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Determiningthe Geothermal Activity of the Menemen Plain (Izmir, Turkey) Through Geophysical Methods

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Abstract:*Western Anatolia is a regionunderdivergenttectonics, with Horst-Graben structures. Amongthestructures, the Gediz Graben is Turkey'smostgeothermallyactiveregion. Thegeologicaldetermination of thereservoirs has criticalimportanceforthegeophysicaldetermination of geothermalactivity. Afterthedetermination of thepossiblereservoir, thegeothermalactivity of theregion can be determinedthroughphysicalparametersusingseveralgeophysicalmethods (gravity-magneticmeasurements, verticalelectricsounding, self potential, electrictomography, CSAMT, etc). Thisstudyconcerns a geothermalprospectionthatwasconducted in a 300-km2 area. Thedatawerecollectedfrom 100 pointsusingverticalelectricsounding (VES). Theevaluation of thedatasuggestedhighresistivity. Subsequently, thespecificresistance of theexposedsurfaceswasmeasured. Thisvaluewasusedto form a three-dimensional model of thestudyfield.*

Keywords:*Geothermal Activity, Exploration, VES*

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I. Introduction

Geothermalenergy is a moreeconomical, cleanandsustainableenergy form comparedtothefossilfuels. It isespeciallyimportant as it does not cause a greenhouseeffectand it has extensiveapplicationpossibilities: agriculture, heating, electricityproductionandtouristicpurposesaredifferentareasthat can utilizegeothermalenergy. Turkey is a part of theAlpine-Himalayanorogeny; thus, it has a highgeothermalpotential.

The literature indicatesthatTurkey has theseventhlargestgeothermalpotential. Of thecurrentcapacity, 820 MWt is usedfordirectconsumption (493MWt for urban heating, 327 MWtforbalneologicalpurposes), and 20.4 MWt is usedforelectricityproduction. Thegeothermalsitesproduce 120.000 tons of carbondioxidegases[1].

A verticalelectricsoundingdatumwasobtainedfromthefield (Figure 1). Thesoundingwas intheSchlumbergerarrayconfiguration (AB/2 1000 m). Thedataandthe model wereusedtoproduceinformationregardingthegeothermalactivity.

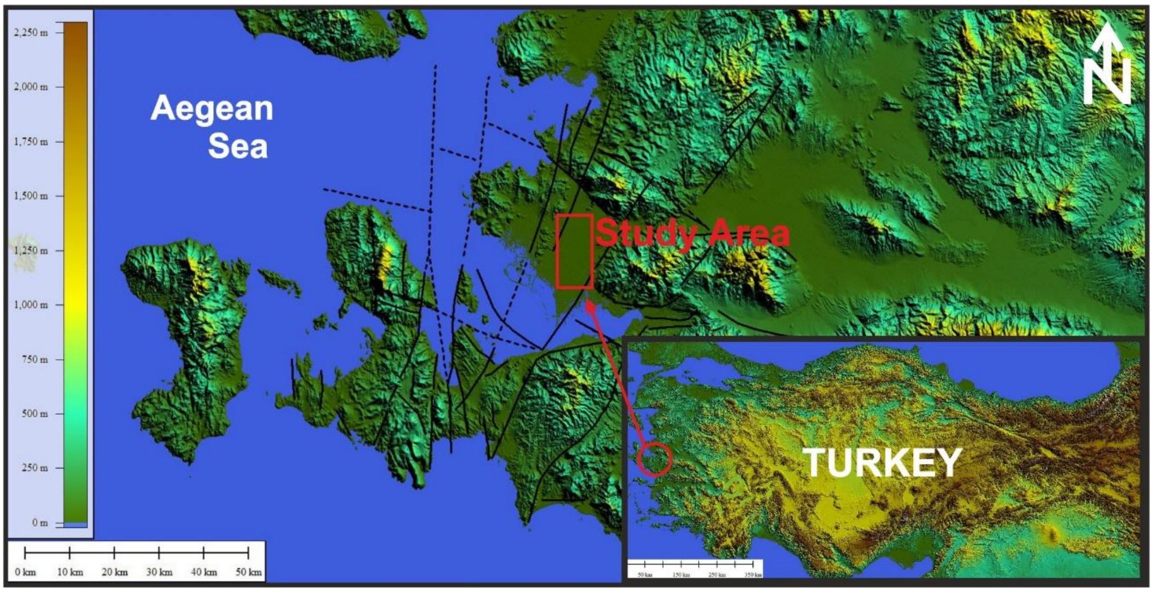

Figure 1. StudyArea

II. Geology of Study Areaand Its Surrounding

Izmir and the surrounding regions are based on the upper cretaceous Bornova mélange [5]. The limestone mega-olistoliths – which are older than the matrix of the mélange – are arbitrarily distributed in the matrix. These limestones are known as the Isiklar limestones in the Altindag region [6]. The Bornova mélange (complex) is made up of grit/shale intercalation, with platform-type limestone and diabase blocked and pebble stone channel fills [2]. The Neogene lacustrine deposits are placed on the Bornova Mélange with angular unconformity. The Yamanlar volcanites non-conformingly cover all the units that are present in the quaternary alluvium field [4]. Even if they develop on the same land fillings, the alluvial plains around the Izmir Gulf have geomorphological differences. In the shores of the inner gulf; there are the Balcova (south), Alsancak (south) and Karsiyaka (north) deltas, which have developed in the mouths of mountain rivers. On the other hand, the Gediz Delta is shaped by the alluvia of the Gediz River coming from a large part of Western Anatolia; thus, it is a large and complex geomorphologic formation [3].

Since the mid-Miocene age, the entire region has been under the effects of neotectonics. This has caused deformations in all units and geological areas under the strains of all kinds and sizes. Subsequently, the graben-horst structures of Western Anatolia have formed.

III. Geophysical Methods

The vertical electric sounding was used in 100 points for the determination of the geothermal activity of the field (Figure 2).

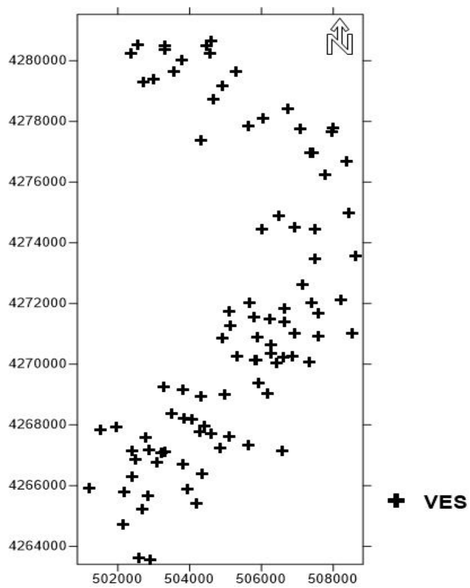

Figure 2. Location of VES Measurements

3.1. VerticalElectricalSounding (VES)

Vertical Electric Sounding (VES) is a applied geophysical method. It aims to use the electrical measurements of the surface to determine the depth and the specific resistance values of the underground layers. For this purpose, an electric field is applied on the surface on two points to measure their potential differences. The electrodes are named as “current electrode” and “tension electrode”. The distance between current electrodes can be increased to help the current reach deeper. This provides information regarding the deeper layers (specific resistance, features, etc.).The spacing between the current electrodes (AB) was arranged according to the depth of the geological foundation and the levels that were desired to be investigated. The maximum investigation depth was 1000m.

The resistivity applications were conducted as follows: firstly, the potential effects of the natural electric field were balanced; then, the potential differences in the artificially created electric field were measured. This process was repeated in every location for every measurement level. The derived and measured parameters were used to calculate the specific resistance values of the layers using the Formulas 3.1 and 3.2. Here; ΔV is the measured potential difference, K is the array factor, I is the current (mA), $\rho(a)$ is the specific resistance (ohm m).

$$\rho(a) = K\ \Delta V/I \quad (3.1)$$

$$K = \Pi\ (AB2 - MN2)/4MN \quad (3.2)$$

The calculated specific resistance values were recorded in log-log form, subsequently, the VES curves of the formations and layers were obtained. These curves were evaluated using the Schlumberger Two Layer Curves, curve superposition, and computer software. The values that were obtained from the two methods were compared to obtain the optimum result.

Three units were distinguished: alluvium, Neogene layers, and the resistive foundation. The specific resistances were measured from every exposed surface. These values are demonstrated below.

Alluvial Unit	:	20-30 ohm m.
Neogene	:	Andesite: 30-40 ohm m.
		Aglomera-tüf: 8-5 ohm m.
		Aliağa clayey limestone: 7-10 ohm m.
		Zeytindağ formation: 10-40 ohm m.
		Yeniköy formation: 20-60 ohm m.
Bedrock	:	Flysch: 60-600 ohm m.

The visible specific resistance level maps and the bottom topography of the Bornova Complex (determined as the resistive base) were mapped in three dimensions (Figure 3).

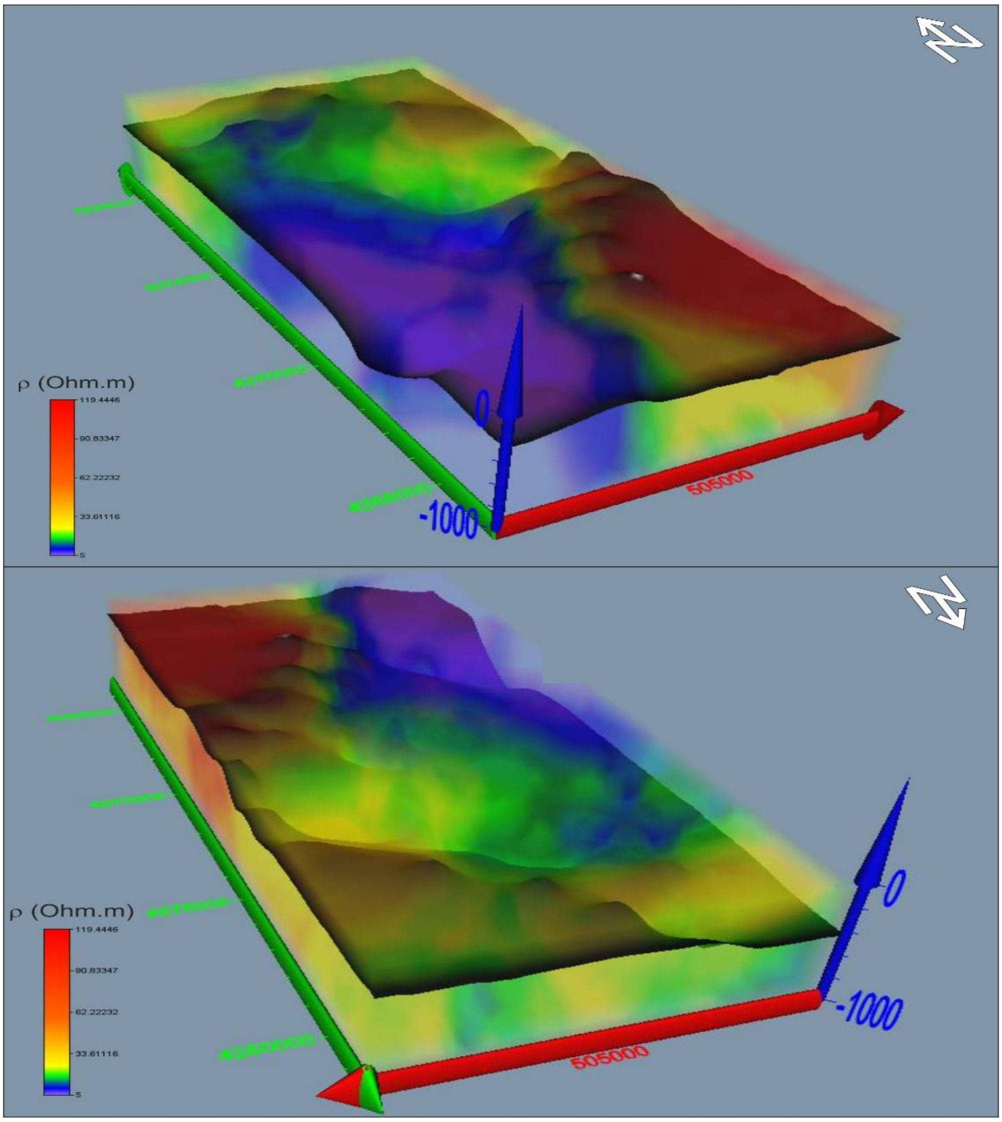

Figure 3. 3D Resistiviy Map and Bornova Melange's Isosurface

IV. Conclusion

The specific resistance level maps (obtained from VES) indicated that the field was mostly homogenous, isotropic and semi-infinite. The physical properties of the ground abruptly changed in the horizontal direction. The 3D topographic distribution revealed a distribution between 0 to 750 m. This range is sufficient to provide information regarding the importance of the effects of the water current and the general tectonic structure of the field. The porosity, permeability and saturation levels of the layers suggest that abrupt changes are probable. For the further understanding of the geothermal activity; the field should be further studied using different methods [VES, Controlled Source Audio Magnetotellurics (CSAMT), self-potential (SP)].

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