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Utilization of a basaltic aquifer for cooling purposes in Harrat Al-Shaam, Jordan – a feasibility study

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Summer maximum temperatures in Jordan are increasing continuously, especially over the last few years. Because of this warming, the cooling of buildings is requiring a huge amount of energy. This increased energy demand has caused an enormous pressure on the supply of conventional energy resources such as oil and gas. Jordan has a limited amount of these resources so an alternative such as geothermal energy is needed. There is little experience in using geothermal energy in Jordan. For this reason, detailed investigations and evaluations concerning the possible use of geothermal energy are necessary.

Infrastructure cooling can be done in an environmentally friendly way by using shallow low temperature geothermal resources found in all parts of the world, including Jordan. Here, groundwater is used as a cooling storage media. One promising groundwater resource is the upper basaltic groundwater reservoir in the Amman Zarqa basin in north east Jordan. This aquifer is also close to the city Zarqa (prospective purchaser) and is considered as the main shallow aquifer within Harrat Al Shaam basaltic rocks.

Harrat Al Shaam basaltic rocks are located in the Jordanian part of the north Arabian volcanic province. This province extends to the territories of Saudi Arabia and Syria hereby covering an area of about 12,000 km2. Successive basaltic flows extruded over a thick limestone bed have formed this reservoir. The reservoir is underlain by a marlstone layer with a thickness of about 30 m and is characterized by numerous NW-SE trending faults. These faults are enhancing the hydraulic conductivity which is important for the reservoir productivity. With respect to geothermal use, this basaltic reservoir has excellent physical, mechanical and thermal properties. Therefore, this upper basaltic reservoir could be used as a shallow geothermal resource for cooling purposes. Both geothermal wells as well as borehole heat exchangers could be applied in this situation. To verify the suitability of this reservoir system a detailed investigation was started.

To estimate the hydraulic and thermal properties of the prospective geothermal reservoir, a large number of thermal conductivity, permeability and porosity measurements were performed on rock core samples. In addition to these property measurements, several water table measurements were also analyzed.

Based on the lithological and additional structural geologic data, a 3D GOCAD model was set up which included the fault structure of the area. The model covers about 400 km^2 and a ground thickness of around 300 m; this comprises a volume of 120.000 km^3. The 3D model is necessary to characterize the upper basalt reservoir in terms of its structural and stratigraphic settings. Subsequently, hydrogeological properties are assigned to the main units. Based on these geometric and physical properties a 3D heat transport model is set up using the Finite Element code FEFLOW. The purpose of this numerical model is to simulate the reservoir efficiency as a cooling storage. First results of the numerical modeling will be shown and discussed.