Association of Petroleum Geologists. India
Registered under Societies Registration Act,No. 21 of 1860

GEO India 2022

Revival Strategy of High Water Cut Horizontal Wells Of Vasai East Field By Delineating Fluid Contacts And Deciding Effective Landing Points Through Drilling of Pilot Holes

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Abstract

In Vasai East field the Bassein formation is characterized by thin Oil zone sandwiched between overlying Gas cap & underlying aquifer but the lower part of Bassein formation is devoid of hydro carbon. The presence of Vugs & Karstification leads to severe drilling complications like Mud loss, string stuck up, etc. Initially wells were flowing with ~1% W/C, but currently majority of the wells are flowing with average ~80% W/C. As the development wells are drilled as horizontal wells, effective side-tracking of the high water cut wells in undrain oil saturated areas is the only option to attain a better recovery. Through analyzing the pressure production behavior of the entire field, it was observed pressure depletion inside the reservoir and rise in the Oil-Water contact. Due to variable fluid contacts and to further delineate the fluid contacts i.e., GOC & OWC, a strategy was adopted to drill pilot hole and to decide the effective landing point so that early water encroachment can be avoided. This strategy is so far been successful as 6 drain holes are successfully placed which are producing with good oil rate with minimal water cut and is encouraging to achieve better recovery factor in future.

Introduction

Vasai East field discovered in 2001 is located in the Heera-Panna-Bassein Block of Mumbai Offshore. The field is about 78 km WNW of Mumbai City. Water depth in the area is about 50m. From the geological perspective, two formations i.e. Bassein formation & Panna formation were tested through five exploratory wells. Thin Oil rim is sandwiched between underlying aquifer and gas cap gas. The formation is highly heterogeneous and underwent through sub areal exposer which developed secondary porosity. Bassein formation is higly karstified and is vuggy in nature. Due to this, wells in the field are prone to high water cut as well as high GOR.

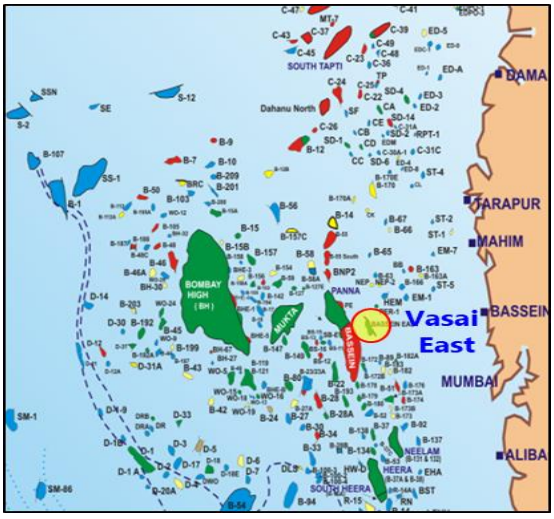


Fig-1: Location Map

In Vasai East, the observed pressure in first exploratory well was of ~152 Ksc in 2001 while in development wells, it is varying from of 131 to 134 Ksc during 2008-09. The continuous decline of pressure in Vasai East field is mainly due to production of nearby Bassein field which is hydro-dynamically connected near to oil-water zone.

Geological and Stratigraphy

Vasai East field is falling in the saddle between Bassein field and Eastern homocline in the Central graben of Mumbai Offshore Basin. Two N-S trending longitudinal lows separates the field from Bassein and Eastern homocline. Vasai East structure is an anticline plunging towards north and separated by a small low from B-172 structure in the south. In Vasai East structure, oil and gas accumulations are

found within Panna and Bassein formations. In the Bassein formation, Bassein limestone is the main pay belonging to Middle Eocene age. The carbonates rocks are mainly foraminiferal packstones and wackestone with thin intercalations of mudstones. The Bassein limestone thickness ranges from 515 to 730m. Bassein pay is situated at the top part of the formation and secondary porosity in the form of solution channels and vugs is present. The porosity is varying from 20 to 25% has been observed in wells drilled. The permeability of the reservoir derived from production testing analysis of the drilled wells ranges between 50-350 mD. The higher side of permeability may be attributed to localized karts and vugs. The stratigraphic succession from Paleocene to Recent, overlying the basaltic basement is present in the field.

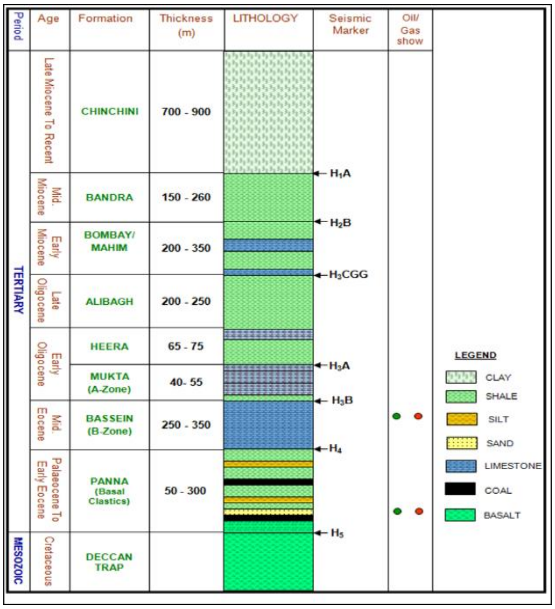


Fig-2: General Stratigraphy of the Area

Development Strategy

The initial development scheme of the field was implemented during 2008-09 and field was put on production in May-2008. For sustained production, all the wells are completed with Gas lift system. Currently, the field is having a total of 36 wells (34 OP + 4 WI) drilled from 3 well head platforms to target oil & gas from Bassein formation.

Wells of Vasai East fields are very prone to high water cut and GOR due to presence of fractures, vugs & karst in Bassein pay along with bottom aquifer.

The field has been exploited by drilling horizontal development wells barring few conventional wells tap the thin oil rim of from Bassein formation. In order to exploit the oil optimally from the reservoir, precise landing of horizontal section is important to avoid early water break-through and gas cusping problems. The original oil-water and gas-oil contacts were established at 1748m and 1719m TVDSS, however with time due to continuous production of hydrocarbon from the field, there has been a variable change in depth of oil-water contact across the field. Besides, the horizontal wells are completed with segmented completion comprised of sliding sleeves and swell packer in order to avoid breakthrough of water in the sections of the horizontal wells.

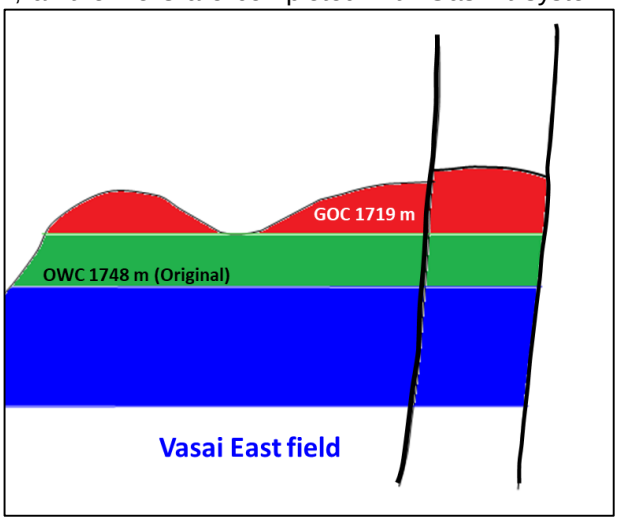
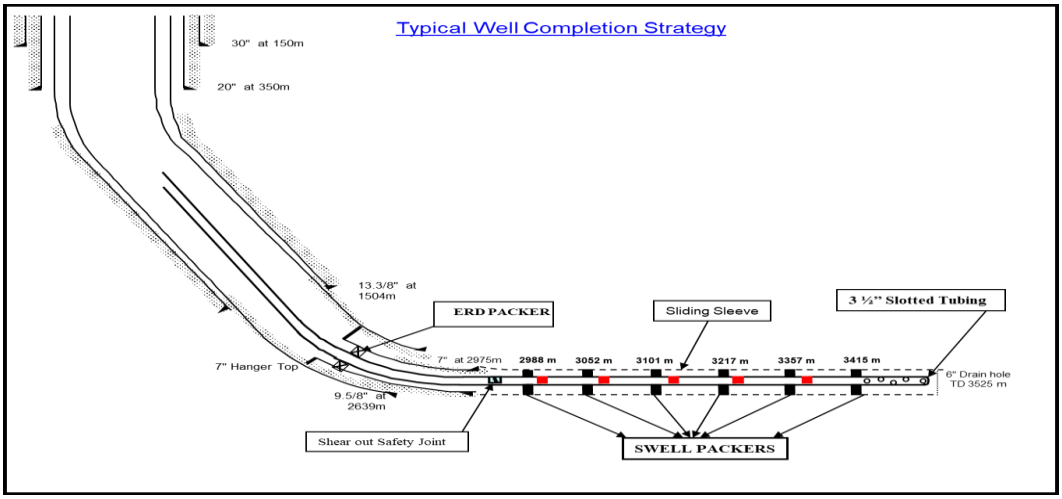


Fig-3: Schematic of fluid Contacts in Vasa East field



Need for Pilot Hole Drilling

In developing a field, pilot holes are mainly required for drilling side-track infill horizontal wells. In 2020 two wells were ceased and remaining wells were flowing sub-optimally due to high water cut. All these wells were needed to be side-tracked to better oil saturated and un-drained place.

Since the field is under continuous production, the OWC is gradually rising and GOC is gradually lowering due to expansion of Gas cap gas. As a result, the oil zones are becoming thinner. The rising of OWC and lowering of GOC are not uniform in the entire field; hence the fluid contacts found to be varying well to well level. In some wells the formation tops varied significantly with prognosis data and different fluid contacts were obtained at different wells in same field which are shown in the following table & bar graph. Due to heterogeneity and high secondary porosity pressure, facies and salinities are also found varying at different sectors of the field. Hence, the distance between pilot hole and main hole are kept as minimum as possible (~50-60m max). The landing points for these wells were revised based on pilot hole and after put on production the wells have produced better than envisaged.

Well	Expected Bassein Top	Actual Bassein Top	GOC	OWC	Proposed LP	Actual LP	Envisaged oil rate	Actual Peak oil rate
	mTVDss	mTVDss	mTVDss	mTVDss	mTVDss	mTVDss	bopd	bopd
A	1705	1713	1724	1741	1728	1728.8	350	603
B	1708	1705.5	1720	1739	1728	1725	308	507
C	1718	1726	1732	1743	1730	1729	305	384
D	1709	1716.8	1724	1743	1730	1728	311	529
E	1698	1695.5	NA	NA	1727	1726	302	410
F	1713	1721.5	NA	1741	1725	1727.5	344	484
G	1688	1692.5	1718	1740	1725	1726	377	U/Cleaning
H	1685	1688	1720.5	NA	1725	1724.84	360	371
I	1695	1703.5	1718.5	1728	1725	1722.8	361	252

Table-1: Formation Top and Fluid Contacts identified in various wells

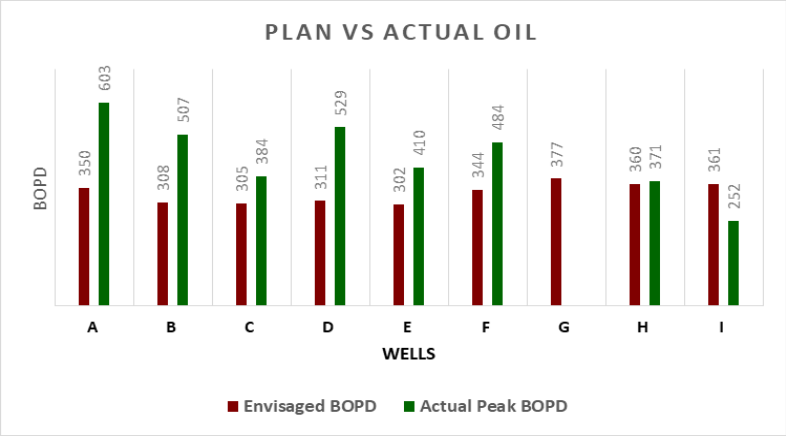


Chart-1: Plan vs Actual Oil in various wells drilled with the experience of pilot hole.

Advantages of Pilot Hole:

1. It helps in ascertaining the formation top & fluid contacts (GOC & OWC).
2. Pressure, temperature can be recorded and nature of fluid can be identified in this hole prior to drill the main hole.
3. It helps in deciding the precise location for landing the DH based on the above parameters.

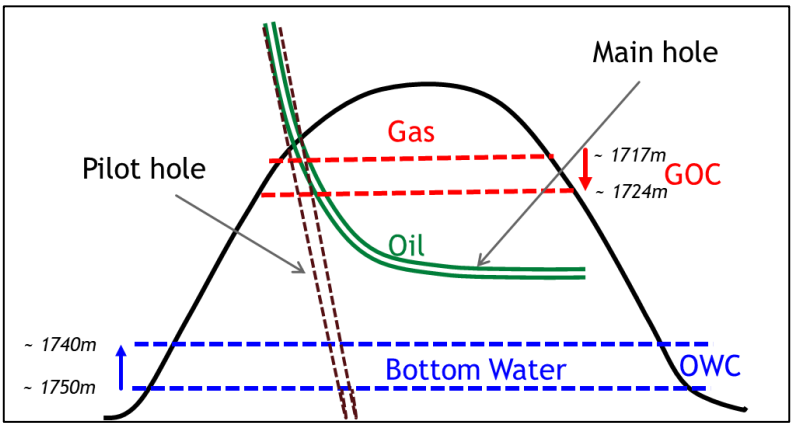


Fig-4: Pilot Hole to main hole placement strategy

Case Studies

1. Well No. A: The original well was flowing with high water cut (>88%) and gradually ceased to flow due to water loading in the drain hole section. In order to revive the well, it was decided to side-track the well after ascertaining fluid contacts through pilot hole. Accordingly the well A was drilled with the target to exploit oil from Bassein formation and an 8 ½" pilot hole was drilled in the well to identify landing depth for horizontal section. The well encountered Bassein Top at 1713m TVDSS, GOC at 1724.5m TVDSS and OWC is at 1741.5m TVDSS in the pilot hole. Based on the pilot hole data, 1729m TVDSS was decided as landing point and actually landed at 1728.8m TVDSS. Subsequently, 500m long drain hole was placed inside oil rim of Bassein Limestone having log porosity in the range of 22-28%, resistivity in the range of 18-90 ohm-m and estimated water saturation of 25-36%.

In 8-1/2” pilot hole pressure points were recorded and at Bassein formation the pressure found in the range of 93-95 ksc.The well has flowed with a peak production of 603 bopd of oil and 71824 m3/d of gas with only 8% W/C where the envisaged oil rate was 350 bopd and the well is currently under flowing condition since more than two years.

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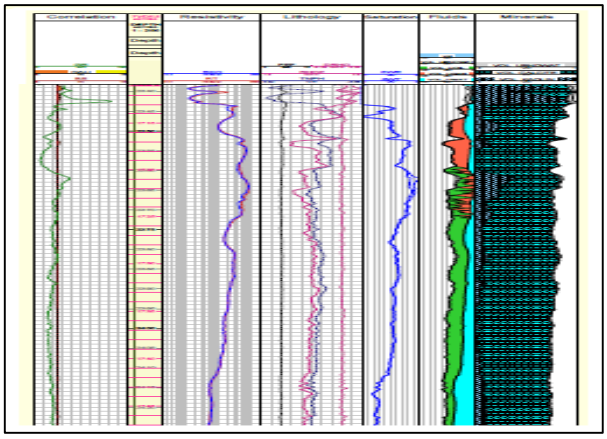
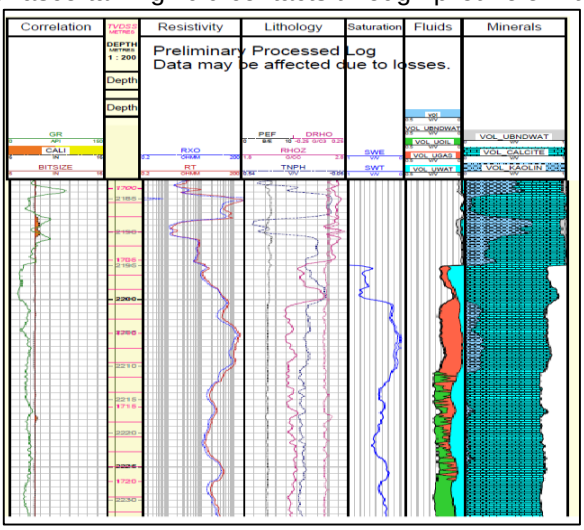


Log Motif of Well A

2. Well No. B: The original well was flowing with high water cut (>86%) and gradually ceased to flow due to water loading. The well was side-tracked after ascertaining fluid contacts through pilot hole with the target to exploit oil from Bassein formation.

The pilot hole well encountered Bassein Top at 1705.5m TVDSS, GOC at 1720m TVDSS and OWC is at 1739m TVDSS. The following petrophyiscal parameters were recorded; log porosity in the range of 16-30%, resistivity in the range of 10-150 ohm-m and estimate d water saturation of 10-95%. Based on pilot hole log, at 1725m TVDSS was decided as landing point and however the actual landing point was at 1724.94m TVDSS and 500m long drain hole was placed in Oil rim of Bassein Limestone.

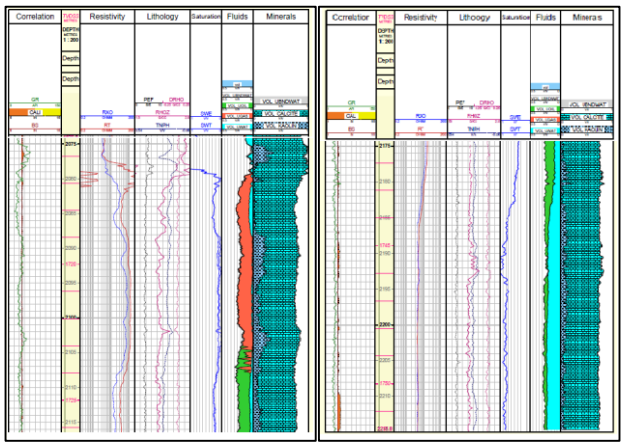
The well has flowed with a peak production of 507 bopd of oil and 70450 m3/d of gas with only 15% W/C where the envisaged oil rate was 308 bopd and currently well is under flowing condition since more than two years.



Log Motif of Well B

3. Well No. D: The original well was producing oil @ 1238bopd with nil W/C, however within 6 months period the oil production from the well declined to 806bopd with an increase in water cut to 49%. Subsequently, the water cut rose to the level of >85%.
The well was side-tracked after ascertaining fluid contacts through pilot hole with the target to exploit oil from Bassein formation.
The pilot hole well encountered Bassein Top at 1709m TVDSS, GOC at 1724m TVDSS and OWC is at 1743.5 TVDSS.

The following petrophyiscal parameters were recorded; log porosity in the range of 12-30%, resistivity in the range of 10-200 ohm-m and estimated water saturation of 10-100%.
Based on pilot hole log, at 1728m TVDSS the well was landed and 450m long drain hole was placed in Oil rim of Bassein Limestone.



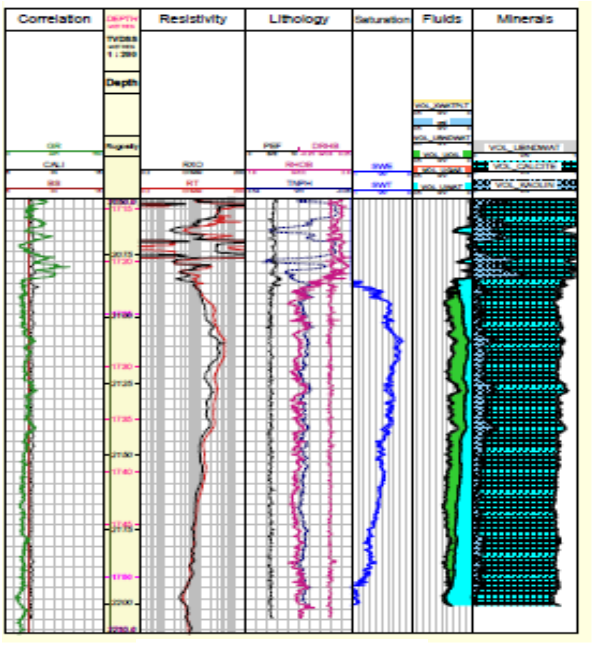
Log Motif of Well D

In 8-1/2" pilot hole pressure points were recorded and at Bassein formation the pressure found in the range of 94 -97 ksc. The well has flowed with a peak production of 529 bopd of oil and 85312 m3/d of gas with only 35% W/C where the envisaged oil rate was only 311 bopd and currently well is under flowing condition since last one year.

4. Well No. F: The original well was producing with more than 91% W/C and decided to side-track. Accordingly, the well was side-tracked after ascertaining fluid contacts through pilot hole with the target to exploit oil from Bassein formation.

The pilot hole well encountered Bassein Top at 1721.5m TVDSS and OWC was at 1741 TVDSS. However, the notable point is the well was devoid of gas cap gas. The following petrophyiscal parameters were recorded; log porosity in the range of 10-22%, resistivity in the range of 2-50 ohm-m and estimated water saturation of 25-90%. Based on pilot hole log, at 1727.5m TVDSS the well was landed and 300m long drain hole was placed in Oil rim of Bassein Limestone.

In 8-1/2" pilot hole pressure points were recorded and at Bassein formation the pressure found in the range of 93-95 ksc.
The well has flowed with a peak production of 484 bopd of oil and 91799 m3/d of gas with negligible W/C where the envisaged oil rate was only 344 bopd and currently well is under flowing condition since last six months.



Log Motif of Well F

Conclusion:

Vasai East field being operated under gas cap gas expansion as well as water drive mechanism, during production phase it is observed that GOC has gone down and on the other hand OWC has moved upward, which has been validated through the recently drilled sidetrack wells. Due to the heterogeneous nature of the field, the movement of contact points are uneven and also leads to thinning of the oil column. Accordingly, the pilot hole drilling has become essential to ascertain the formation tops, fluid contacts and the landing points for drain hole placement. This minimizes the risk of gas cusping from above and water breakthrough from below. It has been observed in the acquired pilot hole logs that there are 5-8 m variation in Bassein tops encountered in different wells from the planned depth. The variations in Bassein top is very important to determine, as the high secondary porosity in Bassein formation leads to severe drilling complications. In order to mitigate such problem, effective mud and drilling parameters are required to maintain in the drain hole section and in this scenario the acquired Log data in the pilot hole section became very useful to design such parameters. The acquired pilot hole log data is effective way to determine the precise landing point as there are significant variation in fluid contacts observed in some wells like in Well F there is no Gas cap Gas identified and there is approximately 6-8 meter variation in the fluid contacts identified across the field. The production performance of the drilled wells with this strategy are very encouraging as all the wells have outperformed the envisaged production rate.