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Mapping of Crustal Thickness, Moho depth, and lithosphere Thinning for Libya derived from integration Satellite Gravity data with geological and geophysical data

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ABSTRACT The aim of this paper is to present how geological information can be extracted from satellite imagery, and to show how this information can be merged with geological and geophysical data to build up consistent geological model for surface and subsurface. The moho depth, crustal thickness and geothermal of Libya are determined based on using of satellite gravity. The using data are currently available via Internet. It should be noted that, some software like Surfer 9.0 are used in this paper, but the main program is written in Fortran. Satellite imagery is a large scale surface geological mapping technique, which offers the unique opportunity to investigate the geological characteristic of the earth surface for specific areas to compute a precise and high resolution model from space, Satellite gravity is gravity field measurements that is available recently in the last decade. Without any need to accesses the area on the ground, it also improves our understanding of the overall earth tectonic history.
key words: geological information , from satellite imagery.

وضع خريطة لكل من سمك القشرة ، وعمق موهو بالإضافة الى معامل الشد للغلاف الصلب لليبيا من خلال بيانات الأقمار الاصطناعية

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الملخص الهدف من هذه الورقة البحثية ، هو توضيح إمكانية استخلاص المعلومات الجيوفيزيائية من صور الأقمار الاصطناعية، بالإضافة الى إمكانية دمج تلك البيانات مع البيانات الجيولوجية والجيوفيزيائية لتكوين نموذج جيولوجي لكلا سطح وتحت السطح الارض. تم تحديد، عمق كل من موهو – القشرة بالإضافة الى مفهوم الجاذبية الحرارية لليبيا من خلال الأقمار الاصطناعية (خصوصا تلك المتخصصة في بيانات الجاذبية) ، مستعمل في ذلك البيانات المتوفرة حاليا من خلال الشبكة العنكبوتية. تجدر الإشارة الى أن بعض البرامج استخدمت في ذلك) لغة البرمجة – FORTRAN برنامج SURFER الإصدار 9 .(إن تقنية الحصول على بيانات الأقمار الاصطناعية المتوفرة حاليا وبشكل كبير ومتاح، أوجدت فرصة لاستكشاف الخواص الجيولوجية لسطح وتحت سطح الارض، لأي منطقة محددة وبدقة عالية. دون الحاجة الى الذهاب الى تلك المنطقة المستهدف لدراستها . علاوة الى أنها أكدت مفهومنا لمجمل الحركات التكتونية للأرض.
الكلمات المفتاحية: المعلومات الجيولوجية ، من صور الأقمار الصناعية.

INTRODUCTION:

Geological Setting

Libyan territory is situated in north part of Africa continental on the Mediterranean coast, its adjacent area and the concrete is between $(10^0 - 25^0)$ of east longitude and $(20^0 - 34^0)$ of north latitude, it has an area of some $(1.8\times10^6 km^2)$ almost has $(1.8\times10^3 km)$ a shoreline along the Southern margin of Mediterranean Sea. Except for the northernmost parts, the country lies entirely within the Sahara. Difficulties of travel and survival have long caused the country to remain unmapped, and geological information has been acquired slowly [1].

Structurally Libya is part of the Mediterranean foreland formed by the both North African shield, and has a sedimentary section that has been subjected to transgressions and regressions since the early Paleozoic. The result is a mix of sheets of non-marine sediments (*shale* & *sandstone*) the other shallow marine carbonates that have been deposited all over platforms formed in local cratonic basins. The collision of the African and European plates caused a $(N-S)$ directed Compressional stress field in the northern portion of the African continent [2]. The main tectonic events that shaped the structure of Libya are a Compressional early Paleozoic Pan-African event, the Hercynian, and extension related to Cretaceous, middle Tertiary and Holocene events. The structure of southern Libya was influenced by the Pan-African event, whereas the central part of Libya was much affected by the Hercynian tectonic events. On the other hand the structures of north Libya are attributed to the Tethyan extension and Alpine tectonic movements [3]. The opening of the Mediterranean began in Early Jurassic with $(E-W)$ axis direction, but by the

Early Cretaceous the Mediterranean sea floor spreading had ceased entirely.

Material and Method

The major objectives of the present paper is, Generation of gravity anomaly image over Libyan territory and its coast using gravity data furnished by NOAA(National Oceanic and Atmospheric Administration) via Internet, which are being used as an alternative to the samples of data over land. has been to obtain and preprocessed to generate the free-air gravity data over land and then superimposed over the altimetric gravity over its coast. New gravity maps derived from satellite to estimate the crust thickness, Moho depth and thinning factor.

Preparing gravity data

Geophysical data are the main source of information about the subsurface. They represent a critical stage in exploration processes for mineral, underground water, mainly oil and gas exploration. Further they are the main source for information about the composition of the deep interior of the earth (lithosphere, mantle composition, structure and dynamics).
When studying the shape of the earth surface in the connection with the rock layers and their deformation by tectonic forces, we often notice a correlation between shapes and structures at the surface and in the subsurface [4]. This open opportunity to map the characteristics of the surface and infer characteristics of the subsurface. The surface shape depends on topography, and surface lithology.
The idea for satellite gravity measurements significantly helped in improved the knowledge of the earth's tectonic [5]&[6]. Consequently, the gravity field measurements are moved from only calculating the marine gravity field from radar altimeter to measuring the global gravity field using new satellite mission. This step led to improve the quality of the available data and also improve our understanding of the overall earth tectonic history [7]&[8].
The necessity of satellite gravity data to be prepared to use them in inversion process. The free air satellite gravity measurements for study are were downloaded. Then the data were corrected for the mass excess or deficiency due high or low elevation from the mean sea level. Then they corrected by Bourger correction before started to determine the moho depth as well as crustal thickness. As shown in the following flowchart.
The real gravity data are obtained by (extracted xyz data) the region dimensioned of about (230462) points in data base for Libyan area. then the raw are processed and the various correction are applied to obtain Bourger anomaly, fig. (1) as well as Bourger corrected, fig. (2). For detail shown as following flowchart

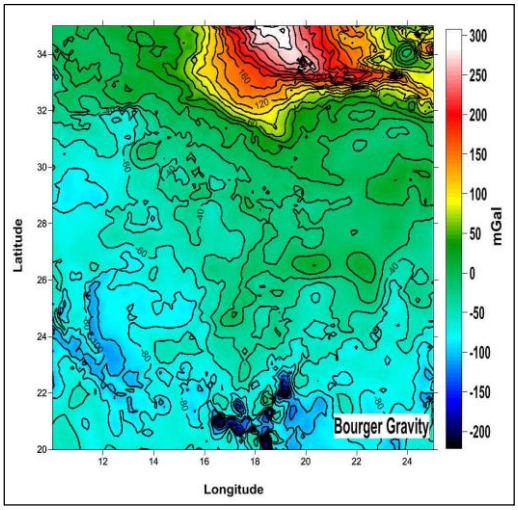

Fig 1. Bourger gravity

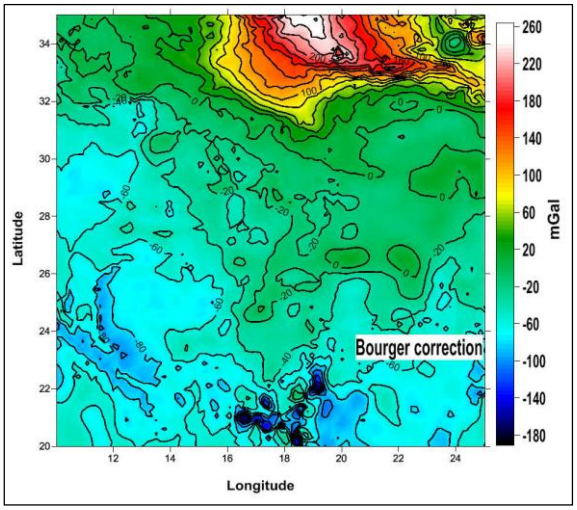

Fig 2. Bourger correction gravity

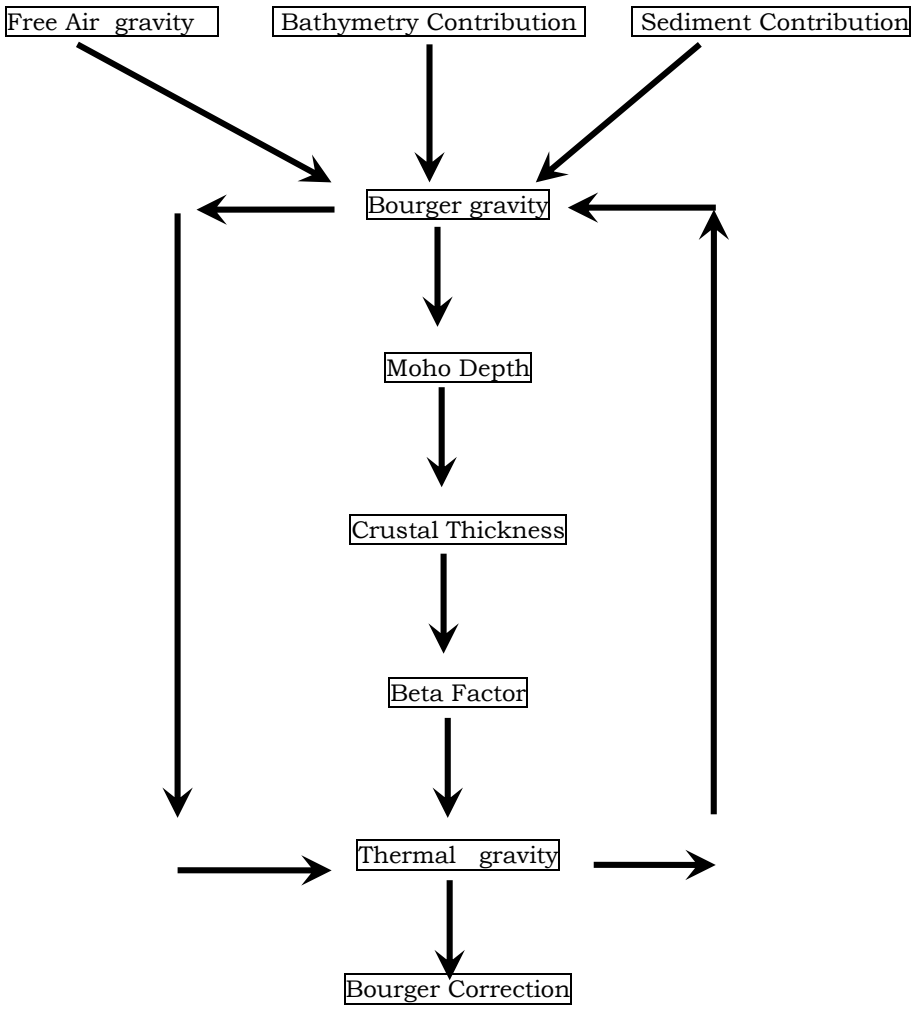

Fig3. Flow Chart of inversion process.

Satellite Gravity:

Recent satellite mission were launched to measure the global gravity field [9]. The new technology of the space age provides unique opportunity to produce a global map of earth's gravity field [10], the determination of the global gravity field has been seen as major task. It's characterized by combination of satellite geodetic and gravity methods. It results significantly improved measurement and will aid the determination of global gravity field with constraint accuracy and higher resolution in geophysical research [11]&[14]. It's currently recognized by several major oil companies as a new important prospecting tool for cost-effective mapping of the marine gravity field in remarkable detail [6]. Some major oil companies have already incorporated satellite gravity in their exploratory (survey), however satellite gravity relies on the fact that change in sea surface height are related to the existence of local gravity anomalies [12]. Satellite based radar altimeters offer the opportunity to measure the sea surface height to a precision of few centimeters. and almost complete global coverage.

In exploration geophysics, study and investigation of gravity anomaly (Bourger) have been used for oil exploration and mining for a long time. The gravity studies in exploration are based on density contrast between minerals and rock surrounding. In a study of local gravity field, except for density variations, other factors such as topography, altitude, geographical location, ..ect. Also affect gravity field, which in most cases their related values are higher than the values related to density variations. For those factors which mention above, the data must be correct before interpretation, the result gravity field (after correction) associated with density variation, is called Bourger anomaly [11]. The Bouguer gravity anomalies of the studying area change differently from south to north as shown in figures (1,2) .

The free-air gravity anomaly counter map has been generated from the high resolution satellite gravity fig. (4)

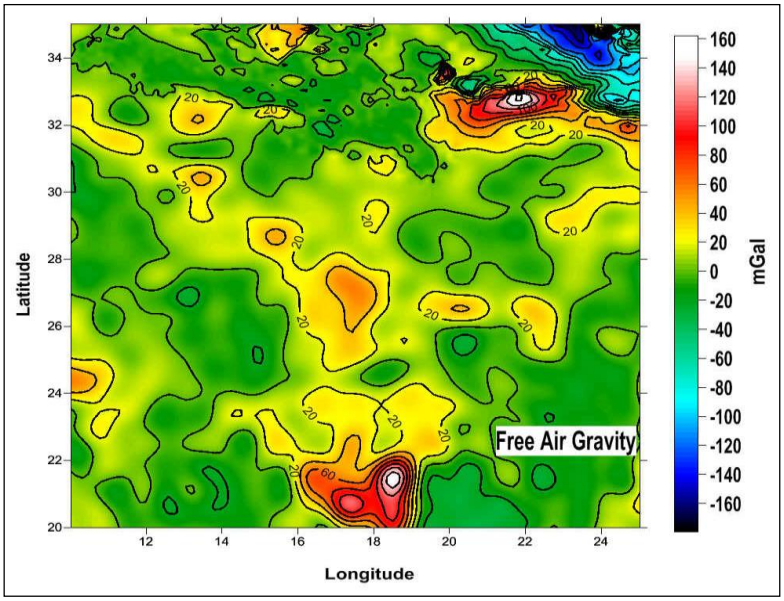

Fig. (4), shows the gravity anomaly. Negative anomalies correspond to low density rock as from thick sedimentary. Whereas positive anomalies correlate with dense metamorphic and basement rock and the onshore. The free-air gravity values in the region vary from (–160 to +160 mGal). The gravity anomaly gradually increases with depth and the range of gravity values became high at very high gravity values (−160 to +160 mGal) due to denser materials. A series of gravity lows are observed near the coast which may be related to low density recent sediments near the coast.

generated the high resolution satellite gravity data for free air gravity, fig. (4) I use the Sandwell & Smith (1997) satellite altimetry

Near surface bathymetry generates major density boundary between rock and water and this tends to dominate the gravity signal. Estimate accurate bathymetry fig.(5) is important to understanding earth's interior be used to figure out the shape and evaluation of the earth [13]. The effect of the sediment layer is evaluated using global sediment thickness model of NOAA. The Moho depth, crustal thickness and geothermal of Libya are determined based on using of satellite gravity. A map of lithosphere extension factor in the sediment basement. Based on the interpretation result of crustal structure.

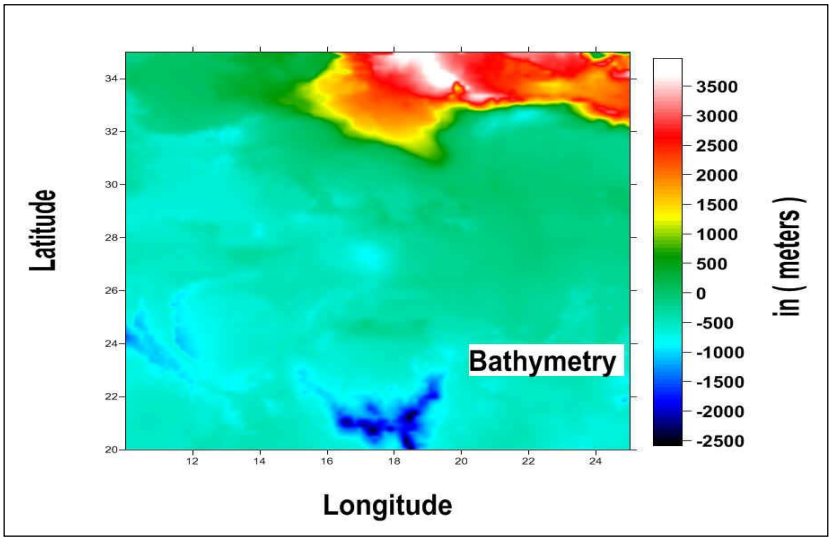

Fig. 5. Bathymetry map

Map of extension factor is constructed from Moho and Crustal depths. In mean while the Moho depth, crustal thickness and geothermal are determined based on using of satellite gravity as mention above. As in the following figures. (6,7,8, and 9)

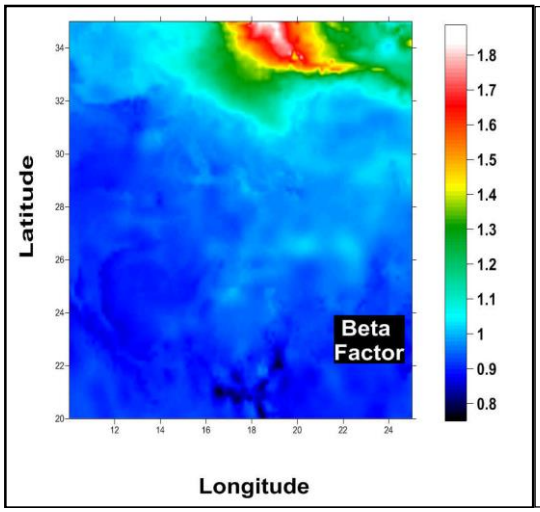

Fig. 6. Thining (extension) factor

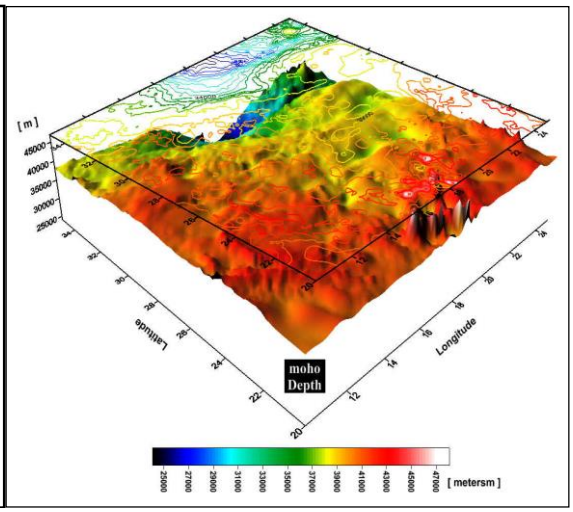

fig.7. Moho depth

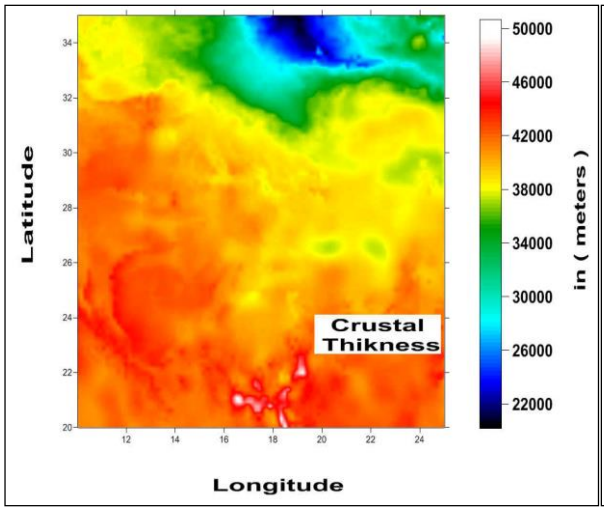

Fig 8. Crustal thickness

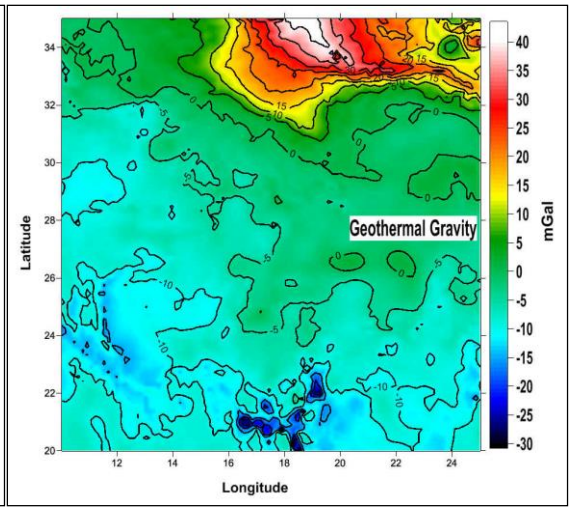

fig.9. Thermal Gravity

Conclusion

Geophysical data are the main source of information about the subsurface. They represent a critical stage in exploration processes for mineral, underground water, oil and gas exploration. Further they are the main source for information about the composition of the deep interior of the earth (lithosphere, mantle composition, structure and dynamics).

From the above study, the following conclusions could be made:

- Satellite imagery unable us the investigation of the properties of the earth surface in remote and over large areas through the mapping of physical properties from satellite
- Gravity field models are being used for different applications which include orbit determination of spacecraft, a variety of geophysical investigation/ exploration, oceanographic investigations using satellite altimetry, including offshore exploration for petroleum
- Gravity anomaly map provide valuable information on subsurface density distribution of the crust and lithosphere. Bouguer gravity anomaly can reflect deep structure characters and it is help to judge deep structures.
- gravity map over the Libya and its Coast is extremely useful for understanding the different geological processes**.**

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