A mine as a source of geothermal energy - case study from Pyhäsalmi, Finland

Kaiu Piipponen, Jaakko Hietava, Nina Leppäharju, Annu Martinkauppi, Kimmo Korhonen, and Lasse Ahonen

Geological Survey of Finland, Finland (kaiu.piipponen@gtk.fi)

Water pumped from flooded coal mines has been considered as a promising option to extract geothermal energy in many countries situating in sedimentary rock environment, where the ground temperatures are clearly higher than those of the crystalline rocks of the Fennoscandian Shield. Extraction of metals from the 1440 m deep Cu-Zn-S mine in Pyhäsalmi, Finland, will end in the near future. This provides us an optimal environment for studying how much heat energy can be utilized at depths of 500-2500 meters and which method would be the optimal for it. In the Pyhäsalmi Energy Mine project funded by European Regional Development Fund (ERDF) we investigated the geothermal energy potential of the crystalline rock, performance of different borehole heat exchangers and optimized the deep borehole field.

Geothermal potential of the Pyhäsalmi site has the typical constraints of the Finnish crystalline bedrock. Field measurements include temperature measurements of ten different boreholes using Distributed Temperature Sensing (DTS) method. Near-surface annual average temperature is about 4 °C and geothermal gradient is 12-14 K/km. The ore deposit is hosted by metavolcanic rocks (ca. 1.9 Ga). Laboratory measurements show that felsic metavolcanics prevailing in immediate contact with ore have thermal conductivity of 3 – 3.5 W/(m·K), whereas the mafic metavolcanics mainly on the western side of the ore body have thermal conductivity of 2.5 – 3 W/(m·K). Relatively high thermal conductivity of the low-porosity crystalline rock promotes heat extraction from the bedrock temperatures 20 – 25 °C prevailing in the bottom of the mine.

The generated and optimized design concept in this project is based on an underground borehole field and a novel insulated coaxial collector type transferring heat from the bedrock to the fluid circulation system. A technical challenge to be resolved is the heat transfer from the depths of the mine to the ground surface. The borehole field placed at the bottom of the mine can be dimensioned to produce nearly 20 °C water with several megawatts power, allowing annual heat production of up to 10 GWh at the temperature range of 70 – 90 °C by means of heat pumps. This allows the use of geothermal heat in district heating network, something not yet done anywhere in Finland. Moreover, the borehole field can be utilized both for heat extraction and charging, making it possible to use the borehole field as a heat storage in a distributed heating network.