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Reservoir Characterization of Olpad Basal Sand in Padra Field for Hydrocarbon Prospectivity Analysis using Multi Component Seismic

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Abstract

An integrated approach using PP-PS pre-stack joint inversion & stochastic inversion outputs incorporating well data was applied to identify possible areas of oil bearing in Olpad basal sand pay of Padra field in western onshore basin. Olpad basal sands are major contributor of oil production in padra area, which is contributing more than 60% of oil production. Olpad reservoirs are generally trap derivatives, variegated claystones and basal clastics which are deposited as fanglomerates. Volumes of P-impedance, S-impedance, Vp/Vs and Density were generated from seismic prestack inversion for Olpad basal sand reservoir by selecting suitable windows. Cross-plots of well logs were generated to understand the behavior of reservoir throughout the area. Petro-physical parameters modeling was performed with inversion outputs using stochastic methods and maps for sand isolith, effective porosity & water saturations were generated. These Maps were analyzed for presence of hydrocarbons using suitable cut-offs and optimized through cross plots of the logs and corresponding attributes at well locations. Pre-stack inversion results P-imp & Vp/Vs volume helped to understand and predict reservoir properties in Olpad Basal sand reservoir. An effort has been made to identify hydrocarbon prospective zones based on these studies.

Introduction

The Cambay Basin *(Fig. 1)* is a narrow elongated intracratonic rift graben situated in north western part of Indian Peninsula in the state of Gujarat and part of Rajasthan covering an area of about 59000 sq. km. The Basin consist of several intra basinal uplifted blocks limited by Radhanpur-Barmer arch (which separates it from the Kutch basin),Saurashtra Craton on the west, Aravalli swell on the northeast and Deccan Craton to the southeast. It extends from north of Sanchor to the south in Cambay Gulf and ultimately open into the Arabian Sea. On the west and east, it is bounded by enechelon faults (Basin margin faults) paralleling the Dharwar trend and cuts across the Aravalli and Satpura trends.

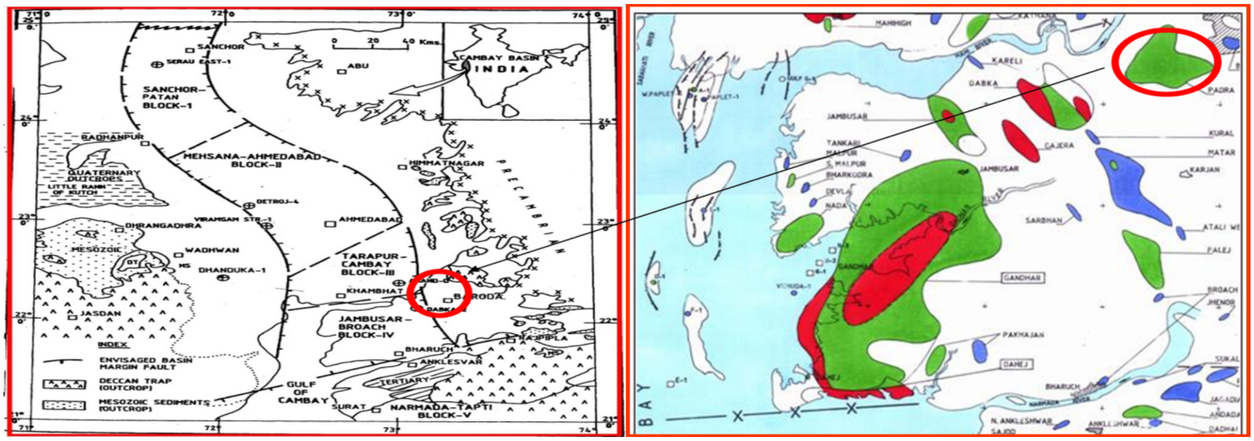


Fig: 1 Location map

The Basin has Deccan Trap volcanic rocks as technical basement over which 8 kms (+) thick Cenozoic sediments were deposited. A large part of the basin is covered by Quaternary sediments including alluvium of Banas, Saraswati, Sabarmati, Mahi, Narmada and Tapti rivers. Tertiary out crops is rare and occurs only on the fringes of the basin in Gogha - Bhavnagar and Jhagadia -Tarkeshwar areas. Present study carried out in Padra field which is eastern rising flanks of basin covered by 172 Sq Km of Area. This area is well explored and more than 100 wells have been drilled. Multicomponent seismic data has been used for reservoir characterization studies.

Geology of Area

The stratigraphic succession of the Padra field is in consonance with South Cambay Basin except that pinching/thinning of the stratigraphic units has been noticed due to Basinal margin position of the field. The drilling results of Padra Field have indicated that Deccan Traps (Cretaceous age) are un-conformably overlain by Olpad Formation (Paleocene) which in turn, are also un-conformably overlain by Ankleshwar Formation of Middle to Upper Eocene age followed by other younger sediments. The main hydrocarbon producers of the field are weathered and fractured Deccan Traps and Olpad Formation in addition to Ankleshwar sands. Following Table shows the generalized stratigraphy of Cambay Basin *(Fig.2)*:

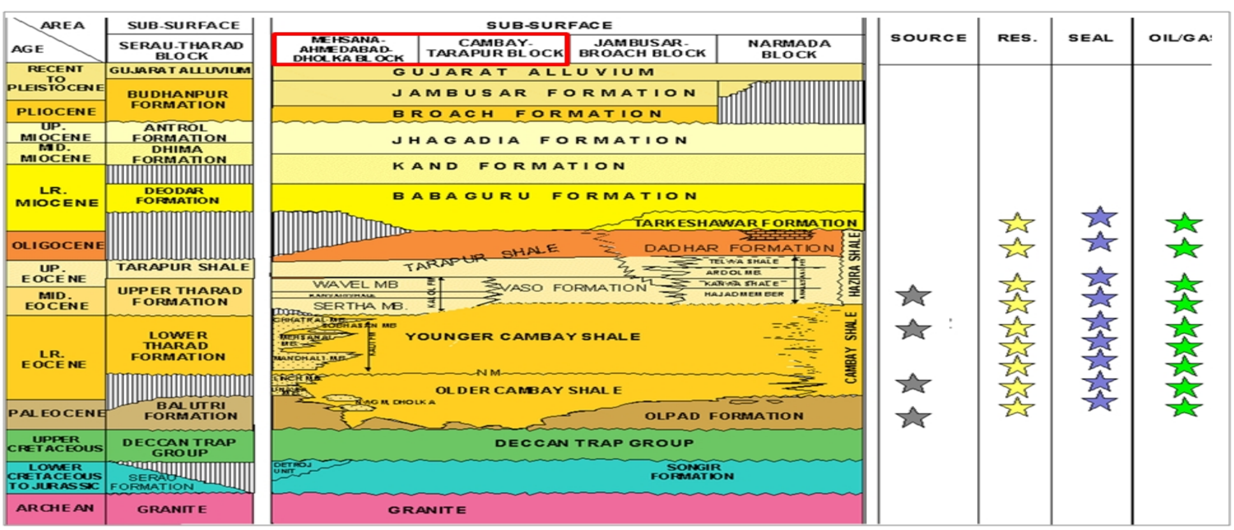


Fig: 2 Stratigraphy of Cambay Basin

The subsequent Olpad sedimentation in the area represent tuffaceous clay trapwash clay, epiclastic volcanic conglomerates sand polymictite gibbsitic conglomerates. Proximity to source area, high energy debris flow, very poor sorting immature composition of volcaniclastic, poor organic richness and stratification, presence of oxidizing facies indicates a terrestrial facies within an alluvium fan complex. The conglomerate lithofacies represents proximal part of fan whereas different clays are deposited in distal part. Olpad sediments are the first sedimentary unit deposited over the basalt with a sharp contact. It is characterized by highly immature sediments having very poor sorting. It comprises of two major lithofacies, namely conglomeratic trapwacke and silty or clay trapwacke. These trapwacke facies comprises of coarse grained basalt fragments (either amygdaloidal or partially weathered) followed by sandstone-claystone facies suggesting alluvial fan deposits. These coarse grained basalt fragments are sourced by weathering followed by erosion of nearby Trap and act as good reservoirs at places. Olpad reservoirs are generally trap derivatives, variegated claystones and basal clastics which are deposited as fanglomerates.

Procedure

Pre-stack inversion

Joint inversion of PP & PS data is a challenging job as PP & PS seismic volumes have variations in event times, frequency contents and PP & PS reflectivity etc. A model based PP-PS pre-stack joint inversion was carried out restricted from Ankleswar to Olpad Formations only. Procedure includes mainly the similar event identification in PP & PS domains and thereby event registration throughout the volumes in both the domains. Pre-stack migrated gathers in PP & PS domain are the seismic input to the joint inversion process along with well data such as dipole sonic logs (P & S), density logs, correlated PP & PS horizons and key markers. Out of 22 wells having DSI logs, only 5 well were found to be suitable to carry out the inversion process. As the thickness of the Olpad pay varies from 2 to 6 mts except in the northern and central part of the study area, it was felt to go for high resolution inversion i. e. Prestack Stochastic inversion to delineate those thin sands which are also good producers at the places. Therefore, Pre-stack stochastic inversion was also carried out throughout the volume restricted to the Ankleswar and Olpad formations. In Prestack Stochastic inversion, angle stacks generated from pre-stack migrated PP gather with suitable angle range were used as seismic inputs. Proper tuning of parameters was done for vertical as well as horizontal variograms to add the low frequencies as well as higher frequencies to the seismic band.

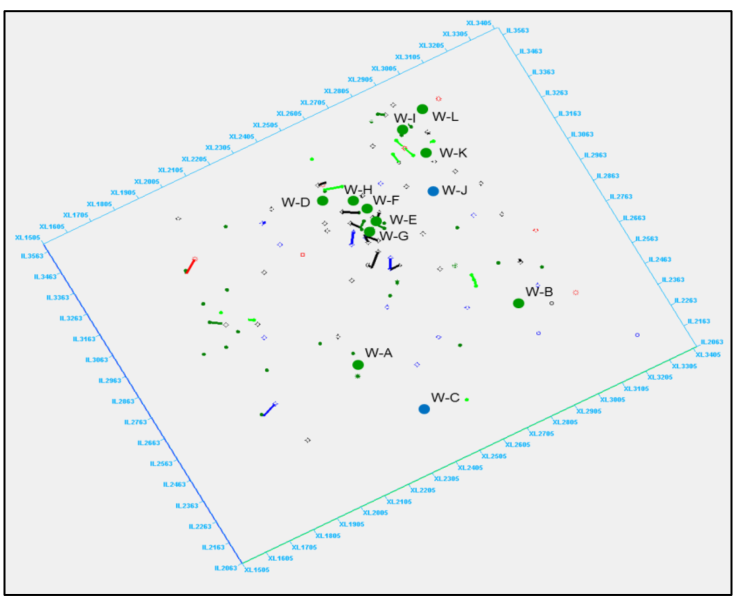


Fig: 3 Basemap

Well log cross plotting

The variation of P-impedance and Vp/Vs were studied within the study area by dividing it into several zones. It has been observed that there is an increase in P- impedance value at the hydrocarbon producing well locations throughout western, middle & eastern parts of the area. Vp/Vs exhibit a lowering tendency at the hydrocarbon producing well locations as expected. The range of P-impedance is found to be more than 6000 units (normally from 6000 to 9500 units) while that of Vp/Vs is from 1.70 to 1.95. The log crossplots at the well locations W-A & W-B where DSI logs are available have been shown in *(Fig 3 to 5).* It is possible to have the higher impedance at some of the well locations which are not hydrocarbon bearing which can be well explained by taking into account the range of Vp/Vs prevailing over there. One such type of scenario has been observed at W-C well location *(Fig. 6).* It is water bearing well from olpad basal sand. Range of P-impedance is found to be from 5000 to 6500 units. But the higher value of Vp/Vs from 2.3 to 2.7 suggests that the scenario is not favourable for hydrocarbon accumulation. Crossplots has been generated to establish this study in western, middle & eastern parts of the study area. Behaviours of P-impedance & Vp/Vs have been studied in oil bearing vis-à-vis water bearing wells and it is observed that oil bearing and water bearing sands could be discriminated with help of those two parameters. In Middle zone of study, where mostly wells are oil bearing, range of P-impedance is found to be more than 6000 units in Olpad section. This has been demonstrated in a multi well (W-D, W-E, W-F, W-G & W-H) crossplot between Gamma Ray and P-impedance *(Fig.7).* Similar multi well (W-I,W-J,W-K & W-L) crossplot has been generated in eastern side of the study area and oil bearing zones show the same range of P-impedance. *(fig.8)*

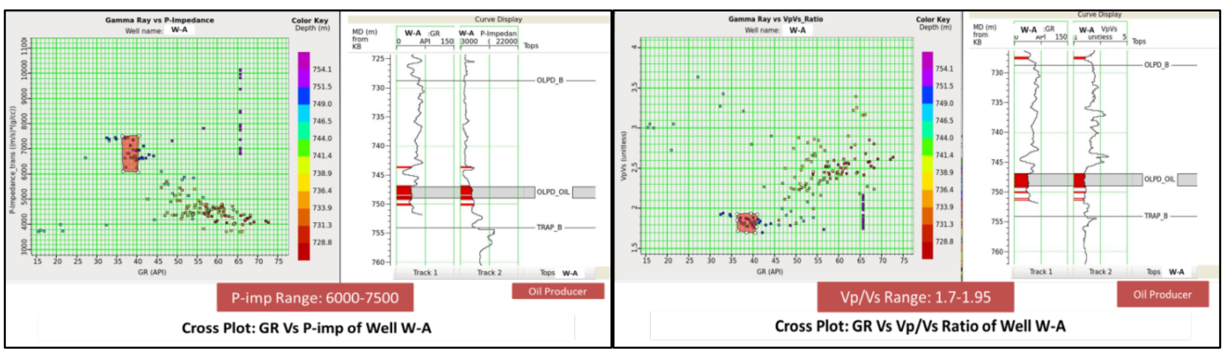


Fig: 4 Crossplots between (GR Vs P-imp) & (GR Vs Vp/Vs ratio) of Well W-A

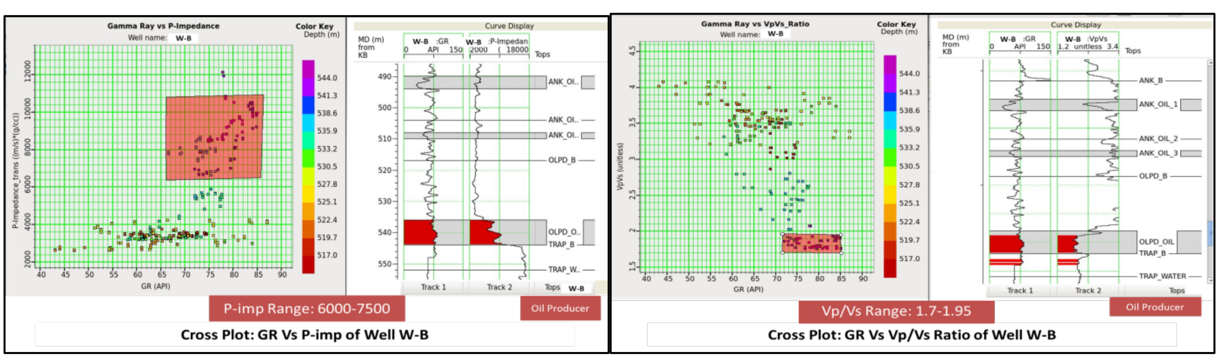


Fig: 5 Crossplots between (GR Vs P-imp) & (GR Vs Vp/Vs ratio) of Well W-B

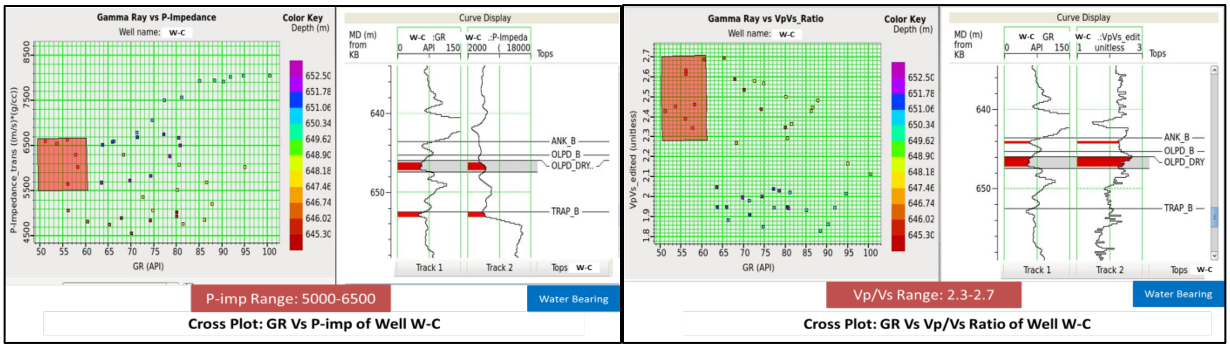
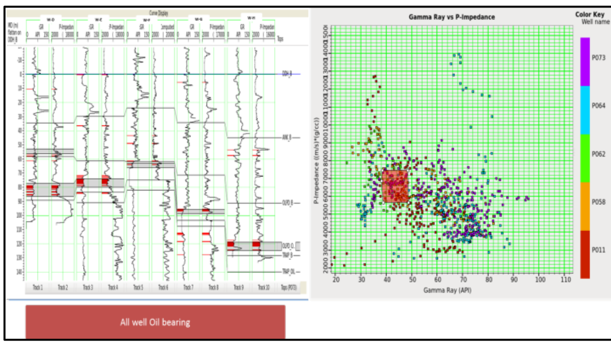


Fig: 6 Crossplots between (GR Vs P-imp) & (GR Vs Vp/Vs ratio) of Well W-C



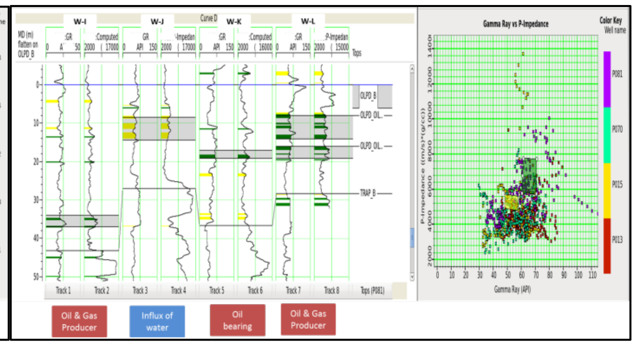


Fig: 7 Crossplots between (GR Vs P-imp) of Well W-D, W-E, W-F, W-G & W-H

Fig: 8 Crossplots between (GR Vs P-imp) of Well W-I, W-J, W-K & W-L

Petro-physical analysis

A multi attribute analysis was carried out between seismic data including inversion outputs and horizon with well data such as reservoir parameters and production data separately. In most of the cases Vp/Vs attribute was found to be more consistent with the well data in terms of correlation factor. Available petro-physical parameters are the point data at well location in a planner view and are spars in nature whereas seismic derived attributes as well as inversion outputs are dense data. By interpolating the point data through co-krigging method to the whole of the study area using the trend of joint inversion output Vp/Vs ratio *(fig.9)*, sand isolith map of Olpad basal sand has been generated *(Fig.10).* In similar way, water saturation and effective porosity maps of Olpad basal sand have also been prepared *(Fig.11&12).*

	Well Log Data	Seismic Data	Correlation
1300	OLPD ISOLITH	Deriv TRAP-20 TRA	-0.207719
1301	OLPD ISOLITH	Dn TRAP-20 TRAP	-0.22458
1302	OLPD ISOLITH	Envl TRAP-20 TRA	-0.259578
1303	OLPD ISOLITH	Ins Freq TRAP-20	0.0640095
1304	OLPD ISOLITH	Integ TRAP-20 TRA	-0.267777
1305	OLPD ISOLITH	Phase TRAP-20 TR	-0.218104
1306	OLPD ISOLITH	VpVs TRAP-20 TRA	0.36814
1307	OLPD ISOLITH	Zp TRAP-20 TRAP	-0.146335
1308	OLPD ISOLITH	Zs TRAP-20 TRAP	-0.364267

Fig:9 Correlation of Inversion output Vs Well data

Fig:10 Sand Isolith Map

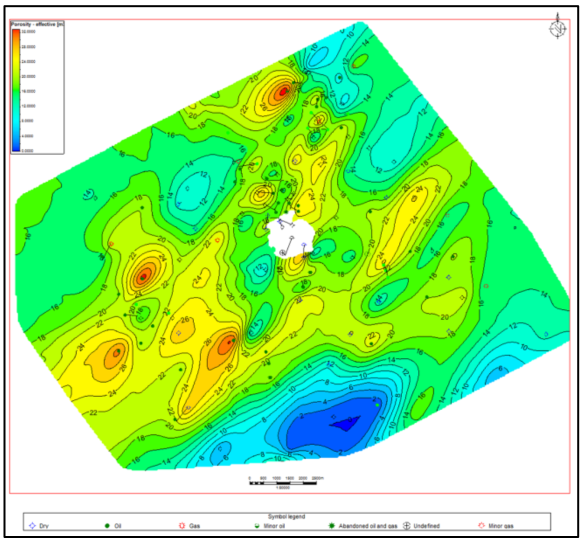


Fig:11 Effective Porosity Map

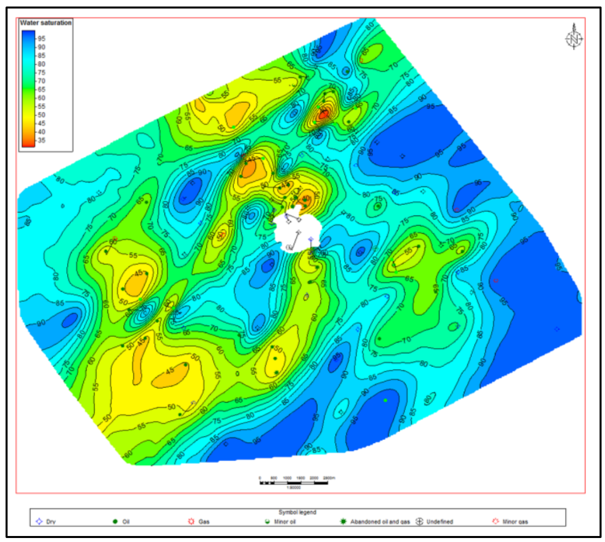


Fig:12 Water Saturation Map

Prospectivity analysis:

Based on prestack stochastic inversion output, maps have been prepared for P-impedance & Vp/Vs ratio for Olpad section *(Fig.13&14).* From cross plot study, it was concluded that the range of P-impedance is found to be more than 6000 units (normally from 6000 to 9500 units) while that of Vp/Vs is from 1.70 to 1.95 in hydrocarbon bearing zones. So using the cut-off of P-imp, Vp/Vs values & Petro-physical modeling results, a hydrocarbon prospectivity map was prepared *(Fig.15).* The prospective zones which were falling within the fair sand thickness more than 2m, good effective porosity range of more than 14% and water saturation less than 70% are possibly hydrocarbon bearing. It was than matched with existing discovered oil pools and found matching fairly well.

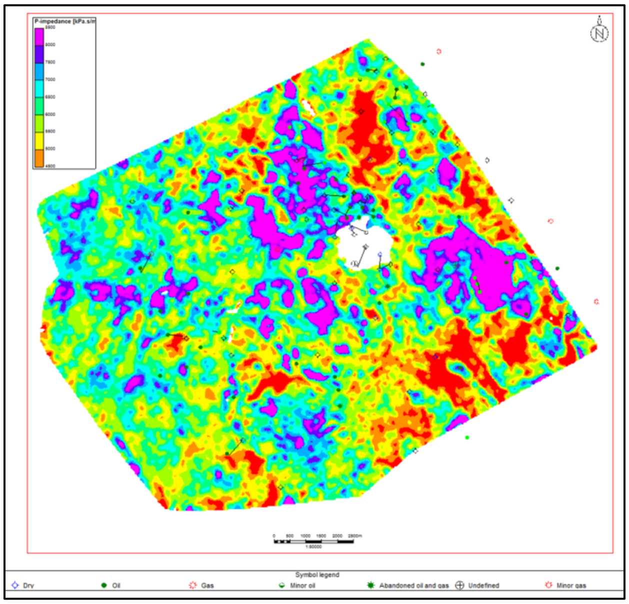


Fig:13 P-imp Map of Olpad Section

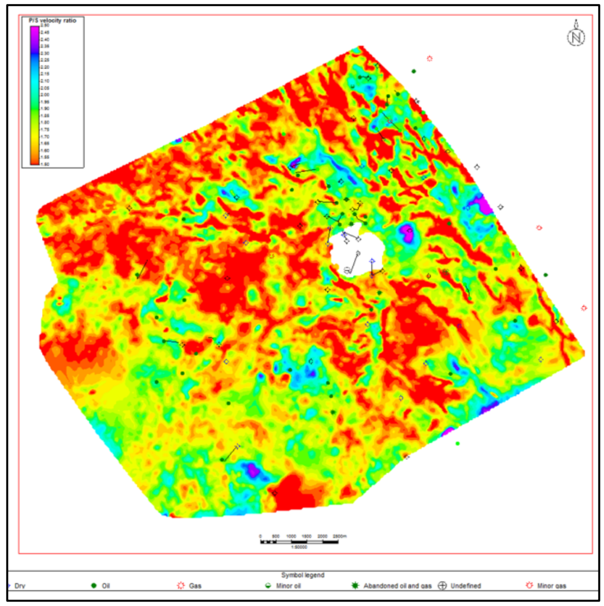


Fig:14 Vp/Vs Ratio Map of Olpad Section

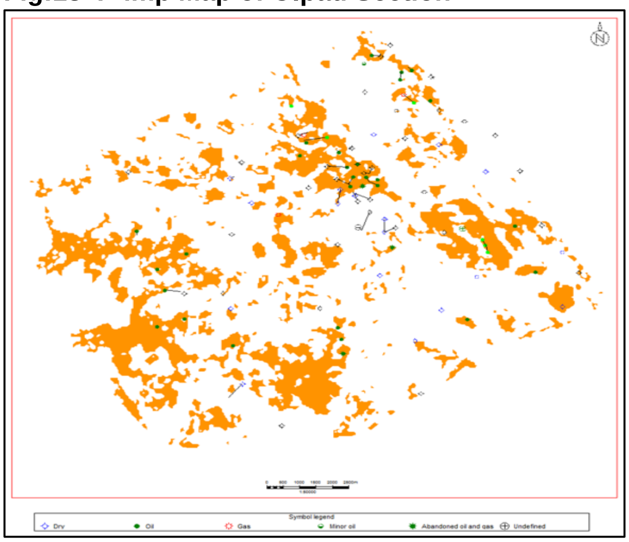


Fig: 15 Hydrocarbon Prospectivity Map

Conclusion

Inversion outputs from PP-PS pre-stack joint inversion were found to be fruitful in deriving the petro-physical parameters throughout the area of interest. Identification of areas of possible oil is quite difficult task but a solution to such an important problem becomes imperative now a days. Methodology adopted in this case integrating PP & PS joint inversion results incorporating well data in the area could provide a reasonably satisfying solution to identification of hydrocarbon prospects at Olpad basal sand pay level of study area.

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