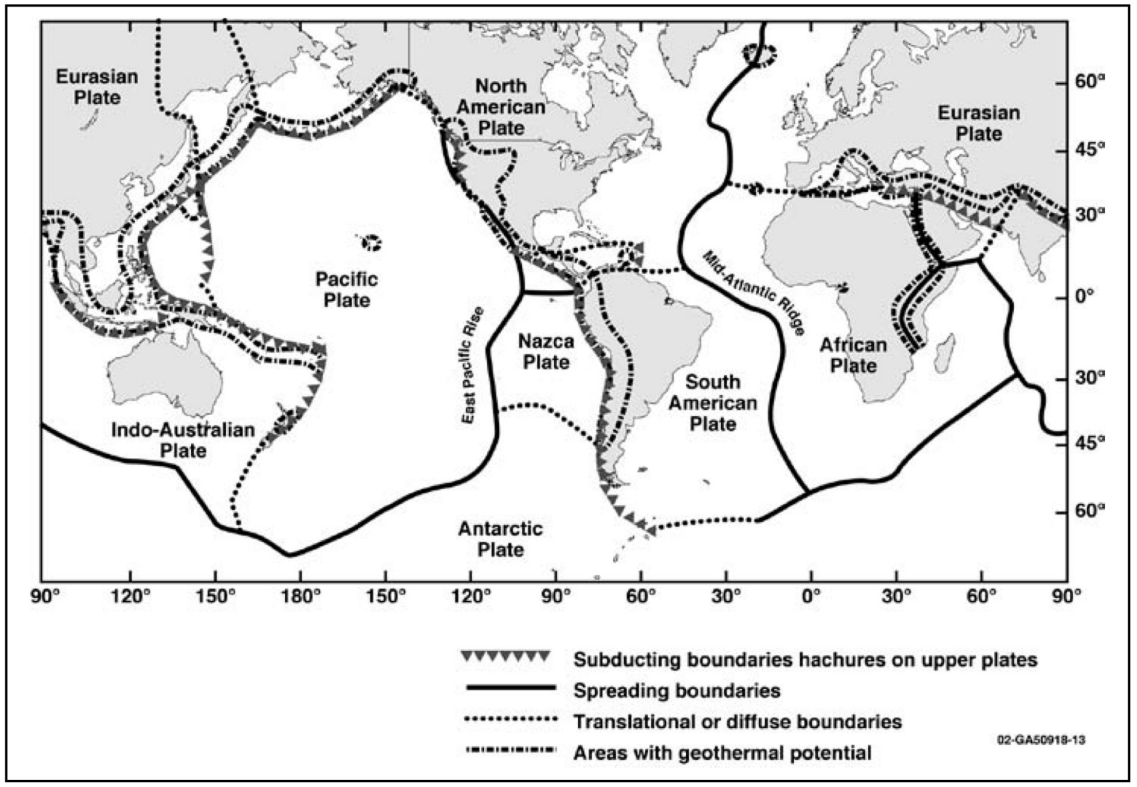
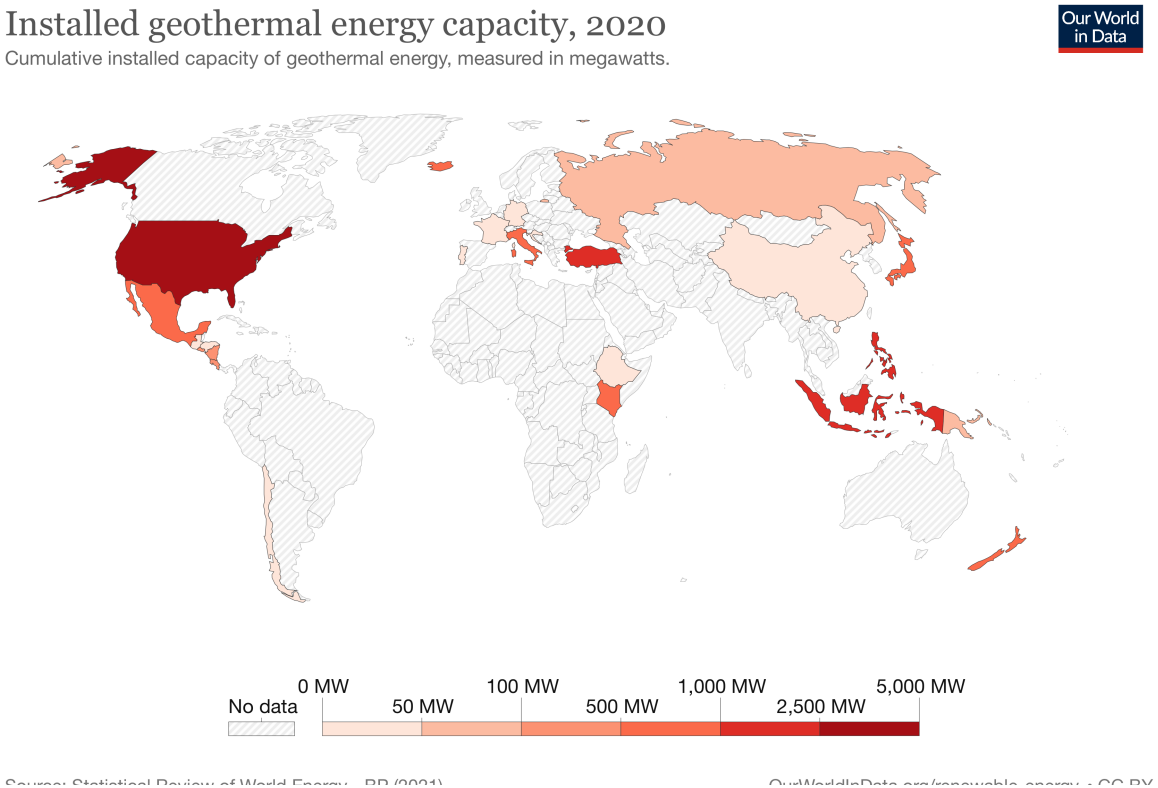
Solutions to Promote More Geothermal Generation

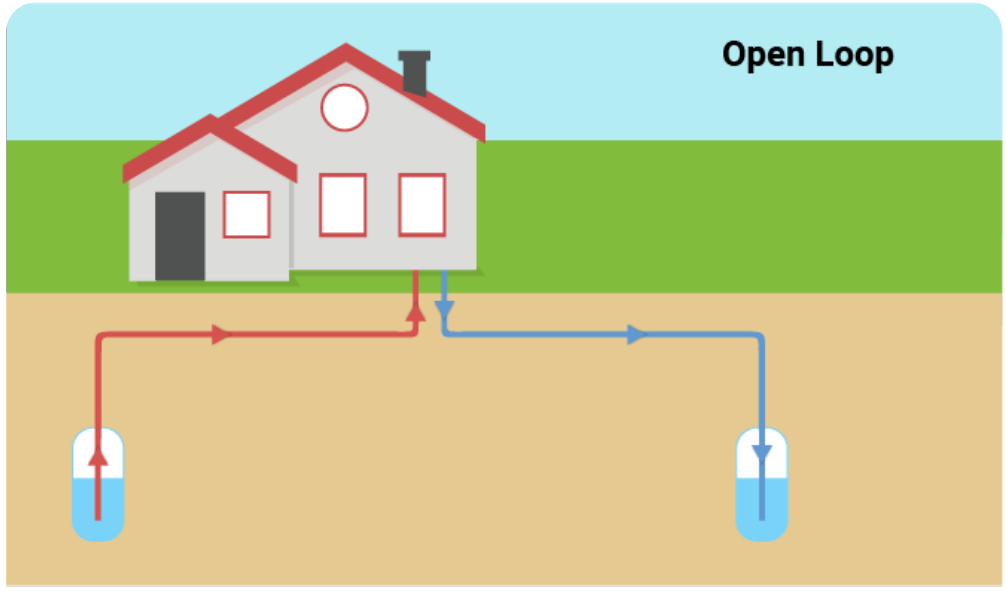
Meddelin Setiawan

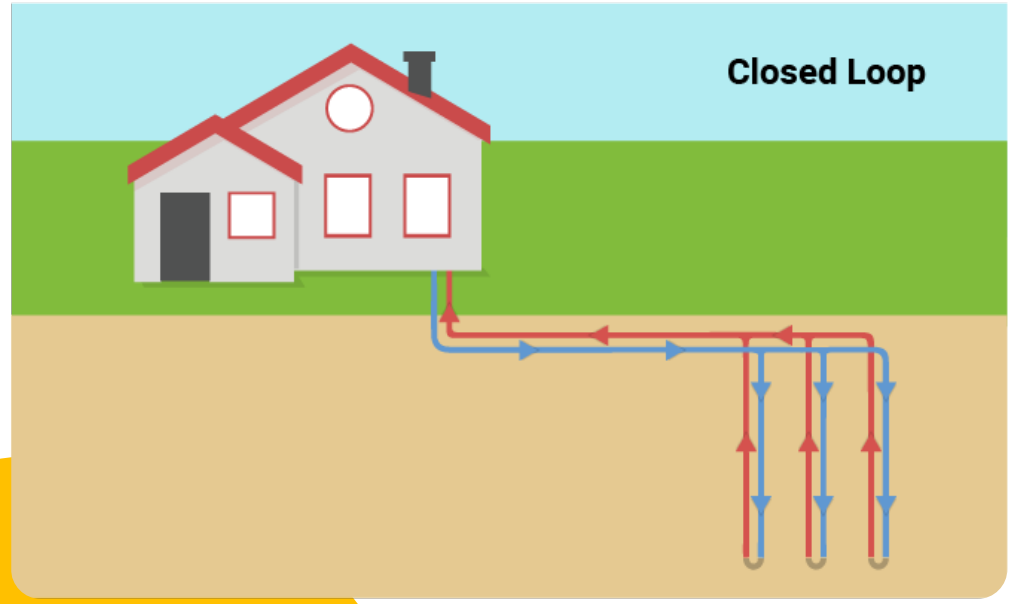




POTENTIALS

Geothermal energy has two primary applications: heating/cooling and electricity generation

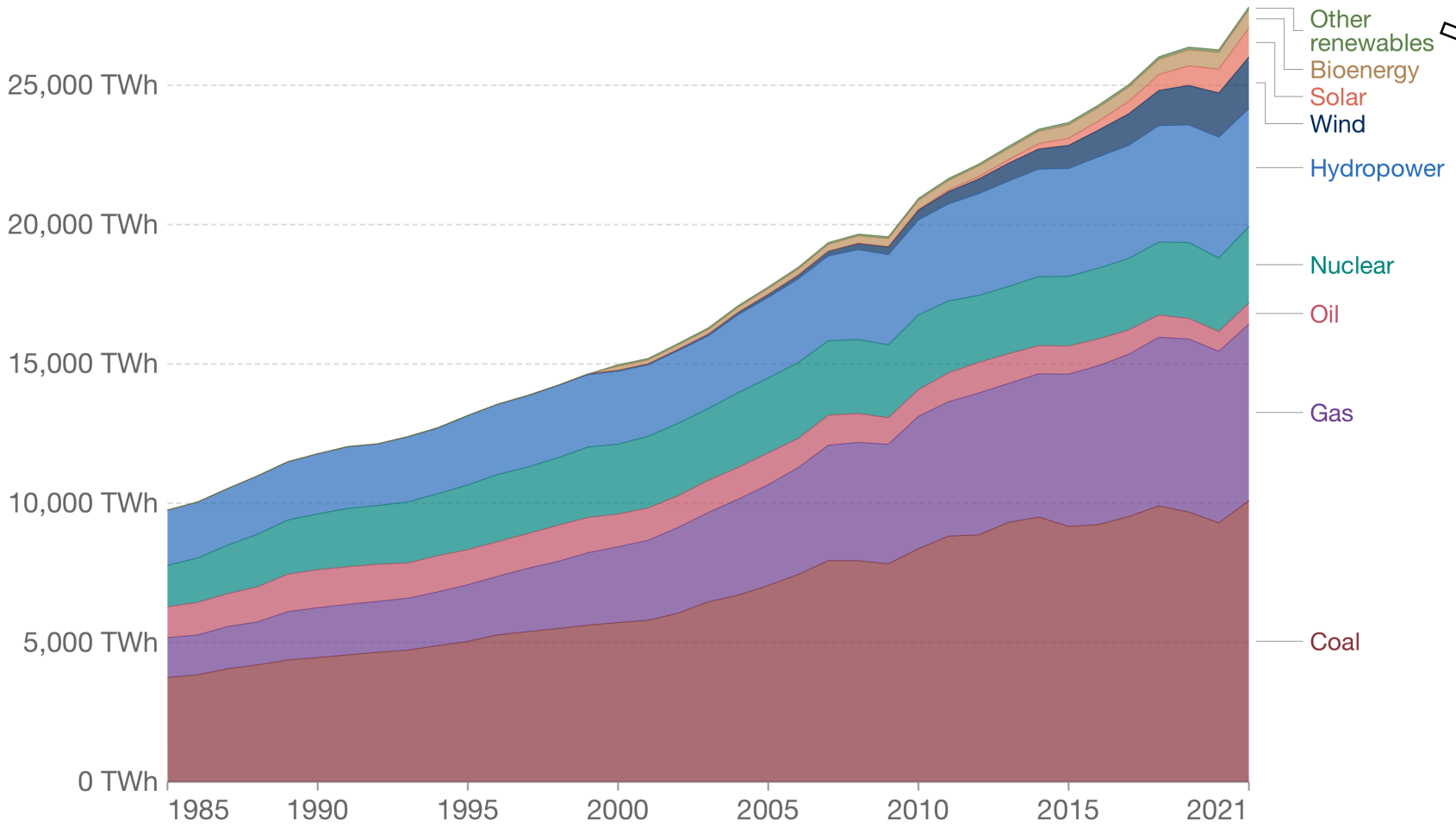




ENVIRONMENTAL IMPACT?

- available 24 hours a day.
- Relatively low emission levels
- Binary power plants: minimal emission of particles and almost zero emissions of greenhouse gases.
- Minimal land footprint and freshwater.
- Most recent plants are designed for 30+ years

Electricity production by source, World



2.5%

Source: Our World in Data based on BP Statistical Review of World Energy (2022); Ember (2023)
Note: 'Other renewables' includes waste, geothermal, wave and tidal.

OurWorldInData.org/energy • CC BY

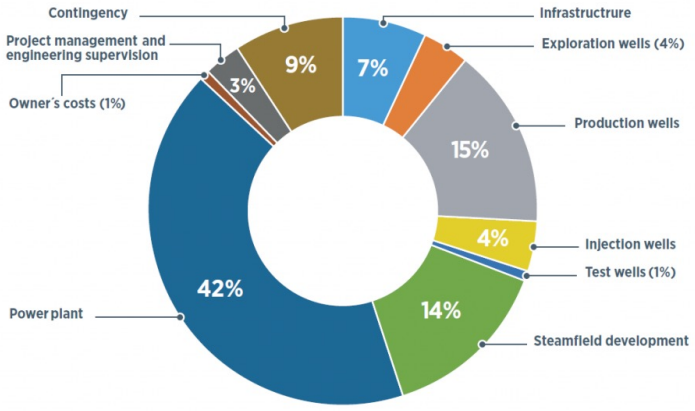
What's the problem?

Expensive Geothermal WELLS !!

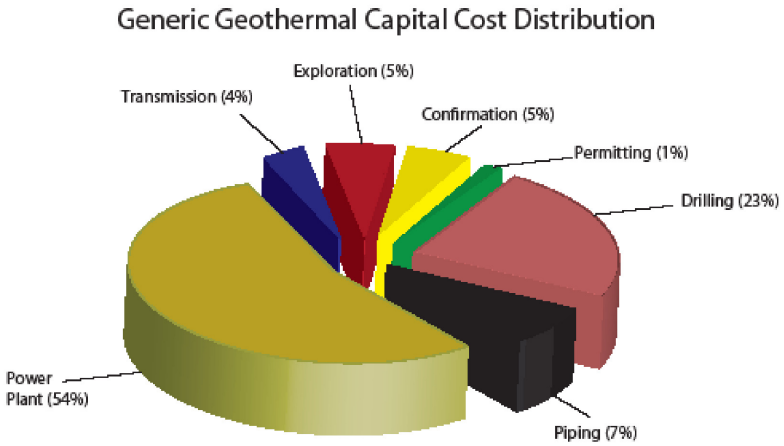
Courtesy: John Mering, respected geochemist at Mercury NZ

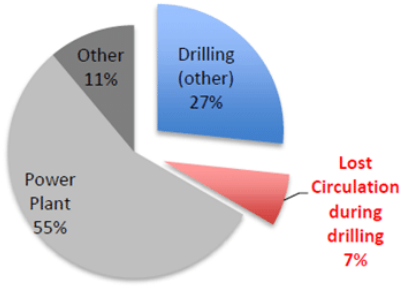
Well and drilling cost can make up to 30-70% of total geothermal project cost

Figure 10: Total installed cost breakdown for two proposed 110 MW geothermal plants in Indonesia



Source: IRENA, 2014



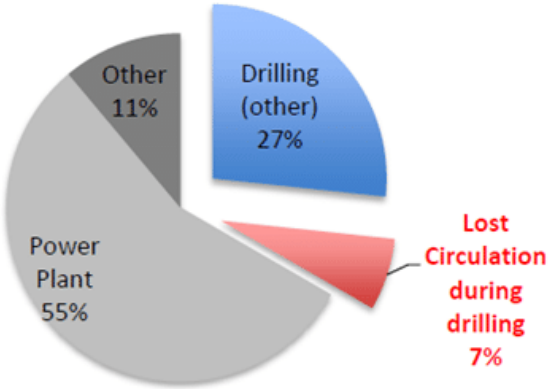


Single well drilling cost:	USD $1-7 Million
Lost circulation drilling cost component:	~ 20%
Lost circulation cost:	USD $200,000-$1.4M
Wells per field:	10-20
Total drilling cost per field:	USD $10M-140M
Lost circulation cost per field:	USD $2M-28M

Low rate of penetration, Severe wellbore stability issues,

Lost circulation

LOST CIRCULATION



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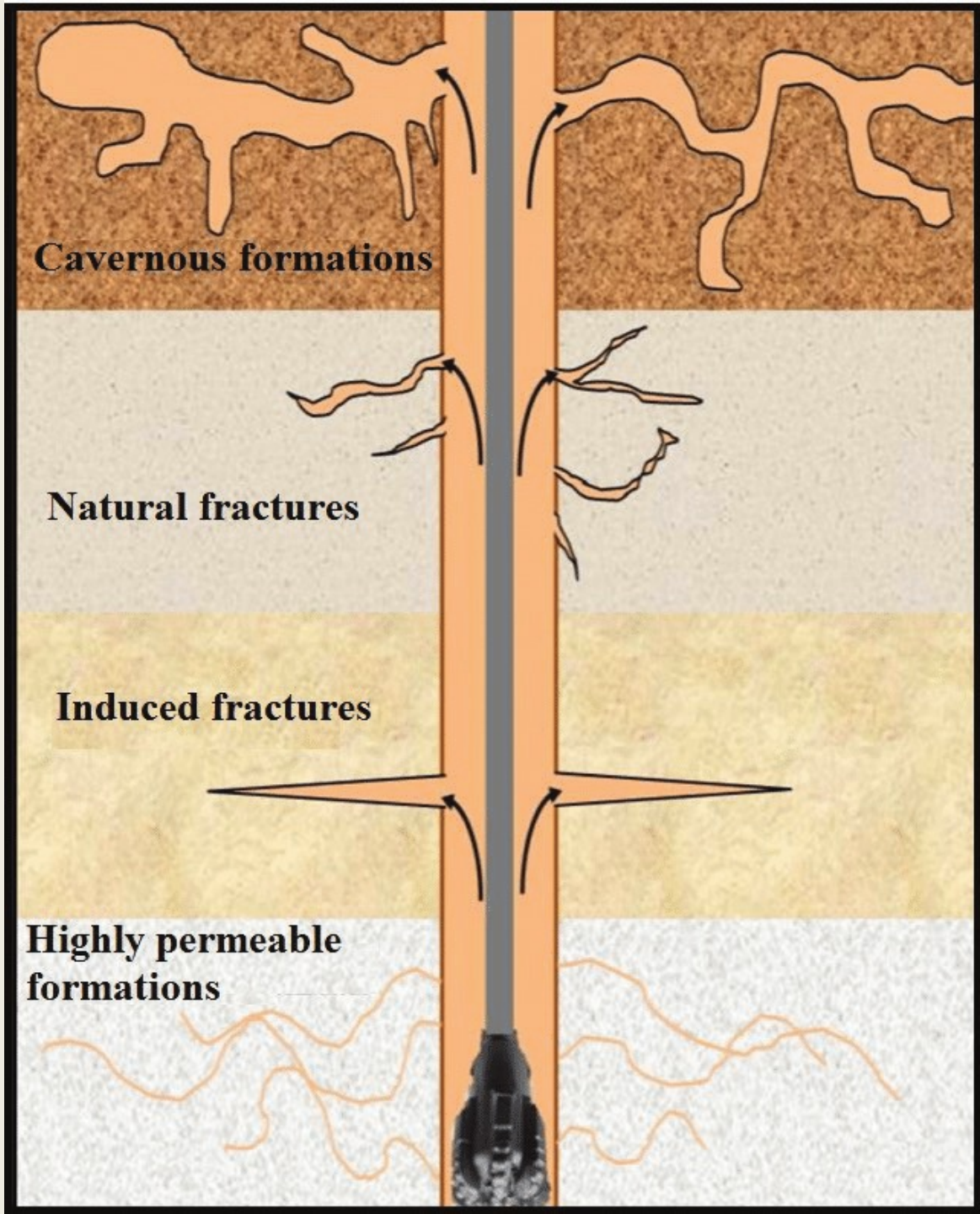
Geothermal conditions

Highly permeable and under-pressured

High non-productive time (NPT)



Solutions to Lost Circulation

(A) Lost Circulation Materials (LCM) and Wellbore Sealing

Conventional LCM Examples:

- Mica flakes
- Walnut Shells
- Fibers
- Marble
- Calcium Carbonate
- Perlite

Geothermal well conditions:

- Temperature up too 300^{o}C
- Gas: CO2, H2S

Most conventional LCMs degrade at 200^{o}C!

24%

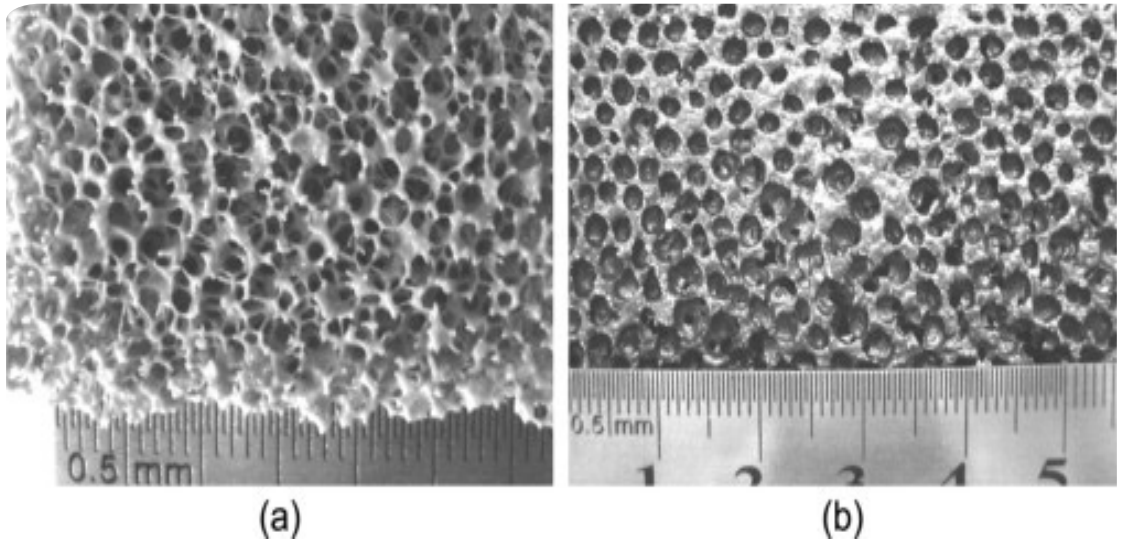
Success rate

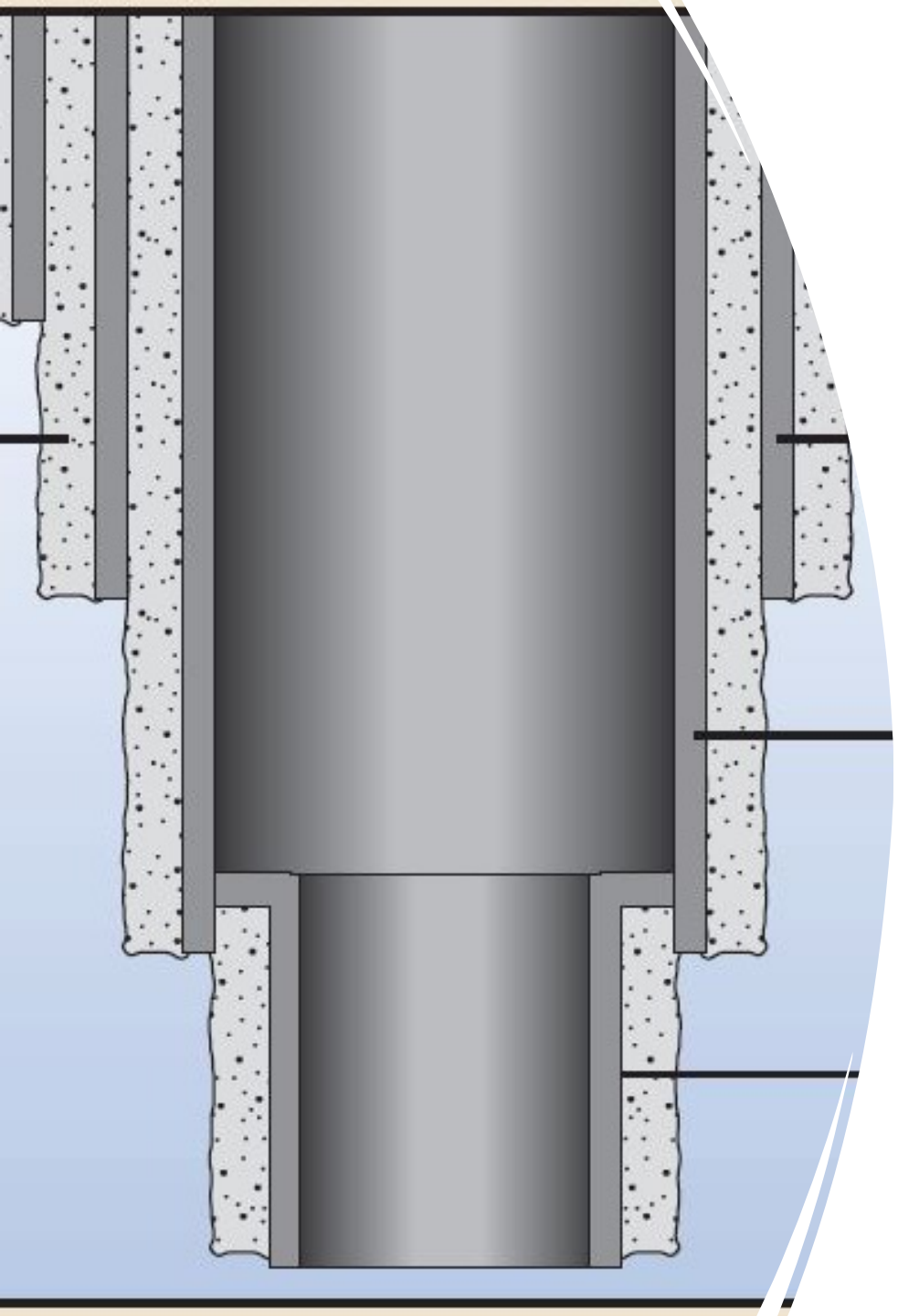
NEW LCMs

SANDIA National Lab:

thermoset rubbers

controlled-porosity ceramic materials





(B) Cement Engineering

- Used for casing and cementitious mud (cement containing drilling fluid)
- Parameters:
  - Time to set
  - Effects of temperature
  - Mechanical properties of cement

Brookhaven National Laboratory

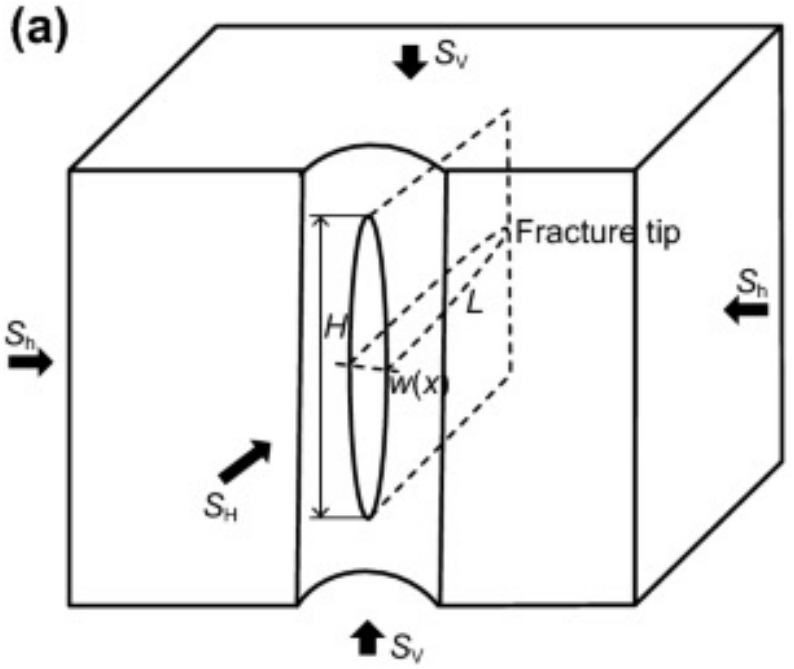
Rapid-setting and temperature-driven cement:

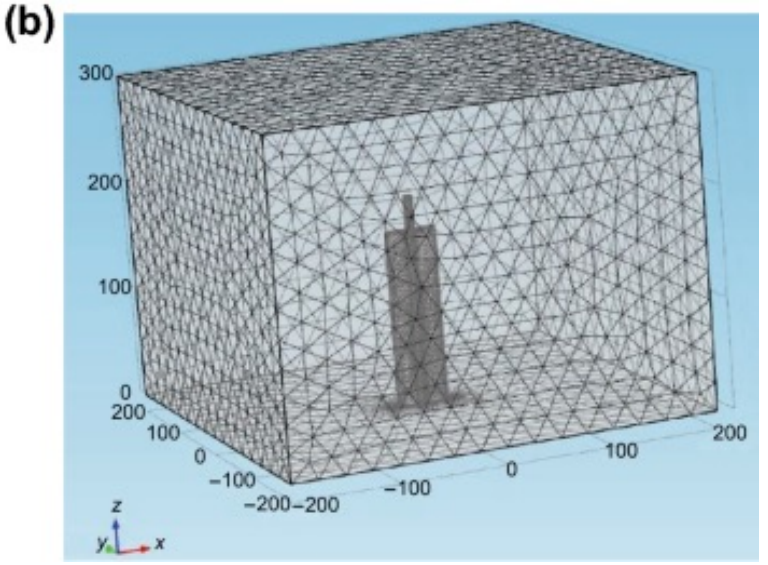
- **mixing conventional bentonite mud with ammonium polyphosphate, borax, and magnesium oxide**

- Significant compressive strength was developed in less than two hours
- the setting time decreased with increased temperature
- material expanded approximately 15% upon setting.

(C) Computational Modeling

- finite element models for wellbore strengthening applications and simulations of fracture creation and sealing
- Based on linear elastic fracture mechanics
- Benefits:
  - predict fracture-initiation pressure
  - effects of wellbore-fracture geometry
  - Improve LCM designs





Lost Circulation Solutions

sustainable geothermal exploitation requires deep seated, large diameter boreholes and long lasting well integrities.

Other Solutions

(A) Innovative Drilling Methods

- Less contact forces and abrasion of drilling head
- less NPT
- longer drill distance

(B) Best Practice Handbooks

- Temperature
- Geology
- Geochemistry
- Drilling practices
- Well Design
- Casing depths, materials, connections, cementation
- Drilling rigs, fluids

Thank You!

SOURCES

- Geothermal Drilling: A Review of Drilling Challenges with Mud Design and Lost Circulation Problem (stanford.edu)
- https://www.mdpi.com/1996-1073/11/10/2572
- https://youtu.be/I4IXeY7JyH0
- *(PDF) Environmental Impact of Geothermal Power Plants*. Available from: https://www.researchgate.net/publication/336375677_Environmental_Impact_of_Geothermal_Power_Plants [accessed Apr 12 2023].
- IEA Geothermal 2021 USA Report.pdf - Google Drive
- Handbook of Best Practices for Geothermal Drilling (energy.gov)
- D-3.3-GEOELEC-report-on-drilling.pdf
- Zhang, J., Yin, S. A three-dimensional solution of hydraulic fracture width for wellbore strengthening applications. *Pet. Sci.* **16**, 808–815 (2019). https://doi.org/10.1007/s12182-019-0317-7