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Integrated geoscientific studies for production revival from offshore brown field platform— A case study in Mumbai High field

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Summary

Mumbai High field has been on production from multi-layers of L-III reservoir since 1976. Some of the earlier platforms now have low oil rate. There is scope of relocating the high water-cut or high gas oil ratio (GOR) wells to tap the undrained oil. While reservoir based redevelopment plan has been prepared and is under implementation, the relocation of the wells through side-track has to be fine-tuned in terms of area and location of the drainholes through integrated classical analysis of the geoscientific data.

This paper discusses the case history of one such platform 'X' located in the northeastern part of Mumbai High South field. The relocation of the wells has helped to bring the low production platform back on stream and added to oil production and recovery from the offshore field.

Introduction

Mumbai High field is a matured offshore oil and gas field of India and is on production since 1976 from multilayered (named A1, A2-I to A2-VII, & B, C, D layers from top to bottom) carbonate L-III reservoir. The South field is on production since 1980 and has been developed in phases through numerous development schemes prepared from time to time to enhance production and recovery from the reservoir. From the South field, over 26% of initial oil in-place has been recovered as on October'09. As many as 72 well-platforms have been installed in South field. Platform 'X' is located in the northeastern part of Mumbai High South field close to the eastern boundary fault (Figure-1). Geologically this is the crestal part of the multilayered L-III reservoir. The nine-slot platform 'X' was installed in 1982-83 and seven wells have been drilled. Out of the seven wells, one well was completed as oil producer from Basement and three were converted as injectors in L-III reservoir during 1989-93 period. Three wells X-A, X-E and X-G are oil producers producing from different sub-layers of L-III reservoir. Although the platform was a prolific producer with initial oil rate of over 10,000 bopd, the oil rate gradually declined due water-cut and high GOR and by end 2007, the platform production was hardly 200 bopd. Integrated geoscientific studies were taken up to examine the possibility of production enhancement from the platform.

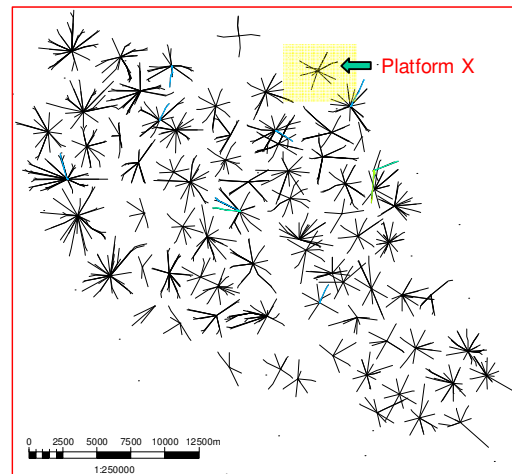


Fig:1 Platform location map of Mumbai High South

Methodology & Results

The drilling, completion and production history of all the wells in the area was critically reviewed. It was seen that on platform X, out of the seven wells drilled, wells X-A and X-E had been closed due to high GOR and water-cut and injection well X-B was also closed being ineffective and also due to non-requirement of injection in the area. Well X-F was completed in Basement and closed in June



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2000 due to high water-cut. Water injection wells X-C and X-D were operative in L-III and of this platform, well X-G drilled in March 2000 was currently the only well on production from A2-VII and B sub-layers of L-III reservoir. Wells X-A, X-B and X-E were considered as good candidates for sidetrack in L-III reservoir for enhancing oil production from the platform and improving recovery of L-III reservoir. The details of these three wells are as under.

Well X-A is an inclined well drilled from X platform in south-easterly direction during May 1983 to October 1983 and completed in layers B (1957-1965 m) and C (1975-1981 m) and subsequently put on production in December 1983. The well was drilled in up-dip part of the structure which encountered gas up to A2-V layer and oil down to D layer. All the sub-layers of L-III reservoir are found to be good in this well with layer thickness varying from 3 to 6m and porosity varying from 20 to 24%. The well on completion in B & C layers started producing with an initial oil rate of 1161 bpd with nil water cut and GOR of about 78 v/v and could achieve a maximum rate of 3177 bpd during January 1984 with nil water cut and GOR of 91 v/v. The production started declining with GOR gradually increased to 753 v/v during August 1986. The well was closed in January'07 due to high GOR and high water-cut. The cumulative oil production from this well has been 3.78 MM bbl.

Well X-B was drilled in north-westerly direction during May to July 1983 and completed in layers A2-I, A2-III and A2-V. However due to poor facies no influx was observed even after acidization. The well was redrilled to Basement in 1993. In all seven objects were tested, five in sub-L-III layers and two in lower and middle parts of L-III. However, none turned out to be significant. The well was converted into injector in L-III in April 1993. The injection was found to be not very effective. Also there was little production to support. Injection was therefore suspended from May 2001 after cumulative injection of 3.93 MM bbls.

Well X-E of this platform was drilled as vertical well during October 1983 completed in 'A2-VI+VII' and B sub-layers. The well was drilled in up-dip part of the structure which encountered gas up to A2-V layer and oil down to B layer. All the sub-layers of L-III reservoir are well developed in this well with layer thickness varying from 1 to 6m and porosity ranging from 20 to 24%. During initial testing the well produced with an oil rate of 2332 bpd with nil water cut and GOR 86 v/v. The well had achieved a peak oil rate of 3643 bpd during December 1983. The oil rate gradually decreased to less

than 100 bpd with increase in GOR and water-cut. The well was closed in September'08 due to high GOR and high water-cut. The cumulative oil production from this well has been 1.97 MM bbl.

The structure contour map at L-III top indicating structural disposition and the location of the wells of platform-X is given in figure 2.

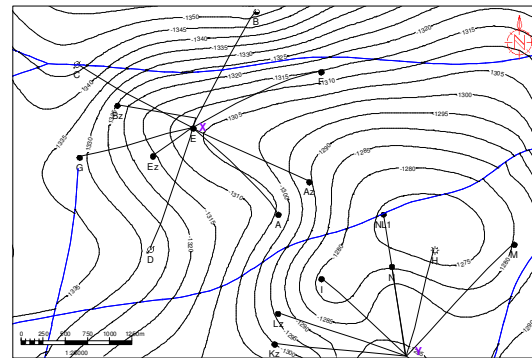


Fig:2 Structure map on top of L-III in platform-X area

The well logs and seismic data were reviewed to get better understanding of the area. Significant variation in the structural position, reservoir facies as well as fluid contacts is observed in the area. The depth varies from 1300m to 1355m TVD SS at L-III top. Towards the north of this platform lies a wide graben containing formations of low energy with poor reservoir facies. Wells X-B and X-F are located close to this structural low (graben) and have reservoir facies are not well developed. The gas-cap gas in this area is up to 'A2-V' sub-layer of L-III in general and oil-water contact (OWC) is in 'D' sub-layer. However, in the north-west part of the platform area near the well X-C, the structure is dipping more steeply as compared to other wells of the platform and so gas-cap gas is not observed in the wells X-B and X-C. The fluid contacts are dictated by structural position/ facies heterogeneity.

A east-west seismic section passing through the centre of the platform covering well X-E is given in figure-3. The section depicts the structural trend perceived in the model.



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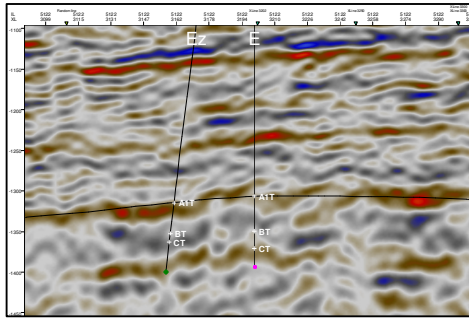


Fig:3 East-west seismic section through well X-E

The log motifs of well X-E indicating development of the sub-layers of L-III reservoir is given as Figure 4.

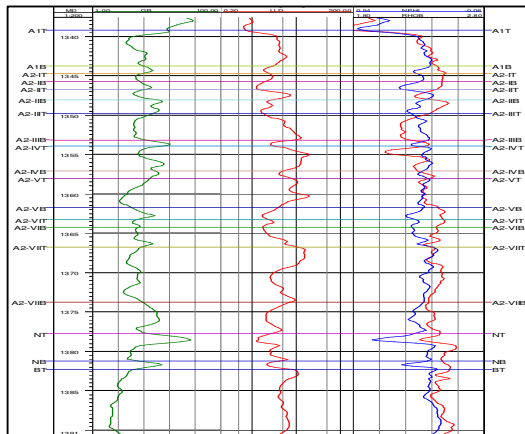


Fig:4 Log motifs of well X-E

In order to enhance production from the platform, the well history of the wells was studied. It was observed that the wells had been worked-over and stimulated in the past. From oil potential point of view it was analysed that better production could be obtained through relocation of wells X-A and X-E which were closed due to high GOR and high water-cut and also injection well X-B could be relocated and used as producer. Detailed log correlation of nearby wells was done to ascertain encountering of oil bearing sub-layers in the area and also seismic attribute analysis was carried out. The attributes were correlated with the petro-physical properties observed on the logs of the existing wells. The relative acoustic impedance and absolute amplitude

east-west sections along well X-E are shown in figures 5 and 6 respectively.

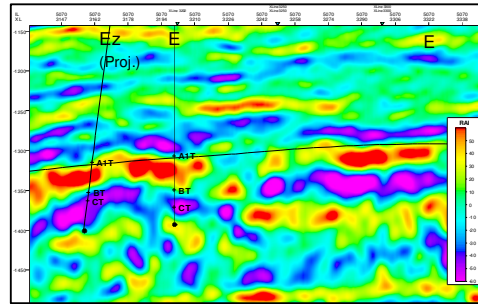


Fig:5 Relative Acoustic Impedance section along well X-E

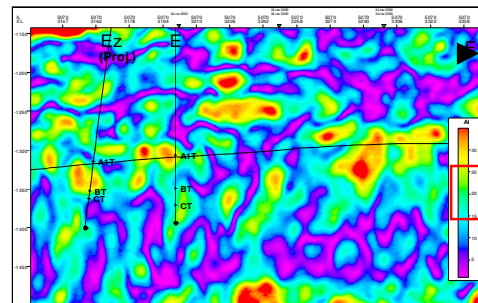


Fig:6 Absolute Amplitude section along well X-E

Analysis of the seismic attributes revealed that the absolute amplitude attribute in general was a better indicator and the yellow-green range could be correlated to good porosity zones.

The sidetrack location of the wells was selected so as to encounter better petrophysical properties, reservoir facies and maximum oil bearing sub-layers which were likely to have remained undrained by the existing producers and injectors. Well X-A was proposed for sidetrack about 500m north-east of present position where it was expected to be structurally higher by about 15m. Well X-B was proposed for relocation from the present northern poor facies area to western side in between the existing wells X-C and X-G and well X-E was proposed for side-tracking towards south-west about 600m away from its present location. The drilling feasibility of the wells using side-track technology was discussed and firmed up with the in-house Drilling Services.



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The sidetracking of the three wells was taken-up by deploying a suitable rig during monsoon 2009. In order to achieve the planned drift, the 9 5/8" casing was retrieved and window in 13 3/8" casing was cut after placing whipstock. Side-tracking was carried out as per plan. Pressure data of the sub-layers was collected using MDT. In well X-A, new technology of 'stethoscope' was used to record pressure while drilling. The pressures were found to be in the range of 1700 to 1850psi.

Based on log characteristics the wells have been completed in various sub-layers of L-III. The three wells have been acidized and put on gas-lift. The three wells' initial production amounts to nearly 1750 bopd. The stabilized production of these wells is over 1500bopd (Figure 7). These wells have helped to ramp-up production from the platform which otherwise had negligible contribution in performance of the field.

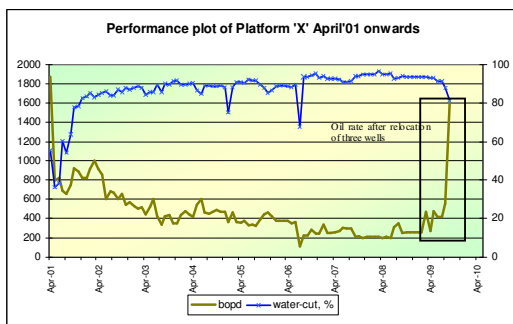


Fig:7 Oil production improvement following relocation of wells X-A, X-B and X-E.

Conclusions

In mature offshore fields there is scope of enhancing production from the early platform location areas by changing drainage pattern through sidetrack of existing poor performers. The reservoir heterogeneity and initial wide well spacing and has led to non-uniform drainage of the sub-layers. Location of these un-drained pockets in the multi-layered reservoir however is a challenge.

The risks can be mitigated by assimilation of all available geoscientific data and using multi-disciplinary approach. In complex reservoir such as Mumbai High, opportunity of production enhancement from poor performance platforms can be identified and realized with careful analysis, judicious use of new technologies and readiness to accept the challenge with some risk.

The success of the MDT approach has been encouraging and similar such studies are to be taken-up for targeting such potential areas in the field.

Acknowledgements

The authors are thankful to the ONGC management for permission to publish the paper based the actual study carried out by the Mumbai High South Area team. The authors are thankful to Shri Apurba Saha, ED-Asset Manager, MH Asset, for providing an opportunity and encouragement for writing this paper. The contribution of Dr. A.K.Srivastava and Shri Sanjay Kohli in finalization and execution of the plan is duly recorded. The authors also place it on record the support and co-operation extended by colleagues of Sub-surface team of Mumbai High Asset.

The contribution of the Drilling, Logging and Well Services of Mumbai region and Surface Team of MH Asset in finalization and execution of the plan is duly acknowledged.