Integrated Surface-subsurface Analysis For High Permeability Zone Delineation In A Geothermal Field: A Case Study From The Western Arabian Plate (Al-Lith, Saudi Arabia)


Abstract

Objectives/Scope: This paper aims to present a novel study focusing on surface-subsurface structural lineaments, high permeable zones, and potential geothermal areas in a non-volcanic geothermal field located in western Arabia. The study specifically investigates the Al-Lith region, which spans approximately 2,897 km² along the western coast of Saudi Arabia. This area offers a unique opportunity for comprehensive research due to its location on a tectonic plate boundary, elevation of 620 m, and extensive wadi network draining into the Red Sea. With numerous hot springs, volcanoes, and hot spots along the coastal area, Wadi Al-Lith has emerged as a promising geothermal target for renewable energy development in Saudi Arabia. The primary objective is to conduct a detailed analysis of structural lineament density and its correlation with high geothermal potential areas.

Methods, Procedures, Process: The research adopts an integrated approach combining remote sensing, geological analysis, and geophysical investigations to map the surface and subsurface geological and structural features (structural lineaments) in the Al-Lith region. Surface lineament density analysis is conducted using digital elevation models and Landsat-8 imagery, supported by comprehensive fieldwork. In parallel, subsurface lineament density analysis is based on aeromagnetic data. By employing these techniques, the study subdivides the study area into zones and identifies high-density areas of structural lineaments both on the surface and subsurface.

Results, Observations, Conclusions: The surface lineament density analysis allowed the division of the study area into ten zones (Zones A-J), with the highest lineament density observed in the northern part of the study area (Zone A). On the other hand, the subsurface lineament density analysis identifies five high-density zones, three of which exhibit a strong correlation with the surface findings. Through this investigation, the main high-permeability zones and associated high potential geothermal areas in the Al-Lith geothermal field are determined. The findings contribute to a comprehensive understanding of the geological and structural characteristics of the area.

Novel/Additive Information: The present study generates a valuable database that can aid decision-makers in the exploration and development of targeted resources, particularly geothermal energy resources. The integrated approach of combining surface and subsurface analysis provides a comprehensive understanding of the structural lineament density and its relationship with high geothermal potential areas. This methodology can serve as a valuable framework for future geothermal exploration projects, not only in the Al-Lith region but also in similar non-volcanic geothermal fields. The research highlights the significance of geothermal energy as a viable renewable energy source in Saudi Arabia, particularly in areas with a high density of structural lineaments and geothermal manifestations along the coastal region.