Interpretation of Gravity and Magnetic Data at the Krishna-Godavari Basin, East Coast India*

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Abstract

The eastern continental margin of India has a long exploration history because of its high hydrocarbon production potential. The area of interest for this study is located in the Krishna-Godavari Basin at the eastern continental margin of India.

The objectives of this study were to understand the origin of the two basement highs at the southern portion of the survey area and to determine the source of the series of strong gravity anomalies at the northern perimeter of the survey area. The objectives were accomplished through the interpretation of a suite of filtered gravity and magnetic grids, both detailed and regional, and the 2.5D and 3D modelling of the detailed gravity and magnetic data. Seismic data were used to constrain the gravity and magnetic interpretation.

The two basement highs at the southern portion of the survey area were interpreted as being intrusive in origin. The series of strong gravity anomalies at the northern perimeter of the survey area were interpreted as caused by oceanic crustal thinning.

Introduction

The eastern continental margin of India has been actively explored for several decades due to its high hydrocarbon production potential. The survey area is located in the Krishna-Godavari Basin at the eastern continental margin of India. The 3D marine survey (seismic, gravity, magnetic, and bathymetry) was conducted in late 2008 to early 2009. The survey has N-S lines with a spacing of ~ 300 meters.

The maximum sedimentary thickness in the basin is expected to be more than 6 kilometers. The deposition is likely to contain primarily clastics with thin bands of carbonates.

It has long been established that a combined interpretation of multiple datasets will lead to improved results with a greater degree of confidence. Based on this understanding, the integrated interpretation of gravity and magnetic data with seismic data was undertaken for this study. The 2.5D and 3D gravity and magnetic models were constrained with seismic data. The goal of the integrated interpretation is the better understanding of basement features mapped in the survey area.

Geology

The basin is expected to have a maximum sedimentary thickness of more than 6 kilometers. It is likely composed of primarily clastic facies of shale, fine sandstone, siltstone and clay with thin bands of carbonates. Mesozoic deposition during Permo-Triassic-Jurassic time was primarily non-marine and associated with horst and graben features. The rift phase continued until Lower Cretaceous time and the end of this phase was marked by a transition from a non-marine to marine environment during Mid-Upper Cretaceous. The post-rift deposition was primarily shallow marine to marine, characterized by prograding clastic sequences.

Growth faults and associated rollover conditions controlled deposition. With an intensive increase of building of the Himalayas during the Mid-Miocene, the Ganga-Brahmaputra River System started dominating the sedimentation of the Bay of Bengal. Post-Miocene tectonism resulted in the formation of smaller but sharp, as well as flat and large, anticlinal structures within the Tertiary sequences in the deep waters. Paleocene sequences onlap onto the paleo-highs of Cretaceous, and Miocene onto Oligocene at the shelf break. Major slope failures act as the primary source of turbidite accumulations. Most channels are filled with coarse sediments.

Gravity and Magnetic Data

The joint interpretation of gravity and magnetic data provided constrained interpretation results as opposed to interpreting each dataset independently. With each dataset mapping differing rock physical properties (density variations for gravity data and magnetic susceptibility variations for magnetic data), the combined interpretation of the two datasets gave less ambiguous results.

Prior to working on the detailed data, regional public domain gravity and magnetic data were interpreted in order to understand the regional framework. Regional data offer the interpreter the chance to see significant broad features which may be lost when looking only at detailed datasets. A good understanding of the regional setting is the key to a proper interpretation of the detailed data.

The regional gravity data is shown in Figure 1. The map shows that the survey area sits at the edge of a regional gravity low. This gravity low is interpreted to be caused by oceanic crustal thickening due to isostatic loading.

The regional magnetic data is shown in Figure 2. The map shows the magnetic striping of the oceanic crust. The magnetic stripes trend NE-SW while the transform faults trend NW-SE. These are the main regional lineament trends in the area.

The detailed gravity data of the survey area is shown in Figure 3. The series of gravity anomalies at the northern perimeter of the survey area is evident on the map. These anomalies coincide with the edge of the regional gravity low seen in Figure 1 and thus interpreted to be caused by the same regional structure causing the regional gravity low. The map also shows two circular gravity anomalies at the south of the survey area which coincide with basement highs mapped by seismic.

The detailed magnetic data of the survey area is shown in Figure 4. The two magnetic anomalies at the south of the survey area coincide with the circular gravity anomalies in Figure 3. As a consequence, these anomalies also coincide with the basement highs mapped by seismic. Given the circular nature of the coincident gravity, magnetic and seismic anomalies at the south of the survey area, the source of these anomalies have been interpreted as intrusives.

Seismic Integration

3D seismic data were used to constrain the detailed 2.5D and 3D gravity and magnetic models. The gravity and magnetic models were created based on the seismic horizon picks from the 3D seismic data. Since seismic imaging was quite clear from the basement horizon to the seafloor, the only horizon that could be adjusted during modelling was the Mohorovicic Discontinuity. Forward and inversion modeling revealed that the basement highs are coupled with deep oceanic crustal roots. This is in agreement with the principle of isostasy.

Results and Conclusions

By undertaking a joint interpretation of the seismic, gravity, and magnetic datasets, less ambiguous results with a higher degree of confidence were obtained. The objectives of this study were achieved via the joint qualitative and quantitative interpretation of the three datasets. It has been determined that the two basement highs at the southern portion of the survey area are intrusive in origin. Additionally, the series of strong gravity anomalies at the northern perimeter of the survey area are due to oceanic crustal thinning.

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Reference

Sandwell, D.T., and W.H.F. Smith, 2009, Global marine gravity from retracked Geosat and ERS-1 altimetry: Ridge segmentation versus spreading rate: Journal of Geophysical Research, v. 114/B01411, p. 1-18.

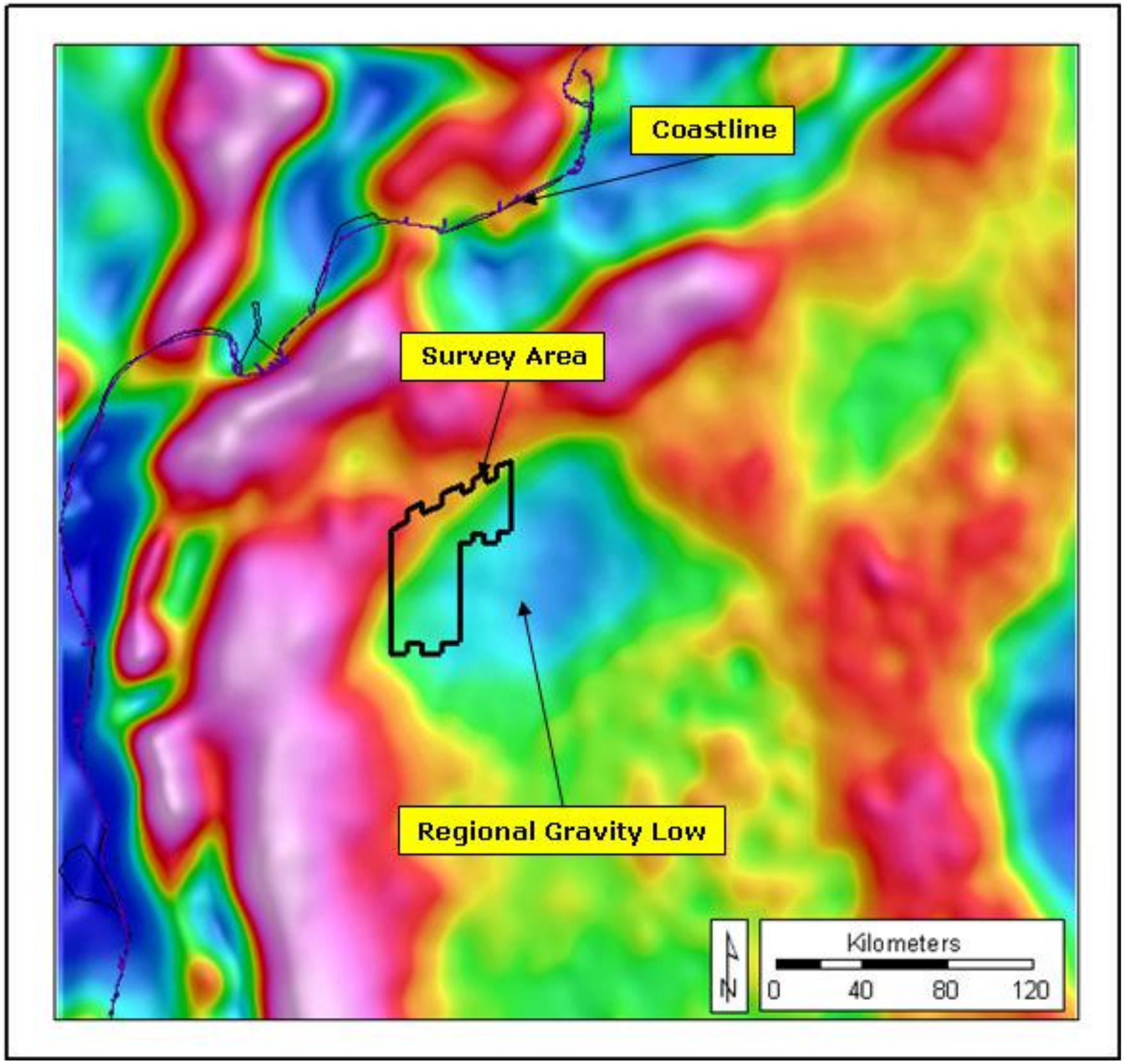

Figure 1. Regional gravity data (Sandwell and Smith, 2009). 2.2 g/cc Bouguer correction. Band pass filtered 40-300 km. Red to blue colors are high to low values. Survey area is at the edge of a regional gravity low.

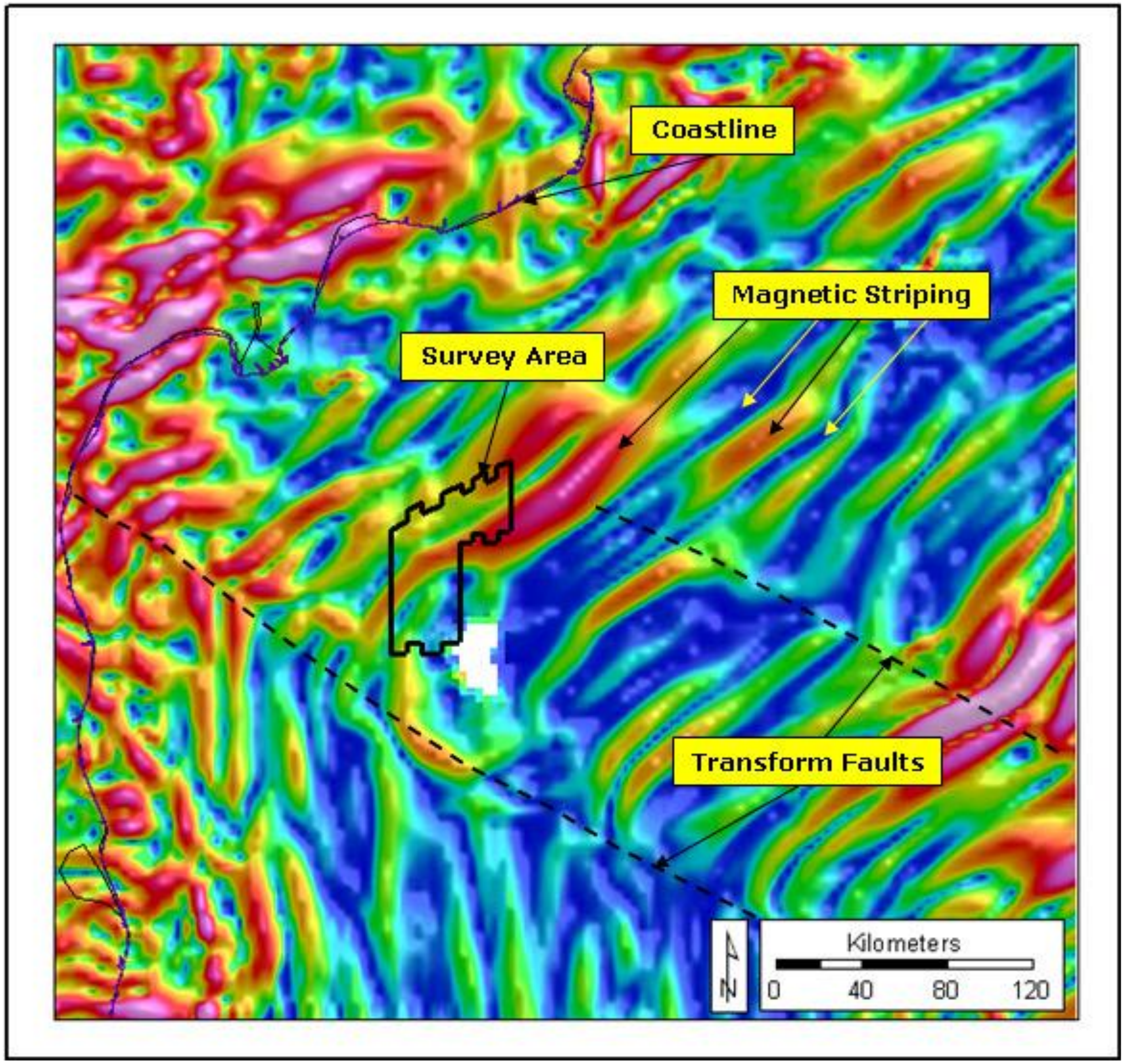

Figure 2. Regional magnetic data (EMAG2). Analytic signal. Red to blue colors are high to low values. NW-SE transform faults and NE-SW magnetic striping can be seen in the data.

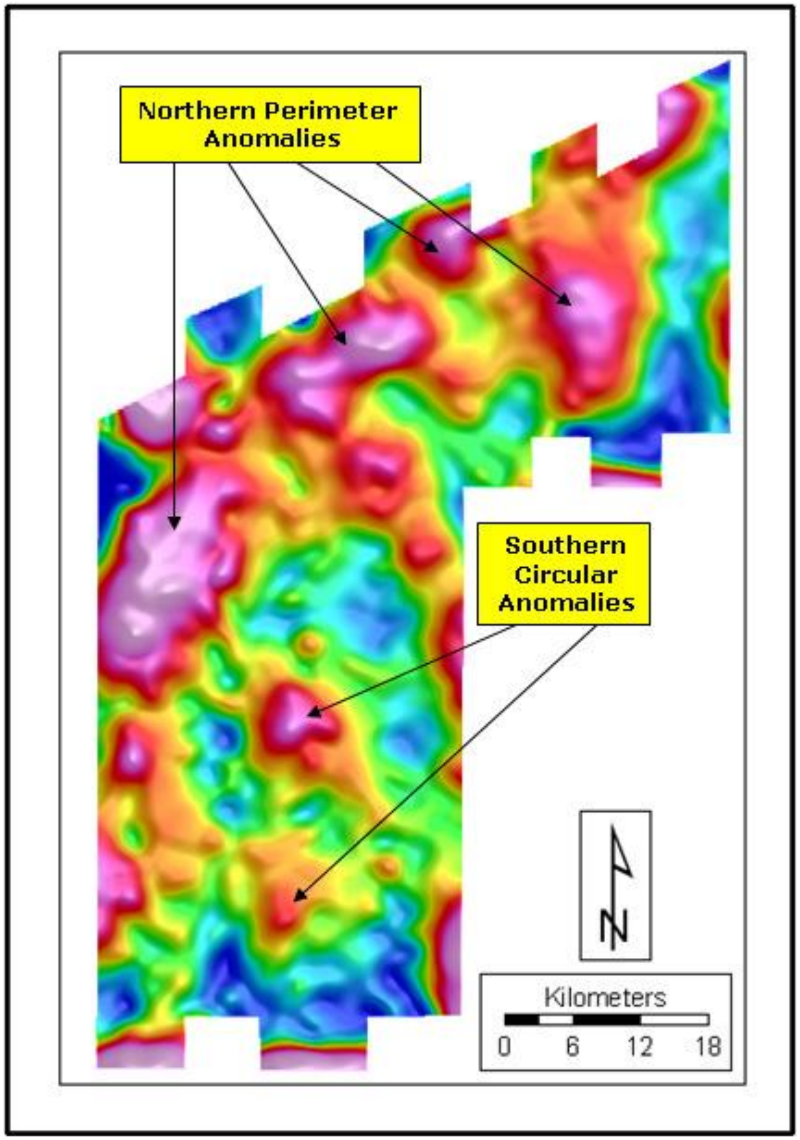

Figure 3. Detailed gravity data. 2.2 g/cc Bouguer correction. High pass filtered 20 km. Red to blue colors are high to low values. Map shows the gravity anomalies at the northern perimeter and the southern portion of the survey area.

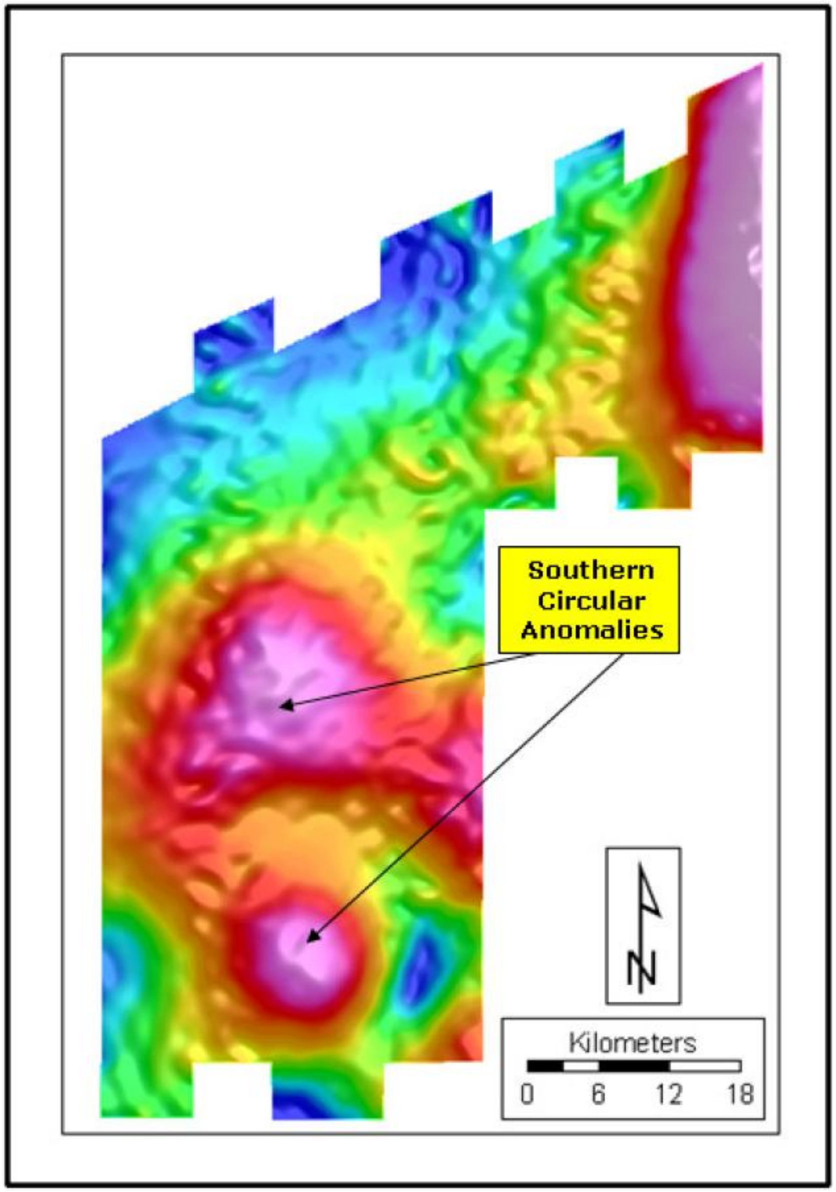

Figure 4. Detailed magnetic data. Analytic signal. Red to blue colors are high to low values. Map shows the magnetic anomalies at the southern portion of the survey area.