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# Regional Bouguer Gravity Analysis for Sub-Surface Topography of the Crustal Configuration in the Southern Part of Deccan Volcanic Province India.

KEYWORDS: Deccan Volcanic Province (DVP),Kurudwadi Lineament, Gravity Highs and Lows, Tilt Derivative.

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**ABSTRACT** *Regional gravity data have been utilized to evaluate the structural trends in parts of Deccan Volcanic Province(DVP) study region .The study area represent the western part of the India, Three deep seated faults, one running N-S, NW-SE and four gravity highs and lows were delineated from qualitative analysis of Regional Bouguer Gravity data.*

*Tectonic difference was elucidated on four layer earth and the depth extent and disposition of the supra crustal (Basalt & Sediment), 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 crustal configuration of the region is computed down to the Moho.*

*The basaltic layer thickness varying from 0.2 km to 1.3 km and sediment layer thickness varying from 0.2 km to 1.4 km, the peninsular layer thickness varying from 1.6 to 10 km, upper crustal layer, varies between 10 to 22km and deep crustal layer 22 to 39 km respectively. The folded nature of the sub surface layer is evident.*

**Introduction and Geology of the Study Area :**

Deccan traps which form a vast flood basalt province in the India pennisular are generally believed to have erupted at the close of the cretaceous, some 65 (±4)mya when the Indian continent-following its separation from Madagascar-moved over the Reunion hotspot during it northward journey(Morgan, 1981: Duncan & Pyle,1988). Geochronological studies have shown that the eruption of these massive amounts of lavas occurred rapidly over a period of only 1-4 myears (Courtillot et al,. 1986, 1988; Duncan & Pyle, 1988; baksi, 1994).

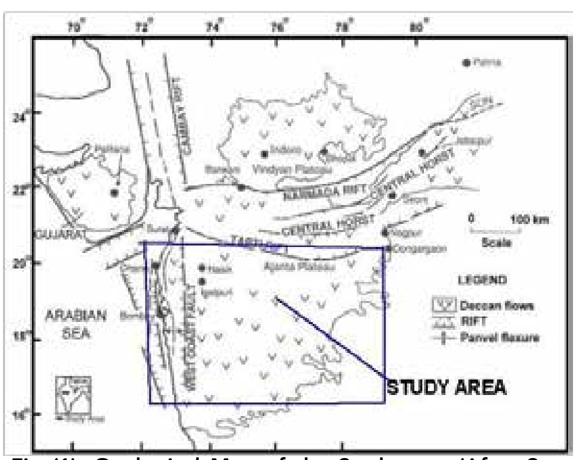


**Fig (1). Geological Map of the Study area (After Somdev and Bhattachari., et al.,2004 )**

Fig (1) shows the geology of the study area of and adjacent region in the western part of the DVP. The region, bounded on western part of India extends from latitude $16^0$ to $20^0$N and longitude $72^0$ E to $80^0$ E and covers an area of 1700 Sq Km. The major geologic members belongs to Deccan Volcanic Plateaus (DVP), The Deccan traps consists of a number of flows ranging in thickness from a few meters to about 100 m with the successive flows recognized in DVP (Deshmukh, 1988) The thickness of the trap cover is largest near the coast reaching to more than 2000m while thinning eastward to a few hundred meters (Kaila, 1989), in general are broadly horizontal in disposition and exhibits gentle gradients. Deccan plateau area and the marginal areas covered by protoerozoic sedimentary basin and the Peninsular Gneissic complex. The basaltic layer overlies the Precambrian granitic basement. In western and central India DVP is exposed mainly in the states of Maharashtra, Madhya Pradesh, Karnataka, and Gujarat and Telangana state.

The present study an attempt is made to examine the regional bouguer gravity analysis data for deciphering the supra crustal and deep crustal structure of the DVP region

**Gravity Analysis:**

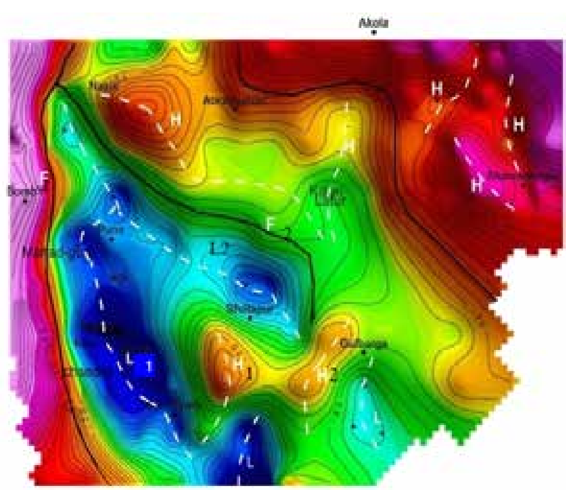


**Fig (2).Show the Bouguer Gravity map of the Study Area (NGRI & GSI-2006)**

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Fig (2) of the regional gravity (Kailasam et al 1972) shows four prominent regional gravity lows, one $L_1$ oriented N-S along western Ghats i.e. from Pune-Koyna- to Kurudvadi, known as Koyna low and the other $L_2$ is trending NW-SE from Pune to north of Sholapur, intrestly these two lows are meeting at north of Pune, and lying in between F1 and F2 faults.. There is a steep gradient in the Bouguer gravity anomaly near the west cost. The origin and characteristics of these large gravity lows (Harinarayana et al 2007) and highs have been a matter of debate. The steep gravity gradient anomaly from west to east coast ( 3-4 mgal/km) has been interpreted as due to deep seated faults( ($F_1$ & $F_2$),these faults are believed to be the cause for the western Ghats scarp ( Pascoe,1964) . From (Fig2) two gravity highs ($H_1$) and ($H_2$) are falling under Kurudvadi rift zone have been interpreted as zones of marked subsidence and uplifts of deep seated nature.

The several studies have been reported over the DVP which is geologically and structurally remain extremely dynamic in the fast characterized by high mobility active history of rifting episodic volcanism and magmatism multiple plume interactions and many other geodynamic events including totally reworked crust (Negi et al, 1986, 1993; Radhakrishna and NAQVI, 1986; Rogers and Callahan, 1987; Pandey & Agrawal.1999; Pandey et al 2009, Ramakrishna-2009).

**Tilt Derivative:**
The gravity tilt derivative, first reported in 1994 and more recently used to derive the local wave number (1997) , it will show that the combination of the tilt derivative and its total horizontal derivative are highly suitable for mapping shallow basement structure and mineral exploration targets and that they have distinct advantages over many conventional derivatives.

The tilt derivative opting calculates the tilt derivative of a grid and optionally, the total horizontal derivative of the tilt derivative grid using the convolution method saves a lot of processing memory and time.

**The Tilt Derivative is defined as:**

$$TDR = \tan^{-1}\left(\frac{VDR}{THDR}\right) \ldots\ldots\ldots\ldots\ldots 1$$

Where VDR = First vertical derivative & THD = Total horizontal derivative

$$VDR = dT/dZ \ldots\ldots 2$$

$$THDR = \sqrt{\left(\frac{dT}{dX}\right)^2 + \left(\frac{dT}{dY}\right)^2}$$

The total horizontal derivative of the tilt derivative is defined as

$$HD\text{-}TDR = \sqrt{\left(\frac{dTDR}{dX}\right)^2 + \left(\frac{dTDR}{dY}\right)^2} \ldots\ldots\ldots\ldots 4$$

The results of tilt derivative shown in fig (3) narrow over merging for minimum and maximum values of tilt therefore the edges of real anomalies are better resolve.

Figure (3) shows the structural fabric of the region this special distribution of earthquakes and there correlation with gravity lineaments. Gravity low of L1 running from NW & NS fault with different gradient towards west and east appear to be effect of tectonic moment of crustal blacks most of the earthquakes are falling along this lineaments.

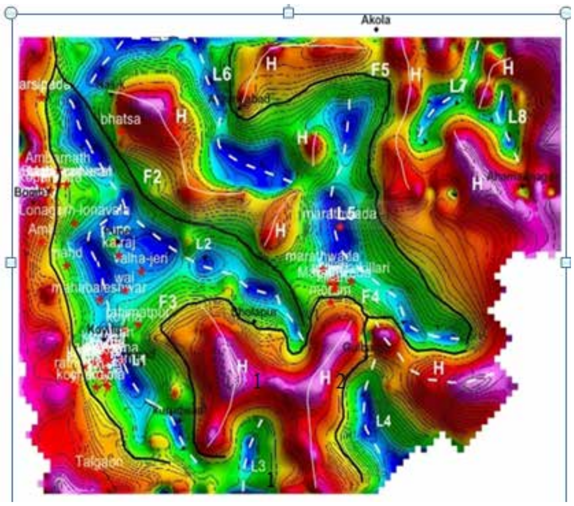


**Fig (3).Tilt Derivative Map of the Study Area**

**Quantitative Analysis:**
The objective of Quantitative Analysis of the gravity data in the Deccan traps area was to understand the subsurface configuration of the area from the inversion of 10-East-West profiles parallel to 16° to 20°.5′ profile interval of every half degree of the length of ~550 to 600km and separated from each other by a North-South direction of 55km running from South to North digitized from the Bouguer Gravity image Fig (4),(Published by NGRI & GSI 2006).

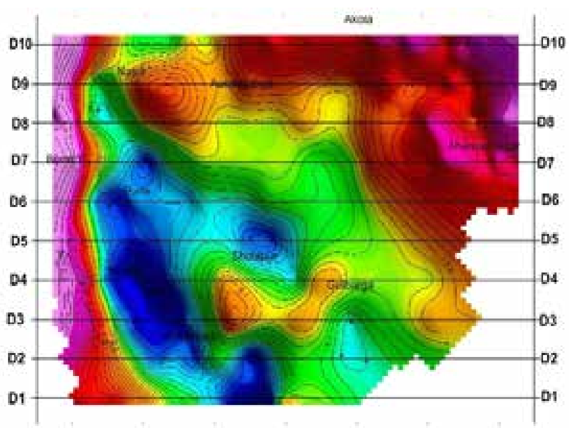


**Fig (4).Show the Profile layout on Bouguer Gravity map of the Study Area**

The software use for inversion is the GM-SYS (2000), a gravity modeling software of geo- soft. This software is based on the methods of Talwani et al (1959), Talwani and Heirtzler (1964), and makes use of the algorithms described in Won and Bevis (1987). The software assumes a two dimensional flat earth model and uses the USGS SAKI (webring, 1985) implementation of the marquardt inversion algorithm (Marqardt, 1963) to linearize and invert the calculation.

A 5-layer earth models was assumed for crustal configuration down to the Moho a top layer of peninsular that forms the basement to the supra-crustal (Basalt-2.8gm/cc;sedement-2.4gm/cc), the upper crustal layer, deeper crustal layer bounded at its lower end by the moho and the sub-crustal layer beneath the Moho. The correspond-

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ing densities assumed by the earlier studies (Mishra et al-2004; Bijendra singh & Arora-2008; Sharma et al-1992), are 2.62gm/cc,2.72gm/cc,2.85gm/cc and 3.3gm/cc respectively. It is be noted that the constant and gravity interpretation for depth control and borehole data (Gupta & Dwivedy-1996, Gupta et al 1996), were abtained from independent estimates for crustal thickness in the region. Further GM-SYS software does not require a regional to be subtracted from the Bouguer Anomaly has the entire crustal configuration down to the Moho is model by means of the assumed 5-layer earth to Moho is model layer was iteratively modified for best fit between observed and computed Gravity anomaly profile. The error in best fit was found to vary between1.2 to 2km, which is well within acceptable limits.

**Sub-Surface Topography of the Crustal layer :**

The depth to the earth of the layer Basalt, Sediment (where present), Peninsular and the upper and deeper crustal layers (moho) along the profile in the study area is present as 3D-contour images. Basalt layer Fig (5(a)), Sediment Fig (5(b)),Younger Granite Fig(6(a)), Upper Crust-Fig(6(b)), Lower Crust fig(6(c)).

From the 3D-contour image of the basaltic layer fig (6(a)), the max depth 1.4km are observed at North central part of the study area, along E-W and also along the Kurudwadi rift zone to be concentrated circular features with a max depth of 1km it is well known that Deccan Volcanic Plateaus (DVP) with large thickness of basalt act as a geological/ geophysical barrier to understand the deep structure. From earlier geophysical studies (Kailasam et al -1972; Qureshy-1981), it is propose that rift like structure lie buried below the Deccan traps cover. The present analysis has shown the variation of Deccan traps thickness from 300 to 400 m along the West coast fault and 400 to 600m towards southern and northern parts of profile to 1000m in the middle. These results are corroborative with (Prasantha et al-2005 Gupta et al -1996, Harinarayan et al-2007). The traps thickness for few profile in N-S, E-W, NW-SE direction are observed. A general variation in the thickness of where has max thickness of traps in 1.2km (1200m) observed at near Nasik region.

Geological/Geophysical investigation of earlier study and present study shown major basement fault /fracture zone in Deccan region. The west coast fault toward western part ovarian in N-S direction. From 3D-depth contours image of the sedimentary layer fig (5(b)) (where present) appear to be consecrated as elliptical features with a max depth of 1.2km similar to basaltic layer, a considerably thick sedimentary layer below traps and sediment thickness is maximum at north part and reduces drastically south side when we look at Bouguer Gravity Map these max thickness are observe at gravity lows This has been correlated with possible source region of the lava flows. Deep electrical soundings along a few profiles in DVP provide trap thickness varying from 220 m to 1200 m (Kailasam et al 1976, Bhaskar Rao et al.1995). There are many flows recognized in DVP (Deshmukh,1988 ) with thickness varying from 10 to 160 m . The thickness of the trap cover is largest near the coast reaching to more than 2000m while thinning eastward to a few hundred meters. According to this sediments basin is covered with thick trap poured out during late cretaceous to Paleocene time, broadly peninsular Gneissic (PG) fig (6(a)) basement occurs at shallow depth 1.6 to 10km in the southern part and central part of the area has compare to N-E and S-W while variation in this layer by themselves give only depth to basement when taken in conjunction with the configuration of the upper crustal layer.

The fig(6(b)) shown the relief in the sub-surface topography of the bottom of the upper crustal layer , varying between 10 to 22km has compare to the peninsular layer that of the Moho which range from 1.6 to 10 km and deep crustal layer 22 to 39 km respectively. Depth to the Moho varies from 22-39 km, deepest inferred under Western Ghats. It decreases to 36 km below the Konkan plain near the west coast. The regional picture shows overall rise from west to east by probably due to Moho.

**Summary and conclusions:**

The results obtained from 10-profiles in Deccan Traps region have been used to map to the 3D sub-surface view of crustal configuration .These results have been summarized as follows.

1. The Bouguer Gravity Map shown number of gravity highs and lows. The different gravity highs and lows observed in fig(2) indicative of marked zones of uplift and subsiding , the interpret Bouguer Gravity anomaly profiles, models using the depth constant from DSS,MT and other studies.
2. Deccan Traps thickness fig (5(a)) decreasing gradually from W-E with about (0.2 to 1.3km). The thickness of the traps observed varies from 0.2km with a max thickness of about 1.3KM, thickness of the traps increases towards North. The observed variations in trap thickness may be partly attributed to the nature of pre-trepan topography and also attended to retrieve a broad region picture of the Deccan traps configuration and also exhibits gentile gradient. The gradients towards ENE-SE drilling at Kilari (Gupta & Dwivedy 1996; Gupta et al; 1998) indicates that the total thickness of basaltic layers is about 338m close collaborating with our results.
3. The sub trappen upper crustal section in the Deccan Volcanic Provence is indicating that it is pre-dominantly representative of granites, gneissic crust, inferred to be continuation of Dharward crust is varying (0.5 to 10.2 km) thick granitic crust appearing to be in the western flank. The average thickness of the layer in the region varies between (0.2 to 1.3km).Fig (5(b)) shown the sedimentary below the Deccan traps with thickness varying (0.2 to 1.4km). The sedimentary thickness is varying from 0.5m while thinning Eastward to a few 1.3k.m (Kaila et al., 1995 & Gokaran et al., 1992, 2001).
4. A sub surface structure coincide with the kurudwadi lineament is observed the lineament shown a relation with basement tectonic to basement faults with strip conducting structures on either side of the lineaments are inferred/identified.
5. The average depth of the Upper crust layer range between (10 to 22km) with higher thickness of Upper crust to 22km occurring in the western part of the area
6. The Moho accurse at depths varying from 22km to 40 km prominent up-warps E-W direction

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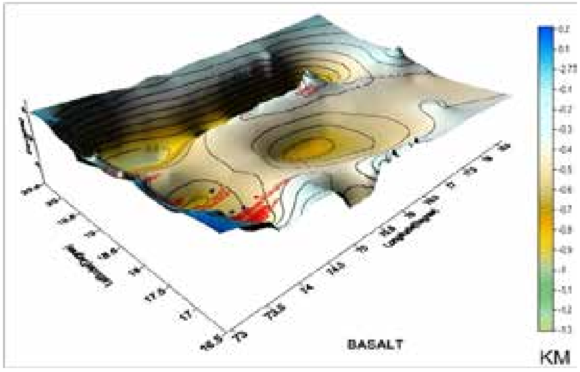


Fig (5(a)) - Basaltic

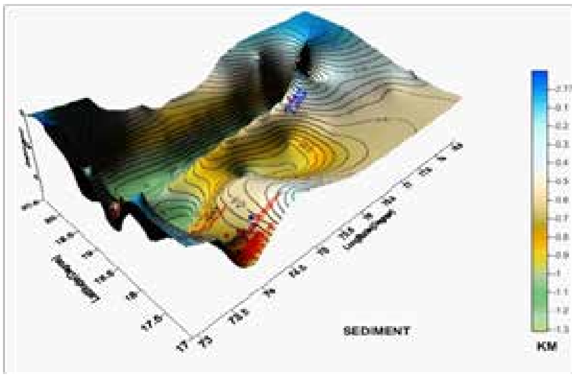


Fig (5(b)) - Sediment

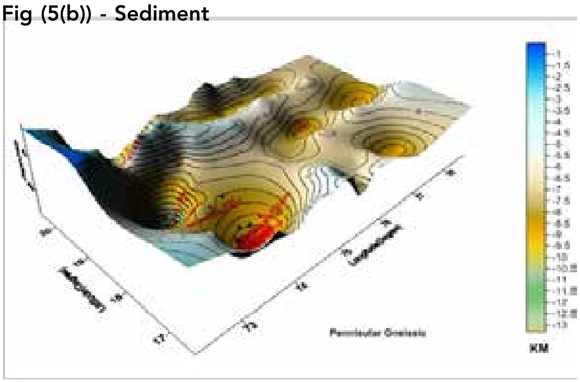


Fig (6(a)) - Peninsular

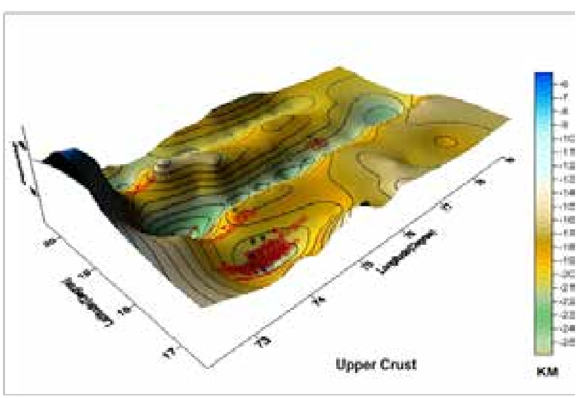


Fig (6(b)) – Upper Crust

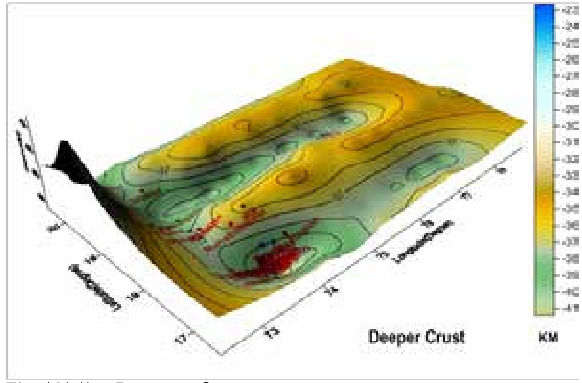


Fig (6(c)) - Deeper Crust

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