Introduction

Krishna-Godavari (KG) basin is a proven petroliferous basin along the eastern continental margin of India in which various geophysical surveys have been carried out, indicating key structural features such as active faulting, mud diapirism, pock marks and pathways of fluid migration (Ramana et al., 2009). Movement of such fluid can be mapped on a seismic section by identifying features like acoustic voids, amplitude blanking and acoustic turbid layers (Dewangan et al., 2010). In many petroliferous basins, fluid migration features are correlated with tectonism and imposed concern on the stability of the basins (Ramprasad et al., 2011). It is therefore an essential task to map the fluid migration network and their relation with ongoing tectonism in an important basin like KG in offshore India to constrain the slumping/sliding related future geohazards, which might eventually affect the available offshore exploration and production facilities.

In the present study, an industry standard high-resolution 3D post-stack seismic volume from the KG basin (Figure 1(a)) is thus studied, in which an integrated analysis of well log and seismic datasets are carried out to delineate potential hydrocarbon zones and fluid migrating pathways, shedding light upon the neotectonism and slumping/sliding associated with the study area (Figure 1).

Study Area

The Krishna-Godavari basin (K-G basin), which is an important petroliferous basin, is located in the central part of the eastern continental margin of India (ECMI). Since late Miocene, huge volume of detrital sediments has been depositing into the basin, carried by Krishna and Godavari river systems, developing a vast alluvial fan in the eastern Indian offshore (Figure 1b). In these deposits, Holocene-Pleistocene sequences are mostly dominated by smectite bearing Godavari clay formations (Rao, 2001). Earlier studies (Dewangan et al., 2010) reported evidence of neotectonism in the KG basin forming various geomorphic features like mounds, shale diapirs, and faults. The bathymetric mounds are mostly found to be associated with fluid migration occurring through the existing fault systems (Dewangan et al., 2010). Moreover, stratigraphy of the KG basin comprises of both syn-rift (Upper Jurassic to Early Cretaceous) and post-rift (Tertiary) petroleum systems (Rao, 1993). The basin formed via rift /syn-rift tectonics between Permo-Triassic to Early Cretaceous and is characterized by lagoonal to fluvial to occasional brackish water sediments. The synrift sediments were deposited during early subsidence by tectonic fault systems. Basin subsidence continued accommodating synrift sediments of late Jurassic-early Cretaceous (Ramana et al., 2001). Rift to drift transition lead to widespread marine transgression.
Methodology

Post-stack seismic data with Inline and Crossline numbers ranging from 50000-50700 and 11200-13100 are used for inversion, respectively. OpenDTeect software was used for visual inspection of the 3D datasets in which various promising gas escape features and faults were identified. Then, a post-stack model based impedance inversion of seismic data was done in Hampson Russel software in which well to seismic tie, wavelet extraction, estimation of initial velocity model were carried out to obtain inverted impedance (Ip) and Vp/Vs volumes. Rock physics analysis was performed then by cross plotting elastic parameters in the target zone to establish a link between reservoir parameters such as: porosity, lithology, water saturation and seismic properties including Vp/Vs, density and elastic moduli.

Results and Discussions

Figure 2 shows a migrated seismic section from Inline 50275 in which position of the well A is marked. A bright spot, which is a high amplitude seismic attribute anomaly indicative of presence of gas, is identified at 2055 ms along with other gas migrating features like gas mound, shallow gas pocket and amplitude blanking zones (Figure 2). A set of southward dipping listric faults are prominent throughout the section. A pull down structure, which is associated with an increase in two-way travel time due to presence of low velocity zone (gas), is clearly seen in the zoomed image of inline 50275 in Figure 2(b).

Well log measurements from well A include Gamma ray (API), Neutron porosity, density (g/cm3), resistivity (ohm-m) and water saturation as shown in Figure 3(a). A potential hydrocarbon zone is marked, identifying a gas bearing zone with a thickness of ~50 ms form the cross-over between the density-neutron porosity logs. Presence of hydrocarbon is further justified from the signature of high resistivity, low water saturation and low gamma ray values (55-70 API) in the target zone, corresponding to a sandy-shale lithology. Figure 3(b) displays cross plot between elastic parameters Vp/Vs and P-Impedance (Ip) is shown for the lithology identification, as the Vp/Vs ratio is useful in determining lithology. P-waves are more sensitive to fluids than S-waves and thus difference in Vp/Vs ratio would indicate different fluid saturations (Mukerji et al., 2001). In Figure 3(b), shale and gas sands are distinguished as high Vp/Vs ratio indicating presence of shale whereas a separate cluster of low Vp/Vs demarcates the presence of gas sand in the target zone.
In Figures 4(c) and 4(d) rock properties like P-Impedance, Vp/Vs, linked to fluid content, porosity, and lithology, are analysed from log and from 3D seismic post-stack datasets. At first, four horizons are picked and used to build initial P-velocity model Figure 4(b) which are used for inversion in HRS for the entire 3D volume to obtain the inverted impedance model (Ip) and Vp/Vs model shown in Figures 4(c) and 4(d), respectively.

![Figure 3](image1.png)

**Figure 3:** (a) Well log suite from well A: Density, Neutron porosity, Resistivity, Water Saturation and Gamma Ray logs. Potential hydrocarbon zone is marked by dashed line (b) Cross plot between Vp/Vs and P-Impedance (Ip) for well A.

![Figure 4](image2.png)

**Figure 4** (a) Seismic section from inline 50275. (b) Initial Velocity model (c) Inverted impedance (d) Inverted Vp/Vs.
The bright spot (gas) identified in Figure 2 at 2055 ms is validated by conventional well log analysis as shown in Figure 3(a). The cross plots obtained in Figure 3(b) also confirms the presence of gas sand. Figures 4(c) and 4(d) further show low Ip and Vp-Vs ratio value at 2055 ms indicating gas, respectively. Previous studies indicate that KG basin shows gravity driven shale diapirism/neotectonism (Dewangan et al., 2010). We have mapped structures like, faults, gas mounds, and fluid/gas venting features in Figure 2(a) which seems to be a result of neotectonism. Several listric faults are observed which are related to neotectonism and act as pathways for migration of gas. Various shallow faults can be seen in our study area which are small in size and not deep rooted, so the scarps produced by them on sea floor are much steeper. These faults can act as failure surfaces resulting in slumping/sliding.

Conclusions

We have identified potential gas zone in the KG basin offshore India and mapped various gas venting features. Rapid sedimentation in KG basin leads to result in slumping/sliding which eventually effects the stability of the basin slope. However, fault system and neotectonic activity have been weakening the compressibility of basin sediments due to movement of gas. Since KG basin is a prospective oil and gas basin and extensive drilling has been carrying out in this region, hence identification of such sites will certainly assist to prevent future geohazards.

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References


