EGU22-2199, updated on 18 Aug 2022
https://doi.org/10.5194/egusphere-egu22-2199
EGU General Assembly 2022

CO_2 injection and storage for geothermal power generation in hydrothermal reservoirs along the Red Sea of Western Saudi Arabia

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As an alternative to water, CO_2 can be used for heat mining from geothermal reservoirs, while also trapping most of the injected CO_2 underground. In addition, supercritical CO_2 has higher mobility and heat capacity than water, rendering CO_2 capture, utilization and storage (CCUS) in geothermal reservoirs a very attractive option in a circular carbon economy. CCUS is also in line with Saudi Vision 2030, which includes the strategic framework to reduce Saudi Arabia's dependence on hydrocarbons and diversify its economy. The western coast of Saudi Arabia, where the young and high-heat-flow Red Sea rift basins are located, are considered suitable for geothermal heat extraction and CO_2 storage. In this study, we explore the potential of CCUS for geothermal power generation and CO_2 storage in the hydrothermal reservoirs of Al Wajh basin located on the Red Sea coast.

Geological studies in Al Wajh basin report that the hot fluid bearing, thick, porous, siliciclastic formations, such as Al Wajh (formation's top depth, TD= 3900 meters), Burqan (TD = 2880 m) and Jebel Kibrit (Umluj member with TD = 1930 m) are sealed by the overlying anhydrite (Kial) and salt formations (Mansiyah). We combine publicly available data with different resolution scales, such as satellite gravity, seismic sections and well-log information to build a 3D geologic model, which enables us to constrain the 3D gross rock volume and the Net-to-Gross ratio/distribution of the target hydrothermal reservoirs. A 3D temperature model shows that the average surface temperature in the region and the subsurface temperature gradient create formation fluid temperature of over 120^{o} C at 3 km depth.

We conduct reservoir simulation of coupled transport of formation fluid, injected non-condensable gas (CO_2) and heat in heterogeneous 3D reservoir model, using CMG STARS. We then estimate the geothermal energy extracting capacity and storage efficiency of CO_2 in the prospective hydrothermal reservoirs in the Al Wajh basin. Our study provides the first semi-realistic reservoir model and simulation study in Saudi Arabia for combined CO_2-based geothermal power generation and CO2 storage potential at a designated target site. The work-flow we propose is transferable to other suitable hydrothermal reservoirs in different locations in Saudi Arabia, thereby enabling CCUS technology implementation along the Red Sea.