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Structure of the crust beneath Qamar Basin, Eastern Yemen based on gravity and magnetic modeling

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Abstract

Gravity and magnetic surveys were conducted in an area about 5000 km² covering offshore region of the Qamar basin in the eastern part of Yemen. An attempt is made to address the gravity and magnetic signatures in term of structural features. In addition, seismic section (NIM-QAM-92-201) compiled by Nimir services limited, 1992 were used to illustrate subsurface structures in sedimentary sequences. Combined gravity and magnetic modeling along section QAM-92-201 by Geomodel 2.5D inversion technique suggest the thickness of sediment to vary from 3.2 to 5.3 km in the Qamar basin (offshore), and the basement rocks are divided into blocks because of existence of several faults extending from basement rocks to sedimentary rocks owing to strong tectonic activities. So the study area may be divided into several major blocks along the Qamar Gulf. It can be concluded that the sedimentary processes were affected by basement tectonics as revealed by the seismic section.

Introduction

Yemen is located on the southwestern part of the Arabian plate and is known, like any other Middle East countries, for Mesozoic tectonics and sedimentary basin evolution. Tectonic evolution is related to Late Jurassic-Early Cretaceous break-up of Gondwana and the inception of basin is linked to rejuvenation of NW-SE and E-W oriented fracture during Gondwana breakup. The emergence of Jiza-Qamar basin in the Qamar Gulf opening to Aden Gulf is attributed to rift (Beydoun *et al.,* 1998). The basin is an elongated E-W extending basin located in the eastern Yemen. It is principally a Cretaceous basin but continued well into the Tertiary in its eastern sector (Bott *et al.,* 1992; Beydoun *et al.,* 1996; Redfern and Jones, 1995; Ellis *et al.,* 1996; Jungwirth and As-Saruri, 1990). The study area lies in the offshore region of the Qamar basin. The area tectonically highly disturbed owing the rift and faults have been noticed (Naji *et al.,* 2009 communicated). In this paper we present the structural features of the crust in parts of offshore Qamar basin by gravity and magnetic modeling.

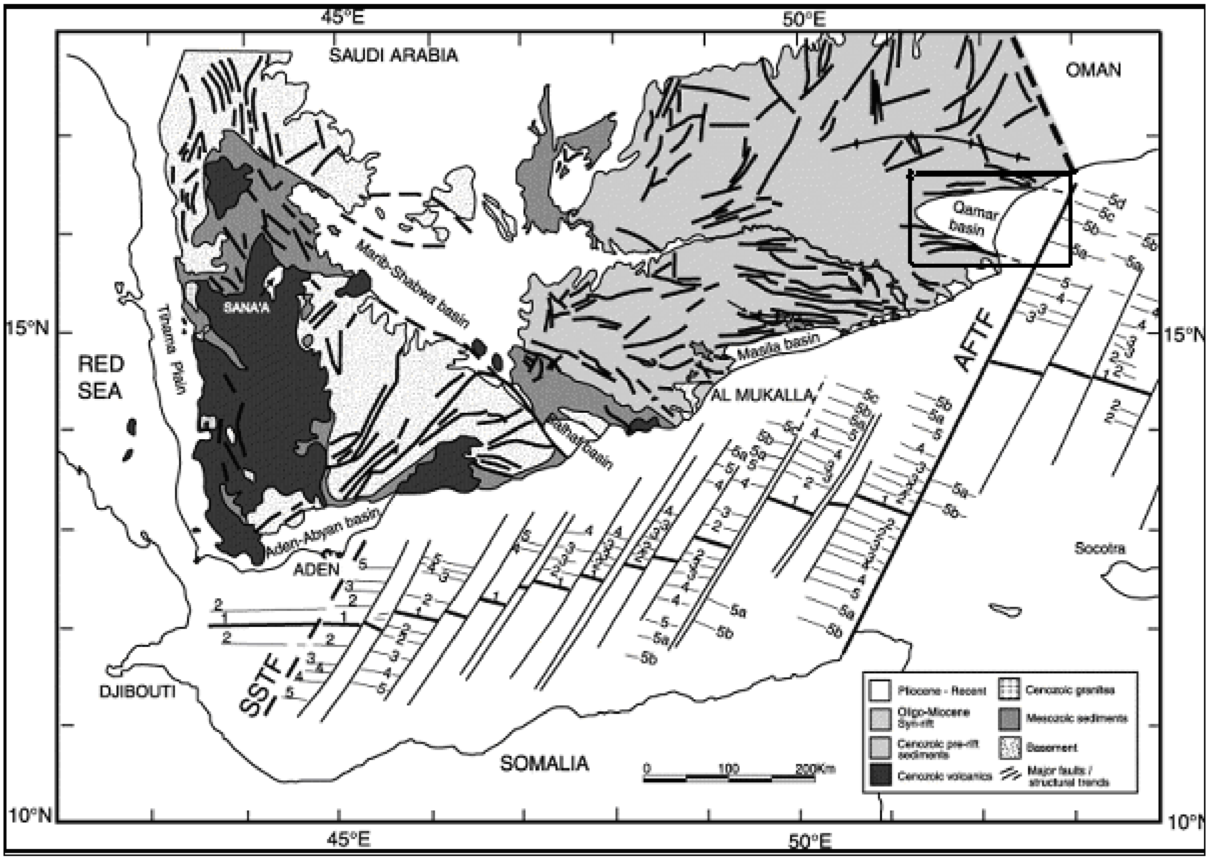


Fig. 1: Simplified geological map of the Republic of Yemen, on northern margin of the Gulf of Aden, and magnetic anomalies from Audin (1999), Cochran (1981) and Sahota (1990). Thick line: oceanic ridge axis. SSTF: Sukra El-Sheikh transform fault. AFTF: Alula–Fartak transform fault. Showing Qamar basin

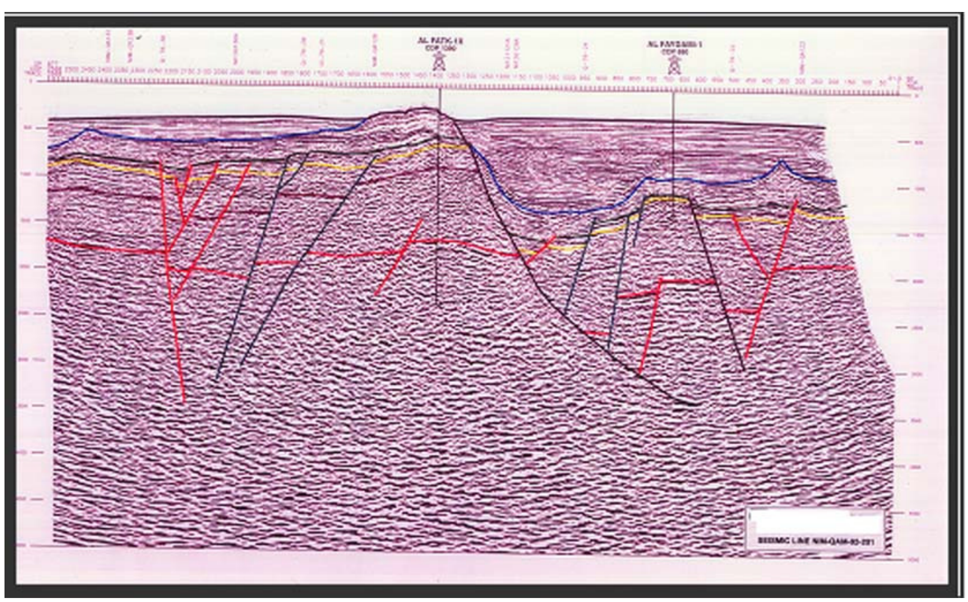


Fig. 2: Seismic Section NIM-QAM-92-201

Structure and tectonics of study area

Development of structural features in the Qamar basin and associated igneous activity are related to the history of Pan-African land. Tectonic stresses associated with Gondwana break up and the separation of India/Madgascar from Afro-Arabia, rejuvenated movement along the old NW-SE Najid fracture system of Arabic during late Jurassic time, initiating a series of rift basins across Yemen and breaking up the pre-rift early upper Jurassic carbonate platform into alternating basins and intervening uplifts (Beydoun et al., 1998). Episodic subsidence of the basin has given rise to structural differentiation into subbasins, half grabens and intra-basinal horsts. This differentiation was probably principally related to intermittent horizontal motion along sectors of rift boundary master faults or along intrabasinal faults (Beydoun et al., 1996). The understanding of the structure of the crust in the Qamar basin is very poor and the structures along the basin are presumed to be due to rift. In this paper, we present subsurface structures of the Qamar basin using the existing gravity and magnetic data.

Bouguer anomaly and total intensity magnetic anomaly maps

An area of about 5000 km² lying between lat 15º 35´N to 16º 25´N and long 52º 00´E to 52º 45´E as shown in Fig. 1 was covered by marine gravity and marine magnetic surveys by Nimir Services Limited in 1992 and from the data compiled by the present authors, the following observations can readily be made from the study of Bouguer anomaly map (Fig. 3). There are several gravity lows in this map. Gravity low is noticed between wells Al-Faydami and Al-Fatk towards N-S, and existence of gravity low extend from west to east of the map through out 16/E well. Total intensity magnetic anomaly map (Fig. 4) studies also supports the Bouguer anomaly map observations.

The reason of occurrence of gravity and magnetic lows are due to existence of several faults and can be seen clearly in the seismic section in the study area. The faulted blocks are of grabens and horsts type. These structures extend from the basement rocks upward into the sedimentary sequences.

Application of 2.5D GeoModel

Computation of the magnetic and gravity effects for 2.5D models with complex geometry was carried out using the 2.5D Geomodeling computer program. GeoModel was written by G.R.J.Cooper, (2004) for the arbitrary 2.5 dimension polygon. GeoModel uses a Talwani type algorithm to calculate the anomaly. Susceptibilities are measured in c.g.s. units and the anomaly is measured in nT. Densities are in gm/c.c and anomalies are measured in mGals. Distances may be measured in Km or m. As well as forward modeling, GeoModel allows the use of inversion, wherein mathematical techniques are used to modify the shape (and other attributes) of the model to improve the fit of the calculated curves to the observed data.

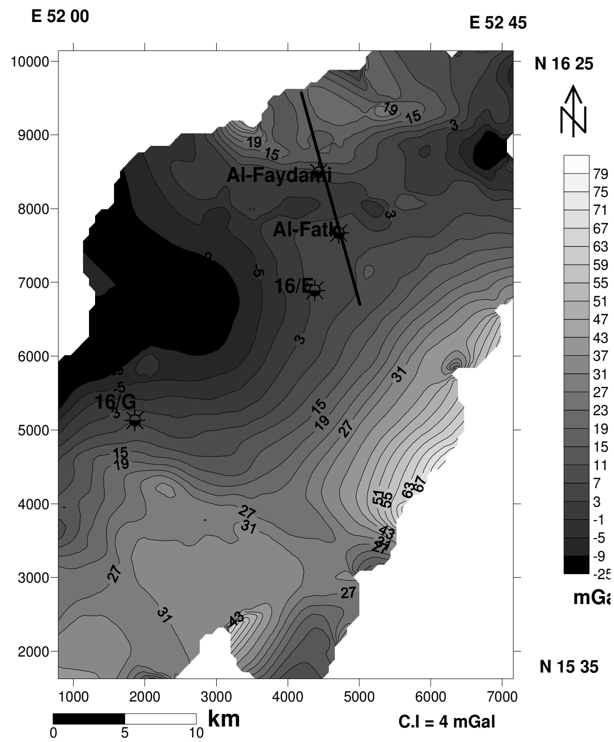


Fig. 3: Bouguer anomaly map (density 2.20 g/c.c.) with seismic line NIM-QAM-92-201 of the study area (after Nimir, 1992)

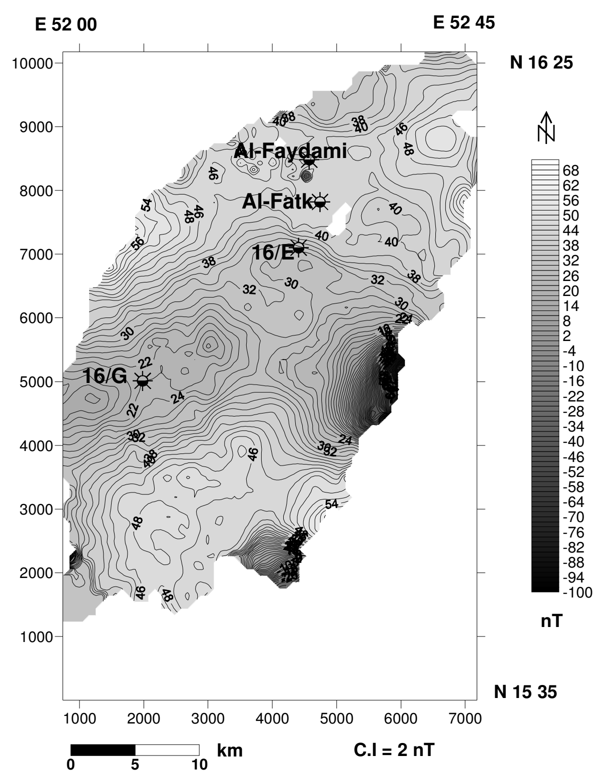


Fig. 4: Total magnetic map of the study area (after Nimir, 1992)

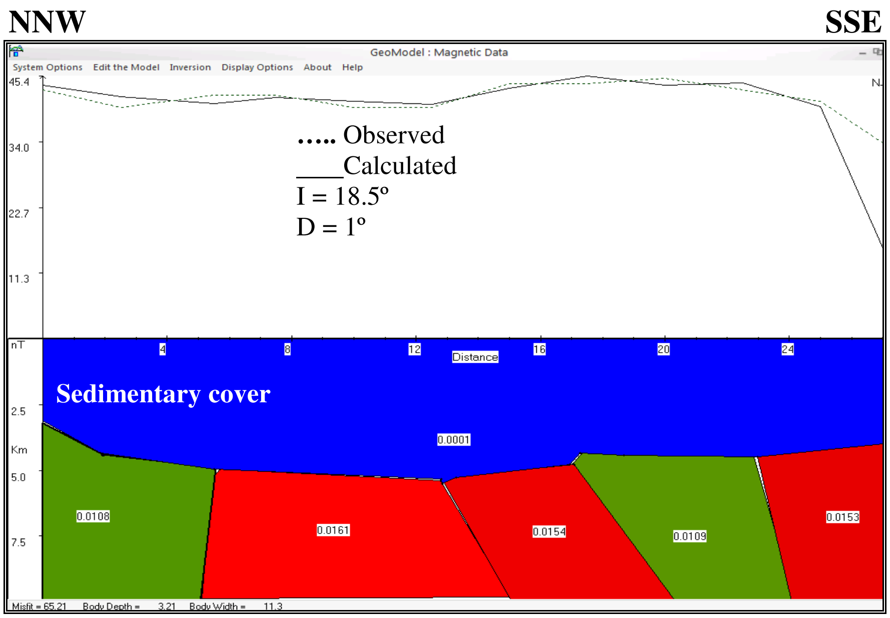
Magnetic and gravity modeling of section QAM-92-201

Fig. 5 shows the potential modeling along the seismic line NIM-QAM-92-201passing through wells Al-Faydami and Al-Fatk in NNW-SSE direction. Its length is about 32 km. This model consist of two layers: First Rock Unit comprises the sedimentary layers, its minimal thickness is about 3.2 km in the N section, and its maximal thickness is about 5.3 km in the center model. The quantity of magnetic susceptibility contrast is -0.0001 cgs, and the density contrast is -0.0005 gm/c.c. Second Rock Unit represents basement rocks (Pre-Cambrian), which comprise igneous rocks and metamorphic rocks (Beydoun and Greenwood, 1968). These rocks are divided into blocks because of the existence of several faults extending from basement rocks to sedimentary rocks resulting from the tectonic activity of opening of the Red Sea and the Gulf of Aden. These blocks have different depths, and the maximum depth for basement rocks is about 5.3 km in the center model, and the minimum depth is about 3.2 km in the N of the section. These differences in the depths of the basement rocks attributed to faults, resulting in the formation of graben and horst structures in the sedimentary rocks.

Conclusions

The potential maps (gravity and magnetic) have several lows due to the existence of several faults which formed grabens and horsts faults in the sedimentary rocks. The 2.5D technique prints out a complete view for the geometry of the basement surface encountering at different depths and the basement rocks are divided into blocks. These results indicate that the structures of the area may be related to the Red Sea and Aden Gulf tectonics. These structures extend from the basement rocks upward into the sedimentary sequences and divide the area into several major faulted blocks that have great important is sealing the oil traps. This work is considered a guide line for further exploration process and geophysical work.

(A)



(B)

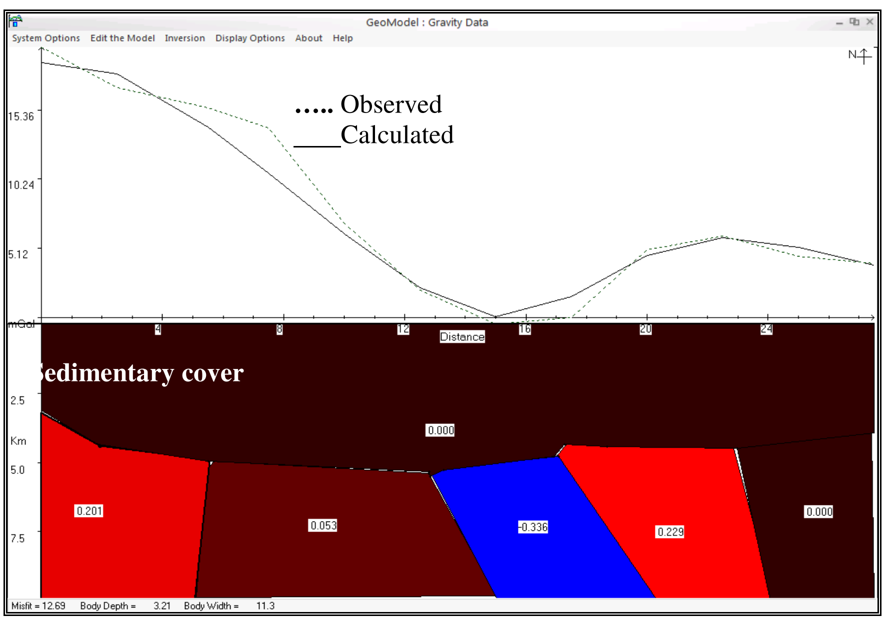


Fig. 5: Potential Modeling Section (NNW-SSE) QAM-92-201
(A) Magnetic Modeling (B) Gravity Modeling

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