Magnetotelluric Imaging of a Geothermal Reservoir in Al-Lith Area, Western Saudi Arabia

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Abstract

With its ambitious vision of 2030, Saudi Arabia has understood and initiated to reduce its dependence on fossil-based energy and diversify its economy. Renewable energy development, including geothermal resources, occupies a very advanced rank in the priorities. The main target is to increase the share of renewable energy in the total energy mix, targeting the generation of 9.5 GW (approximately 10%) by 2030. Based on a couple of studies, Saudi Arabia has considerable promising geothermal resources. The most prominent sites are located around Al-Lith in western Saudi Arabia with the occurrence of four hot springs. Ain Al-Harrah has the highest temperature of the four hot springs in the area. Previous studies suggest that this hot spring's geothermal reservoir is considered promising and may be used to provide the Al-Lith area with long-term electricity. Up to date, only a few geophysical measurements were conducted in this area to better understand the geothermal system. Over the past decades, magnetotellurics (MT) has become one of the most applied techniques for geothermal exploration. Our key objective is to investigate and explore more comprehensively the prospect of geothermal resources around the Ain Al-Harrah hot spring. To provide deep geophysical data for imaging the geothermal system, we carried out a MT survey in this area. Prior to the field survey, we optimized the experimental design by forward modeling studies and resolution analysis using the well-established ModEM algorithm. During our first survey, we acquired broadband MT data in the period range 0.001-300 s for three different sampling frequencies at 15 soundings along two main profiles using KMS-820 systems. The MT data processing is done using KMSpro software with robust statistics. We were able to acquire high quality data. Subsequently the data was interpreted using a smoothness constraint 2D inversion technique. The inversion results show three main units. A very low resistivity anomaly (20-50 Ωm) at depth more than 3.5 km below surface is probably related to a geothermal heat source. The high resistive formations (200-4000 Ωm) are associated with hard-rock geological formations. A medium resistive body (50-200 Ωm) is detected. Although uncertain, the latter possibly indicates the pathway of geothermal fluids forming a convection cell between the hot body and the surface. A lateral resistivity discontinuity detected between two soundings is considered as a fracture zone acting as a pathway for the fluids to reach the surface (hot spring). To gain deeper insight in the geothermal system, the next survey shall take place in 12/2022 to gather dense spatial data and provide a robust 3D subsurface image.