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A MINE AS A SOURCE OF GEOTHERMAL ENERGY CASE STUDY FROM PYHÄSALMI, FINLAND

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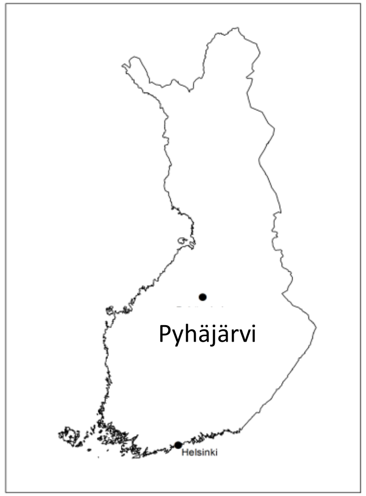
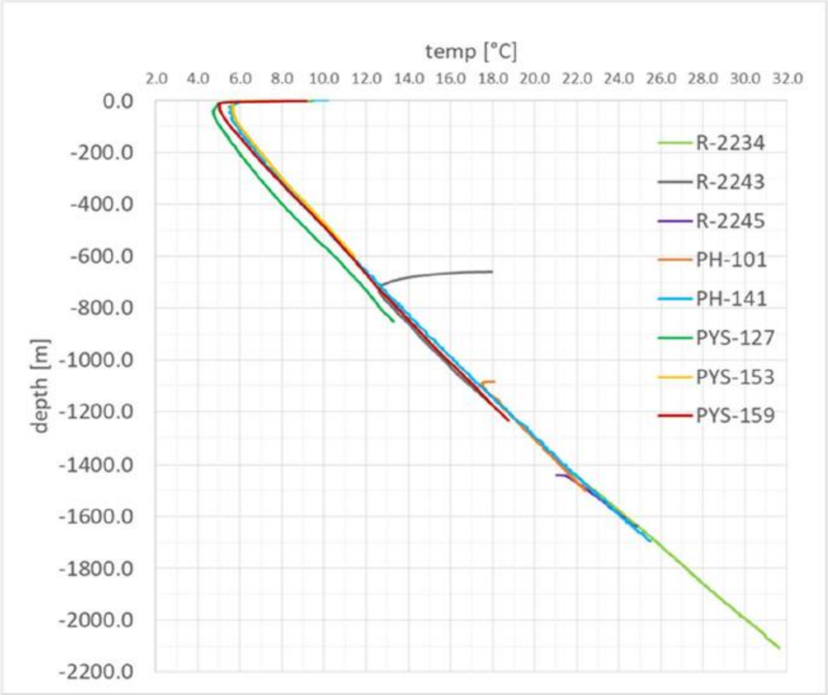
Pyhäsalmi Mine

PROJECT OVERVIEW

- Pyhäsalmi mine is a 1440 m deep Cu-Zn-S mine. It is located in Fennoscandian shield, with Precambrian crystalline rock, low thermal gradient and low surface temperature
- Pyhäjärvi is a municipality of 5100 people. Pyhäsalmi mine is the largest employer of the area, but it will be decommissioned in 2021
- In the project ”Energy Mine” we studied possibilities for geothermal energy utilization and heat storage in a borehole heat exchanger (BHE) field
- The mine is a unique, large underground space, so the aim is to make the best use of it without flooding the mine
- Other projects considered in the mine include neutron detecting facility (Laguna, decommissioned), pumped storage hydropower plant, fish and vegetable farming, drying food, and tourism, among others

Finland

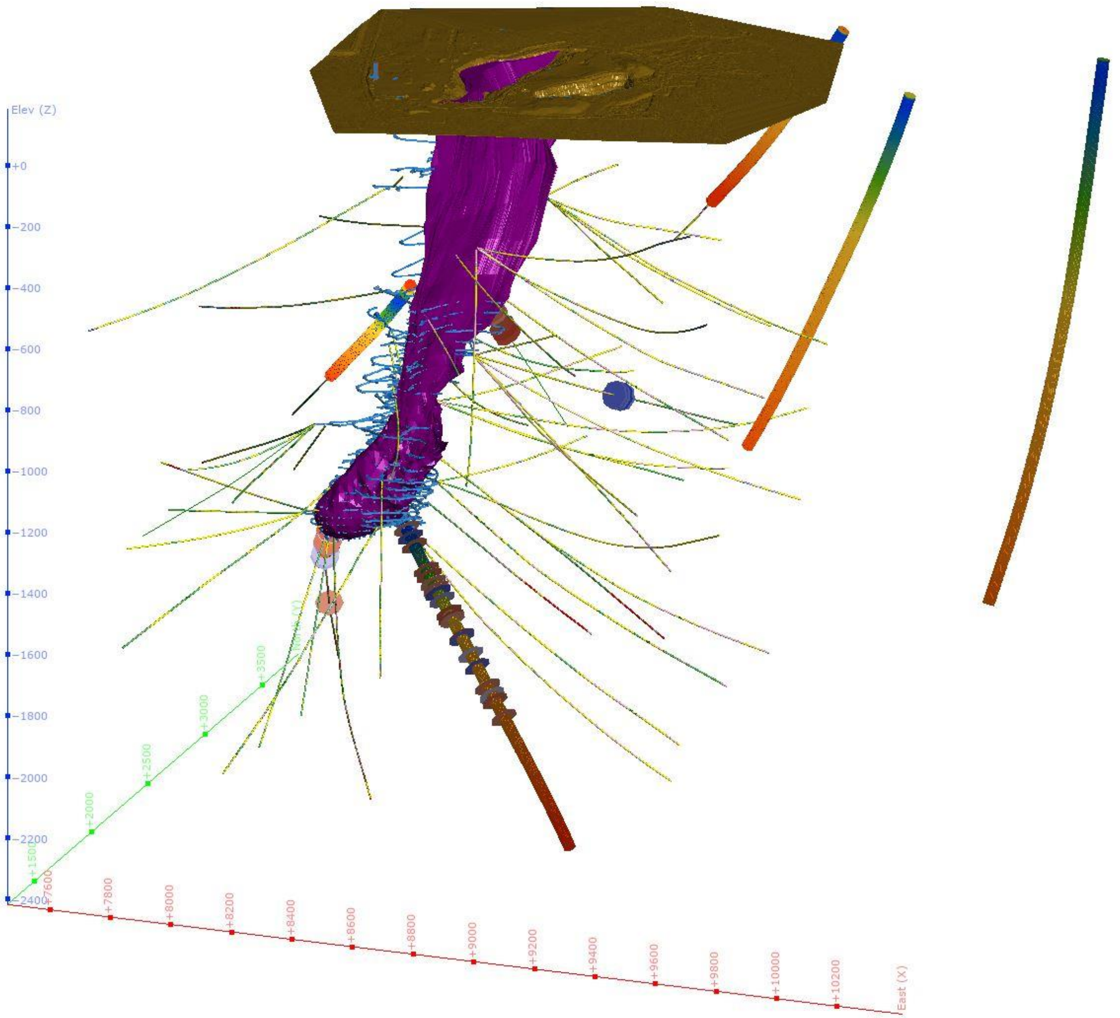




Near-surface annual average temperature is about 4 °C and geothermal gradient is 12-14 K/km. Temperature at the bottom of the mine is 20 - 25 °C

THERMOGEOLOGY: MEASUREMENTS AND 3D MODEL

- All drilling data and geological data is provided by Pyhäsalmi Mine
  - *The figure shows the ore body (purple), tunnels in the mine (blue lines) and drillholes*
- We created a 3D model for the Energy Mine Project:
  - *Selection of suitable Distributed Thermal Sensing (DTS) measurement locations and drillholes*
    - *4 boreholes from the surface and 4 from the mine (thick lines in the figure)*
  - *Selection of petrophysical thermal conductivity samples from specific drillholes*
    - *57 samples from 4 drillholes (marked with disks in the figure)*
  - *Descriptions and modelling of structural geology*
  - *Design of the location and dimensions of a BHE field*



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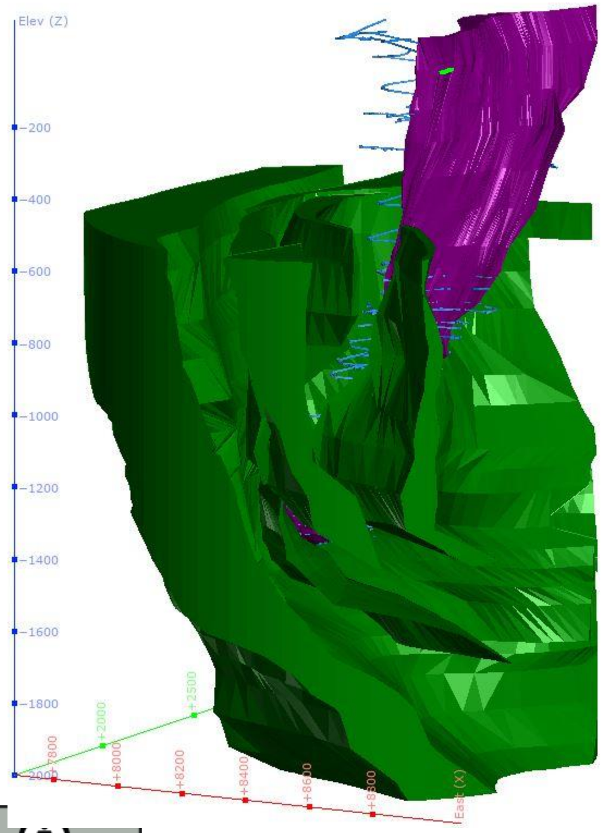
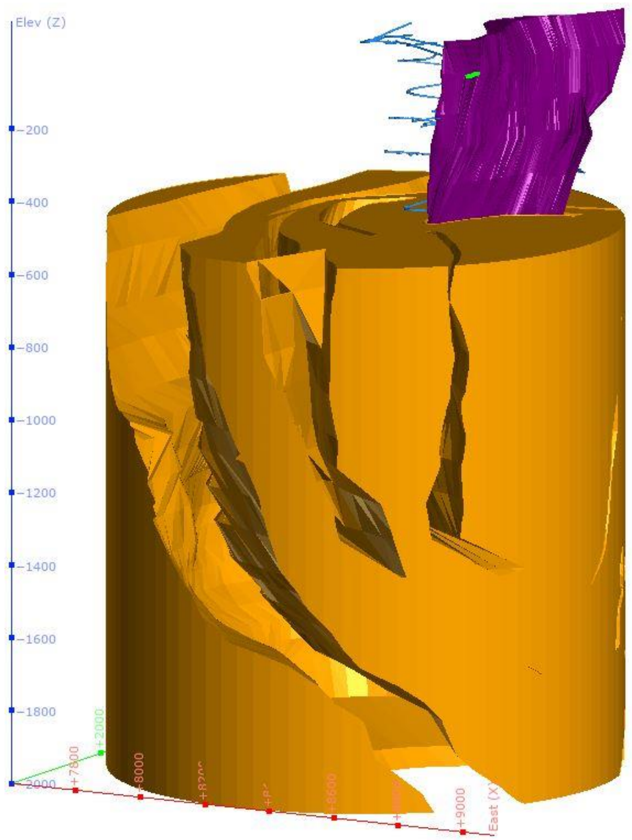
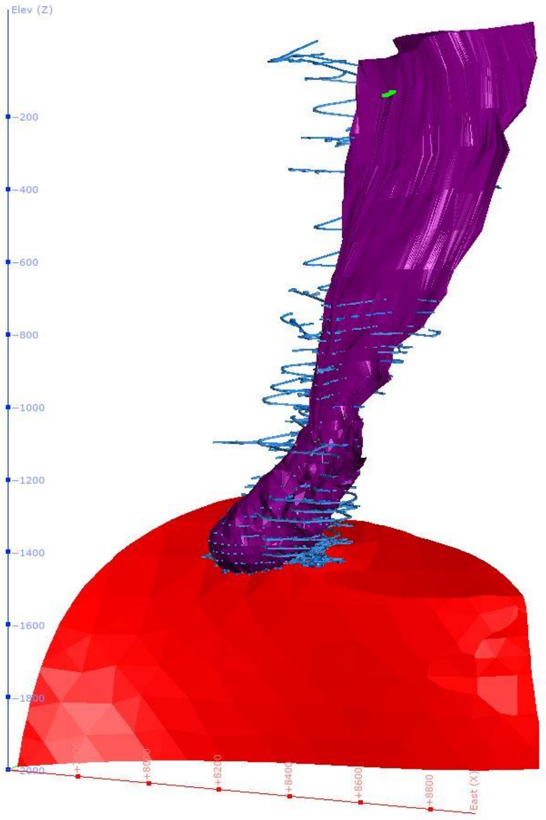
- Thermogeologically the Pyhäsalmi rocks can be broadly divided into three parts:
    - *Mafic volcanic rock; intermediate thermal conductivity; thermal anisotropy*
    - *Felsic volcanic rock; good thermal conductivity; thermal anisotropy*
    - *Porphyry granite, good thermal conductivity, thermal isotropy*

Generalized rock species		Density	Thermal conductivity	Specific heat capacity
	∑ samples	[kg/m³]	[W m^{-1} K^{-1}]	[J kg^{-1} K^{-1}]
Mafic volcanic	22	2975±76	2.27±0.16	682±22
Felsic volcanic	21	2708±46	3.40±0.44	681±24
Granitoid	14	2639±18	3.24±0.22	685±33
Summary	57	2794±156	2.92±0.61	682±25

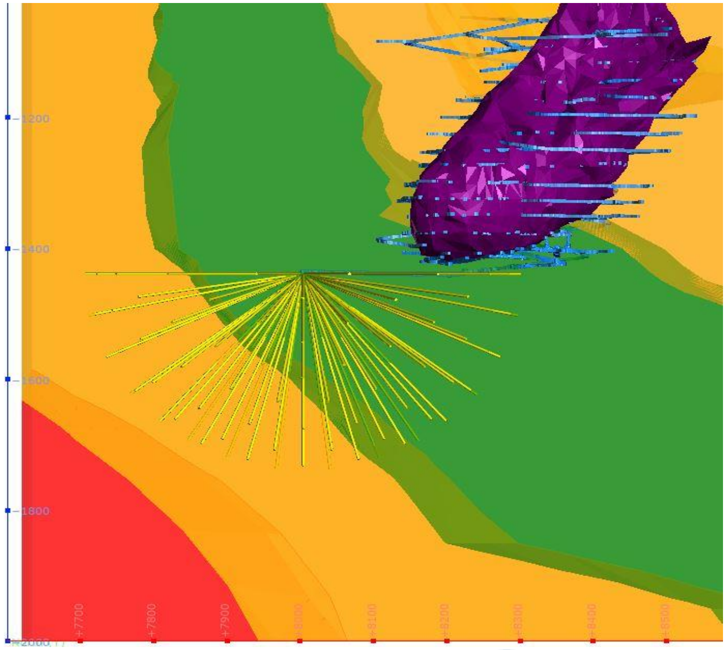






GEOTHERMAL HEAT PRODUCTION

- Borehole heat exchanger optimization was done to compare 300 m deep U-tube and coaxial BHEs. We also compared different insulation levels for the coaxial tube and flow direction in the coaxial BHE
- The results show that insulated coaxial collector has the best performance. Injection through annulus is 2.5% more effective than injection through central pipe
- See details in presentation: D923 | EGU2020-8696 Geothermal energy in Pyhäsalmi mine, Finland: performance evaluation of heat collector type



- The best performing BHE was placed to the underground borehole field. Hemispherical shape allows boreholes to be drilled to different directions from a small space
- The results show that a borehole field of 136 BHEs can sustain heat extraction of 1 MW for at least 44 years
- See details in presentation: D925 | EGU2020-9104 Hemispherical underground borehole heat exchanger field as a source of geothermal energy

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