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Attribute analysis – A tool in development of field. (A Case study)

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Summary

In the current hydrocarbon scenario, discovering the hydrocarbons by conventional methods has become difficult. National and private oil companies all over the world are looking at alternate solutions to find hydrocarbons. Unconventional pays/ traps/reservoirs and their extensions/continuity along with the reservoir properties need different approach.

In the absence of confirmed structural and litho- logical subsurface data, many methods are being identified and used by the oil explorers and exploiters for pin pointing the confirmed presence of hydrocarbons and their extensions.

A marginal field located in the Western part of India was discovered in 2005. Due to poor surface infra structure, and logistic conditions, drilling and development of the field went slowly. The field is nearly ten Km long and one Km wide. It consists of a single hydrocarbon pay named K-XII. Reservoir lithology is siltstone; structurally field is located in low area. Field is trending in NW-SE direction.

Availability of 3D seismic data in 2009 and drilling of additional wells helped in partial development of the field. Seismic attribute analysis helped in positioning the development location at better place. Drilling of a few development wells in strategically located has increased the oil production from 10 tpd to 45 tpd. This all happened due to integrated in put from geology, geophysics and reservoir data

Introduction

Geology: Western part of India consists of Cambay Basin covering an area of 56000 Sq Km. The basin is bounded by Aravalli-Delhi Pre Cambrian fold belt at North East, Champaner Series-Deccan Traps at East, Deccan Traps of Rajpipla-Navsari in South East. At West it is limited by Saurashtra Penninsula & covered by Deccan traps and Mesozoic out crops. At South, basin extends in to Arabian Sea through Gulf of Cambay. A few wells have penetrated Grantic basement. At basin margin and a few deep wells have encountered Deccan trap (Cretaceous) which is considered as technical basement for hydrocarbon exploration. Most of the wells have penetrated upto Younger Cambay Shale formation (Middle Eocene age).

This basin is embedded with more than 80 small- marginal-big & giant oil and gas fields. It also accounts for 18-20% OIIP of ONGC, which is the national oil company of India.

Structure: This basin showing Dharwarian trend i.e. oriented in NNW-SSE direction. It is bounded by set of main boundary faults on Eastern and Western sides. Basin is becoming deeper from NW to SE. It is also divided into six blocks by transverse faults. These fault systems have made the basin into different horst and grabben. The set of horsts and grabben have played major role in petroleum system, from generation to entrapment.

Most of the fields are located on the horst/ ancient highs. At Northern and central part of the basin oil fields are follow basinal trend i.e. NW-SE. At South the fields are oriented in NE-SW direction following Son-Narmada lineament trend.

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Reservoir: In this basin major reservoirs are conventional clastic deposits. They are mainly sand stone and silt stones reservoirs. Un-conventional reservoirs like fractured coal and Basalt (Deccan Trap) are also met in a very few fields. These unconventional pays have insignificant impact on estimates and production.Pays are encountered from as old as Palaocene (Nawagam field) to as young as Miocene (Ankleshavar field). Depth of pay also varies from -300m (Ankleshwar field) to -3000m (Gandhar field). Major fields of Eocene period have water as drive. Structural and combination traps are common. But stratigraphic entrapments are also present in good numbers.

Methodology

In recent past discovery of big / giant oil and gas fields has reduced drastically. Oil companies are working in hostile and hard areas to find oil and gas fields. Theories about usage of different technology for exploration and exploitation are catching the industry. Though seismic survey is an old tool, the new developments are taking place in this field also. Oil companies and their management want quick and 100% success in their efforts. In this direction, seismic survey and their outputs are considered to be the best available tools to know the subsurface data. Data out put from the 3D surveys and their interpretations are of great help in assessing the subsurface configuration, extensions, terminations, anomalies, reservoir properties and contacts between the different liquids and gases.

Seismic attribute generation and interpretation are used in different phases of hydrocarbon exploration and exploitation. Basic attributes like Amplitude, Phase and Frequency are in common use. Depending on the seismic data quality and availability, need based out puts are generated to know the structural and stratigraphic composition of the subsurface.

Processed 3D survey data is interpreted and are utilized for generating the time slice to know the sub surface structure and horizon slice used generally for lithological (stratigraphic) continuity.

In the current case study also RMS Amplitude attribute analysis leads the way to know the extensions of pays.

EXAMPLE (Case Study)

Geology, structure and reservoir in the study area:

Study area is located 40 Km NW of Ahmedabad town. Wells drilled in the study area have penetrated formations from Recent (Gujarat Alluvium) to Early Eocene (Older Cambay Shale) encountering Kand–Babaguru- Tarapur - Kalol -Younger Cambay Shale formations.

As on date six well are drilled. WS#1 located at South is the discovery well for field. WJ#8 is an exploratory well located at the Northern end of the field. Another exploratory well WJ#11 is located in the Northern half of the field. Three development wells (WS#2, 3 &4) are drilled around well WS#1 for K-XII pay. All wells are oil producers from K-XII pay.

Structurally study area/field is located adjacent to a low. The low is oriented in NW-SE direction flanked by two rising limbs of the syncline. Both the rising limbs are parts of major oil fields which are prolific oil producers from Middle Eocene pays. By well data and seismic data subsurface structure is a homoclinal, a general shallowing of events towards South West.

As briefed earlier, the study area lies between two major oil producing fields. Both fields consist of multilayered oil producing pays from Middle Eocene strata. Litho- logically these reservoirs are dominantly siltstone or silty- sandstone. In a few cases silty intercalations in fractured coal seams are hydrocarbon producers. In the study area the reservoir is silt stone overlain and underlain by thick shale of Younger Cambay Shale of Middle Eocene. The only pay of the field is met at a depth of - 1450 to - 1500m. Based on near by field and well data it is envisaged that K-XII is bounded by shale in all directions, implying stratigraphic entrapment.

Pay thickness of 2-3m is encountered in WS#1, 3, 4 & WJ#8 and maximum pay thickness of 5m is encountered in WS#2 & WJ#11. Electro logs don't show oil water contact. Pay is operating under depletion drive or on a weak aquifer support. Right from beginning all wells need artificial lift (SRP) for oil production.

Oil properties (Distillation pattern, Group type, Composition and Gas chromatograph fingerprints of saturate fractions) of WS#1 and WJ#8 well are matching, indicating the hydrocarbon generation, migration and entrapment is same. Stratigraphic correlation of wells (Fig-1) shows K-XII pay met in all wells is well co-relatable.

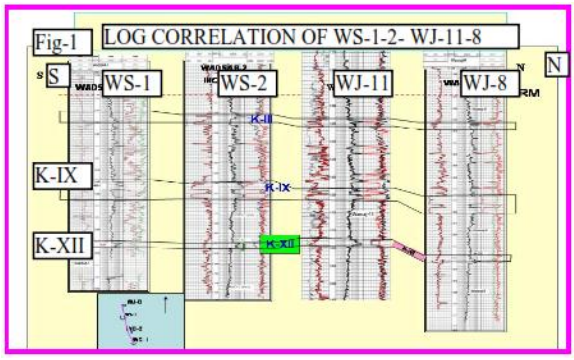

Fig-1.: Log Correlation of WS-1-2- WJ-11-8

According to existing geological model, K-XII pack is spread over the area extending from WJ#8 in North West to WS#3 in South East. With limited well data, field posed a challenge to the geoscientist community, to find the limits and extensions of K-XII.

Management was interested in enhancing the oil production and total development of the field. Geo scientific team was concerned about penetrating better pay thickness and with good reservoir properties. To find suitable subsurface positions for up coming development locations, Geo scientists took seismic as a tool to decipher the problem.

VSP data of WS#1(Fig-2) and WJ#11(Fig-3) were integrated with the 3D seismic investigation No. 451 & 452. Logs of WS#1&WJ#11, the formation and pay tops were tied to the seismic lines (Fig-4).

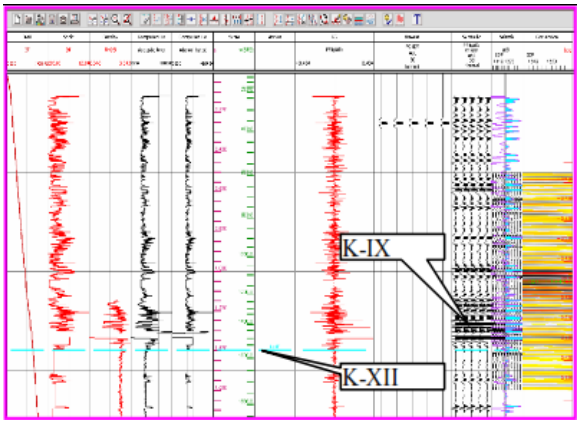

Fig-2:Synthetic Seismogramme of WS#1

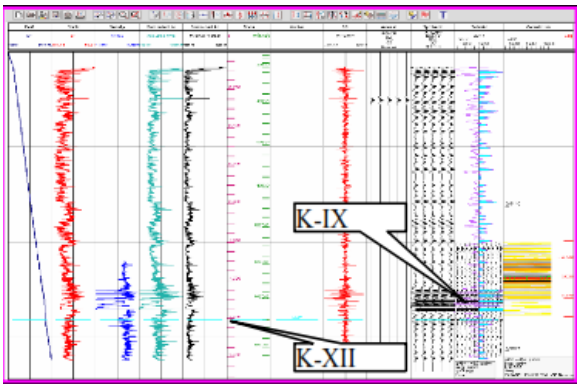

Fig-3,Synthetic Seismogramme of WS#11

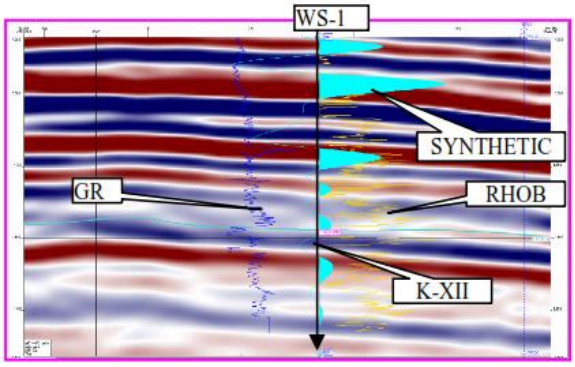

Fig:4 Line 1632 Correlation of Gamma, Synthetic Seismogram & Rhob Curves at Well WS#1

Tracking of the respective formations, horizons and pay i.e. K-XII, over the field was carried out. Structure contour map on top of pay/horizon was generated. As described, the structure indicated a homocline (Fig-5) dipping towards NE, which is in conformity with well data.

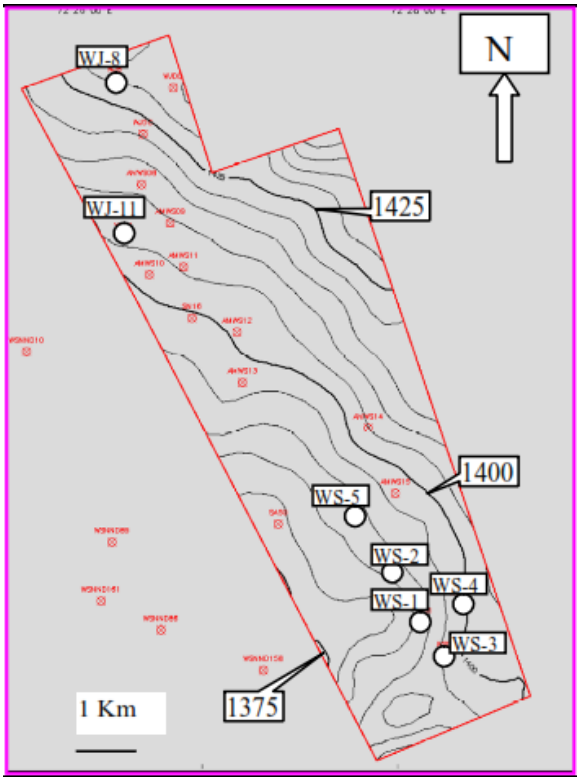

Fig-5, Time Structure Contour Map on top of K-XII

To assess the K-XII sand/pay continuity, attributes windows just above & below K-XII (Ex K-XII+5ms, K- XII+3ms, K-XII [+2-2ms]) were generated. RMS amplitude, Maximum Magnitude and average Amplitude attributes were generated on K-XII at different windows.

Analysis

RMS amplitude attributes (K-XII+3ms) (Fig-6) map generated was analyzed with the available well data for validation.

It is observed that in wells WJ#11, RMS amplitude is in the range of 25000-30000 (moderate amplitude) having 5m pay thickness along with better reservoir properties. In WS#1, 2, 3, 4 and WJ#8 RMS amplitude of 10000-15000 (low amplitude) shows pay thickness of 2-3m.

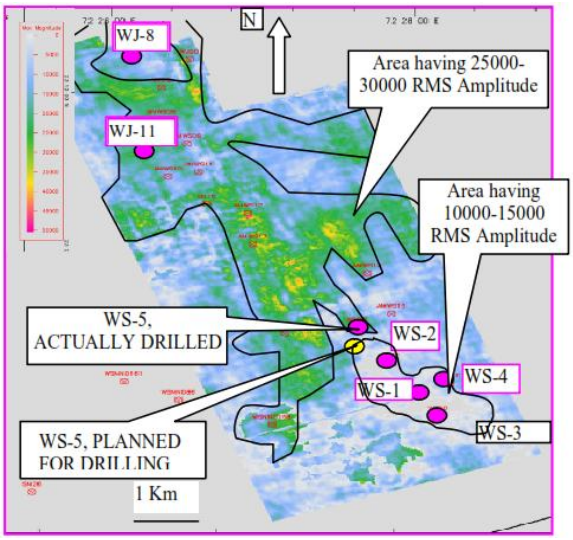

FIG-6: RMS Amplitude map on K-XII+3ms

Taking the lead from the above results, an analysis of curent wells was carried out. A simple graph, Pay Thickness Vs RMS Amplitude is generated (Fig-7). Two trends can be drawn form the existing points.

Trend-1: passing through: Zero - cluster of wells WS#1, 3, 4, 8 - WJ#11. Trend-2: a vertical line parallel to Y axis, passing through cluster of wells WS#1, 3, 4, 8 to WS#2.

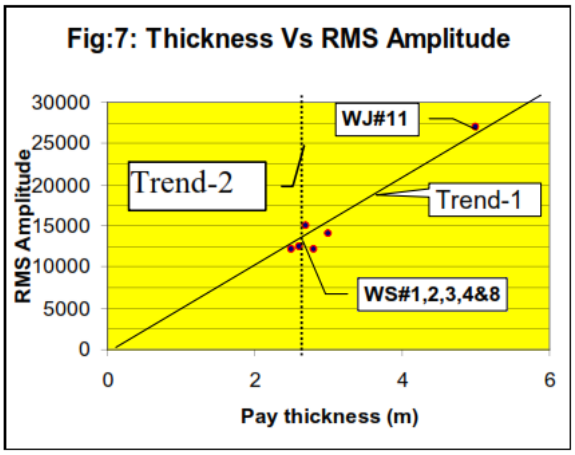

Fig:7: Thickness Vs RMS Amplitude

Trend-1 shows, with the decrease in RMS amplitude, pay thickness is decreasing. And from the Trend-2 increase or decrease in RMS amplitude is not showing variation/difference in pay thickness. Logically there

shold/should be variation in RMS amplitude with respect to pay thickness. Hence Trend-1 is considered to be representing the better subsurface configurations than Trend-2.

In the study area, a development location (WSDB) was about to be taken up for drilling. The proposed location was falling in the low RMS amplitude area (10000-15000). After deliberations, it was decided to be drilled in the area having moderate RMS amplitude (25000-30000). Accordingly, suitable modifications were carried out in drift and direction for the well placement. WSDB (WS#5) was drilled, during drilling well site geological monitoring indicated the presence of hydrocarbon in the form of fluorescence and solvent cut in cuttings. Well was logged, the result was as expected. K-XII pay thickness met in this well was 5.0m.

A clue was observed by the pressure behavior, where pressure observed earlier in wells was in the lower range (130Ksc) in comparison to WS#5 (160Ksc). However considering the Petro-physical properties of pay, oil properties and pressure behavior of this field, it was decided to go for hydro fracturing job, "A healthy well with good HF pays more".

WS#5 found to be most suitable candidate having pay thickness of 5m with 25m shale barrier at top and bottom, having no OWC. Forty (40) ton HF job was successfully executed and well flowed oil @ 18 tpd on self flow with 10 Kg/cm2 THP to tank at drill site. (Oil is viscous in nature and can not be flowed in line without treatment). Generally wells in this field flow @ 5 to 6 tpd with SRP, but the WS#5 yielded 18 tpd, a gain of 12 tpd.

Production performance of the field in last 2 ½ years has increased from 10 tpd to 45 tpd (Fig-8). It is a result of robust multidisciplinary efforts of proactive Geology-Geophysics and Reservoir management practices

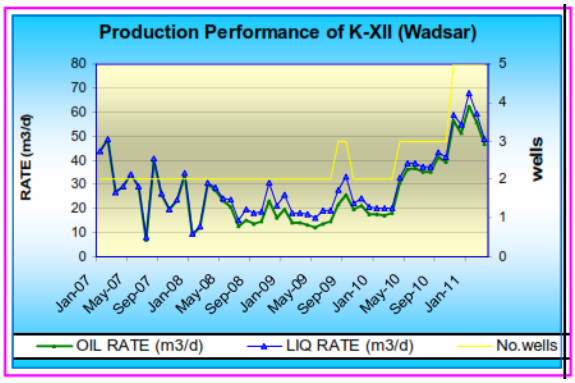

Fig-8, Production performance of Wadsar field

Conclusions

Where well data is scanty, structural entrapment is uncertain followed by the risk of pay/reservoir continuity, subsurface structure and pay continuity can be visualized by the seismic in puts. In the study area 3D seismic data acquisition, interpretation and analysis helped in proper positioning of the well WS#5. As the study and the analysis found to be matching, up coming development locations to be drilled in and around this area are cautiously positioned in moderate RMS amplitude range (25000-30000).

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