Curie Depth And Heat Flow Estimation Using Magnetic Data At A Hot Spring Area In Western Saudi Arabia


Abstract

Objective/Scope: Western Saudi Arabia is a promising area for geothermal energy exploration since it has many fields related to the ongoing evolution of the Red Sea Rift. Several hot springs indicate the presence of potential geothermal resources as the water reaches temperatures greater than 80 °C. The aim of the present study is to characterize the geothermal system of one of the hot springs in Western Saudi Arabia by analyzing ground and airborne magnetic data.

Methods, Procedures, Process: We conducted a profile of ground magnetic gradient data near the hot spring. We also used a dataset of aeromagnetic data over a wider area provided by the Saudi Geological Survey. Data enhancement filters and detailed 2D modeling were applied to the magnetic data to delineate structures of interest and map the distribution of volcanic rocks and tectonic lineaments. Spectral analysis was applied to the magnetic data to estimate the depth of the Curie isotherm, which was further used to constrain a 1D geothermal model and predict surface heat flow and bulk radiogenic heat production in the study area.

Results, Observations, Conclusions: Detailed magnetic modeling and lineament analysis indicated the pathways that geothermal fluids are using to ascent from the reservoir depth to the surface. Spectral analysis of aeromagnetic data indicated that the depth of the Curie temperature is about 16.5 km. The estimated depth was validated by the results of deep magnetotelluric sounding data, which showed an abrupt resistivity decrease at the same depth level. We calculated a constrained 1D geothermal model with three different layers (upper crust, lower crust, and mantle). The constraints included the depth of Curie isotherm and depth to the base of the lithosphere. Furthermore, radiogenic heat production, thermal conductivity, and the thickness of each layer were estimated from published information. The results of the 1D geothermal modeling indicate that the area is characterized by a geothermal gradient of 39.7 °C/km and a surface heat flow of about 100 mW/m².

Novel/Additive information: The results of this study can be used to quantify the potential of the geothermal field for energy production and develop a drilling program that will provide detailed information on the reservoir parameters and put the geothermal resources into production.