

3-D Inversion of Magnetotelluric data from the Aluto-Langano Geothermal Field, Ethiopia

*Dejene Bekele¹, Yasuhiro FUJIMITSU²

1. Graduate School of Engineering, Department of Cooperative Resources Engineering, Kyushu University, 2. Faculty of Engineering, Department of Earth Resources Engineering, Kyushu University

The Main Ethiopian rift valley hosts a number of geothermal prospected area, which is known to be actively deforming with reoccurring periods of uplift and setting. One of the regions where the prospected area is confirmed by drilling is the Aluto-Langano geothermal area. Aluto area is situated in the Main Ethiopian rift valley system bounded by latitude 7.60°-7.96° N and longitude 38.68°-38.92° E. This field has been studied by the Geological Survey of Ethiopia (GSE) since 1980s, and these studies subsequently led to the drilling of 10 exploration wells. This field is currently developed with a Binary power plant of a 7.2 MWe installed capacity. From the results of various regional geoscientific studies in this part of the Ethiopian rift, the area of Aluto-Langano geothermal field was observed to have relatively higher exploitable geothermal potential in Ethiopia. However, more studies are required in order to obtain more information about the subsurface structure and heat source below the Aluto volcanic complex (AVC) and to delineate the parameters of the geothermal reservoir in the area. To address this, Electro Consultant (ELC) and GSE carried out magnetotelluric surveys in the Aluto-Langano geothermal field in 2009 and 2015 respectively. This study combines the two surveys done covering the whole Aluto volcanic complex with a total of 166 MT stations. The MT data was processed and used in the construction of a 3-D MT inversion model, which was then interpreted alongside the available geological information. The dimensionality analysis of MT data was carried out based on the strike and dimensions of the resistivity distribution around the MT sites, by plotting the Phase tensor for each MT site for the frequency range of 10^4 - 10^{-3} Hz. Most of the maps of phase tensor exhibit 3-D structures, hence need for 3-D inversion. In order to get 3-D conductivity models of the subsurface, the MT data were inverted in the period range of 10^{-3} - 10^4 s at uniform distributed discrete periods using the ModEM code. The resultant 3-D resistivity model shows a highly conductive zone with a diameter of around 10 km in the center of the Aluto volcanic complex at depths between 800–2500 m. The identified resistivity distribution corresponds very well to the conceptual reservoir model of a high-enthalpy geothermal system with its mushroom shaped zoning comprising a resistive up-flow zone overlain by a conductive clay cap. From well data analysis it is known that the conductive cap at Aluto is related to rock units and therefore, eliciting the origin of the heat source and delineating the subsurface structure in the study area. The 3-D resistivity model images the resistivity structure in the study area hence showing the origin of Aluto heat sources and delineating the location of faults and fracture system. In particular, the cap rock zones of the geothermal reservoir system by studying low resistivity zones at relatively shallow depths are important in selecting future drilling targets.

Keywords: Aluto-Langano, 3-D Inversion, Magnetotelluric, Ethiopia