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REGIONAL GRAVITY STUDIES OF THE DECCAN TRAP AREAS OF PENINSULAR INDIA *

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EXTENSIVE regional gravity surveys over the Deccan trap areas of Maharashtra and parts of Mysore, Andhra Pradesh and Gujarat in Peninsular India were conducted by the Geological Survey of India during the period, 1964-70, as part of its programme of investigations connected with the International Upper Mantle Project. An area of roughly 3,50,000 square kilometers bounded roughly by latitudes 15° N and 22° N and longitudes 72° 30′ E and 79° E was covered by gravity observations with a station distribution of roughly one per 150 square kilometers. The objectives of these studies were (*a*) the estimation of the thickness of traps and crustal thickness (*b*) the identification and investigation of major subsurface structural features depth that brought the magma to the surface and (*c*) the study of the degree of isostatic equilibrium and compensation in these areas. The results of seismic refraction soundings to estimate the thickness of traps at a number of locations over this trap territory together with the results of some east-west regional gravity profiles and detailed gravity-*cum*-magnetic investigations in the Koyna earthquake affected area were published in Volume 100 of the *Memoirs of the Geological survey of India* (Kailasam *et al.*, 1969).

The regional geological features of the area are shown in the sketch map (Fig. 1) which is based on the geological map of India pub-

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lished by the Geological Survey of India (1962). The Deccan traps which cover an area of more than 6,00,000 square kilometers in Western and Central India consist of a series of basaltic lava flows presumed to have been issued on to the surface in the Cretaceous-Tertiary period blanketing all pre-existing rocks ranging in age from Pre-Cambrian to the Cretaceous in many parts. The basalts show a flow thickness of individual flows ranging from 2 to 100 meters, the successive flows being separated

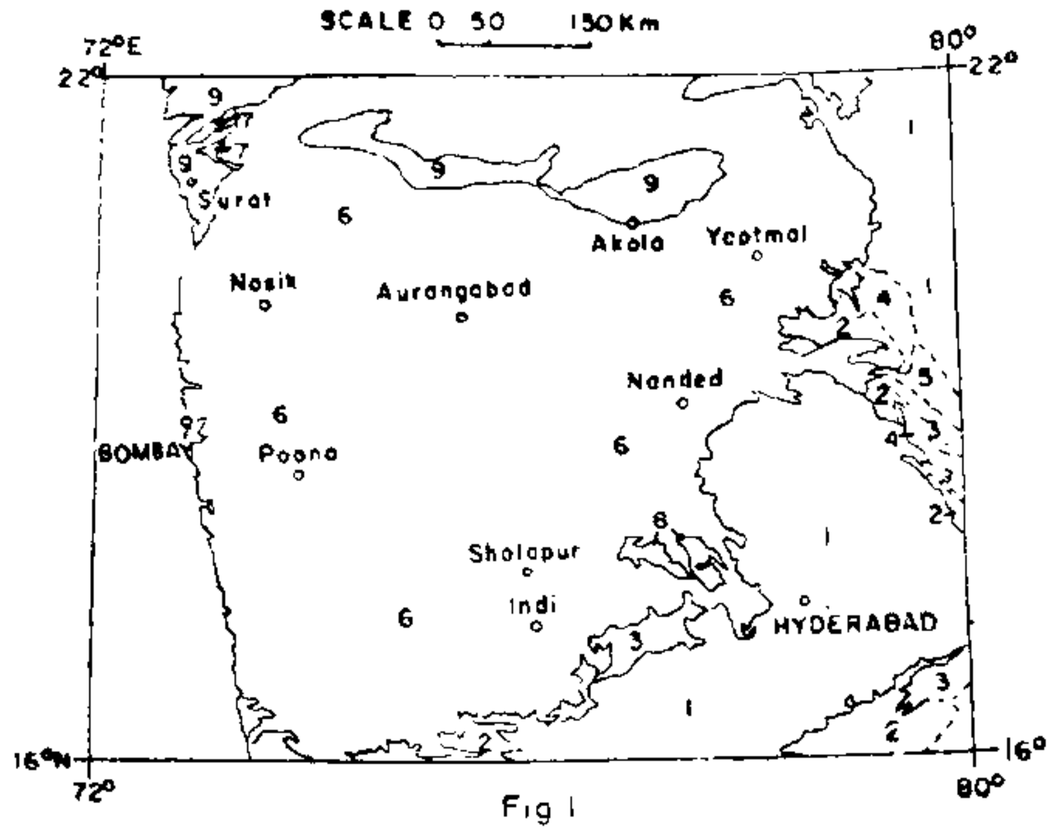


Fig 1

LEGEND

9 RECENT : Alluvium

8 PLEISTOCENE Older Alluvium and Laterite.

7 EOCENE : Undifferentiated

6 MESOZOIC – LOWER TERTIARY : Deccan Traps.

5 MID TRIASSIC – LOWER CRETACEOUS : Upper Gondwana rocks.

4 UPPER CARBONIFEROUS – LOWER TRIASSIC Lower Gondwana rocks.

3 UPPER PRE-CAMBRIAN – LOWER PALAEOZOIC: Vindhyan and Kurnool Systems and equivalent rocks.

2 UPPER PRE – CAMBRIAN : Cuddapah System and equivalent rocks.

1 PRE – CAMBRIAN : Unclassified granites and gneisses including charnockites.

by red bole or intertrappean beds indicating time gaps. The traps vary in lithology from the massive to the vesicular types, the specific gravity showing an average value of 2·9. The flows are generally horizontal with a gentle westerly dip attaining their maximum thickness near the Bombay coast. The geologically estimated thickness of the traps ranges from 60 meters at Belgaum to 1600 meters at Mahabaleswar and 1900 meters over the Bombay coast. The rock generally consists of basalt or dolerite, the prevailing type being a dark green or nearly black basalt of varying chemical composition based on differential trends. Intrusives in the form of dykes and sills occur and many of these dykes, doleritic and basaltic in nature cut these lava flows, swarms of dykes occurring in Saurashtra, Konkan and along the Arabian Sea coast near Bombay. Auden (1948) has suggested the dykes in Western India as belonging to post lava hyperbyssal phase. The principal types of trap met with in the area covered by these surveys are basalts, amygdaloid trap, vesicular trap and with intertrappean sedimentary beds and numerous highly ferruginous clayey beds.

The Gondwana rocks (Permo-carboniferous to Jurassic), fluviatile or lacustrine in nature, occur in the Godavary valley and probably continue underneath the traps in the Badnur, Chindwara and Wardha areas. The Lower Gondwanas consist of graded sandstones, green shales, etc., and contain workable coal seams in the Godavary valley as also the Kamptee and Wardha areas.

The Bhima series comprising submetamorphic rocks of Vindhyan age are seen in the valleys of the Bhima and Krishna rivers with the Deccan traps forming scarps over them, and also occasionally over the granites on the northern side, while in the south they are seen to rest directly over the peninsular granite coloured limestones, laminated limestones, red lithomorphic shales, sandstones, cream coloured limestones, laminated limestones conglomerates and grits. The rocks of this series are presumed to have a maximum thickness of the order of 350 meters.

The Kaladgi formations of Cuddapah age are seen in a well-marked basin located between the banks of the Krishna and Malaprabha rivers, the principal inliers occurring within the Deccan trap plateau at Jamkhandi and Galgali on the south bank of the Krishna river with other small exposures to the north of the Krishna as also some strings of inliers in the valleys of the Vedganga and Dudgganga to the west of the main basin. The Western Ghat section in the Konkan area also contains some tiny inliers of Kaladgis near Lora. The Kaladgis are separated from the crystallines by an unconformity and have been divided into two stages, *viz.*, Lower and Upper, with an average estimated thickness of the order of 600 and 3000 meters respectively. The rocks of the Upper series comprise shales, limestones, schists and quartzites with occasional conglomerates and breccias while the Lower series consist of limestones, clays, shales, sandstones siliceous limestones, cherty breccias, quartzites and conglomerates.

To the south of the trap country are the Dharwar suite of rocks comprising mainly gneisses and schists with occurrences of dolerite dykes, quartzites, etc.

The Kaladgi limestones show a density of the order of 2·6 gm/cc with occasional higher values of 2·7 gm/cc. The Shahabad limestones (Bhima series) show a density range of 2·67 to 2·73 gm/cc while the sandstones of the same series have density varying from 2·47 to 2·64 gm/cc. The average value of these rock types is of the order of 2·6 gm/cc. The average density of the granites and gneisses is of the order of 2·67 gm/cc.

The gravity observations were carried out with a Worden Gravimeter with a scale constant of 0·09215 m.gal/division with a total range of 200 milligals. The Bouguer Gravity map of area surveyed is shown in Fig. 2 with contour intervals conveniently chosen as 5 milligals to avoid overcrowding of contours. The major anomaly features have been contoured in broken lines with a one milligal interval for clarity. A few off-shore values (after Takin, 1966) to the west of the Bombay coast over the Arabian sea have also been incorporated.

The gravity anomalies are everywhere negative, as is normally to be expected over a continental crust, except in strips in the west coast surrounding Bombay and Surat. The crestal values of the positive anomalies are + 46 milligals around Colaba, + 72 milligals around Borivile and + 30 milligals near Surat. On the lowest side, the negative values recorded are — 110 milligals in the Koyna and Karad regions, — 105 milligals near Kurudwadi within the Deccan traps and — 110 milligals in the Kaladgi basin outside the exposed trap boundary in the south. There is thus a marked variation in the Bouguer values of more than 180 milligals for the region as a whole. The Bouguer gravity map reflects a complex anomaly pattern with two main contributing factors, *viz.*, anomalies arising out of the varying thickness of the high density basalts overlying the basement and the regional anomalies of deep seated origin of a subcrustal or isostatic nature. As isostatic compensation of topographic masses takes place at great depths, the Bouguer map reflects the variations in the densities within the various layers within the crust underneath the Deccan platform. A major part of the anomaly can thus be linked to the second factor of deep seated causes over which are superimposed anomalies of relatively small magnitude due to the varying thickness of the high density basalts. The thickness of traps determined by refraction seismic soundings (Kailasam *et al.*, 1969) at various points within the Deccan trap territory varies from 90 meters at Indi and 170 meters at Nanded near the southern and eastern margin of the trap country, to 915 meters at Aurangabad in the north central part and 1400 meters near Nasik in the western parts of the Deccan trap area. The maximum contribution of the thickness of the basaltic layer works out to be of the order of only 2 to 3 milligals.

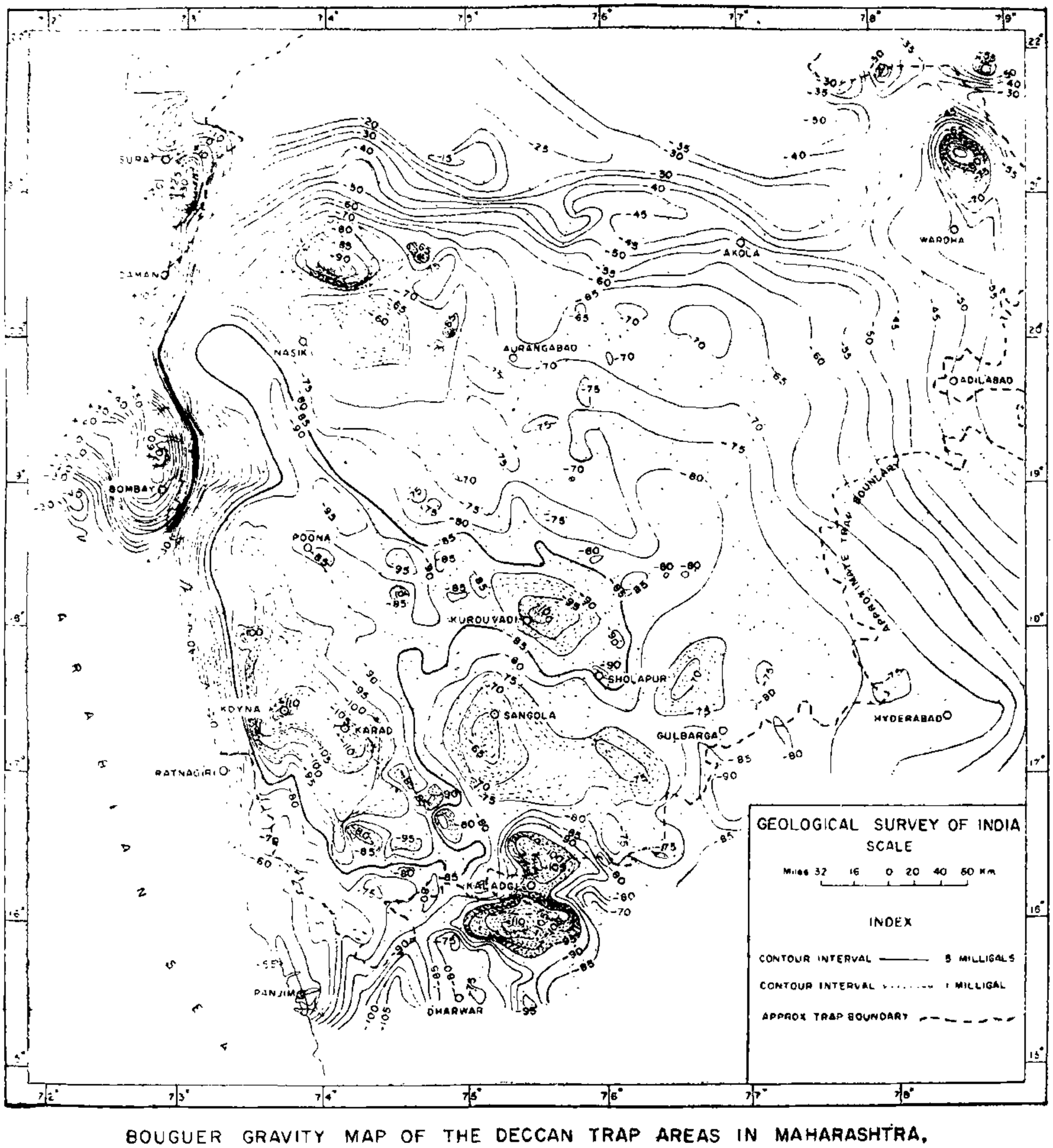
Residual gravity anomalies in the form of distinct closures have been indicated in the regions of Kurudvadi, Sangola, Kaladgi and Nasik. The pronounced Bouguer gravity anomalies suggest that the platform is deformed to varying degrees, giving rise to cohesive and disruptive structures. The prominent structural features suggested by the gravity data may be briefly described :

Sangola Uplift.—The crestal value of — 61 milligals near Sangola against a background value of — 75 milligals gives rise to a positive gravity relief of about 15 milligals, abounding the Kaladgi formations in the south and Bhimas to the east. This indicated zone of uplift in the Sangola area is flanked by gravity 'lows' at Kurudwadi and Karad. Seismic soundings at Indi and Velapur which are located close to this zone, indicate depths of 90 and 290 meters respectively to the base of the trap from the ground surface lends support to this Sangola uplift, the pronounced gravity feature in this region being suggestive of tectonic origin reflecting dislocations in the deeper strata.

Kaladgi Basin.—The Kaladgi basin is partly covered in the north by the Deccan lavas and is brought out as a closed feature in the gravity map with a peak value of — 110 milligals. To the east and west of the basin the gravity values increase rapidly suggesting faulting over the margins of the basin. The axis of lineament connecting Kaladgi and Karad in the northwesterly direction is flanked by poorly defined anomalies in the forms of closures which may possibly represent depressions filled by sedimentary formations some of which are exposed as strings of inliers and outliers.

Kurudwadi-Dhond-Poona Depression.—The dominant gravity feature with a NNW-SSE

PLATE - 2



BOUGUER GRAVITY MAP OF THE DECCAN TRAP AREAS IN MAHARASHTRA, AND PARTS OF MYSORE & ANDHRA

FIG. 2

trend with an average gravity value of — 85 milligals and with an inset basinal closure near Kurudwadi with a value of — 105 milligals is another major structural depression brought out in the Bouguer map. The anomalies in the northern part of the Kaladgi basin and Kurudwadi are of the same order of magnitude. The Kurudwadi basin appears as a closed structure with a gravity relief of more than — 15 milligals, in contrast opposition to the Sangola uplift. The conditions governing the extent of final distribution of sediments in the Kaladgi and Bhima basins are not fully known as these are covered by the Deccan lava flows. The residual gravity values in the Kurudwadi region are negative and if a medium of mass defect is postulated beneath the traps in this zone, the Kaladgi and Bhima series, by virtue

of their proximity to the Kurudwadi region have possible territorial extension beneath the traps.

In addition to the above features, some other interesting features have also been brought in the Bouguer map. The combined feature of subsidence and uplift indicated near Nasik is a zone close to the areas known for intense discharge of magma through volcanic vents in the Narmada and Tapti valleys. The thickness of traps as indicated by the seismic surveys is of the order of 1400 meters pointing to repeated cycles of volcanic activity.

The broad closure of — 85 milligals in the Koyna-Karad area is suggestive of a synclinal sag which might have been formed due to the westward flow of a thick sequence of lava erupted through fissures near the coast.

The well-known Panvel flexure near the Bombay coast is well brought out by the positive gravity values with a very high westerly gradient for the contours and this feature actually appears to be a deep fault extending to the south up to Ratnagiri evidence for which has been published by the authors (Kailasam *et al.*, 1969). There is almost a virtual isolation of the positive anomaly values in the Bombay and Surat regions in the belt of dyke clusters adjoining the Arabian sea.

The arcuate swing of the band of contours eastward beyond latitude 20° 30′ N and longitude 74° E, with smaller gradients than are indicated in the Panvel region, bring out the relationship with the known parallel east-west fault scarps in the Godavari and Tapti valleys of the Satpuras whose dominant trend is the same.

The Airy-Heiskanen anomaly map faithfully reproduces the features brought out in the Bouguer map, reflecting the isostatic stability of the areas where the Bouguer anomalies are strongly negative in the ghat section and even more strongly positive in the coastal tracts. A crustal thickness of the order of 38 kilometers is indicated in the central parts with progressive thinning towards the sea.

The gravity data have brought out two major lineaments, one along the west coast and the other along the 21st, parallel; and no major fracture zones have been indicated barring the one along the west coast and the other along the Satpuras. The results further indicate that the repeated cycles of the Deccan activity have given rise to zones of subsidence with interior basins and uplifts in this negative platform of the Deccan 'syneclise', lending credence to epeirogenic movements presumed by geophysicists and geologists.

The authors are thankful to the Director-General, Geological Survey of India, for his kind permission to publish this paper and their colleagues who participated and assisted in the surveys.

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PROFESSOR CHANDRASEKHARA VENKATA RAMAN (HIS LIFE AND WORK)
BY S. BHAGAVANTAM*

THIS is the biography of a scientist by a scientist, the portrayal of a master by a pupil.

It is not always an easy task to write the biography of a great man. Especially is this so if the subject is both a genius and an idealist. As a genius he has achievements to his credit, and as an idealist he has attitudes which are likely to be misunderstood. The biographer himself should have a certain greatness of understanding and outlook to appreciate these qualities and present them in their proper perspective. Dr. Bhagavantam is eminently suited for this, and the picture he presents of Professor C. V. Raman in this short sketch is as scintillating as the subject himself.

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