Integrated modelling of Durgapur Depression (Damodar Basin)

Jatindra Kumar
Frontier Basins (Onland) Exploration Group (FBG), KDMIPE, ONGC, Dehradun, India
email jit_ong@indiatimes.com

Summary

Damodar basin displays an excellent development of Lower Gondwana sediments in isolated depressions in an East-West trending narrow linear belt with southerly basin slope. In this paper, integrated modelling carried out for the eastern-most depression viz., Durgapur Depression has been illustrated. Mainly the application of *a priori* knowledge of the basin for carrying out modelling has been discussed. Adequate characterisation of the subsurface geologic structure using different data individually is prone to errors. Inherent problems of sills/ dykes and the complexities due to presence of many coal seams necessitate integrated modelling of Durgapur Depression. This prompted us to construct a detailed geological model integrating various sets of data.

Multilayered seismo-geological model generated has been subjected to gravity modelling .Gravity modelling has substantiated the results of seismo- geological model. Innovative use of seismic facies (for density forecast and lateral extent of sill) has been made for gravity modelling which has resulted in fine matching of computed and observed gravity values. Maximum sedimentary thickness appears to be of the order of 4 km. Gravity modelling has demonstrated the practical utility of integrated modelling. Its results provided greater definition of the extent of sill and confirmed coal facies. It has thrown light on basin configuration and has also validated structure seen on seismic which in turn has given information about the hydrocarbon potential. Reasonable consistency in the geologic structure and model is observed.

Integrated modelling has immense potential in areas prone to seismic artifacts viz., sills and dykes infested areas and can aid in Planning, Acquisition, Processing and Interpretation (PAPI) of data for effective hydrocarbon exploration. Full advantage of integrated modelling should be taken to mitigate exploration risks.

Introduction

Raniganj sub-basin, a rhombic basin, situated 200 km. northwest of Kolkata, represents the eastern most and largest basin of the chain of Coal-bearing Gondwana sub-basins which roughly follow the trend of Damodar valley. The major portion of Raniganj sub-basin lies to the east of Barakar river. The Gondwana sediments of the Raniganj sub-basin are bounded to the north, south and west by Pre-Cambrian rocks whereas the eastern boundary is concealed beneath a thick succession of unconsolidated recent sediments beyond and extends in the Durgapur Depression up to Domra-Panagarh area (Fig.1). Laterite cappings are common and widespread in this area. Morpho-tectonically the Raniganj basin shows half-graben structure with a major E-W trending boundary fault which brings metamorphics in the south in juxtaposition with the Gondwanas.

The basin displays rocks from Talchir to Supra-Panchet formations. Rajmahal traps have been encountered along the easternmost fringe of the Raniganj coalfield above Panchet formation (Fig.2). Barakar and Raniganj formation have many coal seams while Barren Measure formation and Panchet/Supra-Panchet formations are devoid of coal-seams.

An interesting aspect of the Gondwana basins is the presence of dykes & sills. Almost all Damodar valley coal fields are intruded by sills and dykes. These dykes are characterized by their great thickness e.g. Salma dyke which runs across the Raniganj coal field. On this analogy, dykes & sills can not be ruled out in Durgapur depression also.

Integrated approach has been adopted for carrying out 2D gravity modelling mainly because of two considerations viz. (i) to address the inherent problems of sills and dykes which cause seismic artifacts and (ii) to account for the coal seams.

Methodology

While gravity modelling is a non-unique process, the use of *a priori* knowledge in gravity models greatly reduces the range of possible models. By applying progressively more *a priori* knowledge to gravity models, a limited set of geologically reasonable models can be

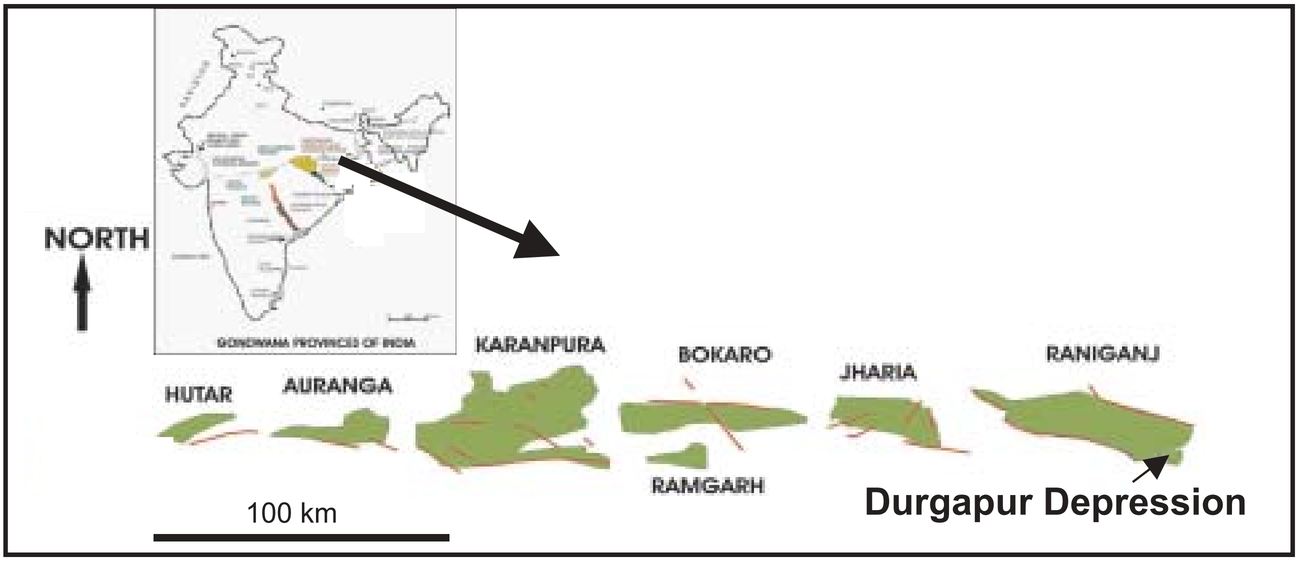

Fig.1: Index map, Damodar Basin

arrived at i.e. *a priori* knowledge constrains the models. These models give much information about the tectonic evolution of the basin and hence their hydrocarbon potential.

The area has been covered with both geological and geophysical data. Methodology involves integration of all the available data i.e. *a priori* knowledge existing in the basin. Multi-layered Seismo-geological model has been generated along a north-south seismic line AA' (Fig.2&3). For this, seismic data calibrated with VSP has been used. An innovative use of seismic data has been made to qualitatively estimate the densities of formations. For this extensive use of seismic facies maps has been made.

To carry out 2D gravity modelling, Bouguer gravity anomaly map (Verma, et.al., 1980) has been used (Fig.2). The sub-crop map has been superimposed on the gravity anomaly map to understand the basin fill (Fig.2). Gravity highs over the subsurface high density intrusive are very well matching with the subcrop map. Residual anomaly map has also been prepared to enhance the local features and to establish correlation with seismic data (Fig.4).

For quantitative analysis, rock density information from well "W-1" and "W-2" has been taken. Gravity modelling has been attempted for the seismo-geological section prepared using available seismic and geological data and the model is extended beyond seismic line in the north and south direction. Igneous intrusive is encountered in borehole Raj.1 (Vijaya et. al., 2002). The density of intrusive

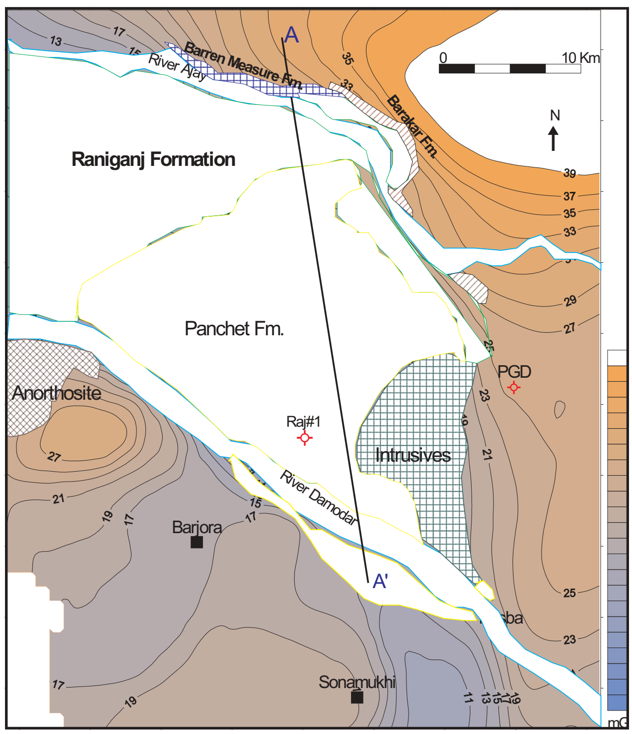

Fig.2: Bouguer gravity anomaly map of Durgapur Depression with subcrop map superimposed

is incorporated for modelling from the data of this borehole. Also seismic facies map has been used to envisage lateral extent of trap. The area shown on seismic facies map as chaotic/poor has been taken qualitatively influenced by

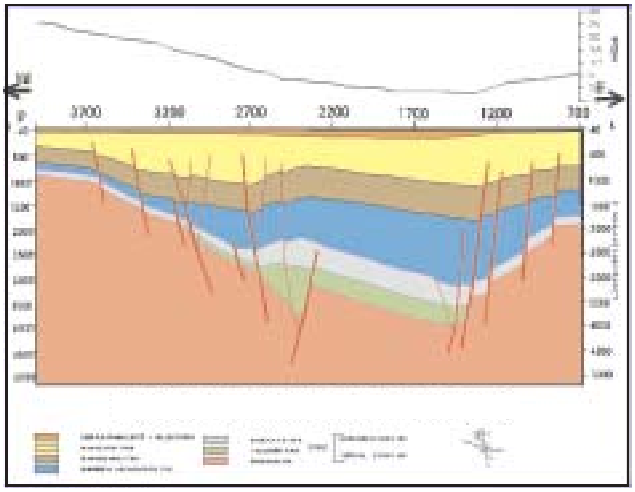

Fig. 3 Seismogeological section along line AA'

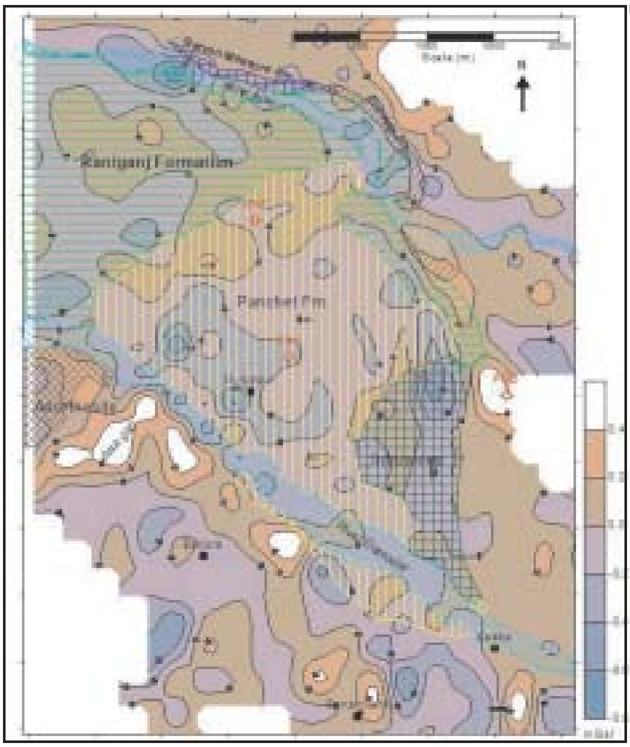

Fig. 4: Residual gravity anomaly map of Durgapur depression (By Griffen's technique, one ring, ring radius=1km.) with subcrop map superimposed.

the trap at shallow level (Fig.5). Density compensation is made on the basis of seismic facies map where high amplitude reflections are seen. These have been interpreted to be originating from sand-shale-coal sequence i.e. predominance of coal.

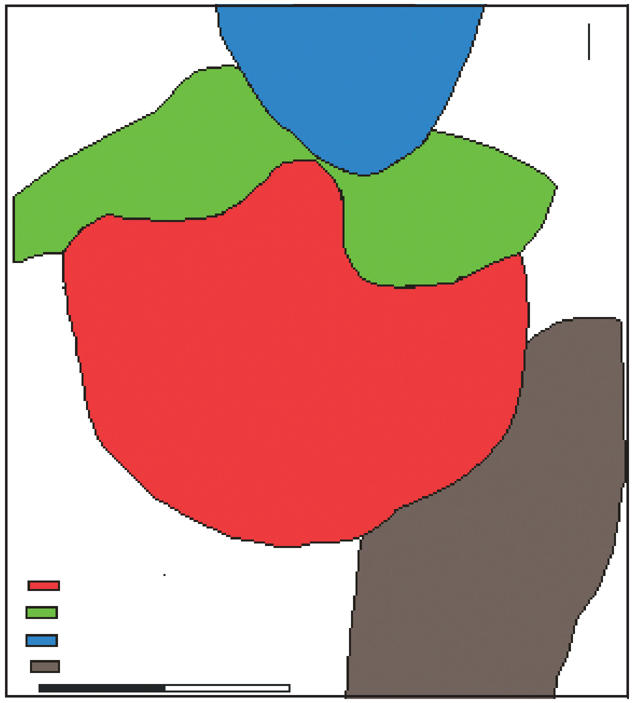

Fig. 5: Seismic facies map, Raniganj Fm., Durgapur Depression

The gravity anomaly data is then analysed with state of the art processing and modelling workstation. Forward gravity modelling, based on Talwani's polynomial method (Talwani et. al., 1959) on GM-Sys modelling program of gravity data has been conceived (Fig.6).

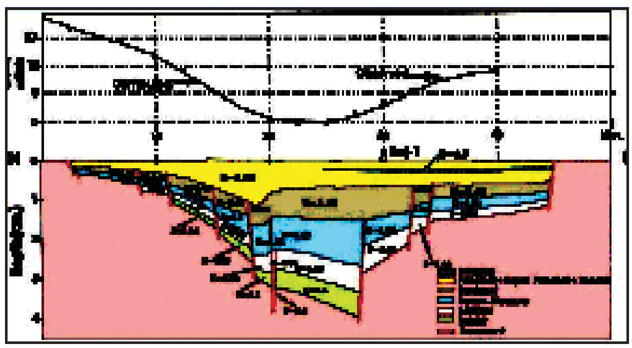

Fig. 6 Gravity Modelling along line AA'

Integrated modelling has yielded much better model than the model obtained through seismo-geological data alone. The innovative approach of adjusting densities on the basis of seismic facies has resulted in fine matching of computed and observed gravity response. This confirms the basement depth to approximately 4 km. and conforms to the structural features seen on the section. Integrated modelling has helped in adequate characterisation of subsurface geological structures.

Conclusions

The computed and observed gravity values are in good agreement. The innovative use of seismic facies, *inter alia*, for integrated modelling has resulted in fine matching of observed and computed gravity data. The modelling has suggested lateral extent of sill but exact position of dyke remains to be ascertained. Coaly facies have also been confirmed by the modelling.

The modelling has also thrown light on the veracity of seismic structure seen on the seismic data and also the basin configuration of Durgapur Depression. Maximum thickness of Gondwana sediments appear to be of the order of 4 km. Application of integrated modelling can be gauged from the fact that the model has given much information about the tectonic evolution of the depression and hence has thrown light on its hydrocarbon potential.

It is evident that integrated modelling (using seismic facies also) is a potent approach and can immensely aid in seismic Planning, Acquisition, and Processing & Interpretation (PAPI) which results in effective hydrocarbon exploration. However it is stressed that more accurate *a priori* knowledge of basin geometry and densities yields the more accurate models.

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References

Talwani, M., Worzel, J.L. and Landisman, M., 1959, Rapid gravity computations for two dimensional bodies with application to the Mendocino submarine fracture zone: J. Geophys. Res., 64, 49-59.

Verma, R.K., Bandhopadhyay, T.K., and Mukhopadhyay, M. 1980. Gravity field, Structure and Tectonics of the Raniganj Coalfield - Three Dimensional Model. Journal Geological Society of India, pp 117-127.

Vijaya and T.K. Bhattacharji, 2002, An Early Cretaceous Age for the Rajmahal Traps, Panagarh Area, West Bengal: Palynological evidence, Cretaceous Research (2002), pp 789-805.