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Tectonics and thermal structure in the Gulf of Iskenderun (southern Turkey) from the aeromagnetic, borehole and seismic data

Funda Bilim[a], Attila Aydemir[b,*], Abdullah Ates[c]

[a] Cumhuriyet University, Engineering Faculty, Geophysical Eng. Department, Sivas, Turkey
[b] Turkiye Petrolleri A.O., Sogutozu Mahallesi 2180 Cadde No: 10, 06530, Cankaya, Ankara, Turkey
[c] Ankara University, Engineering Faculty, Geophysical Eng. Department, Golbasi, Ankara, Turkey

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ABSTRACT

The Gulf of Iskenderun is one of the largest gulfs in the Eastern Mediterranean Sea. Particularly, it is the easternmost and third largest gulf in the southern Anatolian shoreline of Turkey. It contains the Miocene Iskenderun Basin surrounded by the Misis-Andirin uplift to the west, Hatay-Kizildag ophiolites and Dead Sea Fault to the east. There are two large magnetic anomalies within the basin. The largest one extends in the NE-SW direction, almost parallel to the shoreline of the gulf, and the smaller one is located in the far offshore having a relatively circular shape. In this study, relationship between the ophiolites, basalts (and other basement units) and the magnetic anomalies are investigated by constructing 2D models after the depth estimation from the spectral analysis. Additionally, thermal structure of the gulf and vicinity is also investigated by calculating the Curie Point Depth (CPD) and by constructing the geothermal gradient and heat flow maps from the magnetic anomaly data. CPDs are in the range of 8–13 km where the shallow CPDs are represented by closed contours of 8 km around the town of Karatas and deeper ones (13 km) are located to the NE of Yumurtalik, close to the NE edge of shoreline. Another area indicating deep CPDs (13 km) is located between Adana and Kozan towns. However, the area from Kozan through the northeast is a large, shallow CPD region. Trends in the gradient and heat flow maps are also consistent with previous heat flow map in literature obtained from the hot springs and borehole temperatures. Only the large magnetic anomaly in the inner part of the gulf is modeled in this study, because it is completely located in the gulf. There are seismic lines crossing this anomaly and there is a wellbore that penetrated causative body. The borehole and seismic data were used to correlate the models and spectral analysis results, and a reasonable consistency was observed. The Birten-1 well was drilled on the eastern flank of the causative body creating this prominent anomaly. Ophiolites and the main causative body (basalt and peridotite alternation) were encountered at 1306 m and 1454 m, respectively in the wellbore. These units are found at 1260 m and 1640 m in the 2D model of the profile P-Isk-A. Similarly, they are observed at 1248 m and 1596 m in the 2D model of the profile P-Isk-B. Top depths of the main body in 2D models (809 m in the P-Isk-A and 857 m in the P-Isk-B) are also consistent with the depth from the power spectrum (890 m).

1. Introduction

The Gulf of Iskenderun is located on the northeastern corner of the Eastern Mediterranean and it is the third largest gulf in southern Turkey. The region around the gulf is seismically active because the southwestern segments of the East Anatolian (EAFZ) and Dead Sea Fault Zones (DSFZ) are crossing each other around the Maras Triple Junction (MTJ) to the north of this region (Fig. 1). MTJ is accepted as a triple-junction between the Anatolides, Arabian Plate and Africa (Arpat and Saroglu, 1972; Rotstein, 1984; Perincek and Cemen, 1990). As a result of this complex tectonic framework, the onshore surface geology contains the ophiolites, volcanic units and intrusives (as the basement units) together with the Tertiary-Quaternary sedimentary assemblage of the Iskenderun Basin (Fig. 2). Aksu et al. (2005a,b) defined the Iskenderun Basin as a limited depressional area developed between the Taurides and Hatay-Kizildag ophiolites in Miocene. Rojay et al. (2001) investigated the Neotectonic framework and volcano-characteristics of the Karasu (Amanos) Fault Zone in the Hatay province to the east of the gulf. They defined this area as a transition zone between the DSFZ and EAF Albora et al. (2005) stated that the EAFZ has an extension in the Gulf of Iskenderun by using steerable filters on the aeromagnetic data. These tectonic zones and basement units are represented by evident

* Corresponding author.
E-mail addresses: aydemir@tp.gov.tr, attila.aydemir@gmail.com (A. Aydemir).

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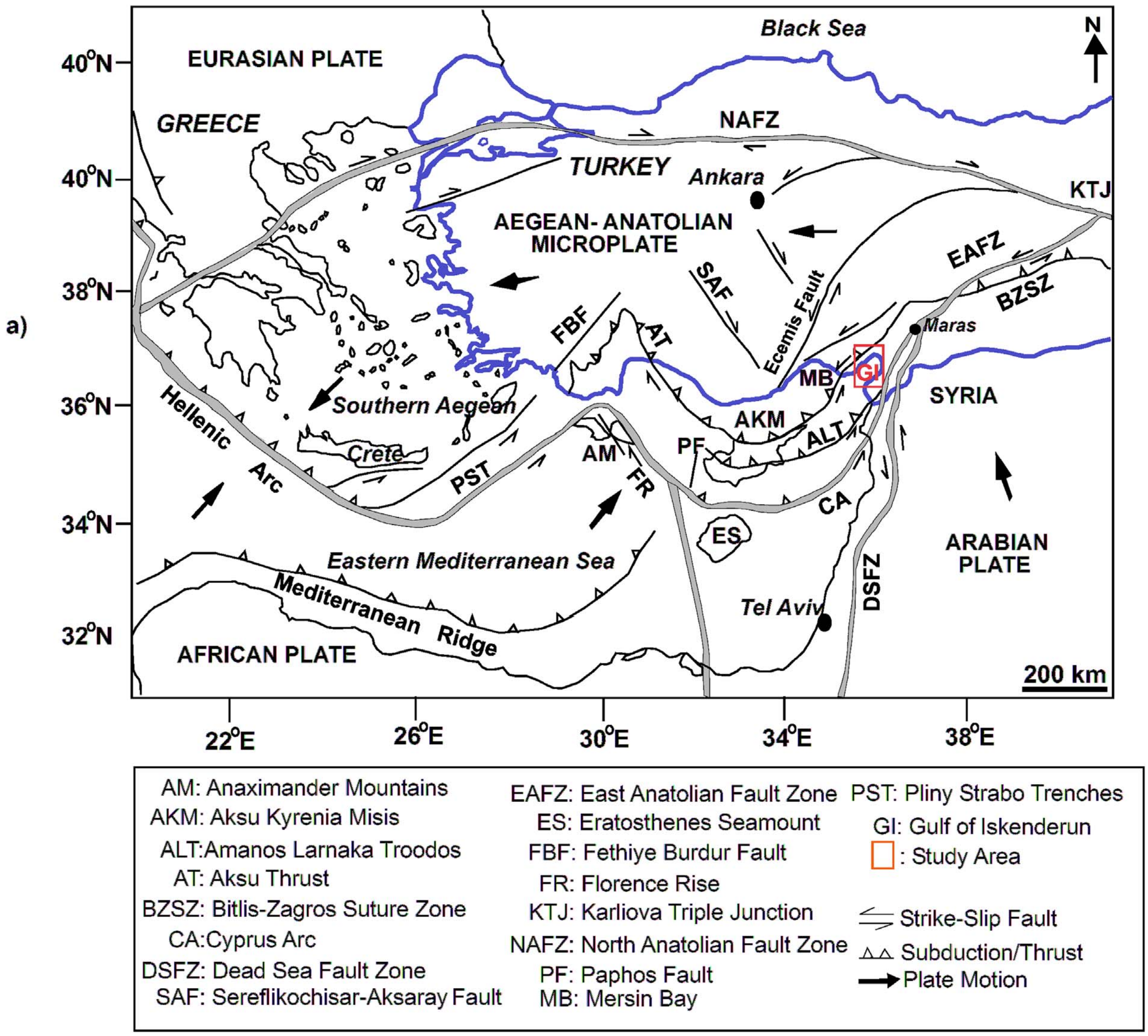

Fig. 1. Geodynamic framework of the eastern Mediterranean and surrounding region. The Gulf of Iskenderun and study area is illustrated within the vertical rectangle in red colour (modified from Aksu et al., 2005a). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

potential field anomalies.

In general, there are several distinctive gravity and magnetic anomalies in the Eastern Mediterranean that originated from mafic-ultramafic rocks, volcanic rocks and basement uplifts (Ben-Avraham et al., 1976; Woodside, 1977). Robertson and Woodcock (1980) suggested that the intensive positive magnetic anomalies in the north-eastern part of the Mediterranean Sea are originated from the ophiolitic zone in the Cyprean arc extending from the Antalya complex in Turkey to the Baer-Bassit Massif in Syria. It is composed of Late Cretaceous ophiolites originated and emplaced by the southern Tethys Ocean onto the Arabian continental margin (Al-Riyami et al., 2002). It is more practical to investigate onshore anomalies and causative bodies due to ease of data acquisition and availability of outcrops to construct a relationship between each other. There are numerous studies on the onshore anomalies in literature (i.e.; Barazangi et al., 1993 for the Syrian anomalies, Ates et al., 1999 for the anomalies in Turkey). Recently, Alp et al. (2011) determined the borders of different lithologies in the Hatay region in Turkey by using wavelet analysis applied onto the gravity anomalies. However, there are only regional studies for the offshore areas in the Mediterranean region (ie; Makris and Stobbe, 1984; Seber et al., 2001; Tirel et al., 2004; Ergun et al., 2005; Cowie and Kusznir, 2012; Bilim et al., 2016). The number of investigations focused on specific anomalies offshore is quite limited, particularly in the Turkish territorial waters.

The main objectives of this study are to assess the interactions between the surrounding surface geology and magnetic anomalies in the gulf, in order to determine possible sources of the anomalies and to make an approximation for the origin of the causative bodies. Thermal structure of the gulf and surrounding area was also investigated in this study with estimation of CPDs, geothermal gradient and heat flow values from the magnetic anomalies. Results were compared with the previous heat flow map in the literature based on onshore wells and hot springs. Two-dimensional (2D) models were constructed for the causative body of the evident magnetic anomaly in the Gulf of Iskenderun. Geometries and depths in 2D models were correlated with the available borehole and seismic data. According to the correlation results, a good consistency was obtained within the reasonable and acceptable limits. Offshore well, Birten-1 penetrated the basement units and causative intrusives in the gulf is a check point for these correlations. A thick and shallow basalt-peridotite alternation was found as the main causative body for the magnetic anomaly. CPDs are quite deep in this part of the gulf indicating that these are old emplacements and may not have any contribution to the geothermal potential of the region and to the hydrocarbon maturation originated from the Neogene source rocks in the Iskenderun Basin.