J. Ind. Geophys. Union, 30(4) (2026), 241-252
https://doi.org/10.71122/JIGU.30(4)2026.0024

Shallow upper crustal structure of south Rewa Gondwana basin, Central India constrained from different geophysical studies

Sudeshna Moharana[1,2*] and Laxmidhar Behera[1,2]
[1]CSIR-National Geophysical Research Institute (CSIR-NGRI), Hyderabad - 500007, India
[2]Academy of Scientific and Innovative Research (AcSIR-NGRI), Ghaziabad -201002, India
*Corresponding author: sudeshna.ngri19a@acsir.res.in

ABSTRACT

The south Rewa basin is located in northern part of the Son-Mahanadi rift system in Central India, which has huge deposit of Gondwana rocks. The basin is affected by active tectonic activities towards north and ubiquitous presence of Deccan Traps in south, making this basin geologically complex to image the subsurface geological features. The hydrocarbon prospect of the Gondwana rocks in this sedimentary basin, has encouraged multi-disciplinary geological and geophysical investigations. The upper-crustal P-wave velocity model (V_P) of the south Rewa rift-basin is derived down to 10 km depth by using the 2-D traveltime inversion of both seismic refraction and long-offset reflection traveltime data along the 155 km long Hardi-Samatpur seismic profile. The model shows V_P variations of 3.2-3.5 km/s for the first-layer, which are mainly composed of complex mixtures of exposed upper-Gondwana rocks, basalts and dykes, as well as weathered rocks with alluviums. The second-layer mainly comprises high-velocity-layer (HVL) basalt with V_P varying from 4.9-5.1 km/s, corresponding to the Deccan volcanics that overly the low-velocity-layer (LVL) Gondwana rocks of velocity 4.0 km/s. The basement is highly undulated, forming horst and graben structures, having V_P variation from 5.9-6.1 km/s, showing significant upwarping on either side of the basin along the profile. The deep-basinal faults constrain the presence of Gondwana rocks below Deccan Traps in a graben structure that may have potential for hydrocarbon accumulation. The sub-basement, with V_P varying from 6.4-6.5 km/s, follows the basement geometry, showing significant upwarping towards the Narmada-Son-Lineament (NSL). The results obtained from the inversion of seismic data are further corroborated using residual-Bouguer-gravity anomaly, magneto-telluric (MT), well lithology, magnetic, and heat-flow studies over this region along the Hardi-Samatpur profile. The MT, magnetic, and gravity information suitably complement the seismic results corresponding to gravity-lows, conductive-zones, and low-velocity zones associated with deposition of the Gondwana rocks, confined by intra-basinal faults. Hence, with the help of suitable integration of different geophysical studies, we have obtained good constraints on the nature of subsurface geological features in the upper-crust in the south Rewa Gondwana sedimentary basin of Central India.

Keywords: Seismic refraction and long-offset reflection; Ray-trace inversion; Horsts and grabens; Gondwana rocks; Basement; Upper-crust, South Rewa basin

INTRODUCTION

The Gondwana sedimentary basins of the peninsular Indian shield have undergone multiple stages of drifting and rifting during different geological time periods, forming continuous changes in basin development. The south Rewa basin (Figure 1) is a sub-basin of the Son-Mahanadi intra-cratonic rift-basin located in Central India (Mukherjee et al., 2012; Chowdari et al., 2017). The rift-basin contains heterogeneous rocks with complex geological settings controlled by deep-basinal faults, linear belts and undulated basement. The basin came into the limelight because of the presence of hydrocarbons. The south Rewa rift-basin is classified as a Category-IV sedimentary basin in India for conventional petroleum systems. The basin contains undiscovered conventional hydrocarbon reservoirs and is currently producing unconventional coal-bed-methane (CBM). The Deccan volcanics mask the hydrocarbon-bearing Gondwana rocks by intruding into the Gondwana strata, which was corroborated by the findings from the Tihki exploratory well (Figure 2) drilled by ONGC (Kumar et al., 2005). The paleomagnetic study and $^{39}Ar/^{40}Ar$ dating of mafic dykes exposed along the Son river, near the Shahdol region, conforms with the Deccan volcanism (Lala et al., 2011, 2014; Chowdari et al., 2017). The presence of high-velocity Deccan Traps overlying the low-velocity Gondwana strata creates a challenging situation for imaging the sub-trappean geological features of interest.

The seismic wave propagations through the high-velocity basalts create significant loss of energy due to scattering, absorption, dispersion, diffraction, attenuation, mode-conversion etc., thus limiting the effectiveness of conventional near-vertical reflection techniques for imaging the sub-basalt structures (Behera et al., 2002, 2004). To overcome this challenge, the long-offset seismic refraction and reflection data are acquired, in which the energy can penetrate the high-velocity basalts to image the deep-seated targets of interest, like low-velocity sediments and basement configurations. In case of the presence of thick low-velocity rocks overlain by thin high-velocity rocks, the lowering of seismic energy is observed in the first-arrival data, resulting traveltime delay in the seismic section called “skip”, indicating the occurrence of velocity inversion in the subsurface earth (Greenhalgh, 1977; Whiteley and Greenhalgh, 1979).

The main aim of this study is to suitably integrate the results from other geophysical methods like gravity, magnetic, magneto-telluric (MT), exploratory well and heat-flow with the corresponding velocity model derived along the Hardi-Samatpur seismic profile of south Rewa basin (Figure 1).