MINIMIZATION OF RISK FACTOR INVOLVED IN DRILLING OF A HORIZONTAL WELL THROUGH RESERVOIR CHARACTERIZATION ACHIEVED BY SAIL ANGLE DRILLING – A CASE STUDY

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ABSTRACT:
Makum-North Hapjan field was discovered in 1993. All the wells were completed as oil producers in the field. In order to quickly enhance the production and arrest the gas coning and water coning problems as well as to overcome the land acquisition hassles, a multi disciplinary study was initiated to examine the feasibility of horizontal wells in the field. Based on the recommendations, OIL first time introduced horizontal well drilling in the North Eastern India. The endeavor proved successful and OIL was able to considerably enhance the production from the field. The drilling of the horizontal wells was accompanied by the uncertainty in the lithological characteristics because of the presence of intervening shale layers. These shale layers were discontinuous and not correlatable in the wells. To tackle this problem, sail angle was drilled prior to drain hole in order to recognize any sub surface variations.

INTRODUCTION:
Makum-North Hapjan field in upper Assam basin discovered in 1993 produces approx 2500 klpd oil from Fourth + Fifth Sand reservoir of the Barail Arnaceous sequence through 46 wells (6 horizontal and 40 conventional vertical wells). Makum-North Hapjan structure was first identified on the basis of interpretation of 24 fold CDP seismic data acquired in 1987-88 and results were presented in OIL internal publication. Presence of oil was established in Barail fourth + fifth sand reservoir with the drilling of wells in 1993 and 1994 in the North Hapjan and Makum structures. All the wells completed in the field have been completed as oil producers and the initial production rates of the conventional vertical wells are around 50 klpd. The reservoir is having good permeability and the wells are producing with very low drawdown. In order to enhance and optimize production from this field and to arrest the gas coning and water coning problems as well as to overcome the land acquisition hassles, a multi disciplinary study was initiated to examine the feasibility of horizontal wells in the field recently. The study was particularly taken to combat gas/water coning phenomenon prevalent in the reservoir. Based on the study, a comprehensive development plan was suggested, following which a few horizontal locations were proposed for drilling. Encouraged by the successful drilling and completion of these wells in the area, additional horizontal wells are in plan to be drilled. The following paper presents a case study of one of the horizontal well drilled in this field and the obstacles circumvented in its successful completion.

GEOLOGICAL STRUCTURE AND RESERVOIR DESCRIPTION:
The depth contour map of Barail 4th+5th sand based on seismic as well as evidence from the 46 wells drilled so far is presented in Fig 1. The structure is a horst block bounded by NNE-SSW trending normal
faults on either side (F1&F24). Fault F24 is in the northern flank of the horst block and dips towards north with a throw of about 200 m. Fault F1 with a throw of about 220 m and dipping towards south lies south of the horst block and separates the north Hapjan field from nearby producing Hapjan field. Within the horst block, both Makum and North Hapjan structures are elongated anticlines. These two structures are separated by two opposite dipping NNE-SSW trending faults, passing through the middle of the horst block. Besides these two faults, there is a number of NE-SW trending normal faults with minor displacement.

The two adjoining but opposite dipping, discontinuous faults (F14 and F15) separate the Makum structure from North Hapjan structure. Because of the discontinuity, Barail 4th+5th Sand reservoirs of these two structures were considered to be in communication. The thickness of the pay zone (50-60 m) itself is more than the displacement of the faults (0-30 m) and hence, sands on two sides are juxtaposed to each other paving way for fluid communication. The same was supported by reservoir pressure measurements and fluid distribution pattern on the two sides. Therefore, both the blocks/structures were considered to be in communication and the whole of the unit was considered as a single reservoir unit. After plotting the LKO(Lowest Known Oil), HKW(Highest Known Water) and LKG(Lowest Known Gas), HKO(Highest Known Oil) for all wells as interpreted in the logs, it was concluded that initial OWC(Oil Water Contact) was at 2660 m and initial GOC(Gas Oil Contact) is at 2615 m.

From the electro logs it was evident that intervening shale layers of 1-2 m in thickness are present within the oil zone in most of the wells whereas thicker shale bands are present below the oil water contact. However, it was observed that all the shales were not correlatable and shale continuity could not be established with confidence, especially in the oil zone. The shale bands in correlation were found to be discontinuous in some of the wells thus leaving windows at places for vertical movement of fluid.

RESERVOIR SIMULATION:

In order to optimize the production from the field, the simulation study was carried out. The simulation grid was prepared with the help of commercial software. The grid system used was a uniform regular block centered grid with 58 x 60 x 49 cells, the size of each cell being 100m x 100m x 1.938m. The layering in the model was not up scaled to preserve the fine heterogeneities in the reservoir model. Based on the actual log data, the shale / shaly sands were incorporated in the model. For History Matching purpose, well wise monthly production data for all wells were used as input. The well wise GOR, water cut, and the flowing / static pressure data were used as history matching parameters. The production behavior for the proposed development locations were obtained from the simulation model.

SAIL ANGLE DRILLING IN WELL HTR-H:

Well HTR-H was proposed as a development location to drain the Barail 4th+5th reservoir in the Makum-North Hapjan Field. The GOC and OWC as expected from the available data and correlation was 2619 m and 2660 m. The drain hole landing position was planned to be at 2630 m. In the earlier drilling of horizontal wells, OIL did not go for sail angle drilling, for it requires greater rig days and thus increase in expenditure. This location is in the southern part of the North Hapjan structure, where there was no well control. Due to unavailability of well data in the southern part, the proper shale layer sequence could not be identified with confidence. Hence to avoid the horizontal section being placed in the proximity of a shale, it was decided to go for sail angle drilling (at an angle of 65°) which also assisted in precise location of GOC and OWC. It provided with some gripping information about the well. The GOC and OWC were established at 2609 m and 2640 m. The most important thing which came out was the discontinuity of the sand. It was seen that the oil pay column was not continuous as expected but was separated in parts by two interjected shale breaks. The first shale break was from 2615.5 – 2623.5 m while the other
shale break was only 1 m below the planned landing point of the horizontal section. This was quite alarming and lead to a complete revised plan for drain hole drilling. The drain hole landing position was revised from 2630 m to 2625.5 m. The sections showing drain hole position initially and after revision is depicted in figs 2a-2c. Finally the well was drilled successfully according to revised plan and completed as shown in fig 3. The production obtained from the well is shown along with the production behavior of the well as predicted from the simulation model in fig 4a and 4b.

CONCLUSION:

The infill well drilling in the Makum- North Hapjan field have successfully enhanced the production of the field as can be seen from the production profile shown in fig 5. The sail angle drilling was intended to minimize the risk associated with the large investment required to drill a horizontal well. Though it increases the expenditure, it is well within the limits considering the risks associated with failure. The experience from this location has driven OIL to go for sail angle drilling prior to drill the drain hole in case of any subsurface uncertainty.

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Fig 1: Structure Contour Map of Barail 4th+5th Sand of Makum North Hapjan Area

Fig 2a: Drain Hole position as per original plan

Fig 2b: Intervening shale layers as detected from sail angle drilling
Fig 2C: Revised Drain Hole Position

Well: HTR - H
CASING DIAGRAM

Surface

13.3/8" Casing shoe @ 150.0 m

7" Liner Hanger Packer @ 1741.0 m

9.5/8" Casing shoe @ 1867.24 m

KOP @ 1920 m

2.7/8" Tubing

Tubing Packer @ 2549.96 m [MWD]/52.3°/2461.30 m TVD

7" Liner shoe @ 3139.0 m (MD)/2687.09 m (TVD)/2625.56 m (mbd)

4.1/2" Slotted Liner Replacement @ 3094.0 m

4.1/2" Slotted Liner Shoe @ 3568.5 m

Total Horizontal Drilled 411 m

End Point @ 3570 m (MWD)/2665.65 m (TVD)

OWC as per Pilot Hole 2640 m bd

Pilot Hole End Point @ 3172.40 m (MWD)/2754.62 m TVD

Pilot Hole/Sail Angle

1904 m (VD)/1904 m (TVD)

1942 m (MD)/1942 m (TVD)

2380 m (VD)/2634.57 m (TVD)/2592.47 m bd

2930 m (VD)/2335.5 m (TVD)/2483.97 m bd
Fig 3: Well completion Diagram of well HTR-H

Fig 4a: Actual Production Behaviour of the well

Fig 4b: Predicted Production Behaviour of the well

Contribution from Horizontal Wells
Fig 5: Production Profile of the Field