Petroleum Res. J. Vol. 11 (1999); P. 13-17, 4 Figs.

Interpretation of Gravity Data in the Murzuq Basin, SW Libya

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تفسير معلومات الجاذبية في حوض مرزق بجنوب غرب ليبيا

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الخريطة البوجيرية المستنبطة من معلومات الجاذبية المتوفرة عن حوض مرزق تبين وجود بروز في اتجاه الشمال الشمال الغربي – الشمال والشمال الشرقي. الجهة الشمالية الشرقية والشمالية من حواف حوض مرزق لها درجة ميلان شديدة، أما في منتصف الحوض فإن قيمة الشاذة السالبة التي مداها 50 مليجال مرتبطة أساساً بالجزء الأكثر عمقاً بالحوض. توضح معلومات الجاذبية أن الصخور القاعيّة ضحلة في الجزء الشمالي والشمالي الغربي من الحوض حيث لوحظ أن هناك إزدياد للقيم نحو الشمال، أما الحافة الغربية للحوض فقد لوحظ أن لها ميلان شديد وقد يعزى هذا الميلان إلى كثافة المعلومات المغطى. تم تطبيق طريقة المشتقة الأفقية على المعلومات البوجيرية للجاذبية لتحديد التراكيب الجيولوجية وتبين الخريطة المستنبطة من المشتقة الأفقية وجود قيم عالية لدرجة الميلان في الاتجاه الشمال الشرقي – الجنوب الغربي والتي بدروها تحدد حواف الحوض في الجهة الشرقية أما الاتجاه الشرقي – الشمال الشرقي والغربي – الجنوب الغربي في الجهة الشمالية من الحوض فله علاقة بالصدوع السطحية والتحت سطحية الموجودة بالمنطقة.

Abstract: *A Bouguer gravity map of Murzuq Basin, produced from the compilation of available data, shows prominent NNW and NNE trends. The northeastern and northern flanks of the Murzuq Basin are marked by steep gradients. In the central part, a negative anomaly of amplitude ca. 50 mGal is associated with the deepest part of the basin. The gravity data suggest the basement is shallower in the north and northwest since the values increase northwards. The western flank is marked by a steep gradient that may be related to data coverage. Horizontal derivative method was applied to the Bouguer gravity data to delineate subsurface structures. The total horizontal derivative map shows high gradient values with NE-SW trends which mark the boundary of the basin in the east. The ENE-WSW anomaly trends in the north may be related to fault structures on the surface and subsurface.*

INTRODUCTION

The Murzuq Basin covers an area of about 250,000 km^2. Even though exploration activity in Libya started more than 40 years ago, little is known about this basin because all the activity was concentrated in the Sirt and Ghadamis basins which are the main petroleum producing basins of Libya.

This study involves the analysis of gravity data from the Murzuq Basin and surrounding area. The gravity data were collected from different sources,

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i.e. Africa Gravity Project (AGP), Petroleum Research Centre (PRC), and Geodetic Survey Department of Libya (SDL). In total 17269 gravity values were assembled of which 1706 were taken from SDL, 5133 from PRC, and 10430 from AGP (Fairhead *et al.*, 1988).

The main purpose of this study is to compile all available gravity data in order to: a) better understand the tectonic evolution of the Murzuq Basin and b) to define more accurately and in more detail the border/regional interpretations of this area.

GEOLOGICAL SETTING

Several authors have studied the tectonic history of the Murzuq Basin (Fig. 1). Unpublished works mainly concerned the geology of the Palaeozoic outcrops of the western and eastern flanks of the basin (Amoseas, 1958, Echikh and Suleiman,1984). Studies conducted by the Industry Research Centre were within the geological survey of Libya (Banerjee,1980).

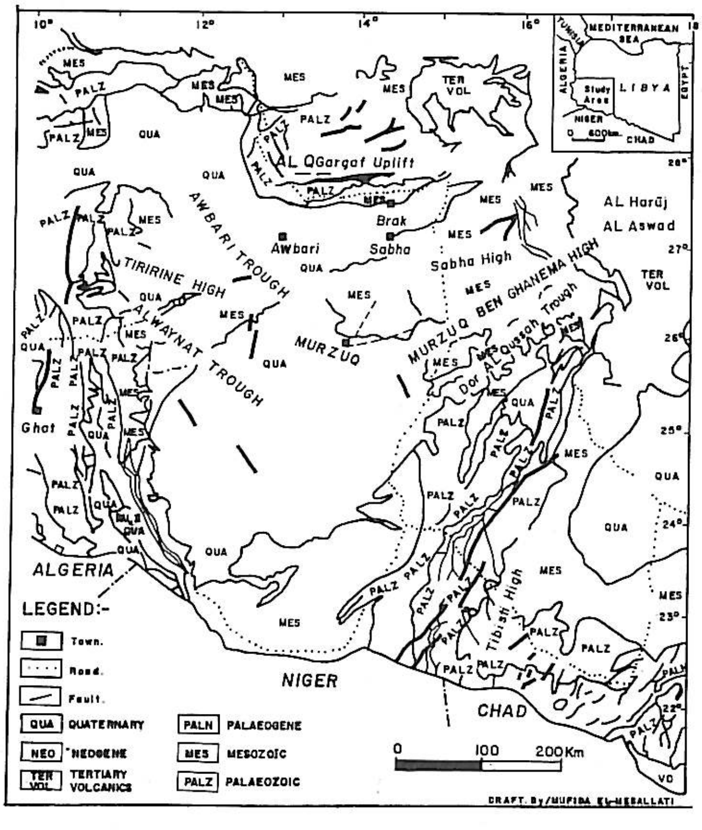

Fig. 1. Geologic sketch map of the Murzuq Basin.

The Murzuq Basin was subjected to three major periods of structural development (Klitzsch, 1969). The first stage started in Precambrian time with folding and consolidation. The second stage began in Cambrian time with the formation of northwest to north-northwest striking horsts which later, in Silurian and Devonian time, became the core of uplifts separated by troughs (Adamson *et al.*, 1998). The structural relief of early Palaeozoic time was the result of a northeast- southwest tension (Echikh and Sola,1998). The third stage was initiated during late Mesozoic time by the formation of the northeast trending uplifts and troughs (Glover, *et al.*, 1998). During Jurassic time or within the Jurassic-Cretaceous transgression, block faulting occurred along the edge of some uplifts.

Triangular shaped depression of the Murzuq Basin is bounded on the west and south by the Precambrian Hoggar and Tibisti massifs. On the north it is bounded by the Qargaf uplift, which separates it from the Ghadamis Basin and on the east by the Tibisti-Al Haruj uplift.

GRAVITY DATA

The first compilation of the Bouguer gravity maps of Libya was prepared by Essed (1978), using data obtained from Shell Libya Oil Company, Libyan-American Oil Company, and Mobil Oil Company.

Thirty percent of the Murzuq Basin is covered by gravity surveys whose data are generally available only as simple Bouguer gravity anomaly maps. These maps have been prepared by petroleum companies alone in the 1950's, in their search for hydrocarbon accumulations. Most of the surveys were tied to the Potsdam base station at Tripoli airport, which has a value of 979538.80 mGals. The reduction of the gravity data to simple Bouguer anomaly maps for most of the surveys was carried out using the International Gravity Formula 1930 (IGF-30) and a reduction density of mostly 2200 kg/m^3. The Petroleum Research Centre digitized Bouguer anomaly maps to produce a gravity map of Libya. In 1985 the Geodetic Survey Department of Libya created a gravity network tied to the International Gravity Standardisation Network 1971 (IGSN 71). In

1988, the University of Leeds Industrial Services produced a gravity map of all Africa (AGP). All these values (Fig. 2) were recalculated using the Moritz (1984) gravity formula and 2670 kg/m^3 density to produce a Bouguer gravity map of the Murzuq Basin.

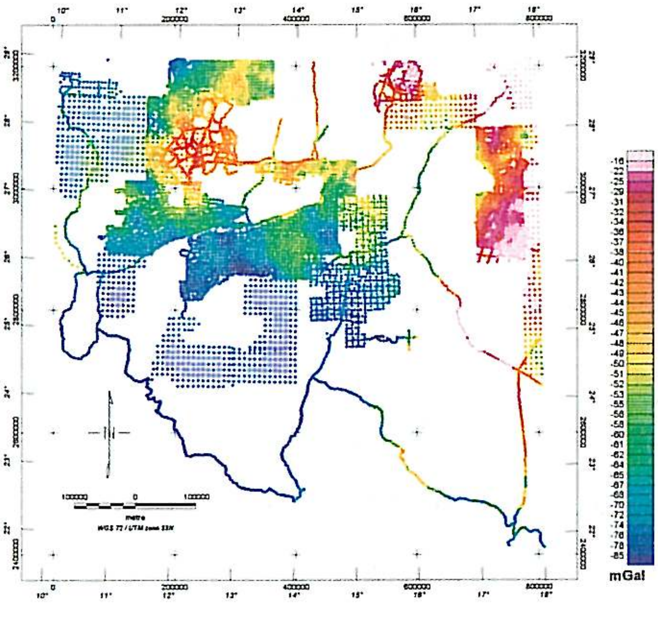

Fig. 2. Showing gravity station distribution in the Murzuq Basin.

Adjustment to a Common Datum and Reduction Densities

All gravity data from SDL and PRC have been tied to the Geodetic Reference System 1980 (GRS 80), using the formula below (Moritz, 1984):

$$g_{th} = 9.780327(1+0.0053024 \sin\theta - 0.0000058 \sin 2\theta) \text{ m s}^{-2}$$

where g_{th} is the theoretical gravity in m s^{-2} (1 mGal $=10^{-5}$m s^{-2}) and θ is the latitude (in degrees) of the gravity station. The Bouguer gravity values were computed using a reduction density of 2670 kg/m^3. Most of gravity data have been converted from the gravity formula 1967 to the gravity formula 1980, using the formula below (Moritz, 1984):

$$g_{80}-g_{67} = (0.8316+0.0782\sin^2\theta - 0.0007 \sin^4\theta) \text{ mGal}$$

where θ is the latitude (in degrees) of the gravity station and g_{80} gravity formula in 1980 and g_{67} gravity formula in 1967.

Projection, Gridding and Contouring

The software used for data manipulation and presentation in this study was the Geosoft PC program. This includes projection, gridding, contouring and plotting. The data were available with latitude and longitude locations. For mapping purposes, the UTM zone33° N Projection was chosen because the longitude range straddled more than one UTM zone. The actual gridder used was Geosoft's RANGRID, which begins with a coarse grid interval and successively refines it, using a minimum curvature criterion. It shows detail where it is existed without making pointlessly large grid files with strange "scars" along traverse lines. The chosen grid interval of 5 km honoured most detail in the point data without introducing gridding artefacts.

Bouguer Gravity Map

The Bouguer gravity anomaly map of Murzuq Basin and surrounding areas (Fig. 3) shows that the gravity values are generally between -18 and -110 mGal. It shows two main positive trends of relative negative values. The first, is the northern part of the area with ENE trending gravity anomaly traversed by N-S trends. The second positive anomaly zone is in the eastern part of the study area where a generally NNE trend is superimposed

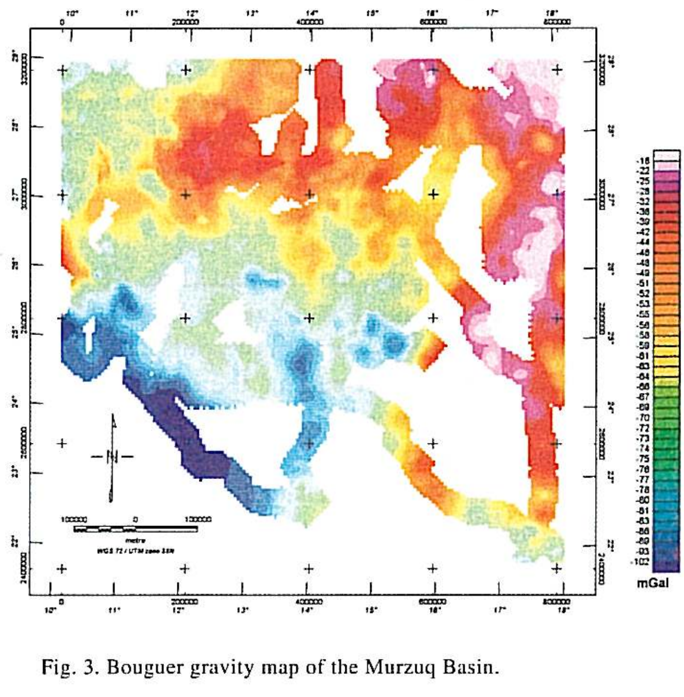

Fig. 3. Bouguer gravity map of the Murzuq Basin.

by smaller N-S oriented anomalies. These positive anomaly zones have strong gradients in the direction of Murzuq Basin, usually between the values -59 to -32 mGal. A negative anomaly covers the central and western part of the area, usually with gentle gradients between the values -66 to -102 mGal. Two extensions of this negative zone extend northward in the western part of study area with NE-SW orientations indicates the presence of another basin north of the Murzuq Basin.

FILTERING TECHNIQUES

In order to delineate lithological boundaries and faults, a horizontal gradient technique was employed in the study area.

Horizontal Derivative

The horizontal gradient method has been used for many years to locate density or susceptibility boundaries from gravity data (Cordell, 1979) or magnetic (as pseudogravity) data (Cordell and Grauch, 1982). These authors discussed a technique to estimate the location of abrupt lateral changes in magnetization or mass density of upper crust rocks. The method is normally applied to gridded data rather than profiles. Maximum magnitudes of horizontal gravity gradient normally occur above geological boundaries such as faults or steeply dipping lithological boundaries. However, in the Murzuq Basin, lithological boundaries within the sedimentary strata are subhorizontal, therefore, horizontal gradient anomalies are related to basin structures. Areas of steep lateral gradients have higher scalar amplitude values of horizontal gravity gradient (Blakely and Simpson, 1986).

The horizontal gravity gradient (Fig. 4) map shows that the northern and eastern parts of the basin are traversed by strong horizontal gradient anomalies. The central part of the basin can be divided into two parts (Fig. 4, area A1, A2): the eastern part (area A1) shows many short anomalies of NNE-SSW orientation; and the southwestern part (area A2) is relatively quiet.

A strong E-NE trending anomaly (Fig. 4, area B) cuts across the northern Murzuq Basin and seems to be the only continuous strong trend of

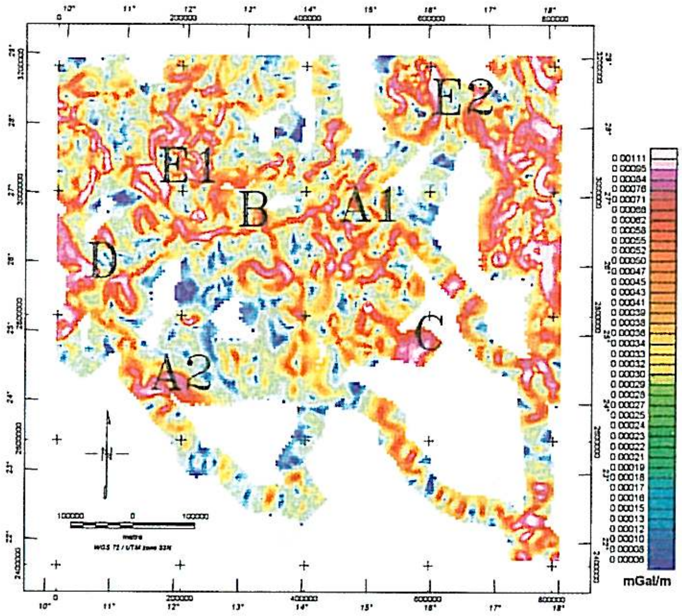

Fig. 4. Total horizontal derivative of gravity from the Murzuq Basin.

that direction. NE-SW (area C) -and NW-SE- (area D) trending anomalies are observed in the map area. North-south trends seem to be predominant in the northern part (areas E1, E2).

CONCLUSIONS

Two main conclusions may be added to the scientific knowledge concerning the geology of the Murzuq Basin and surrounding area as produced from the results of the present research study. The boundary of the Murzuq Basin is better defined than before.

(1) The interpretation of the limited Bouguer gravity data with geological information from the Murzuq Basin has confirmed some geological concepts and brought to light new ideas in previous related geological information. However, the gravity data, in general, shows northeast-southwest trends in the eastern part of the area (Fig. 3) that are occasionally bounded by steep gradients which could indicate faulting. The high anomalies (-18 to -30 mGal) in the northeastern part of the study area are associated with shallow basement. In the northern part of the area, Bouguer anomalies range from -45 to -55 mGal, and are N-S oriented blocks extending across the Qargaf

uplift that may represent horst and graben structures. Negative anomalies ranging from -75 to -90 mGal values of north-northwest-south-southeast trend generally corresponding to the basin margin (Fig. 3). In the central and southern part of the study area, gravity values less than -85 mGal are associated with significant thickness of sedimentary cover (Fig. 3).

(2) Horizontal gradient results have been overlaid with geological information of the Murzuq Basin showing high gradient values trending NE-SW. NW-SE trends mark the boundary of the basin in the eastern and western part of study area (Fig. 4). New faults are ENE-WSW anomaly trends in the north part of the Murzuq Basin. In the northwest part of the study area, N-S oriented anomalies are probably fault blocks traversing the Qargaf uplift.

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