Gravity and Magnetic Investigation along Rewa - Shahdol Basin Central India: Spectral Analysis Results

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Summary

Gravity and magnetic studies have been carried out along Rewa to south of Shahdol transect, Madhya Pradesh, Central India to understand the nature of the structural features conjugated with different geological entities and thickness sedimentary column. The detail gravity and magnetic data have been collected along 220 km long profile with 0.5 km station interval. The qualitative analysis of the data shows multiple geological entities i.e Mahakoshal, Gondwana sediments and deccan trap including deep seated faults (F1: SNNF, F2: SNSF and F3). Further, signature of sediment column under the deccan trap is also identified. Spectral analysis of the potential field data reveals the average depth of the deeper crustal layer approximately 21 km and depth to the basement (Mahakoshal/Crysatalline) 4.0 km on which Gondwana sediments were deposited. The thickness of the vindhyan sediments at Rewa and south of shahdol are estimated as 2.2 km and 450 m respectively. The results are well correlated with the deep borehole data and with gravity and magnetic results, Magnetotelluric and Deep seismic studies. Theese finding may be useful to develop a conceptual model for exploring mineral and energy resources along Rewa to Shahdol transect.

Introduction

The sickle shaped Intra-cratonic Vindyan basin is one of the mid to Late Proterozoic basins of India, It was formed due to continued rifting and subsidence of the central part of the Indian peninsular shield. The most of the basin is covered by Indo-Gangatic alluvium in the north and thick Deccan volcanic lavas in the south. The sedimentation in this basin was begun around 1.7 Ga and continued till the end of the Proterozoic era. It is comprises of un-metamorphosed and mildly deformed sandstone, shale and limestone with a few volcanoclastic and conglomerate beds. Rewa basin is one of the sub basins in the Vindhyan basin and has potential hydro carbon reserves associated with gondwana group of rocks. The exploration studies were done by Oil and Natural Gas Corporation Limited (ONGC) has provided the clues to presence of hydrocarbon in this basin. The evolutionary, paleo-geodynamics and hydrocarbon potential of the basin is very little understood due most of the basin covered by thick alluvial and Deccan trap. In view of the importance of the evolutionary, paleo-geodynamics and hydrocarbon potential of the basin an attempt is made to provide the new insight in to the nature of the basin through detailed gravity and magnetic studies. Hence, detail gravity and magnetic data have been collected along 220 km long profile with 0.5 km station interval to understand the thickness of Gondwana sediments below the Deccan trap for hydrocarbon exploration.

Qualitative Analysis

The nature of the gravity and magnetic data is clearly delineated different geological units i.e Vindhyan, Mahakoshal, Gondwana sediments and Deccan Trap from Rewa to south of shahdol region (Fig 1). The moderate gravity and magnetic anomalies are observed over the vindhyan basement. A gravity low and magnetic high is observed at Mahakoshal. The gravity and magnetic anomalies drawn along the profile shows a typical anomaly pattern of sedimentary basin faulted on its both margins. Three major faults i.e F1, F2 and F3 which are separating the Vindhyan, Mahakoshal / Bijwara group, Gondwana sediments and Deccan Trap sequentially. Further small gravity highs are also inferred within the sediment column may relate to presence of trap/ dolarite dykes under the upper gondawana sediments. The major Narmada south fault (F2) and north fault (F1) are demarcated from this potential data. Very low gravity anomaly is observed over the Gondawana group of rocks due to presence of thick pile of sediments. However, high magnetic anomalies are observed corresponding to gravity due the presence of trap at shallow levels. A low gravity anomaly is also observed over the trap area at shahdol region due to the presence of Gondwana sediments below the trap in this area.

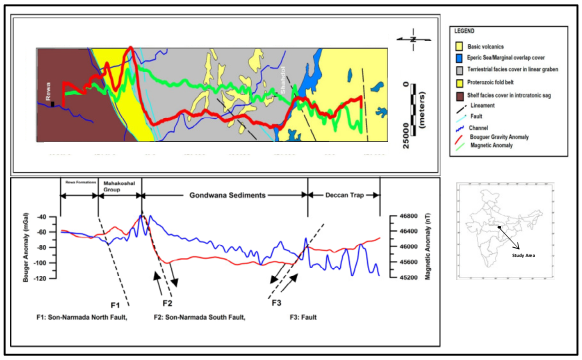

Fig.1. Top panel shows Geological map of the study region from Rewa to south of Shahdol (after GSI, 2000) with gravity and magnetic profiles. Bottom Panel shows the qualitative interpreted results from the gravity and magnetic data.

Spectral Analysis

The advantage of spectral analysis is has been invariable used to estimate the ensemble average crustal depths (Specter and Bhattacharyya, 1966; Specter and Grant, 1970, Naidu, 1970; Hahn et al., 1976; Bansal, and Dimri, 1999; 2006, 2010, 2014; Ghosh, and Singh. 2013; Prabhakara Prasad et al., 2013; Satish kumar et al., 2015, 2016; Raj Kumar et al.,2017) Here, we have used this technique to estimate the average depths of the Gondwana and crustal layers. The low frequency range of the spectrum has been taken to calculate the depth of the deeper horizons. The average depth of the magnetic horizons has been computed by using the following formula.

Depth = $1/4\pi \times (\Delta E/\Delta N)$

Where $\Delta E/\Delta N$ is the slope of the each segment, ΔE is the log energy and ΔN is the wave number increment. Log normalized amplitude averaged spectrum for the regional gravity shows two linear segments and interpreted depths are 21 km and 4.0 km (Fig.2). The calculated depths are representing the deeper crustal layer and depth to the crystalline basement on which Gondwana sediments are deposited respectively. Further, Fig.3 shows the 1D spectra of the individual formations from Rewa to south of shahdol. The thickness of the vindhyan formation is estimated as 2.2 km (Ghosh and Singh, 2011) and it is underlain by crystalline basement (Fig.3a). In addition to this a crustal layer at a depth of 13.5 km is also inferred (Fig.3a). The depth to basement under the Mahkoshal group of rock is estimated as 4.2 km (Fig.3b). The thicknees of the gondwana sediments estimated as 4.0 km (Swarnapriya et al.2017) underlain by basement (Fig 3c). The thickness of trap at shahdol region is 450 m and underlain by vindhyan group of rocks (Fig.3d). As schematic depth section is presented from the individual spectra of the all the formations and regional spectrum of the entire profile in Fig. 4.

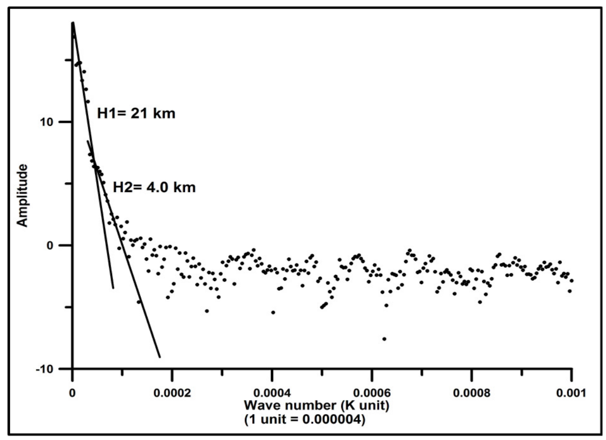

Fig. 2 Log normalized amplitude spectrum of the gravity profile shows two linear segments at low frequency range correspond to source related to depth to the deep crustal layer and depth to the basement.

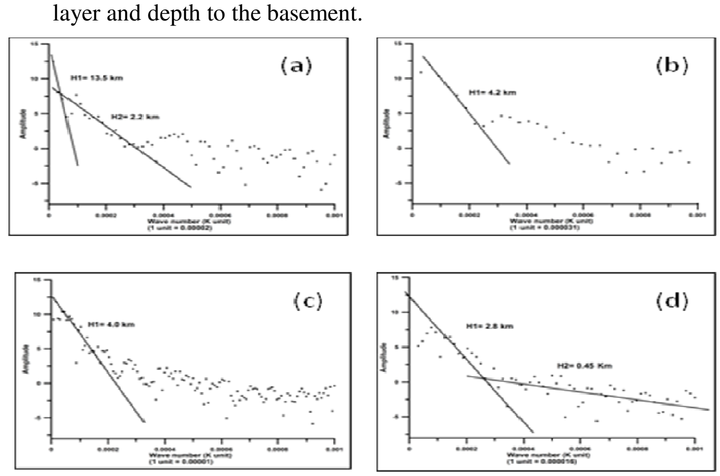

Fig. 3 Log normalized amplitude spectra over the different geological formations shows (a) depth of the upper crustal layer (13.5 km) and thickness of Vindhyan (2.2 km) at Rewa region, (b) depth to the crystalline basement (4.2 km) at Mahkoshal region, (c) depth to the crystalline basement (4.0 km) at Gondwana basin and (d) thickness of vindhyan sediments (2.8 km) and thickness of deccan trap (450 m) at trap region (Fig.1).

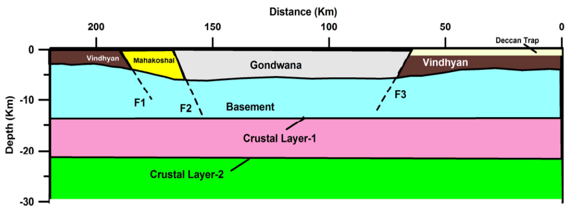

Fig.4 shows the schematic depth model from the 1D spectral analysis.

Conclusion

The nature of gravity and magnetic anomalies along Rewa to south of Shahdol region reveal the presence of crystalline basement, Mahakoshal, Gondwana sediments and Deccan Trap. Both gravity and magnetic anomalies drawn along the profile shows a typical anomaly pattern of sedimentary basin faulted on its both the margins. Three Deep seated faults are also indentified i.e Son-Narmada North Fault (F1), Son-Narmada South Fault (F2) and F3 (Which is separating the Gondwana sediments from the Deccan trap). The 1D spectral analysis of the gravity data indicated the average thickness of Gondwana sediments is 4.0 Km over the crystalline basement. Further, a deep crustal layer at 21 km is also inferred. The thickness of Vindyan sediments at south of Rewa estimated as 2.2 km and thickness of deccan trap estimated as 450 m at south of shahdol.

The obtained results are correlated with gravity and magnetic studies of swarnapriya et al.2017. The 2D power spectrum results of Swarnapriya et al.2017 revels the depth to the basement at north of Tikki is 4 Km and a deep crustal layer is also observed at 21 km. The present results are also correlated with borehole results of ONGC (Jithender kumar et.al. 2005) and the reported depth to the basement is 4 Km. Further, the results are well correlated with the newly acquired magnetotelluric and deep seismic results along this transect.

Further, understanding of heat flow and seismic tomography along this transect may provide same endurance presence of hydrocarbon, crustal-mantel configuration, prevailing lithospheric thermal regime and nature of the geodynamic evolution of the region.

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