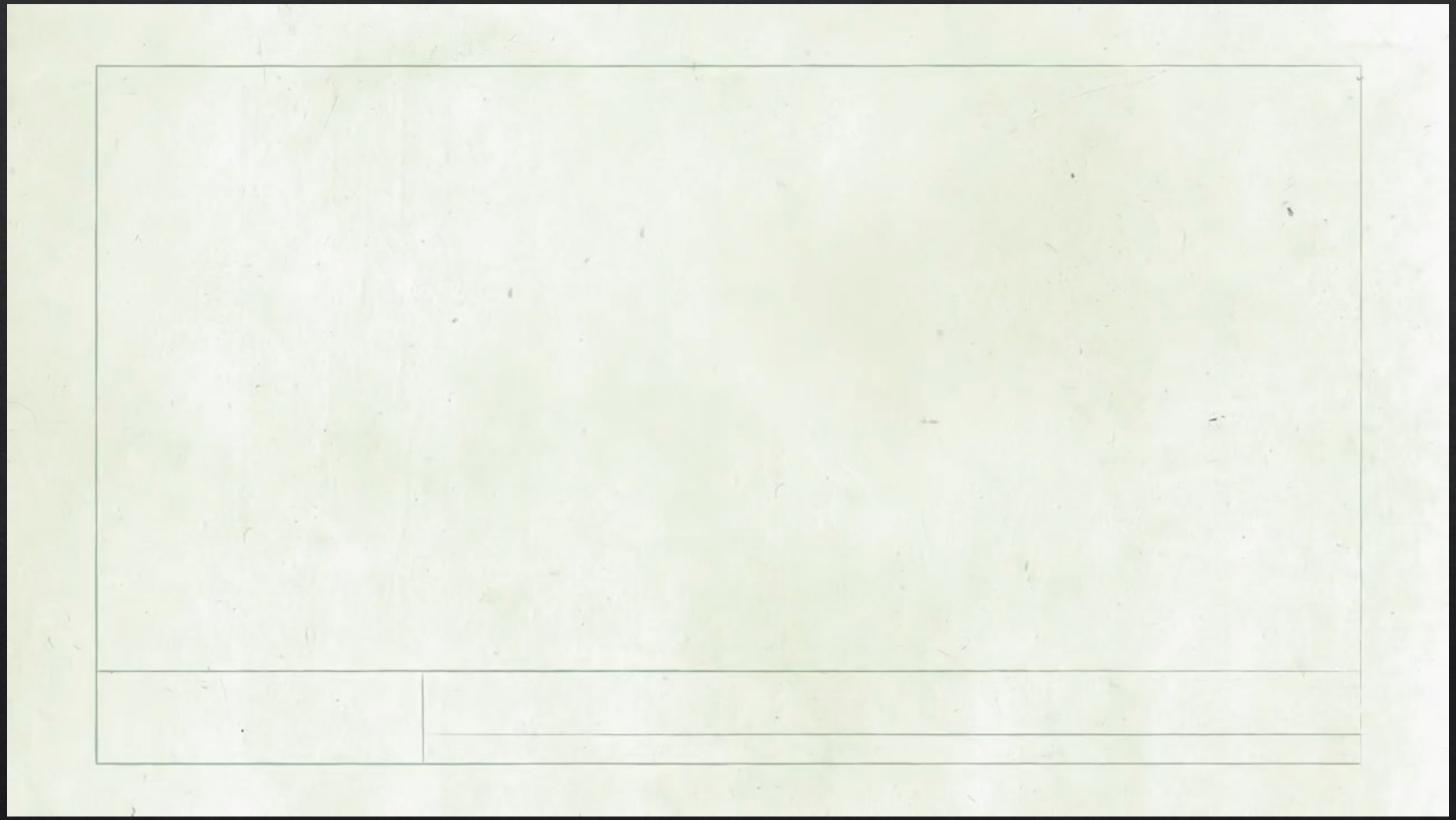


Fig. 9. Geothermal resource potential of Pakistan.
Source: Geological Survey of Pakistan



https://www.energy.gov/eere/videos/energy-101-geothermal-energy

End of Lecture!