Study Of Geological and Geomechanical Aspects of shale Integrity Challenges in KG Basin

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Abstract: To overcome the challenges specific to unconventional reservoirs technologies is needed Design & Testing. Specific reservoir attributes and diagenetic configurations are the solutions to overcome rock and reservoir quality uncertainty, a common scenario in unconventional reservoirs. Enhanced reservoir evaluation allows future planning for drilling and completion strategies. Sensitivity analysis improves increasing the knowledge of the unconventional reservoir behavior and the corresponding impact on the reservoir drainage performance.

Characterizing geomechanical parameters of an unconventional reservoir includes calibrated mechanical earth models. This reduces uncertainty in the geological and geomechanical parameters used to design operations. This report takes Vadaparu shale as a sample for analysis.

Key Words**:** shale, KG basin, wellbore, Geology, Sandstone

1. INTRODUCTION

The unconventional reservoirs have emerged as major hydrocarbon prospects and optimum yield from these reservoirs is dependent on well design and hydrofracturing where rock mechanics play key role. Mostly Sonic tool Measures at borehole condition are used to compute the rock mechanical properties like Stress profile, Young's Modulus and Poisson's Ratio. These are influenced by the anisotropy of layers and variations in well deviation for the same formations.[1]

Wellbore instability is one of the most consequential drilling operation risks in unconventional reservoirs. It is important for engineers to be able to validate wellbore stability coherently when trajectories are planned to adjust and optimize the risk during the planning phase. The risks of wellbore collapse in the buildup sections with formation stress orientation could be catastrophic. Due to shale heterogeneity, the horizontal section of the wellbore also has a high risk of wellbore instability. All the wellbore instability issues can lead to non-productive time and increase the cost of good construction.[2]

Shale has been a major destination for unconventional hydrocarbon resources for its wide stratigraphic coverage as well as high volumetric hydrocarbon potential. Organic richness has been a key factor to determine the potential of shale as it is proportional to the amount of hydrocarbon likely to be generated and stored in available spaces within the shale. The other important factor in this context is shale brittleness as it indicates how feasible the potential shale is. Attempts are made here by strategically using standard

wireline logs in order to evaluate the potential of Eocene Vadaparru Shale in Krishna Godavari Basin, India qualitatively and quantitatively.

The technique used in this study involves the identification of organic lean 'clean shale' interval and establishing a 'clean shale' relation of resistivity as a function of compressional sonic transit time in the study wells, as both the logs respond comparably to shale and its organic content. Using this relation a proxy 'clean shale' resistivity log is generated in shale and compared with measured wireline resistivity. A positive separation between calculated and measured resistivity is then assessed as proportionate shale organic richness, owing to the presence of relatively less dense (corresponding to longer sonic transit time) and more resistive organic content. Shale brittleness is predicted from Young's modulus and Poisson's ratio using compressional, shear and Stoneley wave velocities obtained from sonic measurements, assuming the transversely isotropic nature of Vadaparru Shale.

The Eocene marine transgressive Vadaparru Shale is a dominant stratigraphy in the KG basin as evident by seismic and drilling. Petrophysical analyses in study wells indicated appreciable brittleness within Vadaparru Shale. The organic richness i.e. amount of positive separation between calculated and measured resistivity combined with brittleness quantitatively indicates fair to excellent unconventional potential of Vadaparru Shale. Considerable thickness, Type-II, III kerogen content and geochemical measurements support the study and highlight it as a promising 'shale reservoir' destination.
The subsurface geological complexities in Krishna Godavari Basin, India often result in discrete and challenging reservoirs. Limited geological correlation plus HP-HT regime down-hole further adds up to the challenge to understand reservoir HC potential.
Commercial accumulation of hydrocarbons occurs in sediments from the Permian to as young as the Pliocene. Offshore water channel over bank system has a lot of uncertainties, due to the presence of thin beds, primarily, sand, silt and shale or their combination in term of their petro-physical properties and lateral extent. The complex geology of the study area and inadequate reservoir characterization can cause significant amounts of hydrocarbons to remain unrecovered or to be recovered partially. Hence, proper evaluation of petro-physical parameters plays an important role in field development.[3]

In offshore environments, well prospects are sited at fracture gradients and narrow pressure gradients. Thus in this type of environment drilling hazards are aplenty and this makes wellbore completion a tough challenge. If the wellbore is not completed properly then there can be an economic as well as environmental disaster. In such situations there often exists a drilling window between fracture pressure gradient and also pore pressure through which when drilling done yields out proper results.

2. GEOLOGICAL ASPECTS

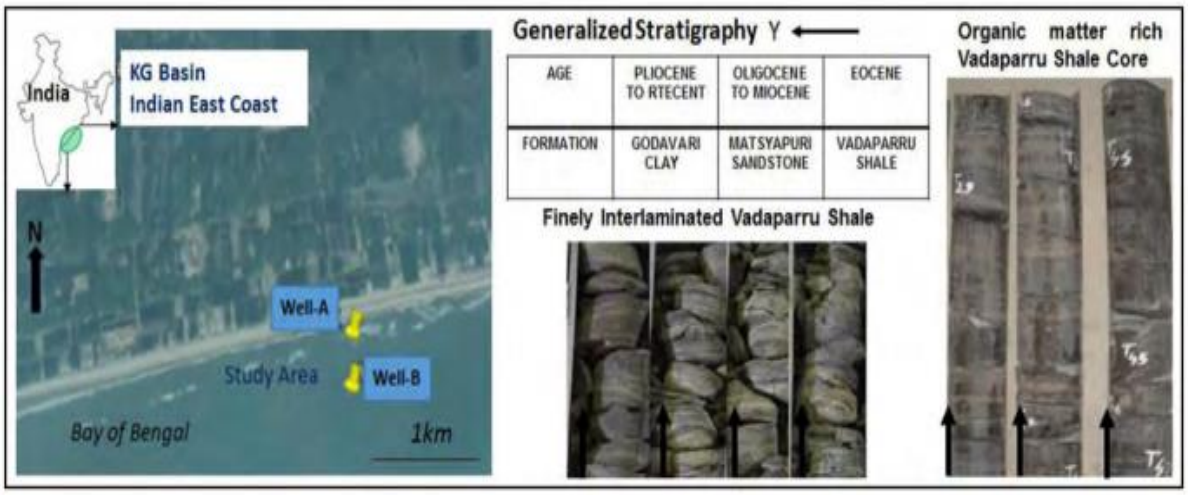


Fig 1:Vadaparru Shale-wells and stratigraphy

Vadaparru Shale Formation is found in the East Godavari sub-basin in KG and is of Eocene age. The shale and interlayered sandstone beds are largely known as Vadaparru play located to the south of Mori-Komarada fault system and has considerable thickness as evident from actutal drilled down depths. As discussed by Sahu (2018) Vadaparru Shale itself is a source-reservoir system and mostly targeted for the conventional oil and gas in sandstone units contained within the shale. The sediments of Vadaparru Shale appear to be deposited in a marginal marine deltaic to shallow marine shelf condition.

3. GEOMECHANICAL ASPECTS

For the geomechanical aspects towards evaluating brittleness of shale strata compressional, shear and Stoneley sonic logs have been used. Sonic travel time and resistivity are essentially comparable and reliable logs as their behavioral patterns proportionately reflect changes in shale characteristics such as total organic content. In general the organic content i.e. kerogen that occupies shale matrix is relatively resistive and less dense due to their physical properties. This makes way for the idea to consider organic lean shale as denser and less resistive in bulk. According to the findings of Passey et al.(1990) such organic lean shale can be identified by overlapping LLD-DT logs, if such logs are properly scaled by 1 logarithmic decade of resistivity (LLD) for 50 μsec/ ft of sonic (DT), after validating with gamma, neutron porosity and bulk density responses. An organic lean ‘clean’ shale interval can be used therefore to establish a relationship (equation-1a, 1b) of logarithmic resistivity as a function of sonic using cross plot method.[4]

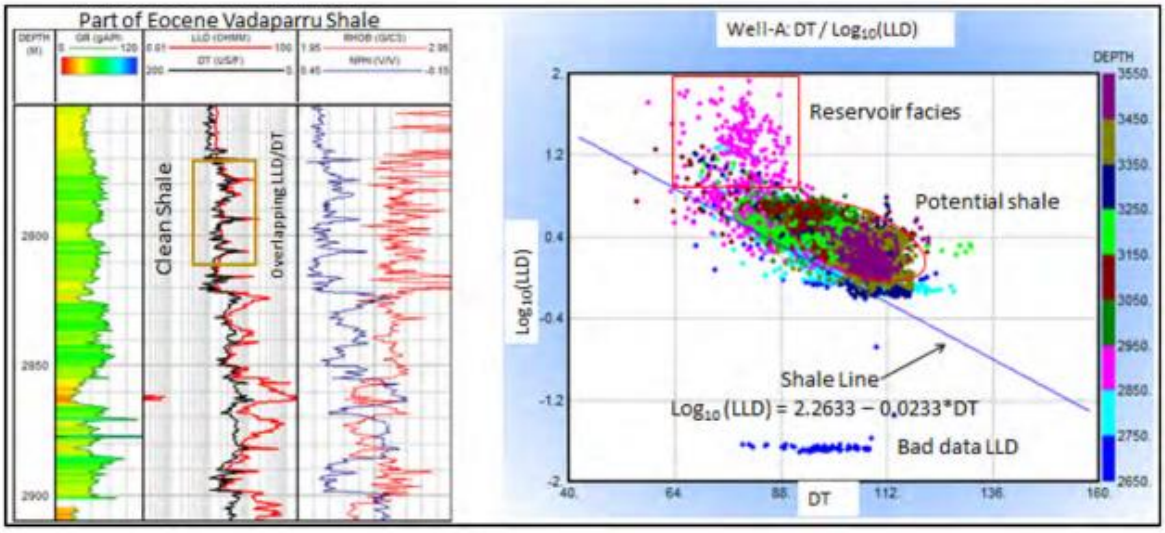


Fig 2: organic lean 'clean' shale interval from the well (URTEC-198280-MS)

Vadaparru Shale thermal maturity lies in the oil window with minor intrinsic variations and can be seen from the Vitrinite Reflectance graph in

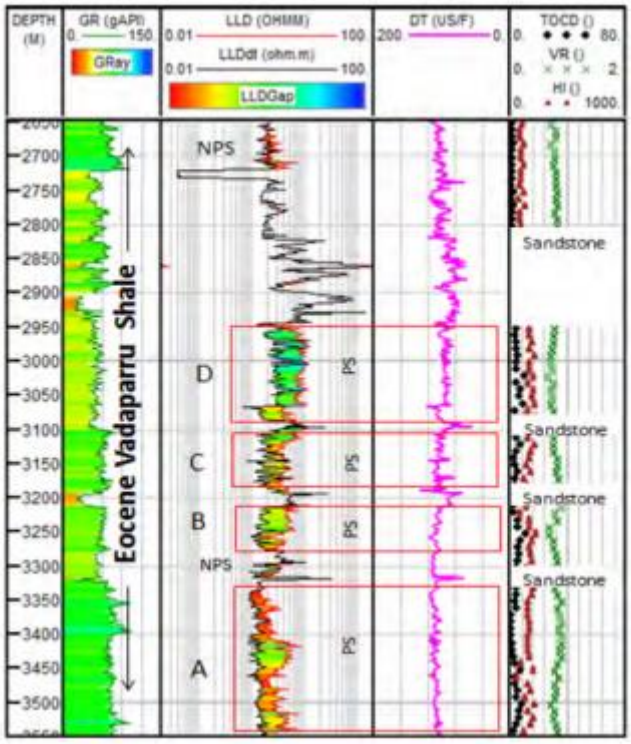
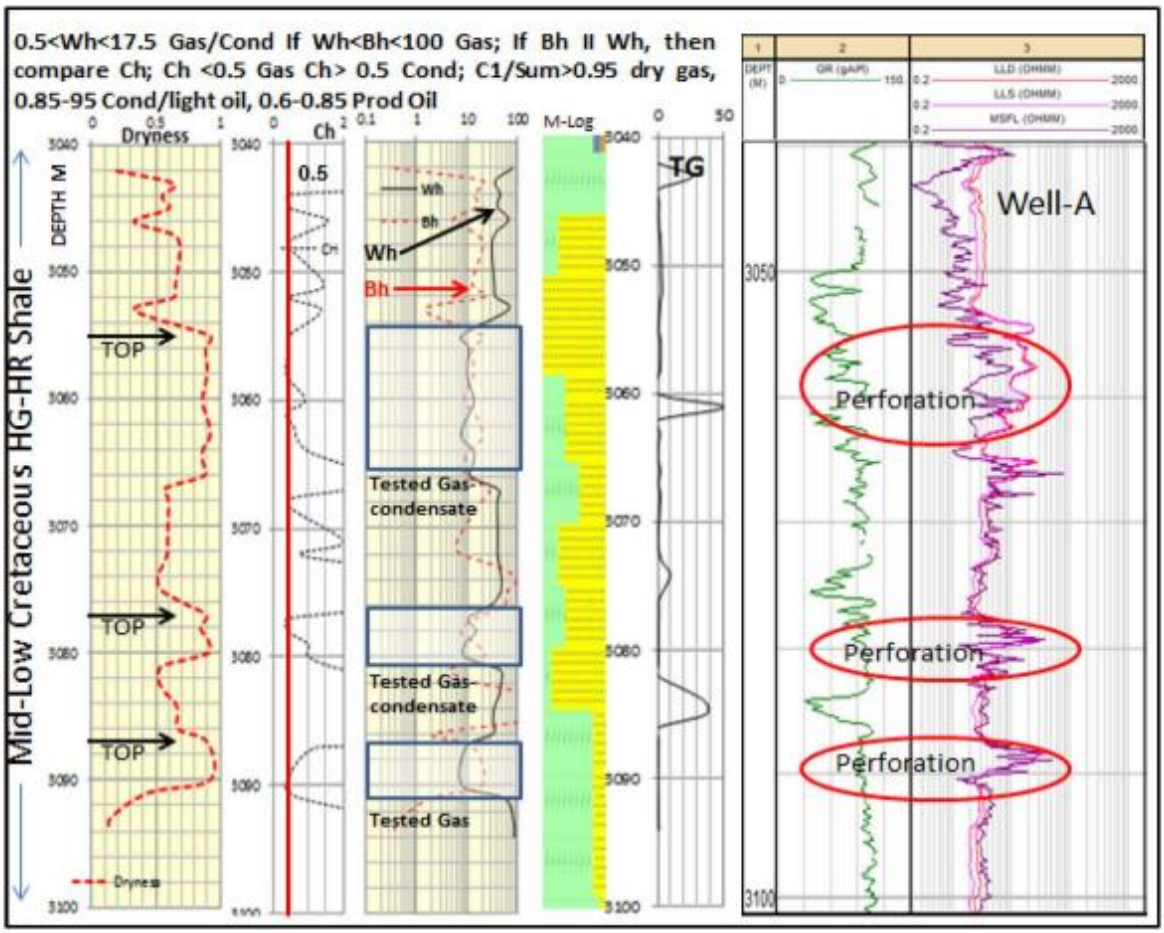


Fig 3:Organic rich potential shale (PS) in well (URTEC-198280-MS)

4. APPLICATIONS IN EVALUATING HC POTENTIAL FROM TESTING FORMATIONS



Testing of Different Intervals for HC identification (OTC-2894-MS)

Here reservoir keen to produce gas alone.

5. CONCLUSION

The study carried out in KG basin Eocene Vadaparru Shale in order to evaluate the organic richness as well as brittleness. Laboratory studies (pyrolysis) of interval cuttings in Vadaparru Shale from wells reveal type-II/III kerogen. Geochemical data show that intervals from wells are having good HI with fair to excellent TOC content. Two essential components of unconventional shale play-adsorbed and free hydrocarbons are largely related to organic richness of shale. e. Heterogeneity as discussed in geological aspects section coupled with organic richness are two important factors which makes Vadaparru Shale a favourable unconventional target. Vadaparru shale appears to be potential as unconventional player. There are further scopes to study this Eocene shale of KG basin in order to understand its log-laboratory calibration of geomechanical parameters, stress regime and distribution of organic richness associated with geological controls.

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