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Subsurface topography of Supra crustals of Dharwar Craton through inversion of Regional Bouguer Gravity

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ABSTRACT

Regional gravity data have been analyzed to estimate the supra crustal thickness in parts of Dharwar Craton (73°30' E to 78° 30' E and latitude 12° N to 17°N). The depositions of supra crustal four deep seated faults and several other lineaments were delineated from qualitative analysis of Bouguer gravity. The supracrustal (Charnokite, Younger granites, Closepet granite, Sargur belt, Chitradurga schist belt, Bababudan group , Deccan Basalt, Bhima sediments, and western part of Cuddapah Sediments) as well as deep crustal (Peninsular gneiss, Upper crustal and deeper crust layer (up to Moho) structural configuration in the Dharwar craton were obtained via the inversion of modeling of eleven east-west traverses (T1 to T 11) digitized from the Bouguer gravity contour map. The sub-surface configuration of each of these supra crustal layers were obtained by digitizing the corresponding crustal structure and presented as 3D contour map reveal structural complexity with plunging synclines, anticlines and refolded along E-W trending warps. The peninsular gneissic layer is very uneven in geometry varying in thickness from 6.9 to 11 km, upper crustal layer varies between 18.2 to 24.55 km and deep crustal layer 34 km to 40 km .

Key words: Crustal configuration, supracrustal, anticlines, synclines, up warps, plunging

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INTRODUCTION

Earlier geophysical studies in the Dharwar craton include gravity [67]; [19]; [21]; [28]; Magsat [30]. Gravity and Magnetic [37]; [22]; [3];[29], [63], [46]and [26], deep seismic soundings (DSS) [Kaila et al., 1979];[Reddy et al., 2000], [23], [31], [18]; [40]; [12]; [53] ; Aeromagnetic [41] and tomographic [54];[12], Magneto- telluric [13] ,[14]. Geologically the Dharwar Craton well documented [33]; [39]; [5]. The tectonic framework of South Indian shield region (SISR) has been studied by various geological and geophysical methods and reviewed by various workers [32]; [8]; [9]; [47]; [56] ,[57]. Petrophysical and crustal configuration [44], [45], and heat flow [10] investigations. They gave an indication of variation in the crustal thickness and suggested the operation of vertical tectonics in the region. However, most studies so far have consisted of large area (small-scale) investigations directed towards regional appraisal.

However, many of the earlier Geophysical studies [62] were focus on eliciting the brought deep seated regional signatures and where as spots on the Dharwar craton. At there are very few reports of the detailed crustal configuration of the region lack of any consensus on the configuration of craton and emphasizes of the need for investigation towards understanding the near surface supra crustal also give valuable information on the geological evaluation on the region and understanding the tectonics and deep configuration structure in the Dharwar Craton keeping in this in mind an attempt has been made all available data sets with our data set for investigation toward the understanding tectonic structural configuration in the study area of 400,000 Sq Km lying between the longitude 73°30' E' to 78° 30' E and latitude 12° N to 17°N [6] is bounded by Arabian sea to the west of the middle proterozoic mobile belt (MPMB) to the east and south. The study area up to 17°N latitude is composed mainly of the Dharwar Craton and a part of the Bastar Craton separated by the Godavary Gondwana graben. Toward the east of the Dharwar and Bastar Cratons is the Eastern ghat mobile belt, the junction between them being the sileru shear zone. South of the Dharwar Craton is the Southern Granulite Terrain (SGT). Fig. 1 gives the generalized geology and tectonic map of the study region redrawn from [50], [15],[16]; [68] (Fig 1).

Geology of the Dharwar Craton:
The Dharwar Craton is split into eastern and western cratons with major differences in lithology and ages of rock units. The western boundary of the Eastern Dharwar Craton (EDC) is poorly defined and is constrained to a 200km wide lithologic transitional zone from the Peninsular Gneisses of the Western Dharwar Craton to the Closepet Granite. The Closepet Granite is a good approximation of the western boundary and is used as such in this paper [50].

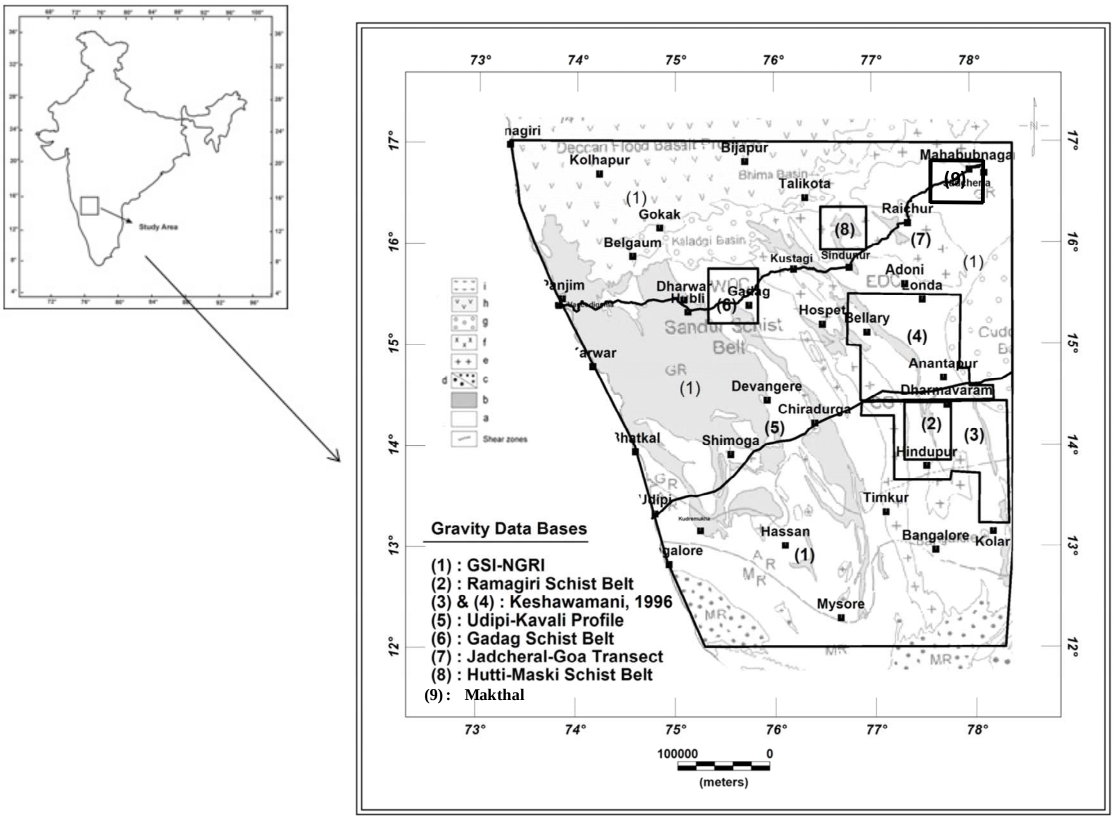

Figure.1: Geology map of the Study Area (After Senthil Kumar et al., 2007)

The Western Dharwar Craton (WDC) is located in southwest India and is bound to the east by the Eastern Dharwar Craton (EDC), to the west by the Arabian Sea, and to the south by a transition into the so-called “Southern Granulite Terraine”. The remaining boundary to the north is buried under younger sediments and the Cretaceous Deccan Traps. The division between the Western and Eastern Dharwar Cratons is based on the nature and abundance of greenstones, as well as the age of surrounding basement and degree of regional metamorphism [52]. The Western Dharwar Craton (WDC) contains two types of supra crustal groups of the WDC, the oldest recognized Sargur group occurs as widely dispersed enclaves within the gneisses where as the younger supra crustal (3 to 2.5 Ga old i.e. essentially late Achaean) of the Dharwar supergroup, namely the Bababudhan, Shimoga and Chitradurga groups, occur as large belts comparable to Proterozoic basins and geosynclines. The southern part of the Western Dharwar Craton (WDC) contains a number of metamophished ultramafic bodies, many of which form large intrusive complexes.

Eastern Dharwar Craton **(** EDC) is bounded to the north by the Deccan Traps and the Bastar Craton, to the east by the Eastern Ghats Mobile Belt, and to the south by the Southern Granulite Terraine [4]. The Craton is composed of the Dharwar Batholith (dominantly granitic), greenstone belts, intrusive volcanic, and middle Proterozoic to more recent sedimentary basins [50]. The supra crustal belts of the Eastern black of the Dharwar Craton are smaller in size than those of the western blocks which are surrounded by gneisses and granites. The prominent greenstone belts of the Eastern Block include Kolar, Sandur and Hutti. These belts contain supracrustal rocks essentially made up of volcanic rocks with subordinate amounts of sedimentary rocks composed of quartzites, polymict, conglomerate, carbonates, BCF/BIF and Mg-rich peletic rocks and phyllites.

Gravity Data Base

New gravity data was collected 601 observation points along > 600 Km from Panaji to Jedcherla transect, 941 at Gadag gravity observations and 548 observation were observed at Makthal a total of 2180 received observation points were acquired by CEG, OU with a station interval of 1 Km with a Lacoste-Romberg (Model-G-940) gravimeter with an accuracy of 0.1 mGal (Ramdass et al., 2006). After all corrections applied to data and it was concentrated in filing the gap and merging 2180 new observations with 10,000 existing Udipi-Kavali transect data from NGRI [62] , [63] and GSI [27], [1] ,Central of Exploration Geophysics [43],[45] shown in Figure.1 . In fact, a further increase in the density and accuracy of observations might provide more information about the structure of the Craton**.**

Analysis of Gravity

The Part of the Bouguer gravity map of India Shield [62],[63]; [27], [1]; [43], [45]; [32], on 1:100,000 scale is presented in Fig 2, between longitude 73°30' E to 78° 30' E and latitude 12°N to 17°N. Interpretation of the Bouguer gravity data of South India correlating all the geologically provinces has been carried out by many workers, in particular [67],

New gravity investigations were carried out between the 73° 30' E - 78° 30'E Longitudes and 12° N-17°N Latitudes in the Dharawar craton from qualitative analysis [Bouguer gravity] several faults/lineaments are determined [2]. The gravity over the Dharwar Craton has range of -20 mGal to -130 mGal near Hassan it is characterized by conspicuous highs and lows alternating and trending NE-SE direction. The gravity high (positive) in most cases are invariably with greenstone belts, while gravity lows (negative) optional occur over granite outcrops and younger granites. The Dharwar, Shimgoa, Bababudan (BN) belts is a wider and shallower basin; it is representing in Bouguer anomaly.

Further, north of the study area Deccan Volcanic Province (DVP) [2]also brought out the structural configuration of the region. Broadly all lineaments appear to follow the preferred direction NW-SE, NS and NE-SW, the major structural features over the NW-SE Western Ghats (F3) and Kurdwar low (L7) was identified.

The Quantitative inverstion modeling of the Bouguer gravity data in the Dharwar Craton area was to understand the supra crustal (Residual gravity) structural configuration of the area from the inversion of 11-West-East profiles parallel to 12° to 17°E Traverse T1,T2,T3,T4,T5,T6,T7,T8,T9,T10 and T11) at an interval of every half degree and separated from each other by a North-South direction of 55 km running from South to North digitized from the Bouguer Gravity map Fig (2).

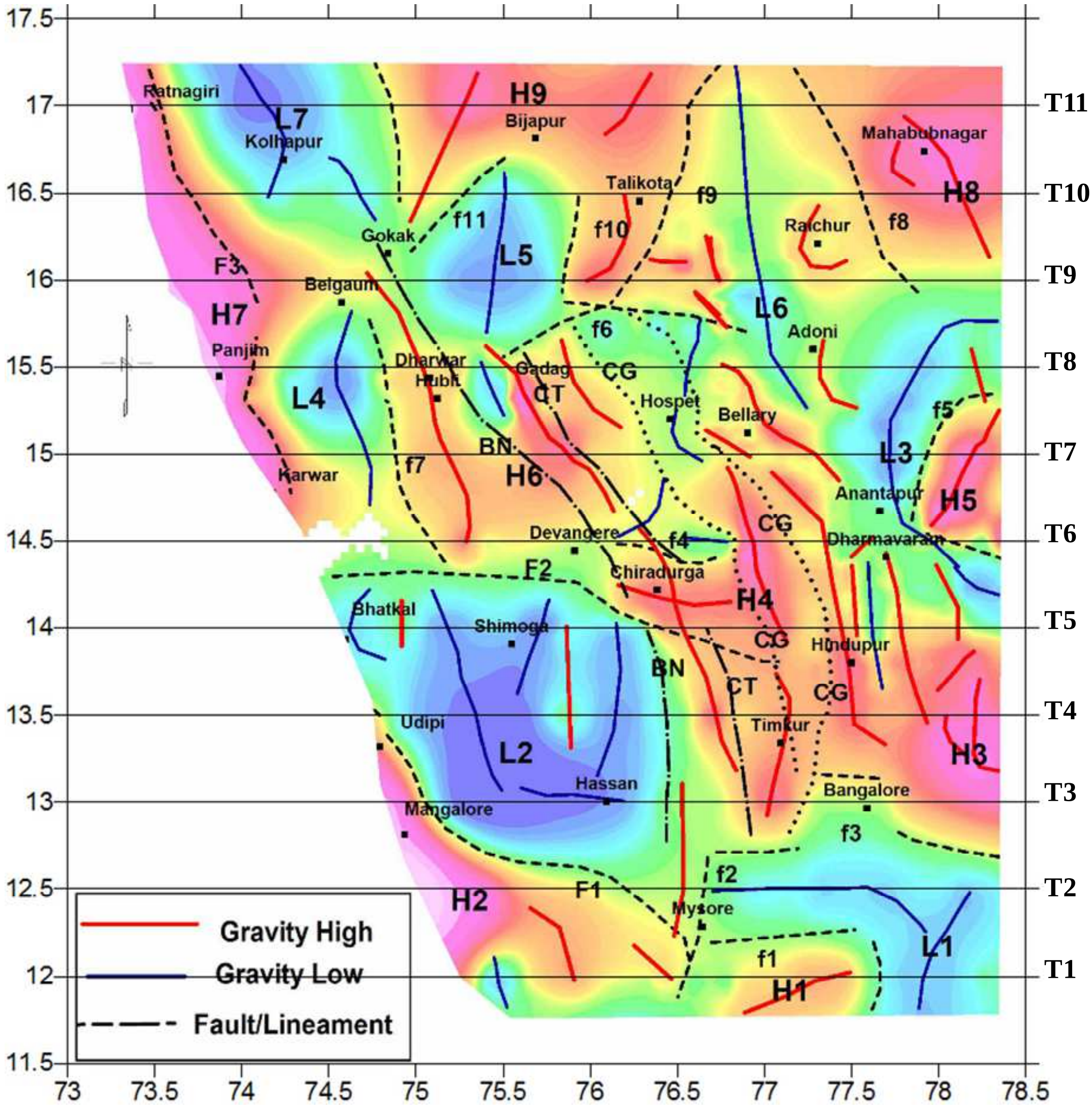

Figure.2: Bouguer map of the Study Area (After Sathish, Bhagya et al ,2015)

A 4-layer earth models was assumed for crustal configuration down to the Moho- a top layer of peninsular gneiss that forms the basement to the supra-crustal (younger granites-2 .6.gm/ cc; schists 2.9 gm/cc), the upper crustal layer, deeper crustal layer bounded at its lower end by the Moho. While the supra crustal within the host peninsular gneisses are broadly identified from the known geology. It is possible to assign representative densities to them from the petro- physical data available from different sources [45], [65], [58], [21], average densities of representative rock sample of major geological units exposed along the traverse are summarized in table-1. The corresponding densities of deep seated formations are assumed by the earlier studies [45], are 2.67gm/cc,2.72gm/cc,2.85gm/cc and 3.3gm/cc respectively. and used as a base to constrain to the present gravity modeling through GMSYS (2010) Software[17]. For each significant local misfit (anomaly), a geometric body with appropriate shape, disposition and property contrast was approximated (Fig.2 and Table 1). The best fit between observed and computed anomaly profiles for the gravity data was obtained by interactively modifying the configuration of the assumed bodies. The least square error between the observed and computed profiles was 1.5% for gravity.

It is to be noted that to justify interpretation of the entire crustal configuration a measure of geological contrast obtained from independent estimates for crustal thickness in the region [45] and petro physics. Further, the GM-SYS (2010) software does not require to be subtracted from the Bouger gravity anomaly as the entire crustal configuration down to the Moho is modeling by means of the assumed four layered earth.

While various techniques are available for the separation of the long wavelength (regional) and short wavelength (residual) components of the observed signal, polynomial fitting (Lowerie,1997) is a relatively straightforward and commonly used method that allows for a judicious mix of bias-free mathematical analysis and ground geology.

As with increasing order of the assumed curve approaches the original set of observations, for optimal fit the appropriate order polynomial has to be selected. Also compute the 5th order polynomials fit to the observed Bouguer gravity along the transect (Figure.3), the 5th order polynomial was founded to be most representative of the expected regional and residual was utilized to explain features of supra crustal.

Travers-1: This traverse (Figure.3.1) runs from west to east along Latitude-12° is approximately 380km in length the crustal section along this profile is for the major part marked by gentle undulations. The Charnokite characterized by a residual gravity high of above 3.6 mGal and 3.9 mGal at west and east of the traverse (Fig.3.2). The estimated width and depth of the Charnokite at 53 km (0.80 km depth) and 21 km (1.45 km depth) respectively assuming 2.85 g/cc density, A large exposure of Younger granites by a gravity low of above -10.55 mGal and -6.4 mGal at west –east of the line. With a density of 2.4 g/cc, these younger granites have a maximum width of at 20 km and 41 km and depths of 0.69 km and 0.64 km respective dip gently to the east.

The Closepet granite has a low-density of 2.56g/cc this is reflected as a small sharp peak of roughly -7.8 mGal in the Bouguer anomaly, have a maximum width of at 53 km and depths of 1.78 km, the peninsular gneissic (P.G) have a variable thickness ranging from 0 to10 km Fig.3.1. The topmost layer comprising younger granites is exposed at surface almost completely, where the higher density peninsular gneissic layer, is exposed to shallow depth. As compared to the deeper layers, these layers have an irregular shape.

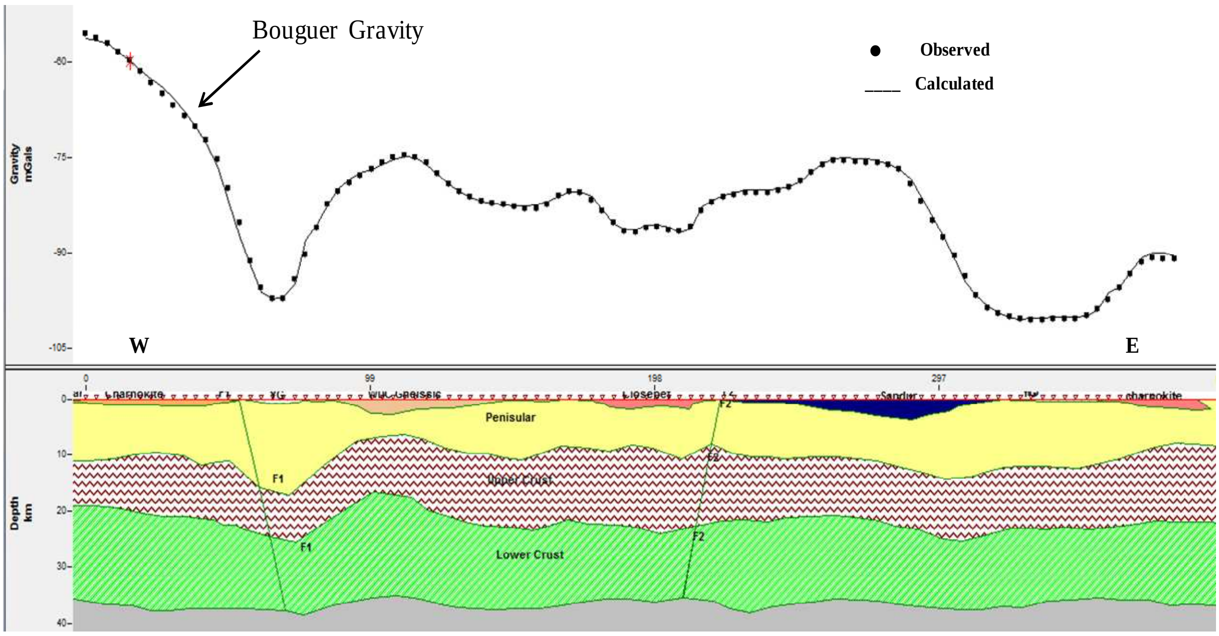

Figure.3.1: Inversion of Bouguer gravity and inferred crustal section along of Travers-1 (parallel to Latitude 12° E)

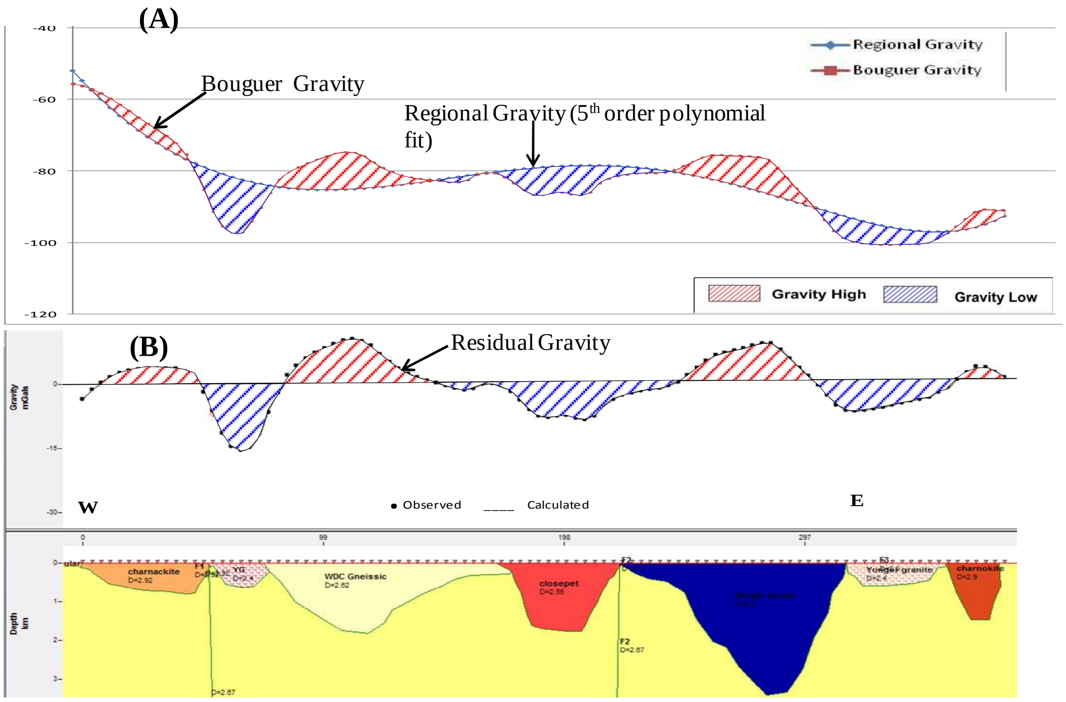

Figure .3.2 (A): 5th Order Polynomial fit for Regional Gravity along Travers-1 (parallel to Latitude 12° E)

(B): Inversion of Residual Bouguer gravity and inferred supra crustal along of Travers-1(parallel to Latitude 12° E)

There are two small faults i.e f1 and f2 is traced at the 51.44 km and 221.77 Km, which is marked by all the underline layers which were infer from qualitative analysis (Figure.2). Surface expressing of these fault the contact between the Younger granite and Peninsular gneissic (Figure.3.2). Peninsular thickness is minimum 8km, maximum 10 km, Upper crustal a thickness is minimum 19 km, maximum 22 km and Deeper crustal thickness is minimum 31km and maximum 37 km.

Travers-2: This traverse (Figure.4.1) runs from west to east along Latitude-12°.30' is approximately 414km in length the crustal section along this profile is for the major part marked by gentle undulations. The Charnokite characterized by a gravity high of about 10.48 mGal and 6.16 mGal at west –east of the line. The estimated width and depth of the Charnokite is 54 km (1.28km depth) and 51 km (0.81km depth) respectively. The charnokite has the high density of 2.92 g/cc Figure. (4.2).

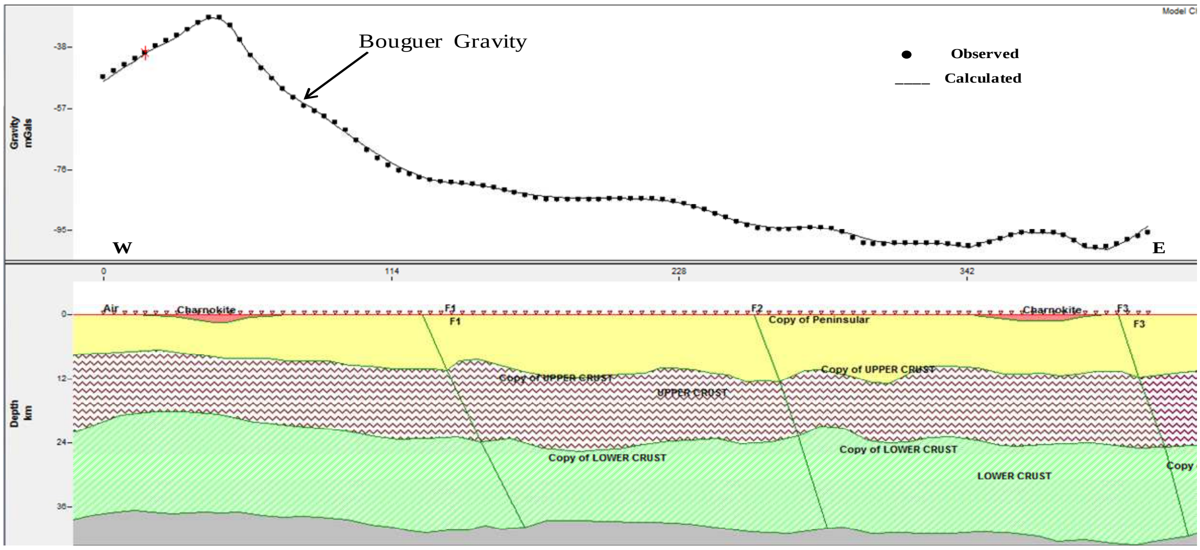

Figure.4.1: Inversion of Bouguer gravity and inferred crustal section along of Travers-2 (parallel to Latitude 12° 30'E)

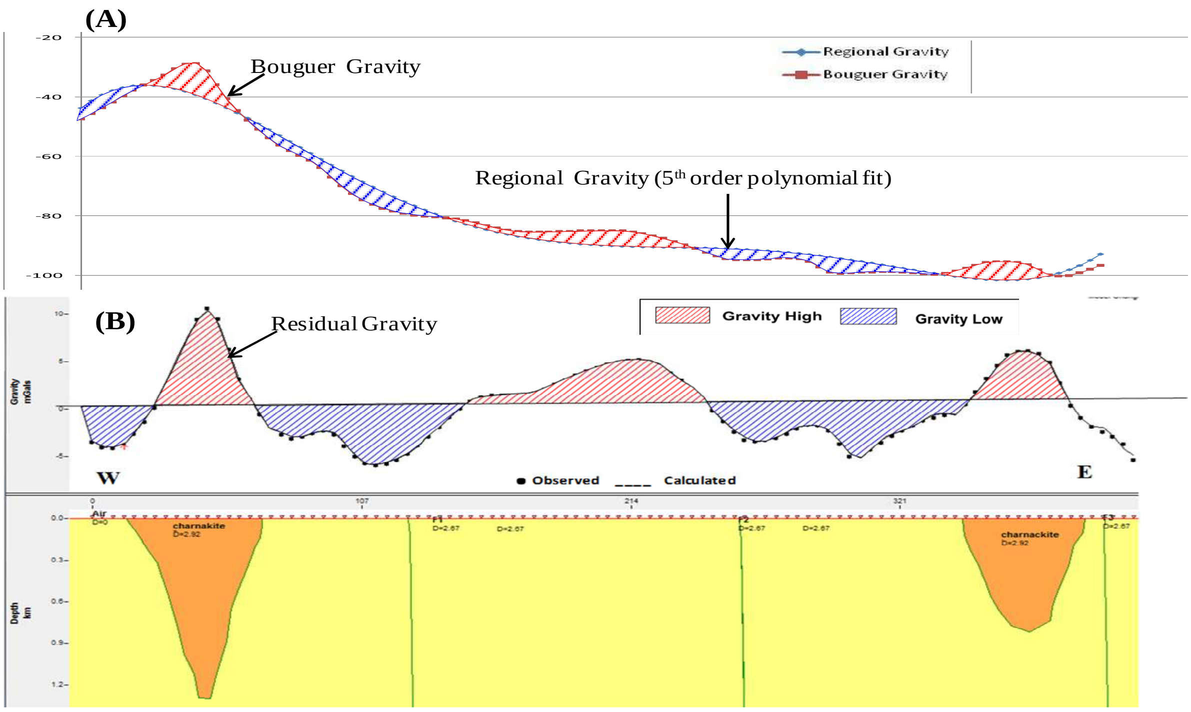

Figure .4.2 (A): 5th Order Polynomial fit for Regional Gravity along Travers-2(parallel to Latitude 12°30'E)
(B): Inversion of Residual Bouguer gravity and inferred supra crustal along of Travers-2 (parallel to Latitude 12°30' E)

The peninsular gneissic (P.G) have a variable thickness ranging from 0 to10 km Figure.(4.1). The topmost layer comprising younger granites is exposed at surface almost completely, where the higher density peninsular gneissic layer, is exposed to shallow depth. As compared to the deeper layers, these layers have an irregular shape.

There are one dipping faults i.e F1 is located at the 124.4km and two small faults f2 and f3 were identified at 256.5 km and 401km respectively which is marked by all the underline layers which were inferred from qualitative analysis (Figure.4 2). Surface expressing of this fault the contact between the Yonger granite and Peninsular gneissic. Peninsular thickness is minimum 8km, maximum 11km, Upper crustal a thickness is minimum 20km, maximum 23km and Deeper crustal thickness is minimum 35km and maximum 39km (Figure.4.1).

Travers-3: This traverse (Figure.5.1) running through the Hassan, Bangalore and near Kolar villages from west to east along Latitude-13° is approximately 424km in length south of traverse T2 the crustal section along this profile is for the major part marked by gentle undulations. The Charnokite characterized by a gravity high of above 15.9 mGal and 10.13 mGal at west –east of the line. The estimated width and depth of the Charnokite are 69 km (1.52km depth) and 68 km width and 1.45km depth respectively with density of 2.92 g/cc, A large exposure of Younger granites by a gravity low of above -13.09 mGal at west –east of the line. With a density of 2.4 g/cc, these younger granites have a maximum width of at 45 km and depths of 0.25 km respective dip gently to the east. Sargur schist (Dharwar schist) having maximum width of 98 km and depth 3.73 km respectively with density of 2.8 g/cc and sargur belt having high gravity value of 7.24 mGal. The eastern green belt having high gravity value at 2.85 mGal and maximum width of 89 km and 1.89 km depth respectively. The Closepet has a low-density of 2.56g/cc this is reflected as a small sharp peak of roughly -7.8 mGal in the Bouguer anomaly, have a maximum width of at 53 km and depths of 1.78 km, the peninsular gneissic (P.G) have a variable thickness ranging from 0 to10 km. The topmost layer comprising younger granites is exposed at surface almost completely, where the higher density peninsular gneissic layer, is exposed to shallow depth. As compared to the deeper layers, these layers have an irregular shape.

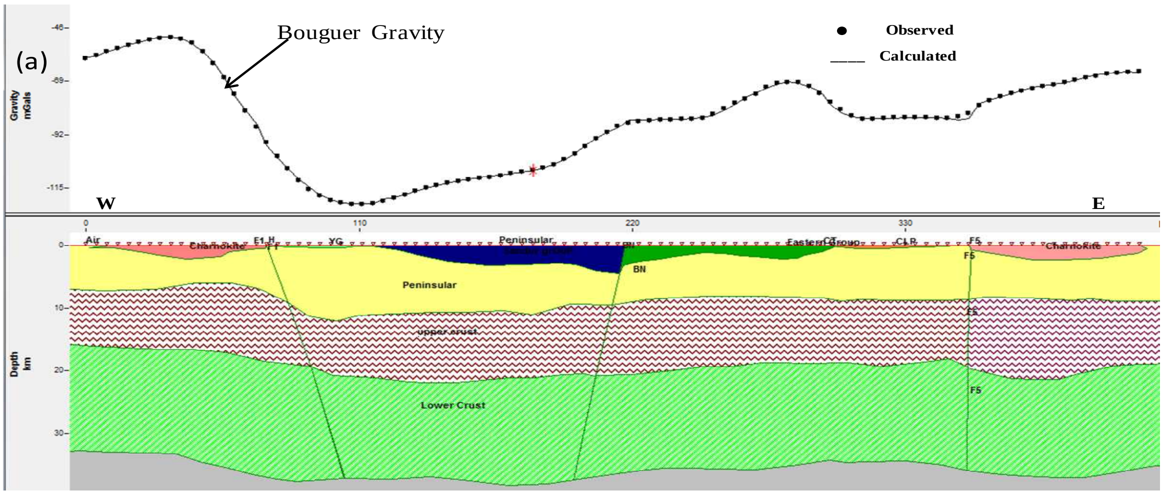

Figure.5.1: Inversion of Bouguer gravity and inferred crustal section along of Travers-3 (parallel to Latitude 13° E)

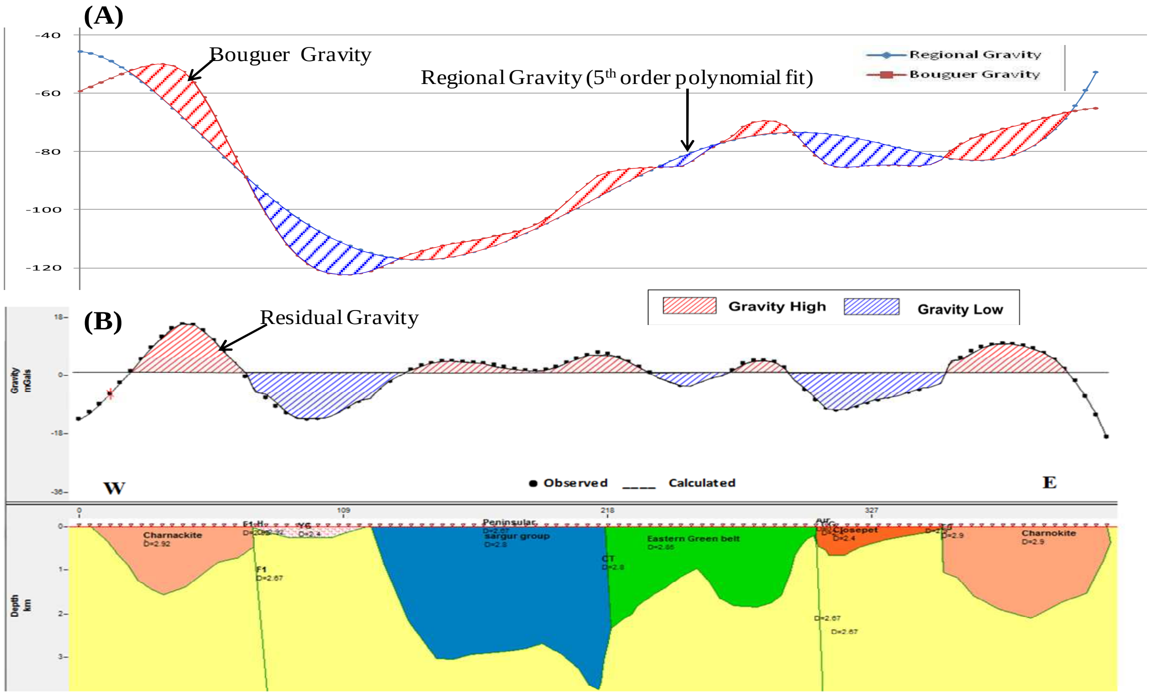

Figure .5.2 (A): 5th Order Polynomial fit for Regional Gravity along Travers-3 (parallel to Latitude 13°E)

(B): Inversion of Residual Bouguer gravity and inferred supra crustal along of Travers-3 (parallel to Latitude 13°E)

There are two dipping faults i.e F1 is indicated at the 71.90km and BN at 304 km respectively which is marked by all the underline layers which were infer from qualitative analysis (Figure.3c). Surface expressing of this fault the contact between the Yonger granite and Penisular gneissic. Peninsular thickness is minimum 8km, maximum 11km, Upper crustal a thickness is minimum 14km, maximum 22km and Deeper crustal thickness is minimum 33km and maximum 37km.

Travers-4: This traverse (Figure.6.1) runnings from west to east along Latitude-13°30' near North of Timkur village is approximately 429km in length the crustal section along this profile. The Charnokite characterized by gravity high of above 6.74 mGal at west –east of the line. The estimated width and depth of the Charnokite are 52 km and 0.89 km depth respectively with density of 2.92 g/cc, A large exposure of Younger granites by a gravity low of above -4.4 mGal and -8.95 mGal at west coast of the line. With a density of 2.4 g/cc, these younger granites have a maximum width of at 81 km and 55 km and depths of 0.33 km and 0.64 km respective dip gently to the east. Dharwar schist having maximum width of 43km and depth 2.31 km respectively with density of 2.9 g/cc and having high gravity value of 13.81 mGal. The Bababudan having high gravity value at 9.59 mgal with density 2.9 g/cc and maximum width of 56km and 1.03 km depth respectively. The eastern green having high gravity value at 2.53 mgal and maximum width of 30 km and 0.52 km depth respectively.The Closepet has a low-density of 2.56g/cc this is reflected as a small sharp peak of roughly -2.20 mGal in the Bouguer anomaly, have a maximum width of at 35 km and depths of 0.04 km, The Intrusive having high gravity value at 2.8 mgal and maximum width of 48 km and 0.57 km depth respectively. The peninsular gneissic (P.G) have a variable thickness ranging from 0 to10 km. The topmost layer comprising younger granites is exposed at surface almost completely, where the higher density peninsular gneissic layer, is exposed to shallow depth.

There are three dipping faults i.e F1 is indicated at the 51.92km, BN (F2) at 232.65 km and CG (f3) at 321 km and one small fault CT (F4) at 276.68 km respectively which is marked by all the underline layers which were infer from qualitative analysis (Figure. 2). Surface expressing of this fault the contact between the Yonger granite and

Penisular gneissic. Peninsular thickness is minimum 8km, maximum 11km, Upper crustal a thickness is minimum 17km, maximum 23km and Deeper crustal thickness is minimum 36km, maximum 38km.

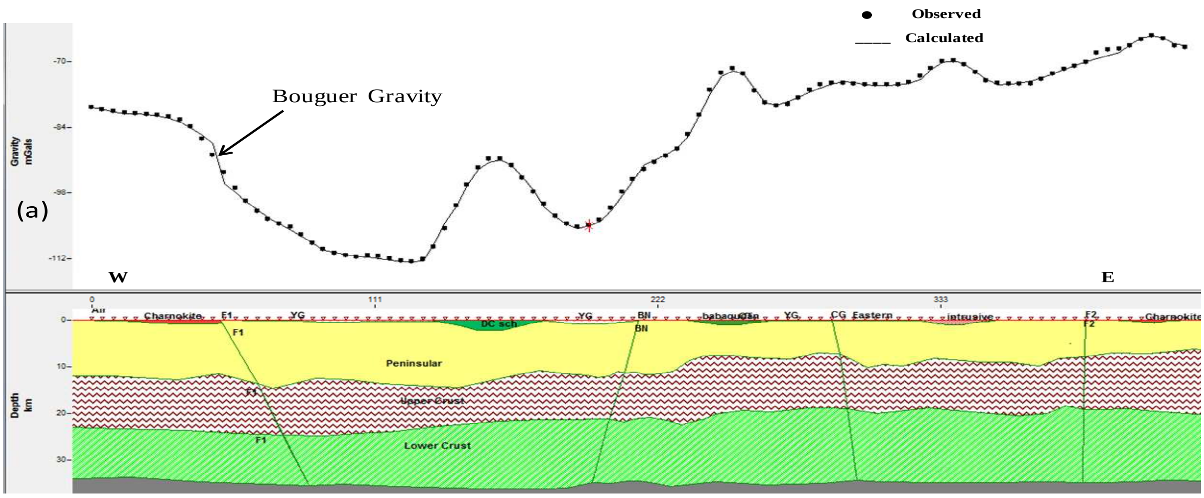

Figure.6.1: Inversion of Bouguer gravity and inferred crustal section along of Travers-4 (parallel to Latitude 13°30' E)

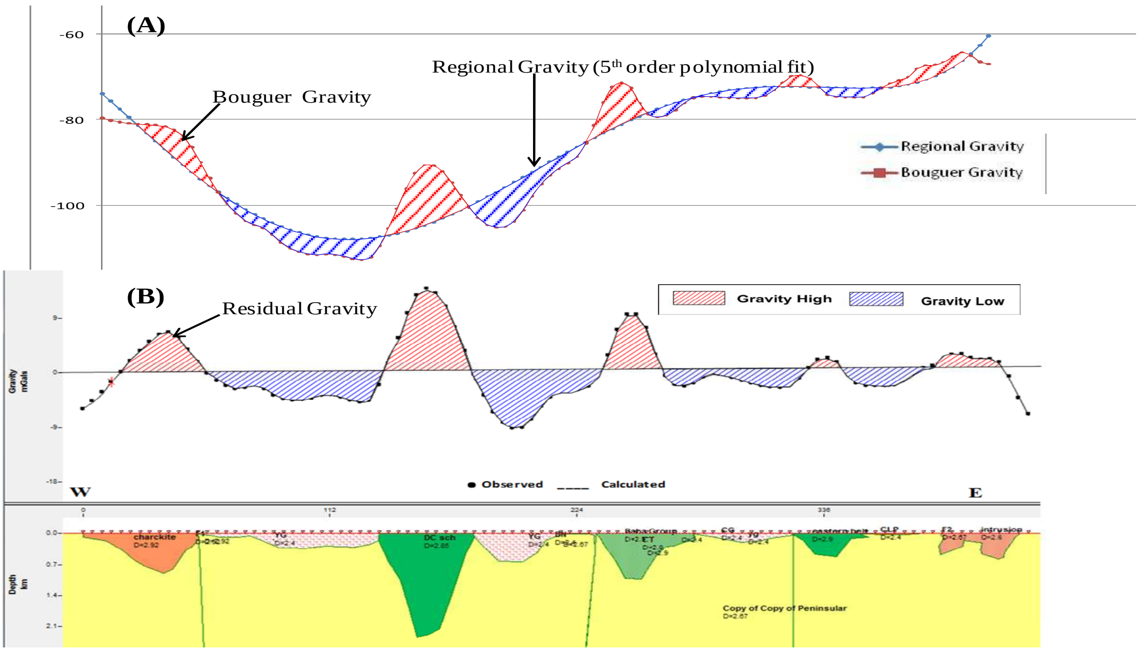

Figure .6.2 (A): 5th Order Polynomial fit for Regional Gravity along Travers-4 (parallel to Latitude 13°30'E)

(B): Inversion of Residual Bouguer gravity and inferred supra crustal along of Travers-4 (parallel to Latitude 13° 30'E)

Travers-5: This traverse (Figure.7.1) running through the Maktal and north of the Simoga and Hindupur villages from west to east along Latitude-14° is approximately 424km in length. The Bababudan group having high gravity value at 8.6 mgal with density 2.9 g/cc and maximum width of 59km and 2.27 km depth respectively, sargur belt having high gravity value at 4.25 mgal with density 2.8 g/cc and maximum width of 48 km and 2.07 km depth respectively, Closepet having low gravity value at 8.26 mgal with density 2.4 g/cc and maximum width of 17 km and 16 km and 0.18 km and 0.15 depth respectively, Dharwar schist having high gravity value at 1.91 mgal with density 2.8 g/cc and maximum width of 27 km and 1.55 km depth respectively,Younger grnite having low gravity value at -6.59 mgal with density 2.4 g/cc and maximum width of 21km and 0.19 km depth respectively, Chitradurga schist belt having high gravity with density 2.85 g/cc and maximum width of 93 km and 0.41 km depth respectively and The Intrusive having high gravity value at 2.8 mgal and maximum width of 66 km and 0.57 km depth respectively

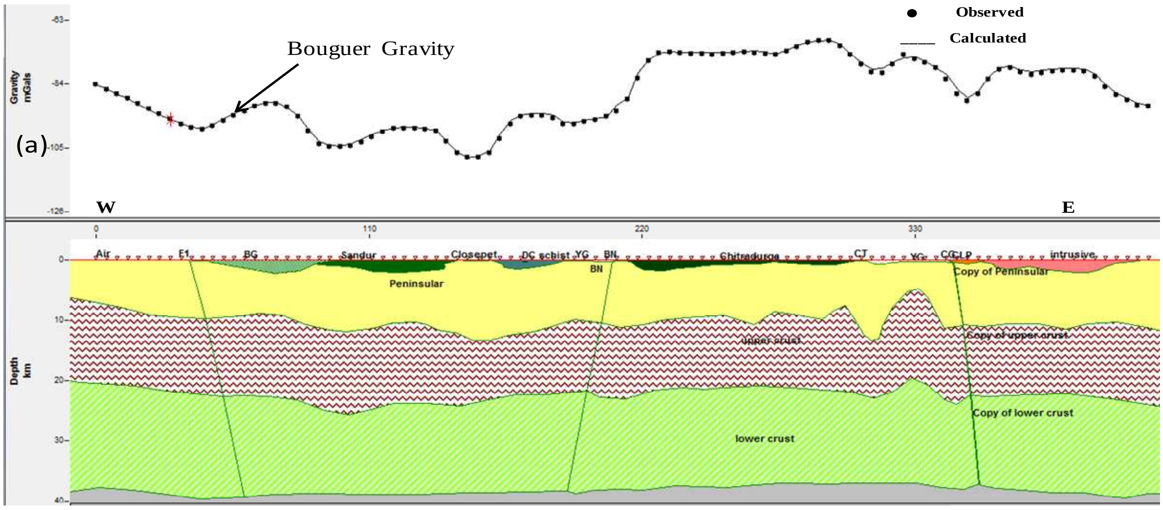

Figure.7.1: Inversion of Bouguer gravity and inferred crustal section along of Travers-5 (parallel to Latitude 14° E)

There are three dipping faults i.e BN, F1 and CG is indicated at the 141km, 209 km and 342 km and one local fault are identified i.e CT evidented at 302 km. Peninsular thickness is minimum 7 km, maximum 13 km, Upper crustal a thickness is minimum 20 km, maximum 25 km and Deeper crustal thickness is minimum 36 km and maximum 40 km.

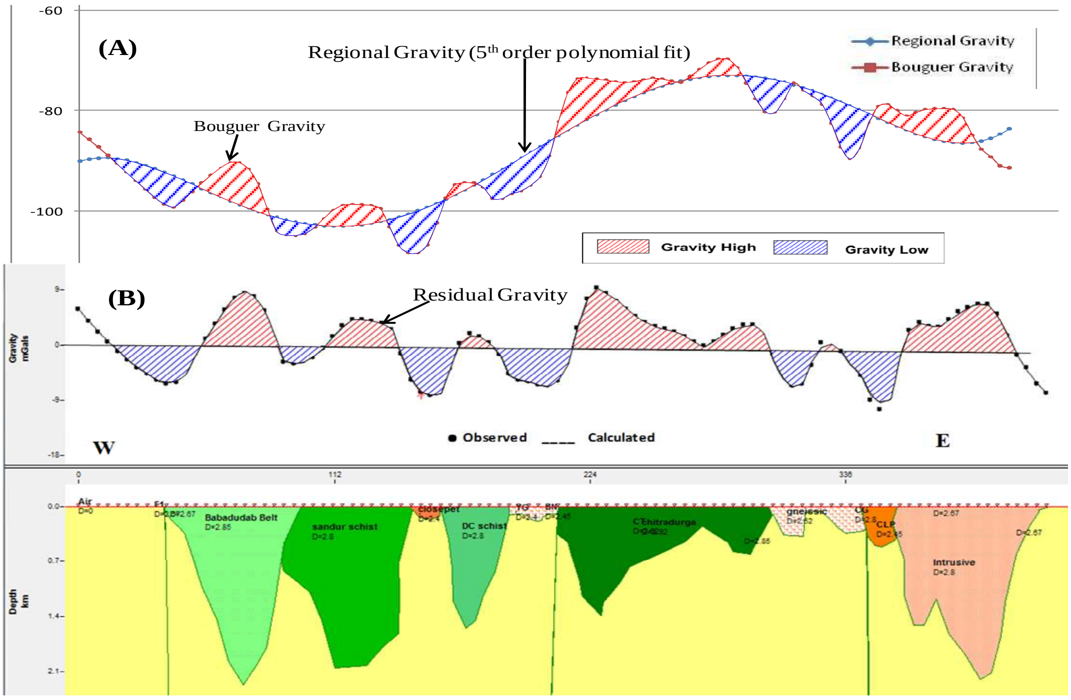

Figure .7.2 (A): 5th Order Polynomial fit for Regional Gravity along Travers-5 (parallel to Latitude 14°E)

(B): Inversion of Residual Bouguer gravity and inferred supra crustal along of Travers-5 (parallel to Latitude 14°E)

Travers-6: This traverse (Figure.8.1) running north of Devangere and Darmavarum villages from west to east along Latitude-14°30' is approximately 460 km in length. The Dharwar Craton having high gravity value at 5.63 mGal with density 2.85 g/cc and maximum width of 188 km and 1.75 km depth respectively, Younger granite having low gravity value at -5.81 mGal with density 2.4 g/cc and maximum width of 27 km and 3.13 km depth respectively, CSB having high gravity value at 13.22 mGal with density 2.9 g/cc and maximum width of 74 km and 3.13 km depth respectively, Closepet granites having low gravity value at -6.0 mGal with density 2.4 g/cc and maximum width of 49km and 0.25 km depth respectively and Intrusive having high gravity value at 11.75 mGal with density 2.9 g/cc and maximum width of 54 km and 1.97 km depth respectively.

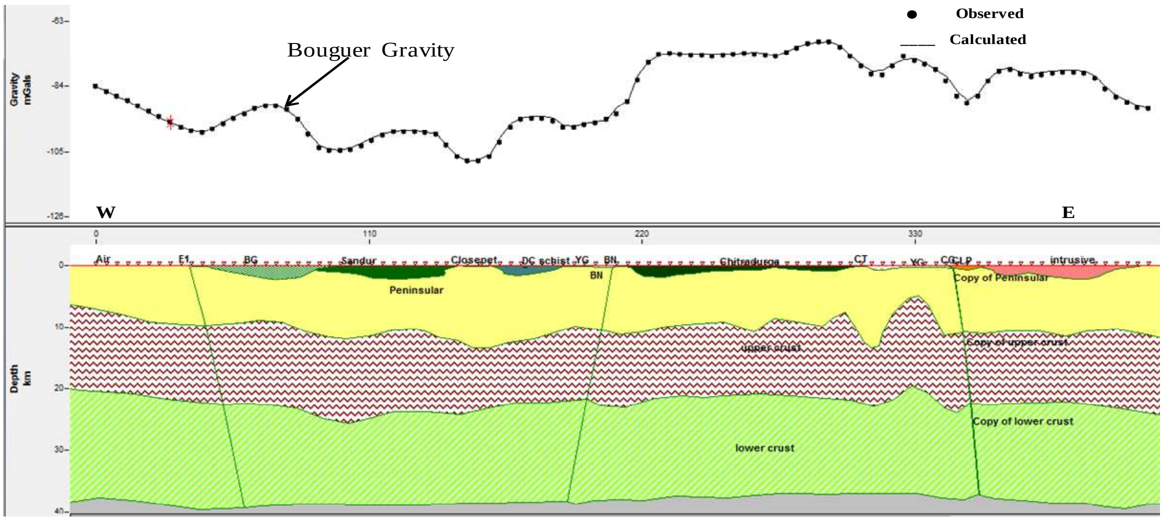

Figure.8.1: Inversion of Bouguer gravity and inferred crustal section along of Travers-6 (parallel to Latitude 14°30ˡ E)

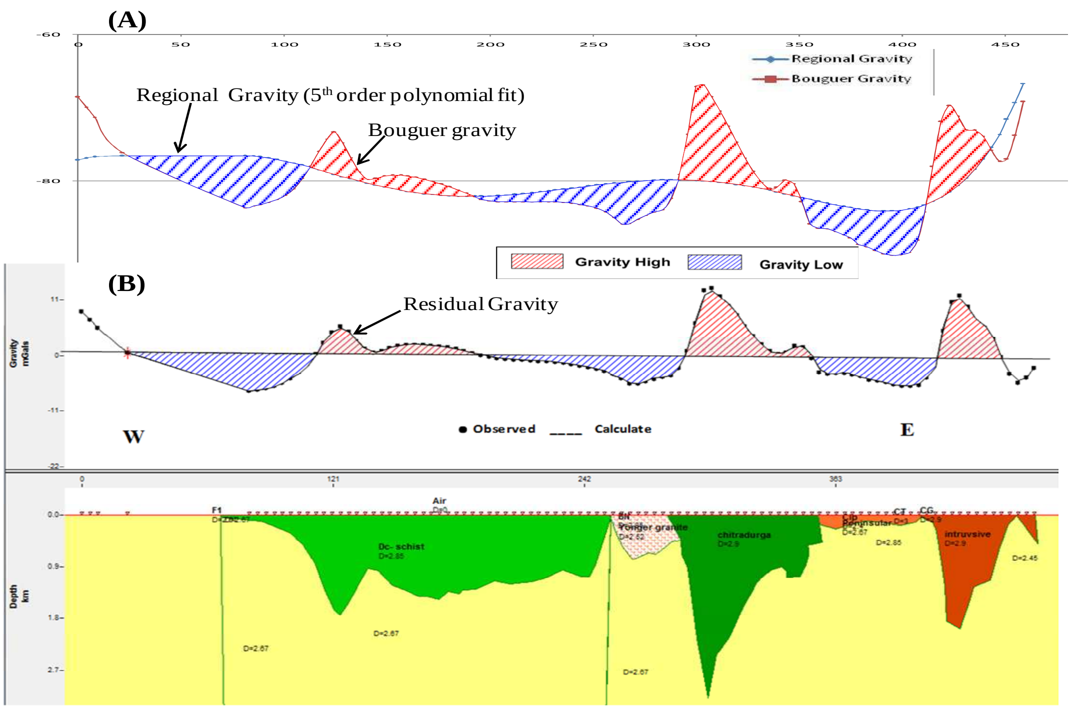

Figure .8.2 (A): 5th Order Polynomial fit for Regional Gravity along Travers-6 (parallel to Latitude 14°30ˡE)

(B): Inversion of Residual Bouguer gravity and inferred supra crustal along of Travers-6 (parallel to Latitude 14°30ˡE)

There are two dipping faults i.e BN and CG and three small fault, CT and f5 is indicated at the 254 km and 403km and shallow depth faults located at 66.44 km, and 354 km which is marked by all the underline layers which were infer from qualitative analysis (Figure. 2). Surface expressing of these faults the contact between the Yonger granite and Penisular gneissic. Peninsular thickness is minimum 6km, maximum 10km, Upper crustal a thickness is minimum 16km, maximum 21km and Deeper crustal thickness is minimum 33km, maximum 34km.

Travers-7: This traverse (Figure.9.1) runs from west to east along Latitude-15° is approximately 513km in length the crustal section along this profile is for the major part marked by gentle undulations. The Dharwar Craton having high gravity value at 7.86 mgal and 6.57 mGal with density 2.9 g/cc and maximum width of 67km and 60 km , 2.22 km and 2.74 km depth respectively, Younger granite having low gravity value at-7.58 mGal,-1.72 mGal, -7.44 mGal and -12.44 mgal with density 2.4 g/cc and maximum width of 64 km,24 km, 67km and 30 km and 0.82 km, 0.60km, 1.14 km and 0.49 km depth respectively, CSB having high gravity value at 7.14 mgal with density 2.85 g/cc and maximum width of 43 km and 3.42 km depth respectively, Eastern belt having high gravity value at 12 mgal with density 2.85 g/cc and maximum width of 96 km and 4.31 km depth respectively and Cuddapah having high gravity value at 10.43 mgal with density 2.8 g/cc and maximum width of 59km and 2.27 km depth respectively.

There are three dipping faults i.e F3, BN and CG and one small fault CT is indicated at the 67 km, 191 km and 421km and 323 km shallow depth faults which is marked by all the underline layers which were infer from qualitative analysis (Figure. 3g). Surface expressing of this fault the contact between the Yonger granite and Penisular gneissic. Peninsular thickness is minimum 9km, maximum 13km, Upper crustal a thickness is minimum 20km, maximum 24km and Deeper crustal thickness is minimum 36km and maximum 39km.

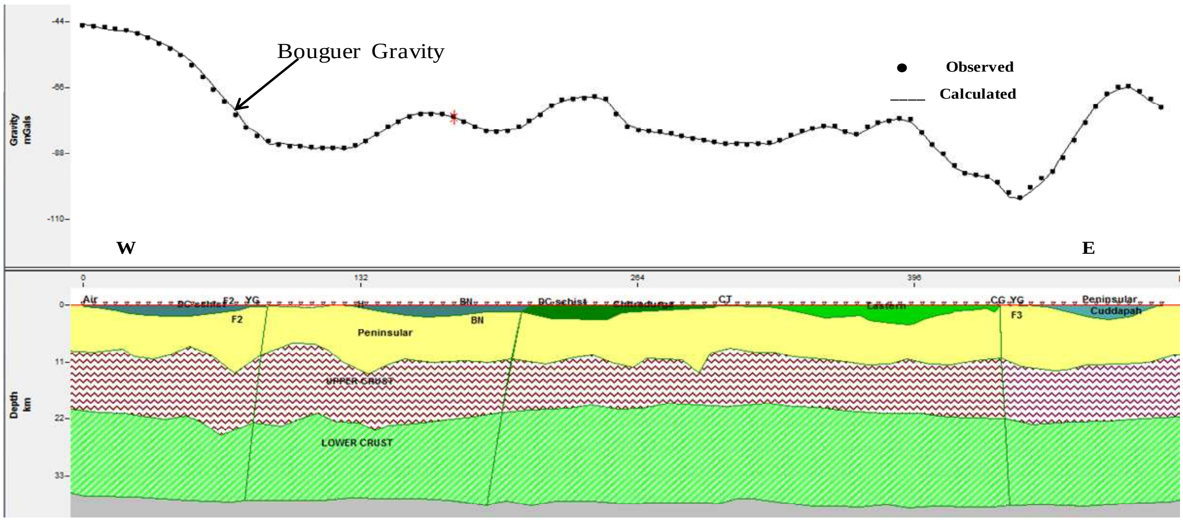

Figure.9.1: Inversion of Bouguer gravity and inferred crustal section along of Travers-7 (parallel to Latitude 15° E)

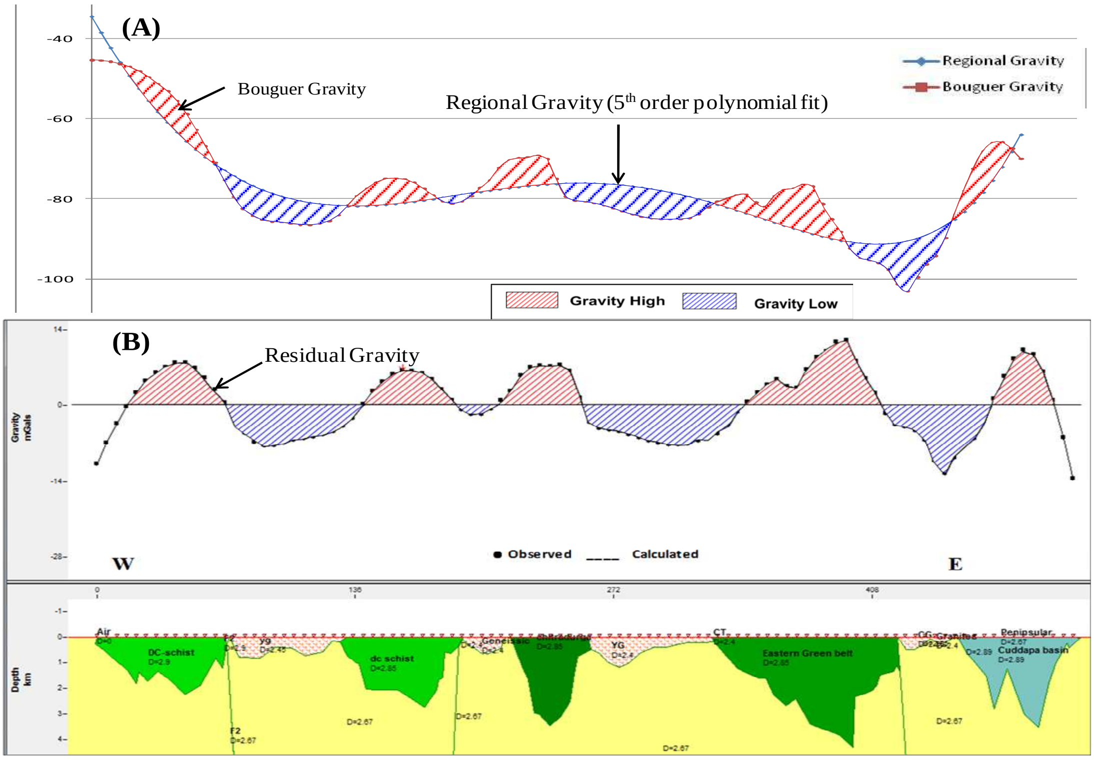

Figure .9.2 (A): 5th Order Polynomial fit for Regional Gravity along Travers-7 (parallel to Latitude 15°E)

(B): Inversion of Residual Bouguer gravity and inferred supra crustal along of Travers-7 (parallel to Latitude 15°E)

Travers-8: This traverse (Figure.10.1) running near Panjim, Hubli, gadag and Londa villages from west to east along Latitude-15°30' is approximately 528km in length is north to the travers-7. thickness is 2.89km, closepet width varying 466 to 496km and thickness is 5.81k m and cuddapah width varying 496km to 529 and thickness is 3.71km. The dharwar having high gravity value at 10.55 mgal with density 2.9 g/cc and maximum width of 87 km and 2.63 km depth respectively, Younger granite having low gravity value at -14.16 mgal and -3.25 mGal with density 2.4 g/cc and maximum width of 57 km and 85 km , 3.32 km and 4.45 km depth respectively, CSB having high gravity value at 8.09 mgal with density 2.85 g/cc and maximum width of 51 km and 4.94 km depth respectively, Closepet having low gravity value at -2.93 mgal with density 2.45 g/cc and maximum width of 55 km and 1.46 km depth respectively, Intrusive having low gravity value at -5.71 mgal with density 2.6 g/cc and maximum width of 31 km and 5.79 km depth respectively,and Cuddapah having high gravity value at 4.24 mgal with density 2.8 g/cc and maximum width of 31 km and 3.6 km depth respectively.

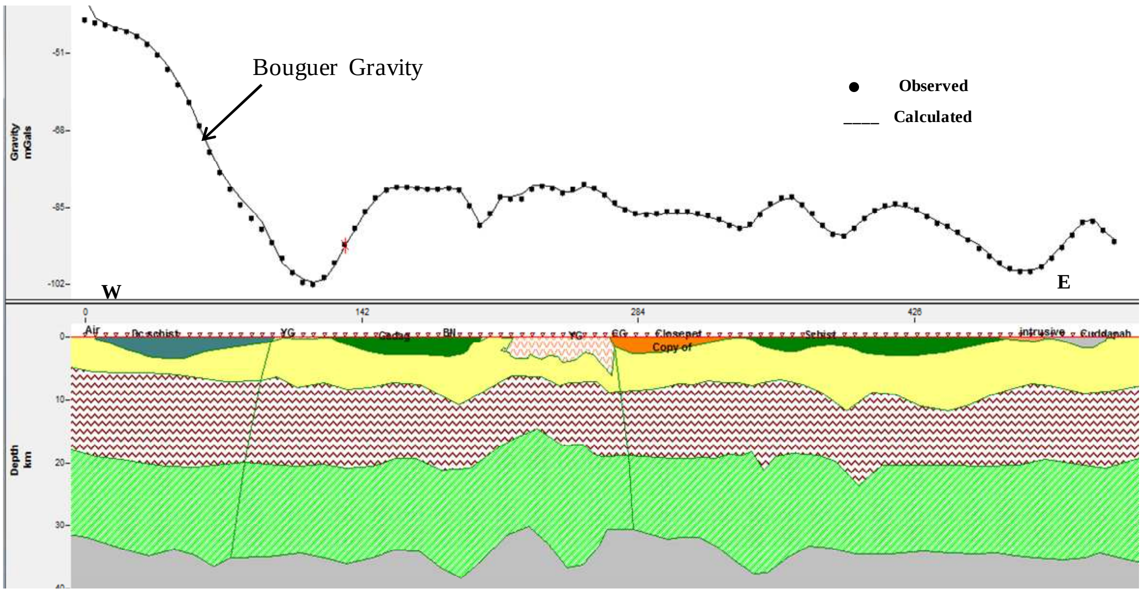

Figure.10.1: Inversion of Bouguer gravity and inferred crustal section along of Travers-8 (parallel to Latitude 15°30ˡ E)

There are two dipping faults i.e BNand CG and one small fault CT is indicated at the 89 km, and 337 km and 199 km. Peninsular thickness is minimum 6km, maximum 9km, Upper crustal a thickness is minimum 17km, maximum 20km and Deeper crustal thickness is minimum 34km, maximum 36km.

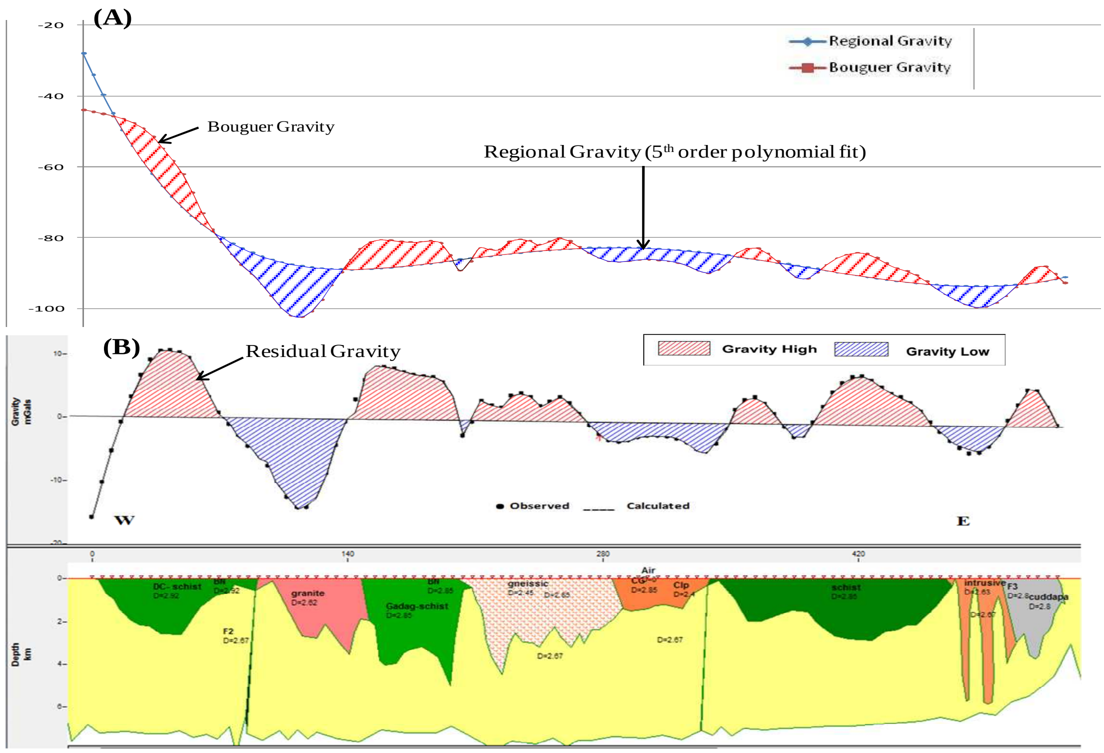

Figure .10.2 (A): 5th Order Polynomial fit for Regional Gravity along Travers-8 (parallel to Latitude 15°30ˡE)

(B): Inversion of Residual Bouguer gravity and inferred supra crustal along of Travers-8 (parallel to Latitude 15°30ˡE)

Travers-9: This traverse (Figure.11.1) running near to Belgum from west to east along Latitude-16° is approximately 554km in length. Deccan Basalt having high gravity value at 8.08 mgal with density 2.85 g/cc and maximum width of 286 km and 1.26 km depth respectively, Bhima belt having high gravity value at 15.93 mgal with density 2.85 g/cc and maximum width of 106 km and 3.5 km depth respectively, Closepet having low gravity value at -11.56 mgal with density 2.45 g/cc and maximum width of 41km and 0.26 km depth respectively and Intrusive having low gravity value at 2.36 mgal with density 2.6 g/cc and maximum width of 120 km and 4.0 km depth respectively.

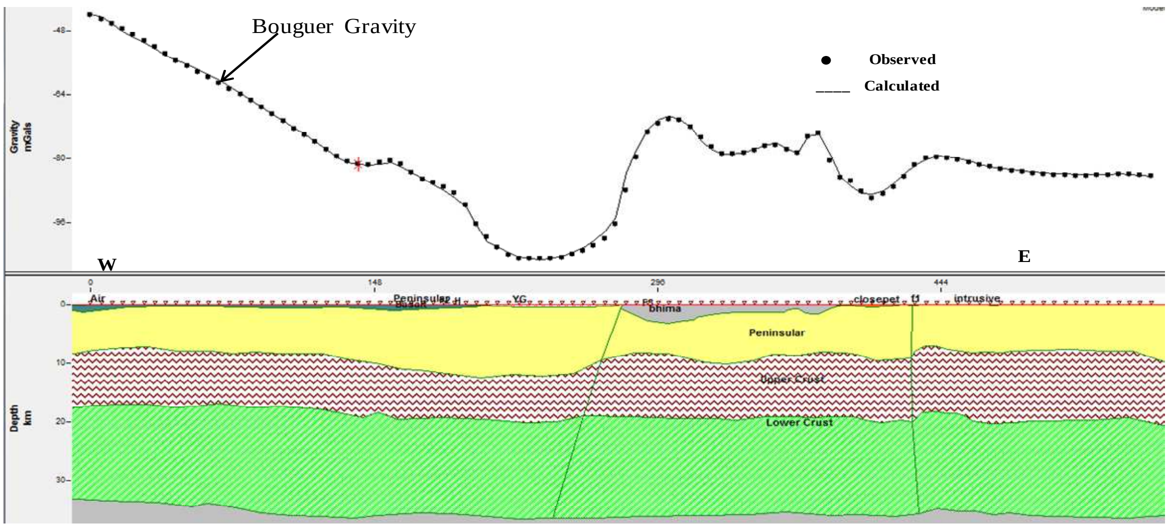

Figure.11.1: Inversion of Bouguer gravity and inferred crustal section along of Travers-9 (parallel to Latitude 16°E)

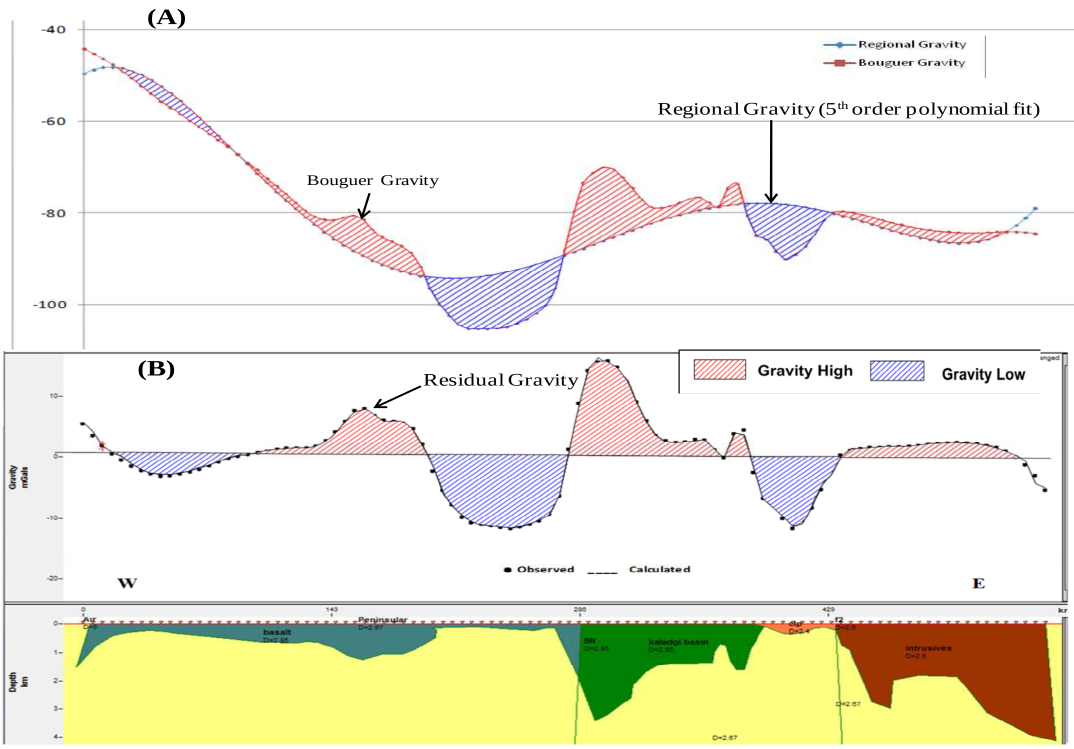

Figure .11.2 (A): 5th Order Polynomial fit for Regional Gravity along Travers-9 (parallel to Latitude 16°E)

(B): Inversion of Residual Bouguer gravity and inferred supra crustal along of Travers-9 (parallel to Latitude 16°E)

There are one dipping faults i.e BN and one local faults f9 is indicated at the 286km and local faults at 432km, which is marked by all the underline layers which were infer from qualitative analysis (Figure. 2). Surface expressing of these fault the contact between the Yonger granite and Penisular gneissic. Peninsular thickness is minimum 8km, maximum 12km, Upper crustal a thickness is minimum 17km, maximum 20km and Deeper crustal thickness is minimum 34km, maximum 36km.

Travers-10: This traverse (Figure.12.1) running near Talikota from west to east along Latitude-16°30' is approximately 570km in length. Deccan Basalt having high gravity value at 9.54 mgal with density 2.9g/cc and maximum width of 250 km and 2.06 km depth respectively, Younger granite having low gravity value at -10.77 mgal with density 2.6 g/cc and maximum width of 32 km and 1.24 km depth respectively, Bhima belt having high gravity value at 7.21 mgal with density 2.85 g/cc and maximum width of 98 km and 1.5 km depth respectively, losepet having high gravity value at -4.73 mgal with density 2.45 g/cc and maximum width of 100 km and 1.07 km depth respectively and Eastern green having high gravity value at 5.70 mgal with density 2.85 g/cc and maximum width of 55 km and 1.28 km depth respectively.

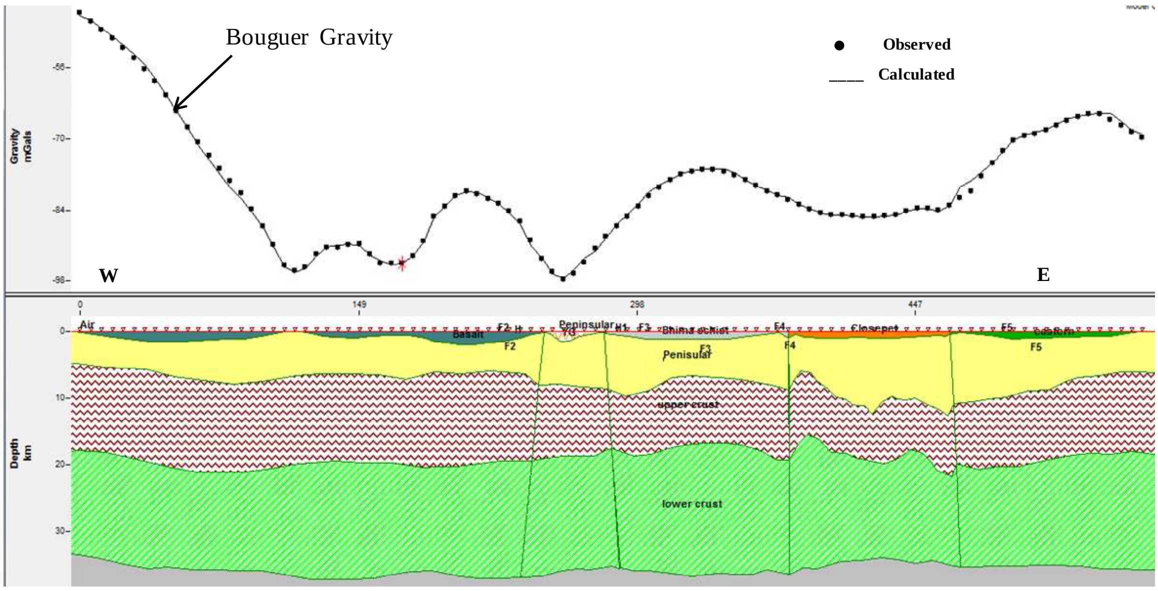

Figure.12.1: Inversion of Bouguer gravity and inferred crustal section along of Travers-10 (parallel to Latitude 16°30' E)

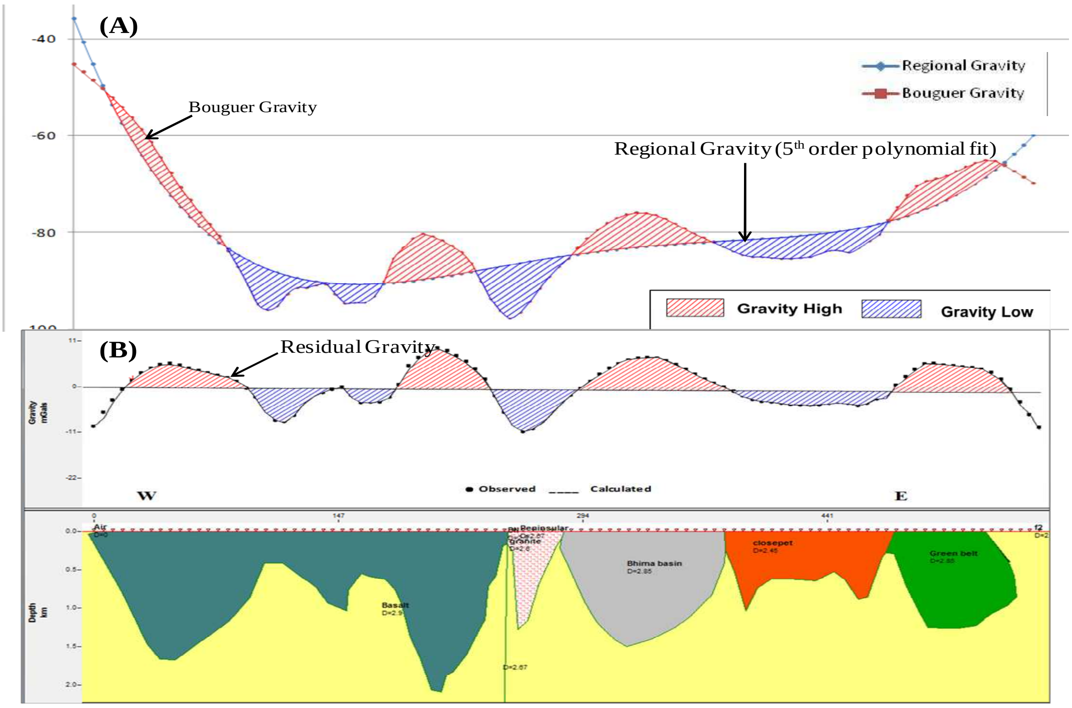

Figure .12.2 (A): 5th Order Polynomial fit for Regional Gravity along Travers-10 (parallel to Latitude 16°30ˡ E)

(B): Inversion of Residual Bouguer gravity and inferred supra crustal along of Travers-10 (parallel to Latitude 16°30ˡ E)

There are one dipping faults i.e F3 and four local faults f12 is indicated at the 250 km and local fault at 535km. Peninsular thickness is minimum 7km, maximum 10km, Upper crustal a thickness is minimum 18km, maximum 22km and Deeper crustal thickness is minimum 35km, maximum 37km.

Travers-11: This traverse (Figure.13.1) runnig through the Ratnagiri from west to east along Latitude-17° is approximately 583km in length. The Deccan Basalts having high gravity value at 17.81 mgal and 5.10 mGal with density 2.9 g/cc and maximum width of 195 and 98 km and 1.46 km and 1.11 depth respectively,. Bhima belt having high gravity value at 10.57 mgal with density 2.85 g/cc and maximum width of 204 km and 2.29 km depth respectively and Closepet having low gravity value at -7.12 mgal with density 2.45 g/cc and maximum width of 76 km and 0.16 km depth respectively.

There are one dipping faults i.e F3 and two local faults f12,f9 is indicated at the 195km and local faults at 399km and 573km. Peninsular thickness is minimum 6km, maximum 12km, Upper crustal a thickness is minimum 21km, maximum 24km and Deeper crustal thickness is minimum 35km, maximum 37km.

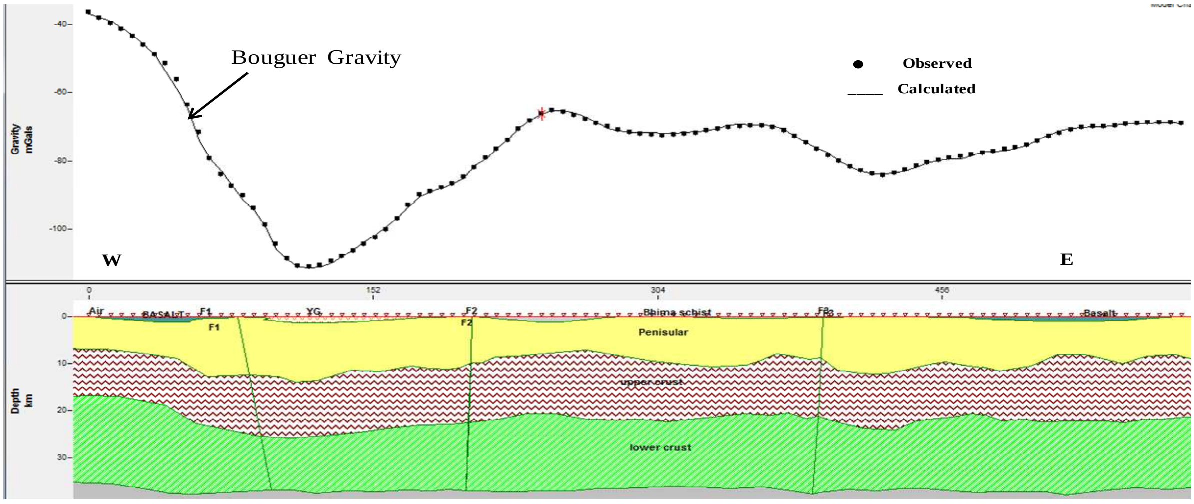

Figure.13.1: Inversion of Bouguer gravity and inferred crustal section along of Travers-11 (parallel to Latitude 17° E)

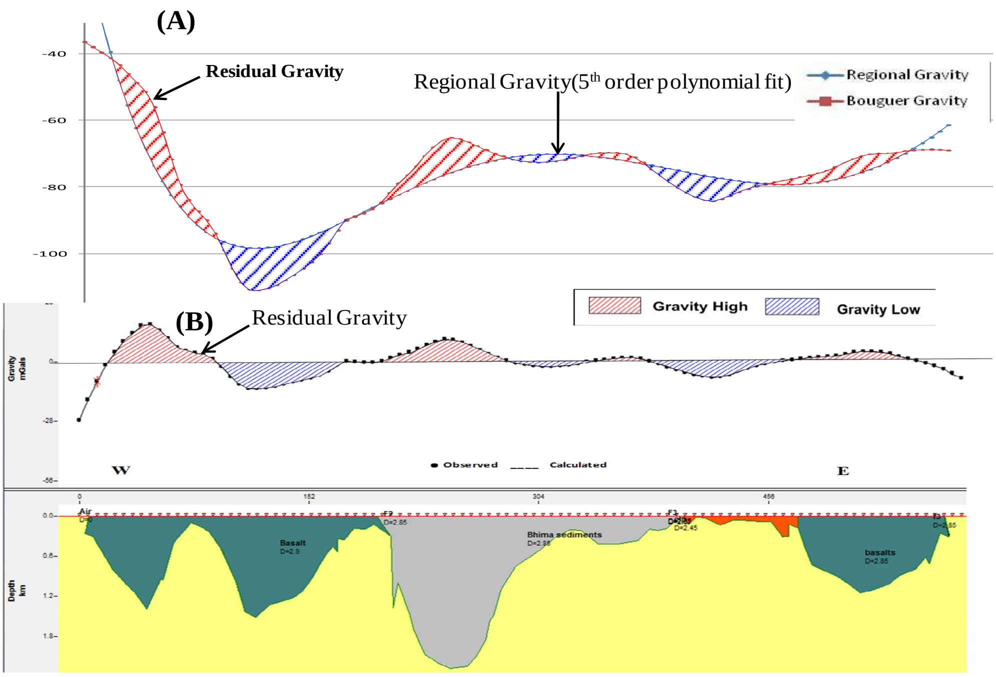

Figure .13.2 (A): 5th Order Polynomial fit for Regional Gravity along Travers-11 (parallel to Latitude 17° E)

(B): Inversion of Residual Bouguer gravity and inferred supra crustal along of Travers-11 (parallel to Latitude 17° E)

Sub-Surface Topography of the Supra Crustal layers:

The depths of each of the layers: Sargur group (Ancient supracrustal), Older and younger Gneissic complex, Larger schist belt , Younger Granites, Granulites, Younger intrusive Dyke Swaps, Deccan Traps, Chitradurga Schist Belt (CSB) and Bhima basin, along the Travers in the Dharwar craton are digitized and presented as 3D contour images.

Ancient Supra crustal (Sargur Type):
The maximum thickness of the younger granite is 2.05km observer at Traver-5 (14°E), The oldest rock dated so far in Karnataka are a group of grey gneisses giving an age ranging from 3000-3400 m.y. The Sargur group of rocks occur as independent enclaves, thin silvers and tectonic slices within the Peninsular gneisses confined mainly to the southern fringes of the lower-grade terrain of the Dharwar Craton and occur within the transition zone between the northern lower-and southern higher- grade terrain.

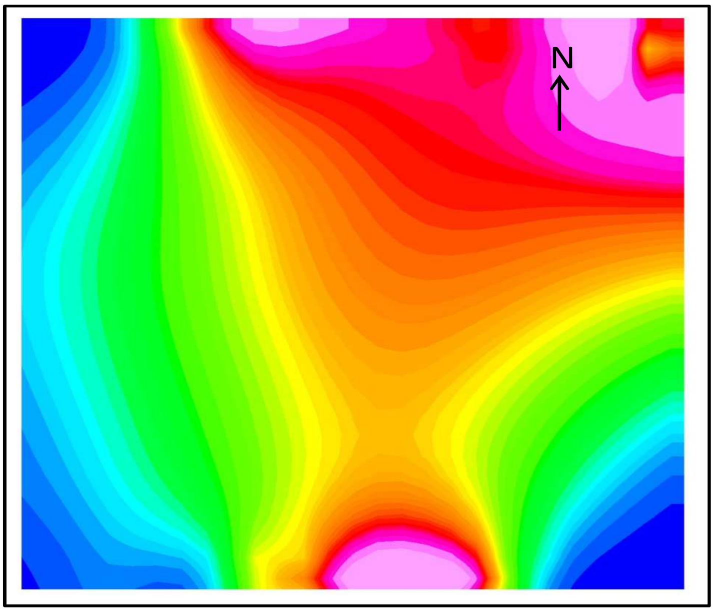

Figure14.a: Bouguer gravity contour map of Sargur belt

The sargur belts characterized by a well detected position gravity anomaly was maximum depth of 3.2 mGal observed. The geophysical investigation method obtain figure.. a depth of about is 2.05km has been obtained for the Sargur belt. From 3D figure that belt (SG) extended upto 1.5 km is probably the result of folding and shallow depth of north plunging system structure.

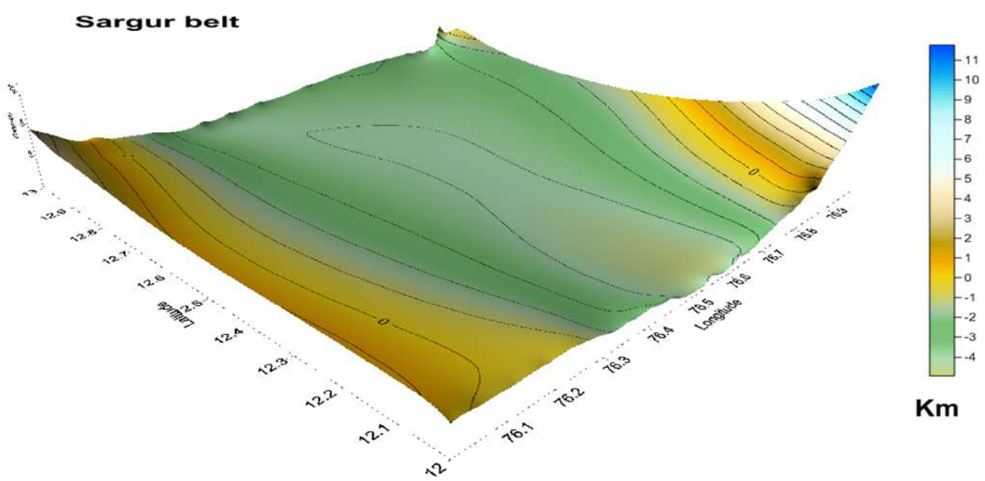

Figure.14 (b): 3D contour map of Sargur belt

2) Older and Younger Gneisses Complex (OGC)

These extensive groups of gray gneisses are designated as the "Older Gneissic Complex" acting as the basement for an extensive belt of schists. The Gneisses records whole rock age ranging from 3400 m.y. to 3000 m.y. (Radhakrishna B. P. and Naqui, 1986) A younger group of gneissic rocks are found in the eastern parts of the state. The rocks belonging to this group are aged from 2500-2800 m.y. mostly of granodioritic and granitic in composition

Gravity values over this unit are generally low ranging fromn 0.6 to 2.0 km and they gradually increasing towards the west coast up. In the interior of the continent mild gravity lows are observed to the west Bengal. Few lows are seen are atrtribute to small granitic intrustions concealed under a thin gnesissic cover.

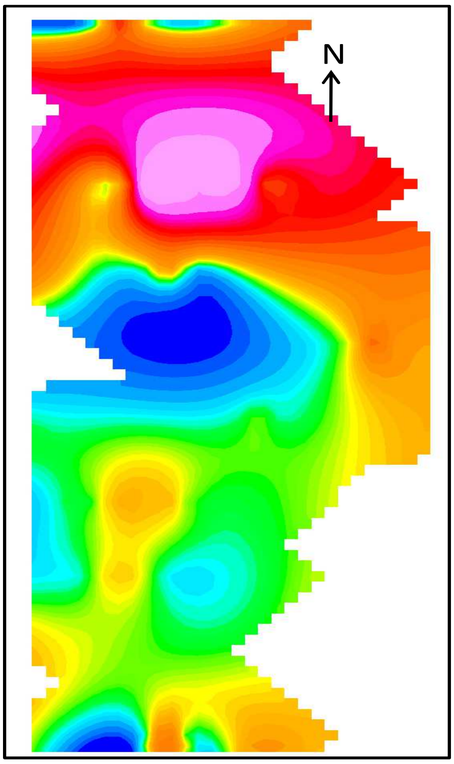

Figure.15 (a): Bouguer gravity contour map of Younger Granite

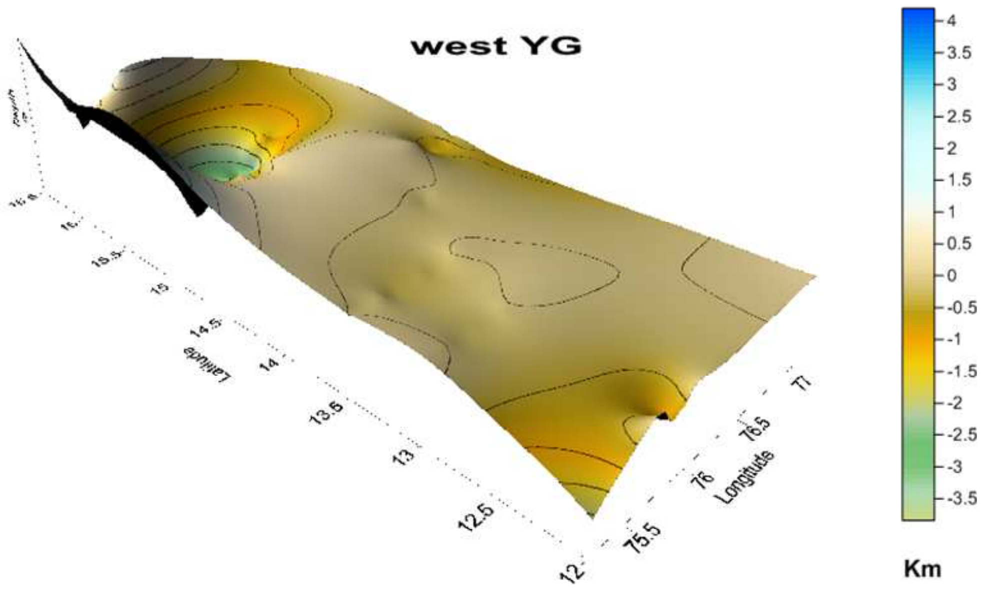

Figure.15.(b): 3D contour map of Younger Granite

The bouguer gravity varies from south to north with a magnitude of more than 2 mGal (shown in figure) which show the colour shaded image (figure.6b) it is evident that there are present only in the northern part exposes appear able to concentrate as circular features.

The maximum thickness of the younger granite is 4.5km observer at Traver-8 (15°.30'E), appear to be concentrated as a circular features with a maximum depth of 4.5 km and is very uneven in general. The depths of crustal column estimated is km.

3) Larger Schist Belts (Dharwar Type):
These are the prominent schistose rocks of Karnataka named "Dharwar schist belt" which has been given a super group status. They are of late Archaean and belong to the age group of 2900-2600 m.y. the two main divisions in this super group are recognized. The older is mainly igneous in character and named as "Chitradurga group". Overlying this is a more extensive group of schistose, largely sedimentary in nature, composed of conglomerates, quartzite, limestone, graywacke and associated manganiferrous and ferruginous cherts. The "Rani Bennur group" is the youngest series of sediments, mostly greywacke in composition and intercalated with cherty iron formation. The maximum thickness of the Dharwar craton is 2.7km observer at Traver-7 (15°E).

The sub surface topography of dharwar Schist (western Dharwar) is very marked figure.7b. The depth varying -2 to 3.2 km as compared to P.G where there are maximum depth accured at North and central part of the Dharwar Craton and estimation of densities and areal extent of the different rock type within the Dharwar schist and adjoining gneisses shows as a high gravity positive anomaly the varying nature of depth of the schist belt is probably the result of folding and shallow formal structure. From figure.7a characterized by three gravity closers characterized by amplitude of 1.8 mGal at western part of the area towards elongated contours indicated the varying nature of the Dharwar schist. This is further sustained by the disposition of gravity maximum in the western part of the belt. However lows are appearing over peninsula and the crustal is estimated at slightly shallower depth (343 km)s s merging come highs with a rise in anomaly level above the regional field. The gravity gradient is steep at the eastern.

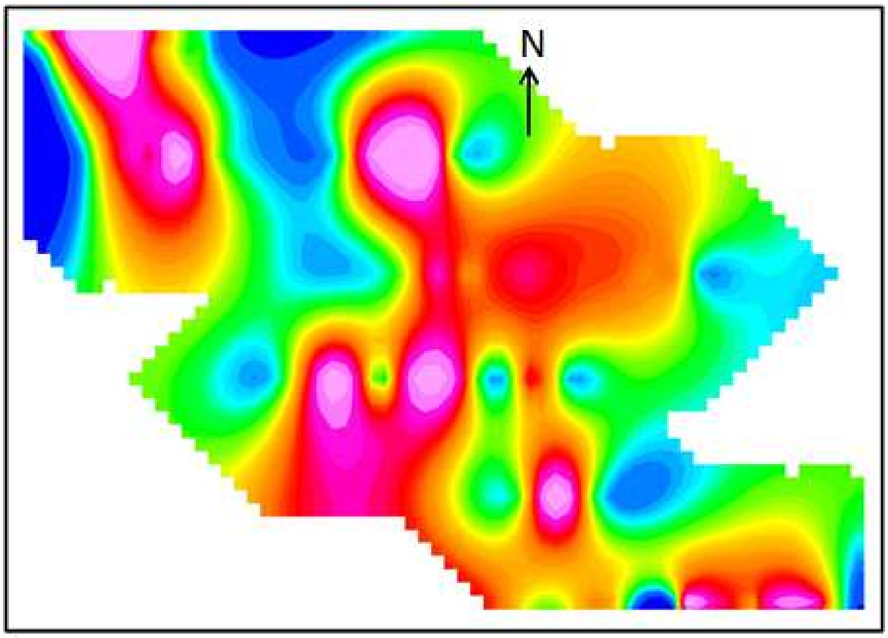

Figure16 (a): Bouguer gravity contour map of Dharwar Craton

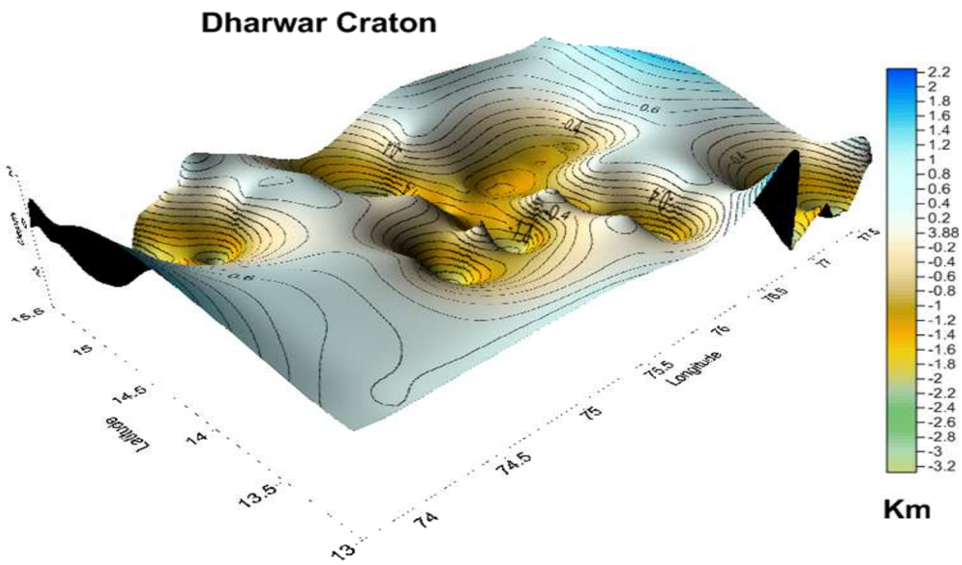

Figure16 (b): 3D contour map of Dharwar Craton

4) Closepet (Younger Granite):

The closepet batholiths, earlier believed to be the boundary between the eastern and western Dharwar Craton is represented by a fall in Bouguer gravity from -80 to 95 mGal. Over the closepet granite a general increase in values is observed towards west with different gradients. However, at the eastern contact, a few gravity low closures indicating the low density granite intrusive have been brought out. Th long wave length gravity high H4 may be correlated to deep seated structural high with a number of mafi inclusions. Gravity highs encountered in to regions where greenstone belts are absent can reasonably be attributed to high density intrusives and/or thinning of the crust. On the other hand, gravity lows are normally due to granitic intrusions and/or thickening of the crust

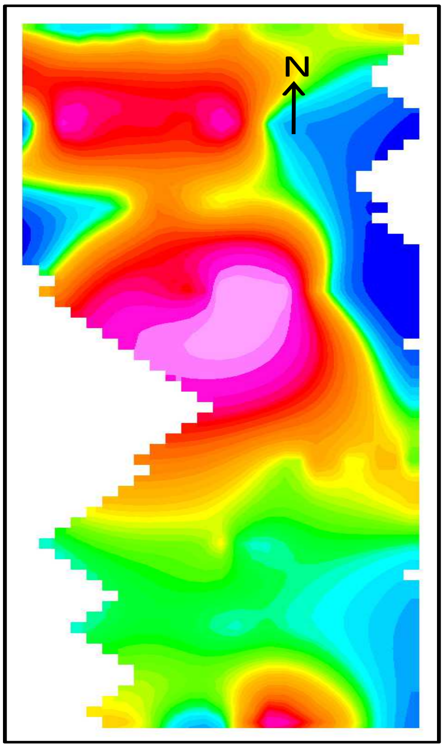

Figure.17 (a) : Bouguer gravity contour map of Closepet Granite

The Closepet granite forms a long linear belt of younger Pottassic granites extending over a length of nearly 500 km. However, between the latitudes 13° and 14.5° N it is flnked on its west by gravity high, whose axis closely follows the trend of the Closepet granite (Fig. 8a). South of 13° latitude it is flnked on its east by abroad star shaped gravity low.

Gravity variation over the clospet granite showsn 0.3 to 1.2 km shows a small high relative to the surrounding granite bodies.

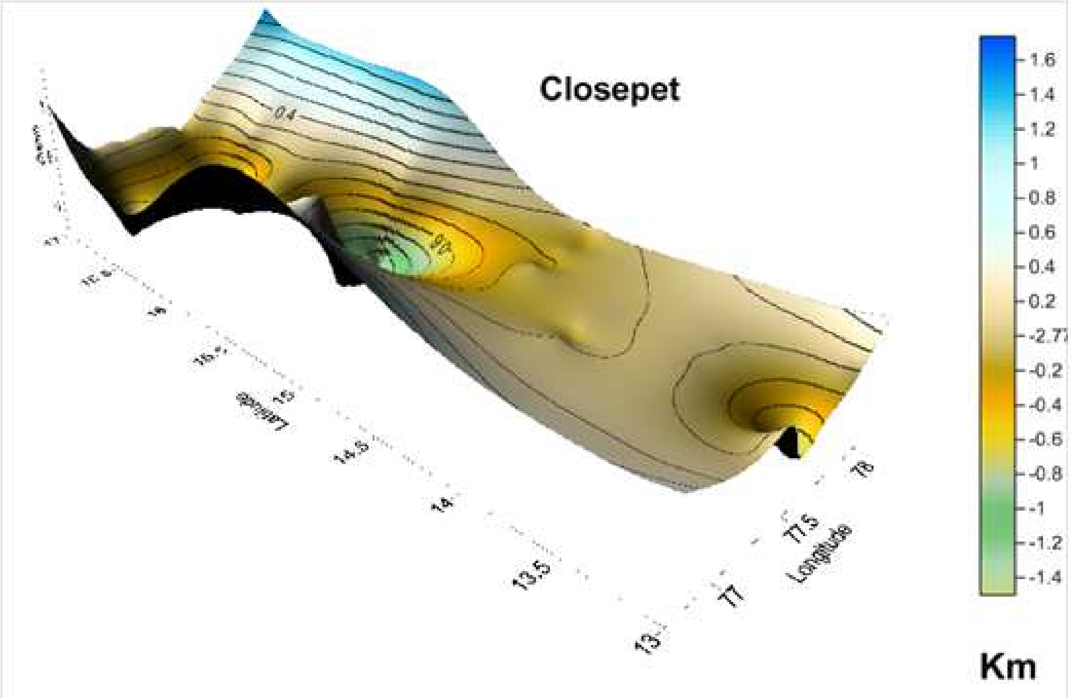

Figure.17 (b): 3D contour map of Closepet Granite

The liner belt of Closepet Granite is having a length of nearly 500 kms and an average width of 20-25 Kms. They are the most prominent of the younger granite. The trend of these Granites extends in a North-South direction and parallel to the structural grains of the host rock. These granites being the youngest, in point of age in the Arachaean complex of Karnataka is termed as 'Youngest Granites'and is also termed as 'Closepet granite', after the town of Closepet where the rock types were first recognized [51]. The geocronological data suggest that the two major events experienced in the emplacement of Closepet Granite at 2400-2600 m.y. and 2000 m.y. Chitradurga and Banawara groups belongs to the same age. The most characteristic rock type of this class is coarse-grained porphyritic granite with large-sized pophyroblasts of pink and grey potash feldspar.

Over the Closepet granite a general increase in gravity values is observed towards Northwest part with different gradient. However at the eastern contact gravity intrusive has been brought out shown in figure (8a). The bouguer gravity also indicated a narrow zone and two gravity highs are observed. The corresponding depth also indicated 1.4 to 1.8 km was estimated and indicating ups and downs. The maximum thickness of the Closepet is 1.7 km observer at Traver-8 (15°.30'E).

5) Charnokite (Granulites):

In the Southern part of the Dharwar Craton are granulites facies rocks represented with extensive development of Charnokite and pyroxene granulite. A vast granulitemigmatitic complex, known as the Coorg granulites complex (CGC), is exposed in the western part of Mysore, which is mainly composed of Peninsular gneisses, migmatites, basic and ultra basic intrusive, high grade schist and granulite-facies rocks. Geochronological data indicates an age of 2500-2700 m.y. These are alternation of the older gneisses.

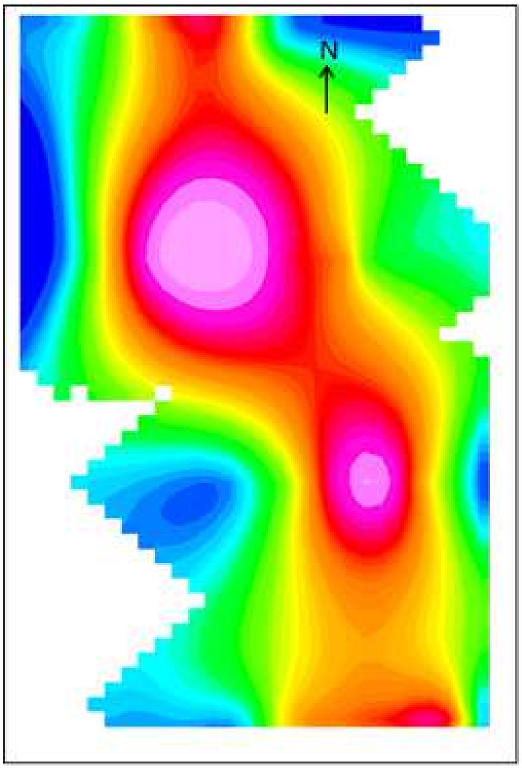

Figure.18 (a): Bouguer gravity contour map of Charnokite

The Charnokite indicated from Bouguer gravity map two gravity highs observe over Northsouth (NS) trend with magnitude of 1.5 mGal and corresponding depth 3.8 km computed.

The sub-surface topography of the Charnokite is very compared to the Peninsular Gneisses layer. The maximum thickness of the sargur group is 1.5km observer at Traver-3(13°E).

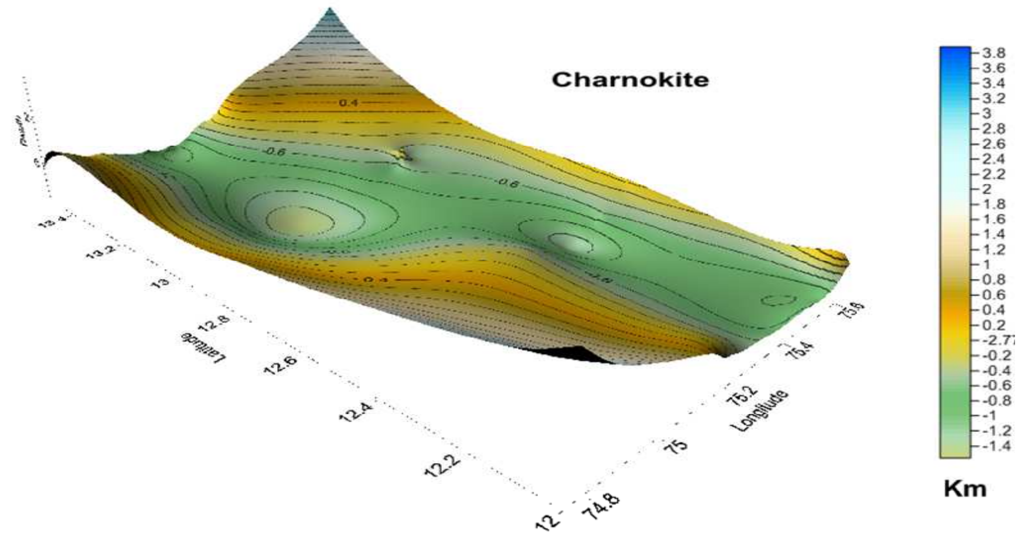

Figure.18 (b): 3D contour map of Charnokite

6) Younger Intrusive-Dykes Swamps:
Younger intrusive are the dyke-formation formed at the close of the Archaean era, ranging from dolerite to alkaline composition with both NS and SW trending dykes traversing rocks of earlier ages. These ultramafic of dolerite composition are found in the Eastern parts of Karnataka (Bangalore and Mysore).

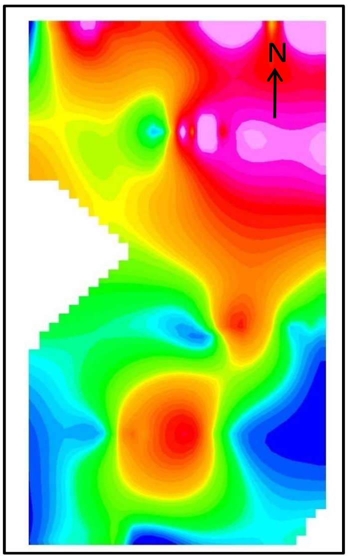

Figure.19 (a): Bouguer gravity contour map of Intrusive

It is observed that dykes on intrusive the gravity respon varying from 2.2 to 2.8 mGal in North-south direction corresponding depth computed 4 km estimated from inversion gravity modeling.
The maximum thickness of the Intrusive is 4.08km observer at Traver-9 (16°E).

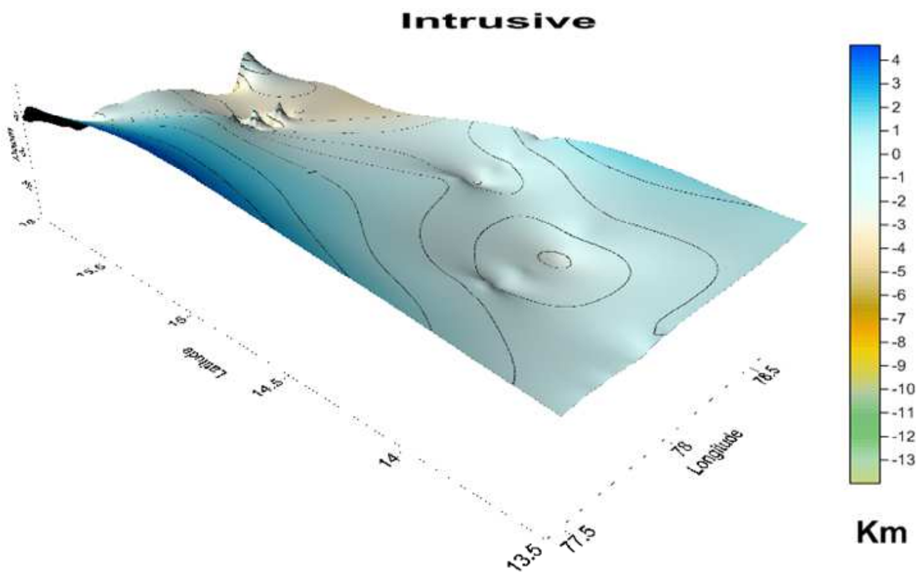

Figure.19 (b): 3D contour map of Intrusive

7) Deccan Traps:

The next major event is the burst of volcanic activity at the end of the cretaceousdawn of tertiary era. Deccan Trap rocks, especially basalts, cover a substantial part of northern Karnataka particularly the districts of Belgaum, Bidar, Bijapur and Gulbarga. This is represented by horizontal sheets of lava piling one upon the other over a thickness of nearly 2 Km and extending over an area of 5,000,000 Km2. The burst of volcanic activity was sudden and continues with hardly any interval between the flows. The volcanic episode was short not exceeding more than a million years. The fossils embedded in these suggest a tertiary age (Radhakrishna and Vaidyanatha, 1997). The western margin close to the coast was affected by large-scale dyke intrusion. The dyke assigned an age around 65 m.y. connects them with Deccan volcanic activity.

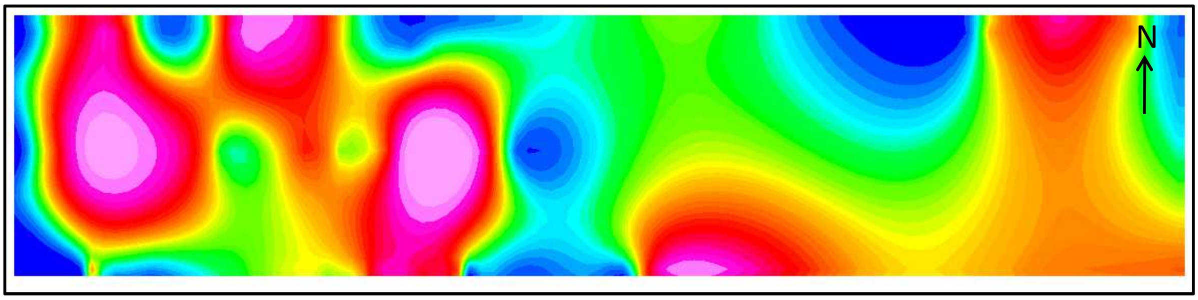

Figure.20 (a): Bouguer gravity contour map of Basalt

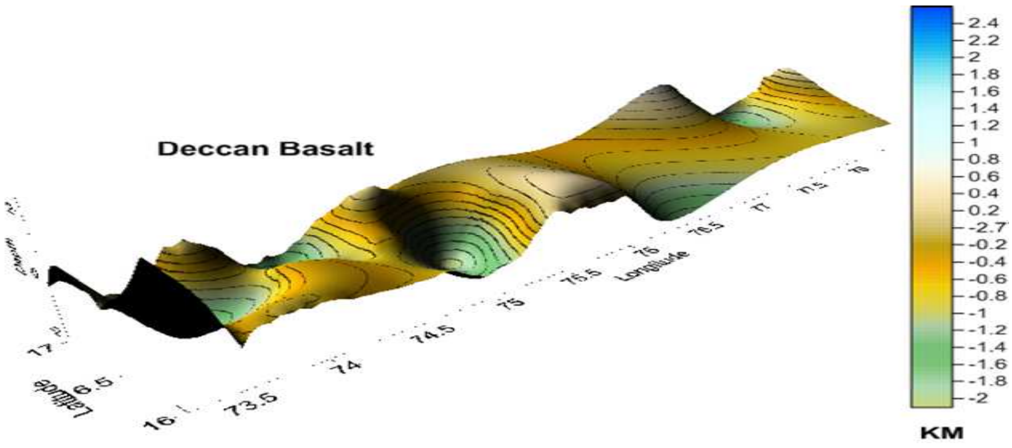

Figure.20. (b): 3D contour map of Basalt

The maximum thickness of the Deccan Basalt is 2.1km observer at Traver-8(15°.30'E) and it is approximately correlated to calculated value from the radial average power sprectrum.

8) Chitradurga Schist Belt (CSB):

Chtradurga Group of rocks, mainly exposed in Chitradurga, Sandur and ShimogaNorth Kanara-GOA shist belts, overly an oligomict or polymict granite clast conglomerate, which are deposited on a basement of tonalitic-granitic gneisses [60]. The basal beds are overlain by basic metalavas and amphibolites, interbedded with cross quartzites and siliceous phyllites and further by.

polymict conglomerate (Taylor conglomerate). The rocks of Chitradurga Group are metamorphosed to lower amphibolites facies in border zones and Green schist faces in the central parts

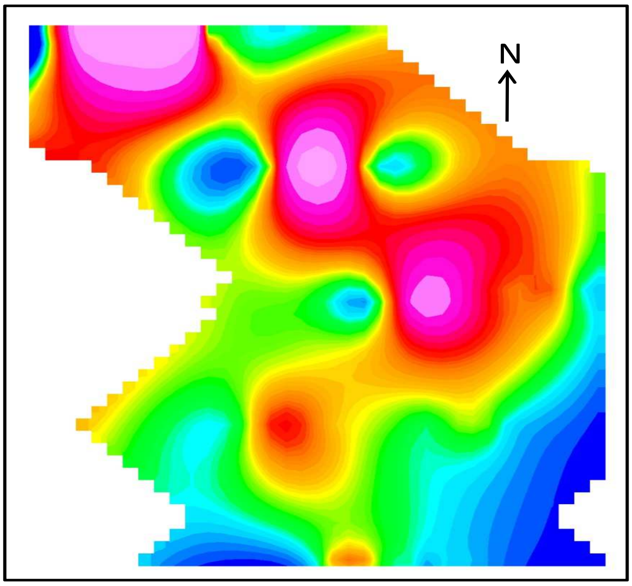

Figure.21.(a): Bouguer gravity contour map of Chitradurga Schist Belt

The maximum thickness of the Chitradurga Schist Belt is 5 km observer at Traver-8(15°.30'E) and it is approximately correlated to calculated value from the radial average power spectrum.

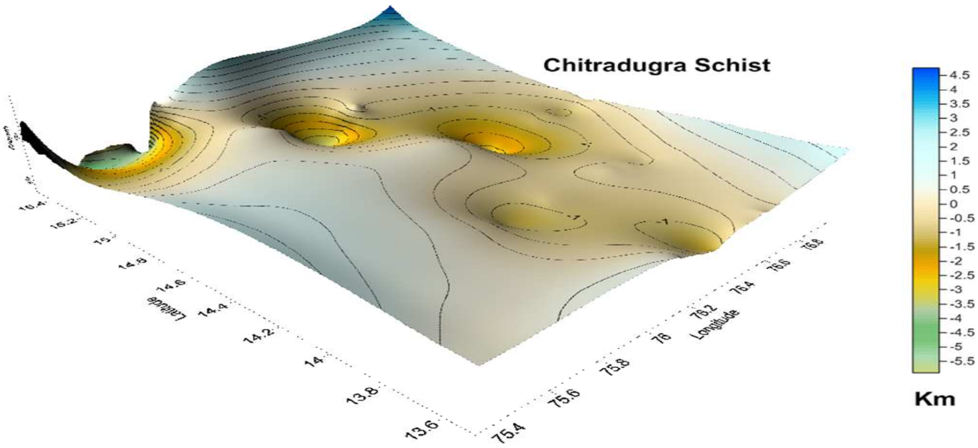

Figure.21(b): 3D contour map of Chitradurga Schist Belt

9) Cuddapah Sediments:

Cuddapah Basin consisting of Cuddapah and a Kurnool Proterozoic sedimentary sequences is one of the most prominent Purna basins of Peninsinualar India (Nagaraja Rao eta., 1987 Kale and Phansalkear,1991).It is a crescent shaped sedimentary basin predominately made up of argillaceous sediments of shelf facies intercalated with volcanic flows/tuffs. The sediments unconformable over lied the Younger granitic complex. The western half of Cuddapah Basin is devoid of any deformation while in the eastern part. Gravity picture over the western part of Cuddapah Basin shows a marked high up to - 50 mGal, might be due to a basic lopolith beneath the basin (Hari Narain 1987).

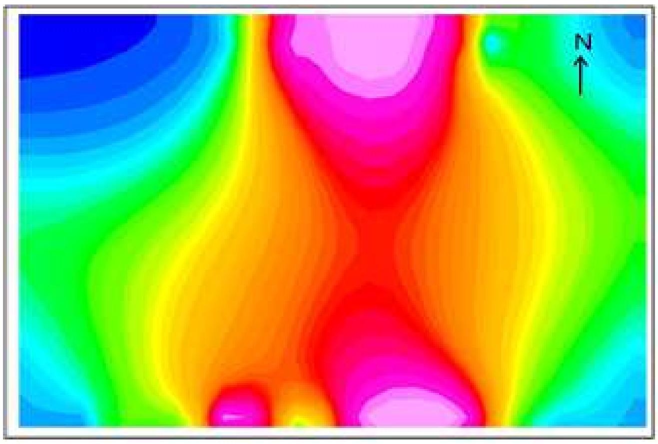

Figure.22 (a): Bouguer gravity contour map of Cuddapah Sediments

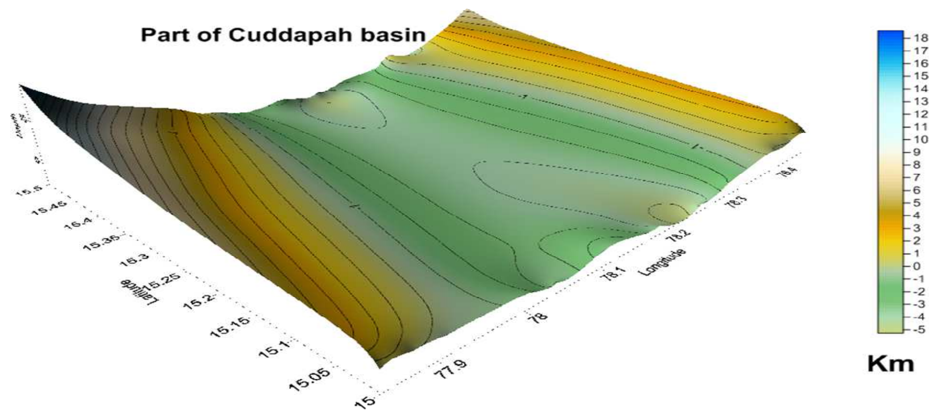

Figure.22 (b): 3D contour map of Cuddapah Sediments

Figure13 a & b: Bouguer gravity and 3D contour map The maximum thickness of the Cuddapah basin is 3.71 km observer at Traver-8(15°.30'E) and it is approximately correlated to calculated value from the radial average power sprectrum Depth of crustal column from inverstion obstined is km. this is corrlatiable with results of DSS profiles data is estimated to be 34 Km.

10 Bihma Sediments:

The Bhima group is concided equivalent to the kurnul and may therefore Upper protorozoic age. The general geology of Bhima basin group overlane a places by the Deccan trapes. The Bhima basin is in the Beejapur and Gulberga districts, Karnataka. Only a small Eastern extention basin in Telangana districs and the formation of Bhima basin made up of conglomerate followed by purple shale and sand stone. The formation rest (Raman and Murthy., 1997) unconformaly on the Rachael basement. The bouguer gravity response over this varying from 0.2 to 1.9 km figure.14.a. the maximum depth obtain 2.5 km observed at travers-11(17°.'E).

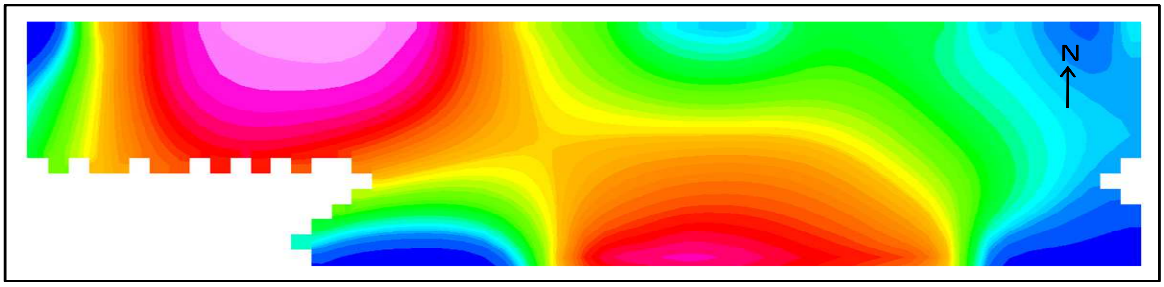

Figure.23 (a): Bouguer gravity contour map of Bhīma Belt

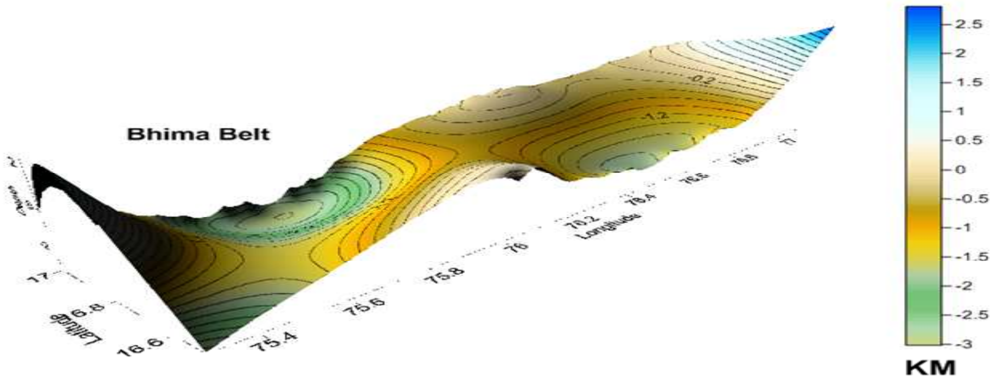

Figure.23 (b): 3D contour map of Bhīma Belt

Table-1: Body parameters of identified Supra Crustal formation along the Traverses from T1 to T11 obtain from modeling of gravity data

Rock type (WDC & EDC)	Density (gm/cc)	T-1 (12°)	T-2 (12°.30')	T-3 (13°)	T-4 (13°.30')	T-5 (14°)	T-6 (14°.30')	T-7 (15°)	T-8 (15°.30')	T-9 (16°)	T-10 (16°.30')	T-11 (17°)
		Width/ Thickness Km	Width/ Thickness Km.	Width/ Thickness Km	Width/ Thickness Km	Width/ Thickness Km	Width/ Thickness Km	Width/ Thickness Km	Width/ Thickness Km	Width/ Thickness Km	Width/ Thickness Km	Width/ Thickness Km
i) Sargur Group	2.8	….	….	….	47 / 2.05	….	….	….	….	….	….	….
ii) Yonger Granite	2.4 -2.6	21 / 0.68	……	46 / 0.23	82 /0.33, 56 / 0.63 4 / 0.20.	21 / 0.17 38 / 0.39 27 / 1.55	29 / 0.76	66 / 2.21, 66 / 1.16 30 / 0.47	80 / 4.43	…….	32 / 1.25	……
iii) Dharwar Schist	2.85-2.9	…..	……	…..	42 / 2.33	…..	188 / 1.73	65 / 2.21, 62 / 2.74	87 / 2.6	……	……	……
iv) Charnokite	2.85	53 / 0.84, 21 / 1.52	63 / 1.31 48 / 0.81	67 / 1.55	51 / 0.90	…..	……	……	………	…….	…….	……
v) Deccan Basalt	2.85-2.9	….	….	….	…..	……	……	……	……..	284 / 1.25	248 / 2.07	284 / 1.25
vi) Chitradurga Schist Belt	2.85	…..	….	….	….	95 / 1.37	71 / 3.15	43 / 3.44	57 / 4.94	….	….	….
vii) Bababuda n group	2.8	….	….	….	44 / 1.02	….	….	….	….	….	….	….
viii) Closepet granite	2.4	54 / 1.77	….	50 / 0.68	….	54 / 1.77 16 / 0.52	49 / 0.23	….	53 / 1.49 63 / 5.81	51 / 0.35	103 / 1.02	77 / 0.31
ix) Bhima basin sediment	2.8	….	….	….	….	….	….	….	….	….	97 / 1.48	201 / 2.27
x) Cuddapah basin sediment	2.8	….	….	….	….	….	….	64 / 3.84	33 / 3.71	….	….	….
Xii) Intrusive rock	2.6	….	….	….	35 / 0.56	66 / 2.20	55 / 1.96	….	….	119 / 4.08	….	….

CONCLUSION

Supra crustal layers of Charnokite, Younger granites, closepet granite, Sargur belt, Chitradurga schist belt, Bababudan group , Deccan Basalt, Bhima belt , western part of Cuddapah basin & Sediment were identified along the traverses (T1 to T11) included in the modeled crustal section with assumed densities of 2.92 gm/cc, 2.6 gm/cc, 2.45 gm/cc, 2.8 gm/cc, 2.85 gm/cc, 2.8 gm/cc, 2.85 gm/cc, 2.8 gm/cc, 2.8 gm/cc and 2.6 gm/cc and corresponding thickness are 2.22 km , 2.2 km, 2.04 km, 4.9 km, 1.02 km, 2.07 km, 2.27 km, 3.8 km and 4.08 km respectively. A peninsular gneiss layer that forms the basement to the supra crustal and upper and deep layers of densities 2.65gm/cc,2.72gm/cc,2.82gm/cc and 3.3gm/cc respectively.

The subsurface configuration of each of these supra crustal layers was obtained by digitizing the corresponding crustal sections and presented as 3D contour images. From the disposition of the crustal layers , a total four deep seated faults were interfered The average crustal thickness determined for the moho is 39 km in the Western block, 34 km in below Chitradurga Schist Belt and for Eastern Dharwar craton 37 km.

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