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CRUSTAL THICKNESS MAP OF AUSTRALIAN CONTINENT AND ITS GEOLOGICAL IMPLEMENTATION

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ABSTRACT

The main target of this study is to estimate the depth to the Moho discontinuity beneath the Australian continent. To achieve this goal the authors used the analytical continuation of the gravity data as well as the formula of semi infinite slab. The values of the estimated depth, that show best fitting between the Moho discontinuity deflections, obtained from both the topography and gravity data, have been used to construct the crustal thickness map of the Australian continent.

The crustal thickness map of Australian continent demonstrates a crustal thickness variations which range between 24 kms. and 66 kms. Such crustal thickness variations reflect different degrees of compensation in the Australian continent, as it has been indicated through studying the relationship between Bouguer anomaly, Free air anomaly and crustal thickness of the Australian continent.

The observed inhomogeneity in the crustal thicknes of the Australian continent has been attributed to the geological situations and tectonic conditions prevailed in the Australian continent, where the areas which show crustal thickness anomalies coincide, on the continent, with areas characterized by the presence of faults and/or complex structure zones of deformation, several sequences of metamorphism and intrusion of granite and other igneous rocks.

INTRODUCTION

Estimation of the depth to the Moho discontinuity has been a subject for several postulates, theories and ideas. The term "Isostasy" is used to describe the condition of compensation and the presence of hydrostatic state beneath a certain depth within the earth. Hence, gravity and isostasy were both used to study the shape and state of the earth, as well as to explain the possible changes on its surface.

Several attempts have been made by Airy (1855), pratt (1859), Hyfordand Powic (1927), and Heiskanen (1938) to compute the effect of the compensating materials, inferred from the visible topography, on observed gravity values and to remove such an effect from the measurred gravity data in order to end up with the Bouguer anomaly. Another trend of studying gravity and isostasy is to estimate a picture of the crustal mantle interface (Moho discontinuity).

This study is concerned with the determination of the depth to the crust-mantle boundary beneath the Australian continent, see Fig. (1)

METHOD OF ANALYSIS

Lindener and Scheibe (1977) used a teĉhnique to determine the depths to the Moho diŝcontinuity. In suchatechnique they applied gravity data as it was taken on a surface having mean depth to the

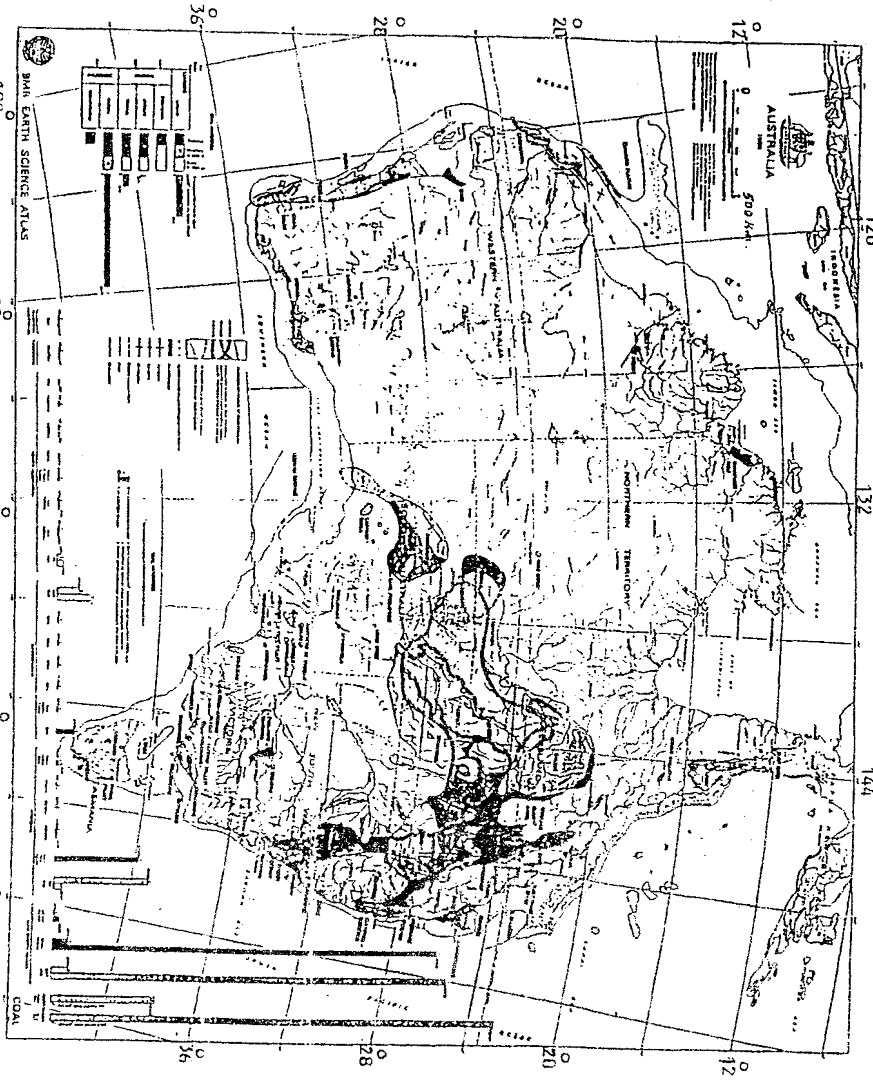


Fig.(1) Location Map Of The Australian Continent.

Moho discontinuity. The gravity values at this surface have been used together with the following formula to calculate the deflections of the Moho discontinuity from such surface.

$$h = \frac{g(-H)}{2 \pi G\rho} \qquad \text{..........................(1)}$$

where, h is the Moho deflection in kms., g(-H) is the gravity field computed at depth -H.,

G is the universal gravitional constant., and ρ is the density contrast between the crust and mantle.

Such an estimate is to figure out the degree of reliability of Airy's hypothesis in the area under study.

Based on the Airy's hypothesis the Moho deflections from a level can be estimated using Heiskanen's formula (1938).

$$h = h.\frac{\rho_c}{\rho_s - \rho_c} \qquad \text{..........................(2)}$$

where, h` is the Moho deflection in kms., from a certain level,

h is the elevation determined from topography,

ρ_C is the mean density of the crustal materials, and

ρ_S is the mean density of the upper mantle.

In this study equations No. 1 and 2 have been used for calculating the depth to the Moho discontinuity. In the mean time fitting has been applied between Moho deflections obtained from both the analytical continuation of the gravity data and topography.

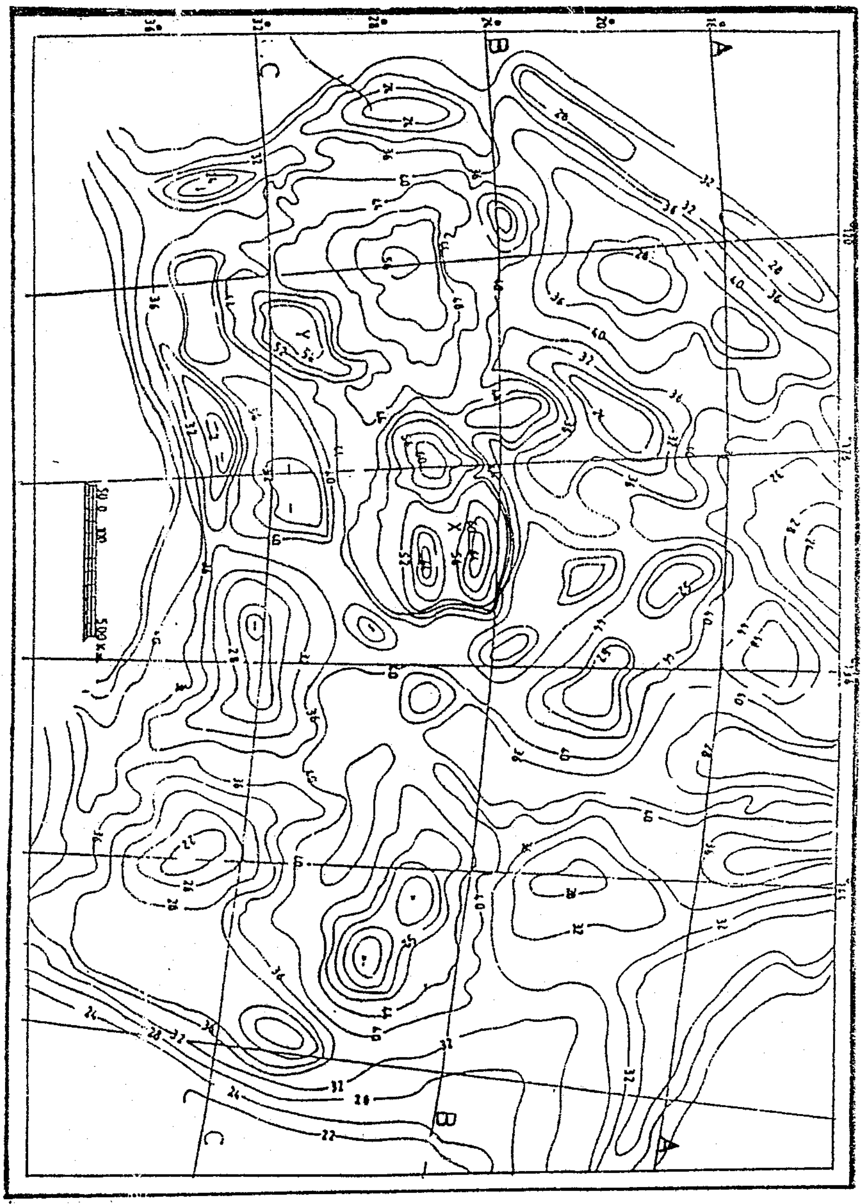


Fig. (2)Crustal Thickness Map Of Australian Continent .

RESULTS OF THIS STUDY

The best fitting between the deflections of the Moho surface, determined from the topography (considering Airy's hypothesis) and those obtained from the gravity data (see equation No.1) have been used to construct a crustal thickness map of the Australian continent as indicated in Fig. (2). This crustal thickness map, Fig. (2), shows the following:

1. The depth to the Moho discontinuity swings between 24 kms and 66 kms.

2. The crustal thickness increases towards the centre of the continent, where it reaches more than than 66kms. between longitudes 130° E and 140° E (see Fig. 2).

3. At the edges of the Australian continent, the crustal thickness ranges between 24 kms, and 40 kms.

The crustal thickness variations, mentioned before (see Fig. 2), reflect inhomogeneties in the crustal load as a result of differences in surface elevations and the mean crustal density, for the purpose of compensating masses in the mantle.

Relation between Free air anomaly, Bouguer anomaly and Crustal thickness:

To understand the relation between Free air anomaly, Bouguer anomaly and Crustal thickness for the various geotectonic units as

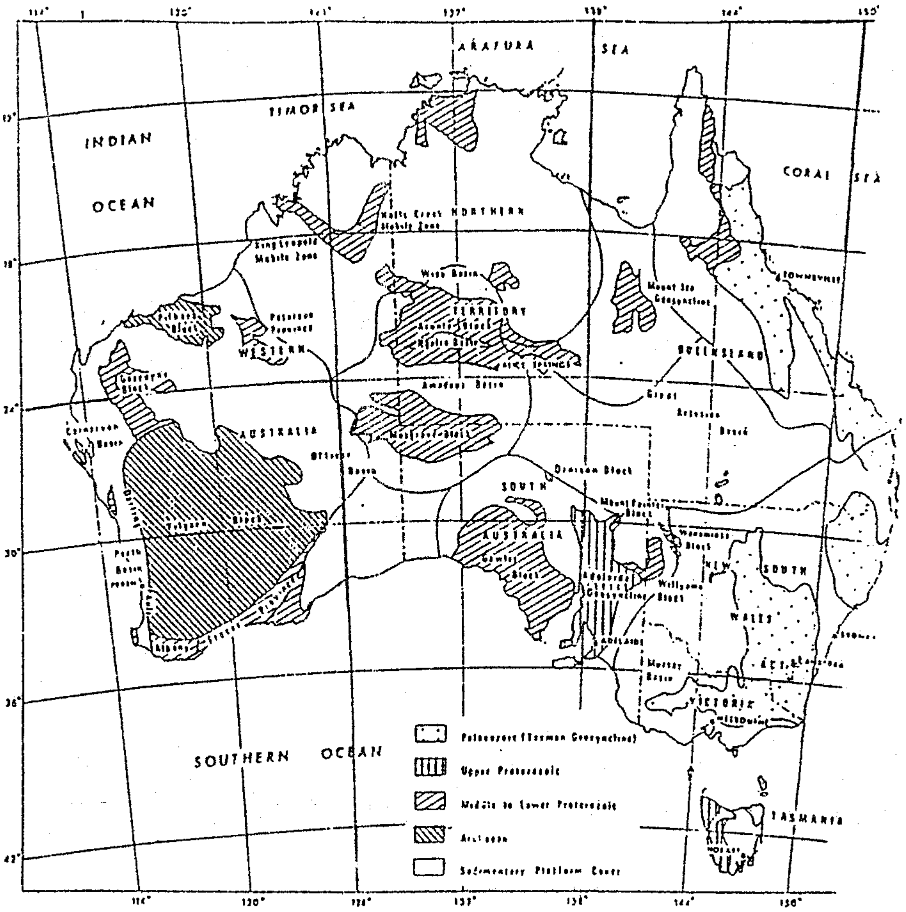


Fig. (3) Simplified geologic Map Of Australia Showing The Varies Orogenic Domains ,Geological Society Of Australia (1971).

demonstrated in Figs. 2, 3, 4 and 5 three profiles across the area under investigation have been selected for complete analysis and labeled on the crustal thickness map , Fig. (2), as A-A, B-B, and C-C. The writers are going to deal with each profile on its own.

I. profile A-A

profile A-A as shown in Fig. (6) runs through the northern part of the Australian continent. The crustal thickness along this profile ranges from nearly 25 kms. to 52 kms. The maximum thickness lies nearly along Longitude 130° E, or nearly the central part of the profile. While the minmum thickness has been met near the two ends of the profile, or near the edges of the Australian continent. The gravitional effect due to this change in crustal thickness is approximately between -110 m.Gal. and +20mGal.

Isostatic positive anomaly (Free air anomaly) along this profile is divided into two major bands (see Fig. 6) which reflect two different degrees of isostasy. The largest positive band lies at Longitude 115° E and reflects a compensation deep in the mantle. The second positive band lies, just, west Longitude 140° E (see Fig. 6). This positive band reflects compensation in the mantle at a level more or less higher than the previously mentioned one.

II - profile B-B

This B-B profile is nearly running across the central part of the contin-ent, at Latitude 24° S, see Fig. (7). The crust becomes

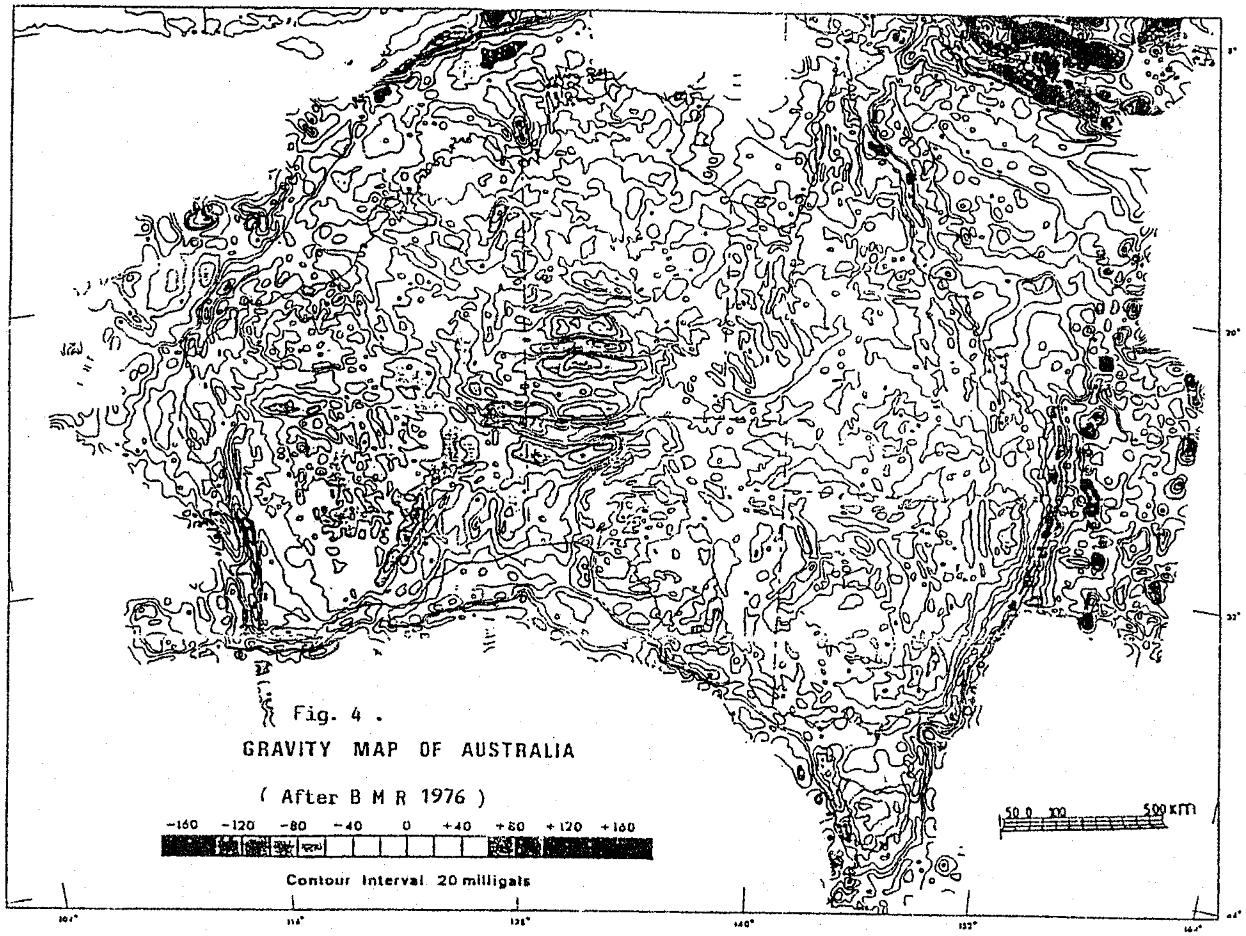


Fig. 4.
GRAVITY MAP OF AUSTRALIA
(After B M R 1976)

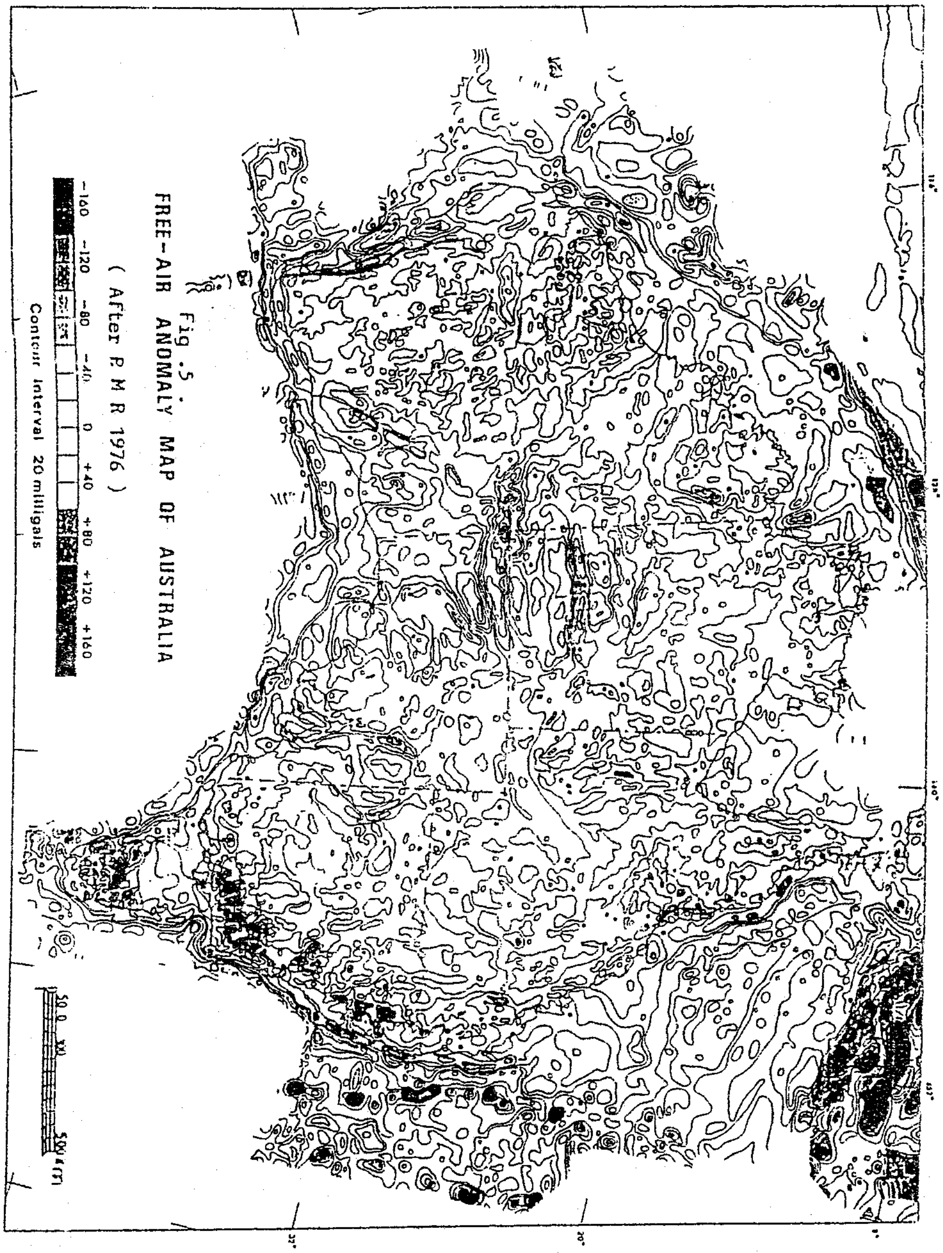


Fig. 5. FREE-AIR ANOMALY MAP OF AUSTRALIA (After B M R 1976)

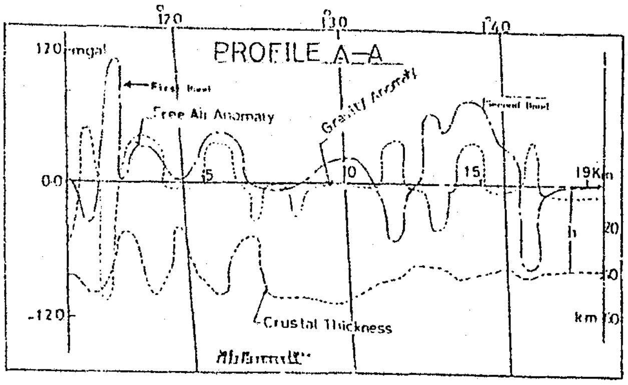


Fig .6 .

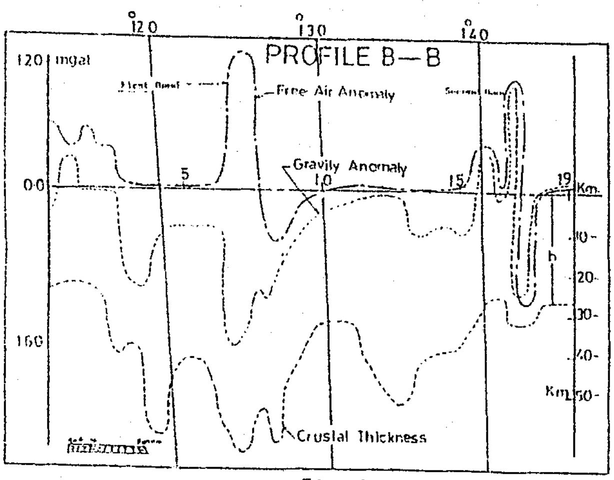


Fig .7 .

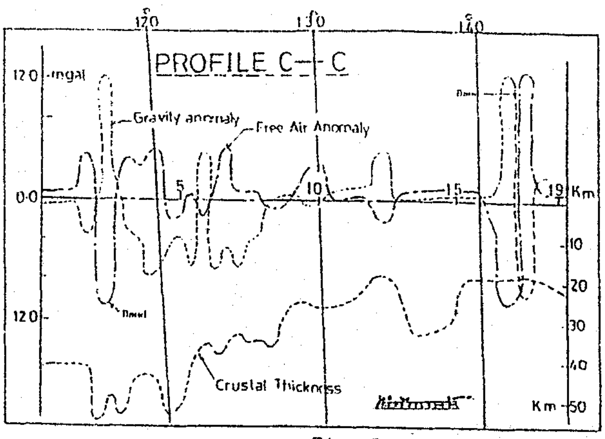


Fig. 8 .

Figs.(6,7,8)Show The Relation Between Free Air anomaly,Bouguer anomaly and Crustal Thickness along Profiles A -A, B -B And C -C considerably thicker towards nearly the central part of the profile, were the thickness of the crust reaches 66 kms., between Longitudes, 124° E and 126° E. The minimum crustal thickness of 25 kms. has been reported on the edges of the continent, the two ends of the profile.

The observed Bouguer anomaly along B-B profile has a wide variation which ranges between +100 mGal. and -140 mGal.

Free air anomaly is divided into some bands with positive and negative values which reflect different degrees of compensation as indicated in Fig. (7),

III - profile C-C.

This profile Fig. (8) runs through the southern part of the continent at Latitude 32° S. The crustal thickness increases near the western side of the continent, where the thickness of the crust ranging between 20 kms. to nearly 45 kms.

The observed values of Bouguer anomaly swings between + 120 mGal. and -120 mGal.

The positive Free air anomaly ranges between slightly more than zero to +120 mGal. with an overall value of + 40 mGal., where the maximum value lies at Longitude 143 E to 144 E and reflect compensation deep in the mantle.

Geological irnplementation of the crustal thickness variations:

The crustal thicness map of Australian continent. Fig. (2), contained two anomalies, defined as anomaly X and anomaly Y. these anomalies represent the areas of maximum crustal thickness at the central and southwestern parts of the continet consequently.

Anomaly X :

Anomaly X lies nearly on the central part of the Australian continent, where the crustal thickness reaches 66 kms. or more . this area, as deduced from the tectonic map of Australia,includes Musgrave block, Arunta block and the Amadeus basin, see (Fig. 9).

The rocks of Arunta and Musgrave blocks consist of gneiss, schist and several sequences of metamorphosed sedimentary and rocks, which are intruded by granite and other igneous rocks. This area had been subjected to at least three major orogenies (in Pre-cambrian, EarlyCambrian and Carboniferous), that led to reactivation of metamorphic roks as well as complex structures and zones of deformation along the northern and southern margins of Amadeus basin, see Fig. (9).. These zones of deformation pass through the crust into the mentle, alonge thrust faults,, and bringing high pressure granulites to the surface. The crust becomes substantially thick as a result of thrust faulting especially in the areas of crustal downwarp.

Anomaly Y:

This anomaly lies on the middle of southwestern part of Australia This particular area, as indicated in Fig. (10), is made up of Archean gneiss and lenticular masses of greenstone and metasediments which are intruded by massive granites.

Increase in crustal thickness of the area occupied by the Anomaly Y can be attributed to the tectonism which brought ctustal rocks to the surface along faults, such as Fraser fault (see Fig. 10).

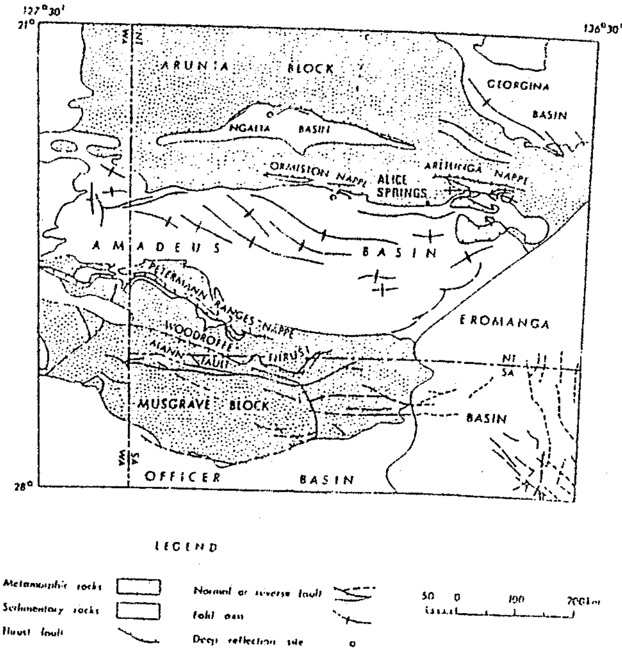
The crustal thickness under the continental margins ranges from 24 kms. and 40 kms. This crustal thickness variation can be referred to the vertical and lateral inhomogeneity of the crustal blocks and basins, as shown in Fig. (3).

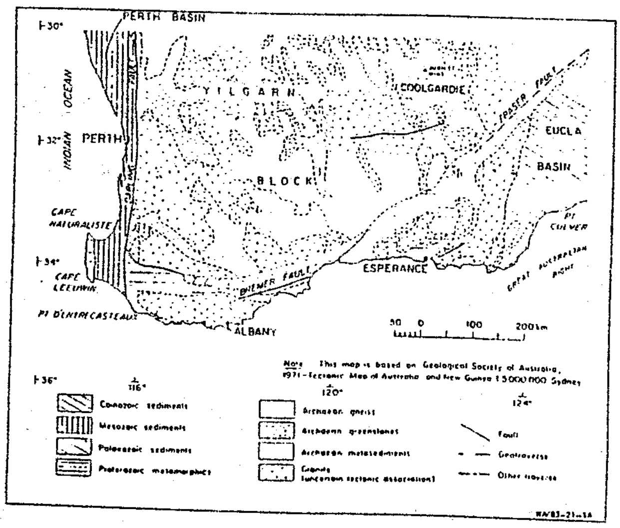
Recommendations:

1. The geological implementation for the crustal thickness of the Austal thickness of the Austra -lian continent is in need for more gravity and seismic models. The models will enhance the effect of large upthrusts, which cut through the mantle, on the crustal thickness of the continent.

2. Areas of crustal thickness anomalies suffer from deficiency or lake of:

a) mineralogical studies.


ARUNTA BLOCK
NGALIA BASIN
GEORGINA BASIN
ORMISTON NAPPE
ALICE SPRINGS
ARLTUNGA NAPPE
AMADEUS BASIN
PETERMANN RANGES NAPPE
WOODROFFE THRUST
EROMANGA
MUSGRAVE BLOCK
BASIN
OFFICER BASIN
LEGEND


PERTH BASIN
INDIAN OCEAN
PERTH
YILGARN BLOCK
COOLGARDIE
FRASER FAULT
EUCLA BASIN
CAPE NATURALISTE
CAPE LEEUWIN
PT CULVER
ESPERANCE
GREAT AUSTRALIAN BIGHT
ALBANY

b) the impact of the geotherrmal gradient on mineralization.

The formerly mentioned points a and b, require inteensive studies to locate and make use of the mineral resources, especially in the areas with abnormal crustal thickness of the Australian continent.

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خريطة السمك القشرى للقارة الاسترالية ودلالاتها الجيولوجية

محمد غريب المالكى ، محمد السعيد البهوتى

الهدف الرئيسى والاساسى من الدراسة الحالية هو تقدير عمق انقطاع موهو أسفل القارة الاسترالية ، ولتحقيق هذا الهدف استخدم الباحثان التواصل التحليلى للمدلولات التثاقلية بالاضافة الى المعادلة المتعلقة بالشريحة شبة النهائية . وقد استخدمت القيم المحسوبة للعمق والتى تبدى اقصى تطابق بين انحرافات انقطاع موهو المحصل من كل من التضاريس والمدلولات التثاقلية لعمل خريطة للسمك القشرى للقارة الاسترالية وتبين هذة الخريطة التغيرات فى السمك القشرى فيما بين ٢٤ ، ٦٦ كيلومترا ، وتعكس مثل هذه التغيرات درجات مختلفه من التعويض فى القارة الاسترالية حيث أمكن الاستدلال عليها من خلال دراسة العلاقة بين تباين بوجير والهواء الحر والسمك القشرى للقارة ويعزى عدم التجانس فى السمك للقارة الاسترالية للظروف الجيولوجيه والتكتونيه التى سادت فى القارة ، حيث أن المواقع التى تبدى تباينات فى السمك القشرى تنطبق على سطح القارة مع المواقع المتميزة بوجود فوالق أو تراكيب معقدة أو هما معا وكذا نطاقات تشوه ، وتتابعات عدة من التحول واندساس الجرانيت والصخور الناريه الاخرى .