7th International Conference & Exposition
on Petroleum Geophysics

"HYDERABAD 2008"

P - 326

Analysis of Crustal Structure in Western Offshore Area Using Gravity Data

P. Unnikrishnan* and T.S. Balakrishnan,
Oil and Natural Gas Corporation Limited, Mumbai
unnikrishnan_p@ongc.co.in

Summary

This work is part of a project on the study of the crustal structure of the Indian plate. The integration of the existing geological map of India with the new geophysical data has not been done so far on any extensive scale. The gravity anomaly map has been chosen as the principal data source. A detailed picture of gravity anomalies obtained both from ship-borne observations and satellite observations is available, which is used to study the crustal structure of the western offshore area of India.

Introduction

The preparation of a good crustal structure map is dependent on the availability of detailed data covering every part of the area investigated. Adequate density of coverage is met in the Survey of India topographic sheets, the Geological Map of India, the magnetic anomaly map and the gravity anomaly map. Of these, only the last two have depth control.

We divide the crust into the lighter granitic part (upper crust) and the heavier basaltic part (the lower crust). The granitic (upper) crust is more or less restricted to the Peninsula. The lower crust (continental basalts) is far more extensive. The high gradient near the coast is due to the rapid thinning and extinction of the upper crust. Thus one would expect the offshore area to be floored by basaltic rocks (continental basalts). These rocks themselves thin out westwards, and vanish at the COB, where the oceanic basalts take over.

Method

The gravity data, both from ship-borne observations and derived from satellite observations, is used to study the structural and tectonic aspects of the western offshore area of India. The free-air gravity map is shown in Fig.1. The Bouguer gravity map was derived from the free-air gravity data, and is shown in Fig.2. Figure 3 represents the regional variation of the Bouguer gravity.

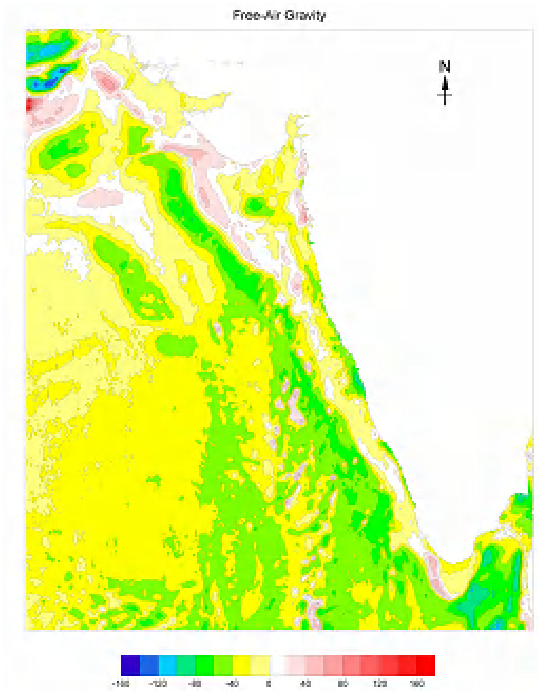

Figure 1: Free-Air Gravity of West Coast Offshore, India

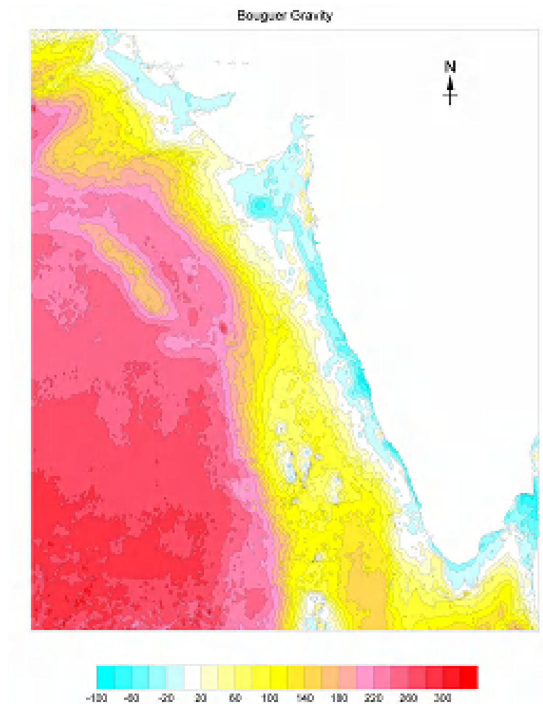

Figure 2: Bouguer Gravity of West Coast Offshore, India

The junction of the peninsula with the western shelf is marked by a sharp gravity low. The anomaly in the onshore area of the peninsula is highly negative (often of the order of -100 milligals). Near the coast the value increases with a relatively high gradient, and is about zero near the edge of the continental shelf. The west coast of the southern peninsula is dominated by a sharp scarp beyond which is a narrow strip of sea level coast. It stretches from the Narmada River in the north to Kanyakumari in the south. This is an area containing the West Coast Fault. The gravity anomaly rises from -110 mgal east of the scarp to around -50 mgal to its west, indicating a steep rise in the Conrad/Moho levels. Thereafter there is a further steady rise although at a much slower rate. West of Lakshadweep islands the picture becomes very flat. This behaviour is ascribed to the steady westward thinning of the crust.

The upper crust under the Kutch-Saurashtra block thins out westwards, and is virtually non-existent in the corresponding continental shelf. This is proved by the investigation of the German Research vessel "Meteor", which shot a few refraction profiles in the vicinity of the shelf and the deep sea beyond (Fig.4). Velocities ranging from 5.5 to 6 km/sec are absent on these profiles and the lack of granitic crust is proved. It shows clearly that the upper crust peters out in front of the Kutch-Saurashtra shelf edge. An E-W shear just south of Saurashtra displaces the shelf edge westwards, and correspondingly shifts the edge of the upper crust.

Refraction seismic has revealed that in the area near Surat, the sediments rest on a floor of very high velocity rocks. Basalts exposed in St. Mary's island near Mangalore have been dated to be of Cretaceous age or older – much older than the Deccan Traps. An offshore well drilled on the Padua Bank has also met basalt at a depth of about 2500metres. Refraction seismic has brought out the absence of the upper crust in Kori Ridge. Seismic refraction work in the sea off Saurashtra-Kutch-Karachi has shown the absence of the granitic crust and the presence of high velocities, again associated with basalt.

It would appear that the offshore area is floored by continental basalts of Cretaceous (or older) age. Occasional patches of upper crust may be expected. The westward crustal thinning could be attributed to the continental stretching produced in the course of separation from Madagascar.

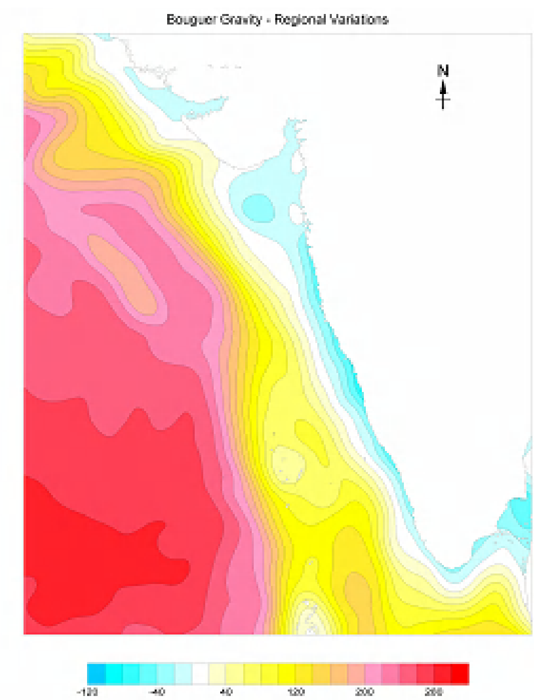

Figure 3: Regional Variations of Bouguer Gravity of West Coast Offshore, India

In the Kerala-Konkan area, a narrow trough is seen immediately to the west of the shelf edge. This can be followed northwards upto the latitude of Mumbai. Further north it opens out into the Mumbai High area to converge again as the Gujarat Rift, the Sanchor and Barmer basins to end up against the Indus Basin. West of this trough is the Kerala-Konkan Rift, whose westward limit is the Lakshadweep Ridge. This major rift is bounded on the east by the Pratap Ridge and on the west by the Chagos-Lakshadweep Ridge. Near Kochi, the Pratap Ridge swerves to a N-S direction, passes across the Alleppy Platform, and proceeds southwards almost upto the equator.

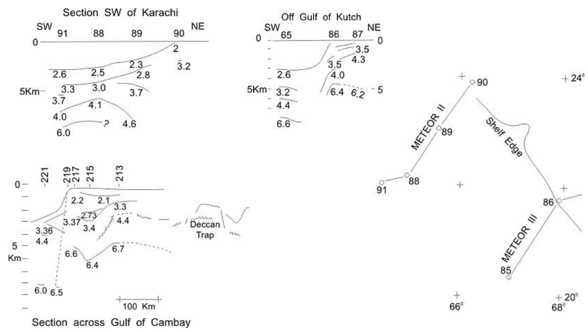

Figure 4: Refraction seismic sections of Western Offshore, India

In the gravity picture the core of this rift is seen to be a gravity high (much like the central high encountered in the Gujarat Rift). One attributes this to a swell in the mantle which has caused the separation of the Lakshadweep Ridge from the mainland. The Lakshadweep Ridge can be traced in the north upto 16° N latitude and the Kerala-Konkan basin swell extends to the west of this, closely following the shelf edge. The latter then swerves northwards upto the Gulf of Kutch. Here, however, the mantle swell has broken through the crust, and oceanic floor is encountered. This has been mapped by NIO as a zone of sea-floor spreading, which separates the Laxmi Ridge from the shelf.

In the south, the N-S extension of the Pratap Ridge is followed on its east by a shallow but extensive low. The Comorin Ridge lies to the east of this low.

The whole of the area between these two ridges could be considered to be a southern extension of the shelf. It has the Kerala-Konkan Rift to its west and the Gulf of Mannar to its east.

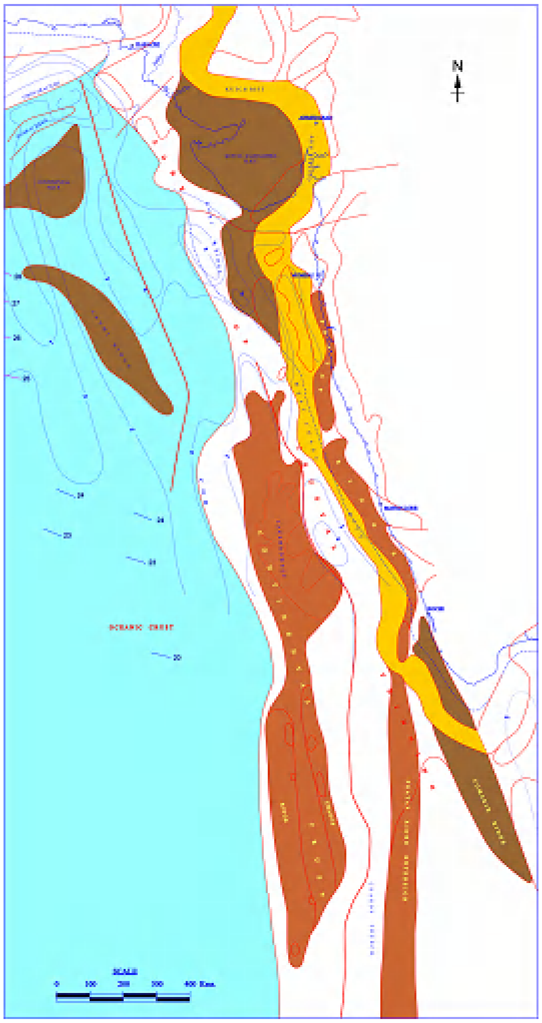

Figure 5: Structural and Tectonic Map of Western Offshore, India

The above observations were transformed into a structural and tectonic map of the west coast offshore area of India (Fig.5).

Conclusions

The structural and tectonic aspects of the western offshore area of India have been mapped based on the available gravity and seismic data. A zone of crustal thinning has been demarcated. The continent-oceanic boundary has also been marked.

The above are illustrations of how gravity anomaly data can be used to handle large scale structures.

Acknowledgement

The present work is part of the project on the structural and tectonic studies of the Indian plate being undertaken at the Western Offshore Basin, ONGC, Mumbai. The authors are thankful to Oil and Natural gas Corporation Limited for providing opportunity to work on this project and for giving permission to publish the work. Dr. AVS Murty, formerly with ONGC, had contributed to a great extent during his tenure with the project. The views expressed are those of the authors and not necessarily of the organization to which they belong.