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Identification of missed Reservoir in Kalol Formation, Sanand-East Field, Cambay Basin, India case studies.

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Abstract

Sanand field is located at the western margin in the southern part of the Ahmedabad-Mehsana tectonic block of Cambay basin which is a north-south trending intracratonic rift basin. Structure is NNW-SSE trending elongated doubly plunging anticline.

Sanand-East field is being developed as oil produces from Shaly silt reservoir identified with in thick Cambay shale layer. Cambay Shale in the intra-cratonic basin is known to have source rock potential and the silts within the Cambay shale have accumulation of hydrocarbon in the local heights. The field has been put on production with three wells from this silt layers. While drilling one of the development wells a sand layer in Kalol Formation above the Cambay Shale has been identified as hydrocarbon bearing and was tested and produced at good rate. Further a revaluation of the log data from other wells in the field has revealed that the zone is nicely co relatable and extended over the entire field. Testing of this sand layer in the other wells also produced oil at considerably good rates.

This paper presents the case study where sand layer escaped attention due to some preconceived notions about the depositional characteristics.

Keywords

Missed Reservoir, Re-interpretation

Introduction

Sanand East field is a producing field located at the western margin in the southern part of Ahmedabad Mehsana tectonic block of Cambay Basin. As per the initial field development plan, production has already been started from Intra-Cambay Formation and the pay zone was restricted only in the silty section of Intra Cambay Formation. This pay zone is very thick with dominant lithology silty shale. The top of which is co relatable both by seismic and wire line log. But one of the appraisals well went dry in Intra Cambay reservoir section and declared as abandoned well. A comprehensive re-interpretation was carried out integrating all data of drilled wells for all stratigraphic units. A thin layer of about 3-4 meters was found in the Kalol level which was not explored in the previous drilling campaign as focus was on the intra cambay reservoir section. This sand layer is regionally co-relatable within all wells and also extended upto two adjacent fields (Sanand-Miroli). The thickness of the layer varies from two to four meters only. So, it was not capable to be captured in seismic section. After detailed Petrophysical analysis, this zone was conventionally tested and found as oil bearing on self flow. This zone became a new discovery in Kalol Formation and added for production as new play. Out of eight wells, six wells are producing with good rate till date. The detail Petrophysical analysis of each wells have been discussed in detail in this paper.

Geological set-up

The discovery area (Sanand East) which is located in central part of (Ahmedabad) Block falls in Ahmadabad – Mehesana tectonic block. This area is limited to the south by the Nawagam – mehesana basement uplift. The NW-SE marginal faults of the Cambay basin can be envisaged in SW portion of the block. The block is segmented longitudinally (NNW-SSE) into two major half grabens each associated with prominent basement faults. The present-day structural highs are aligned with basement trends and are sub parallel to marginal faults **[Figure.1]**.

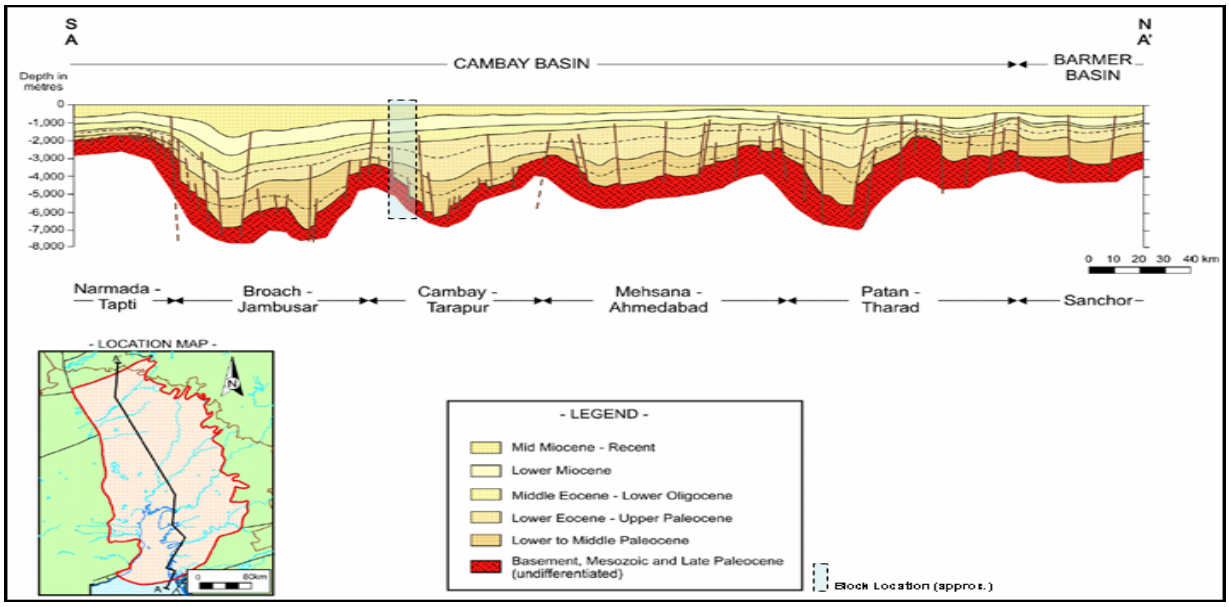


Figure.1 N-S Geological Section of Cambay Basin showing the different tectonic blocks.

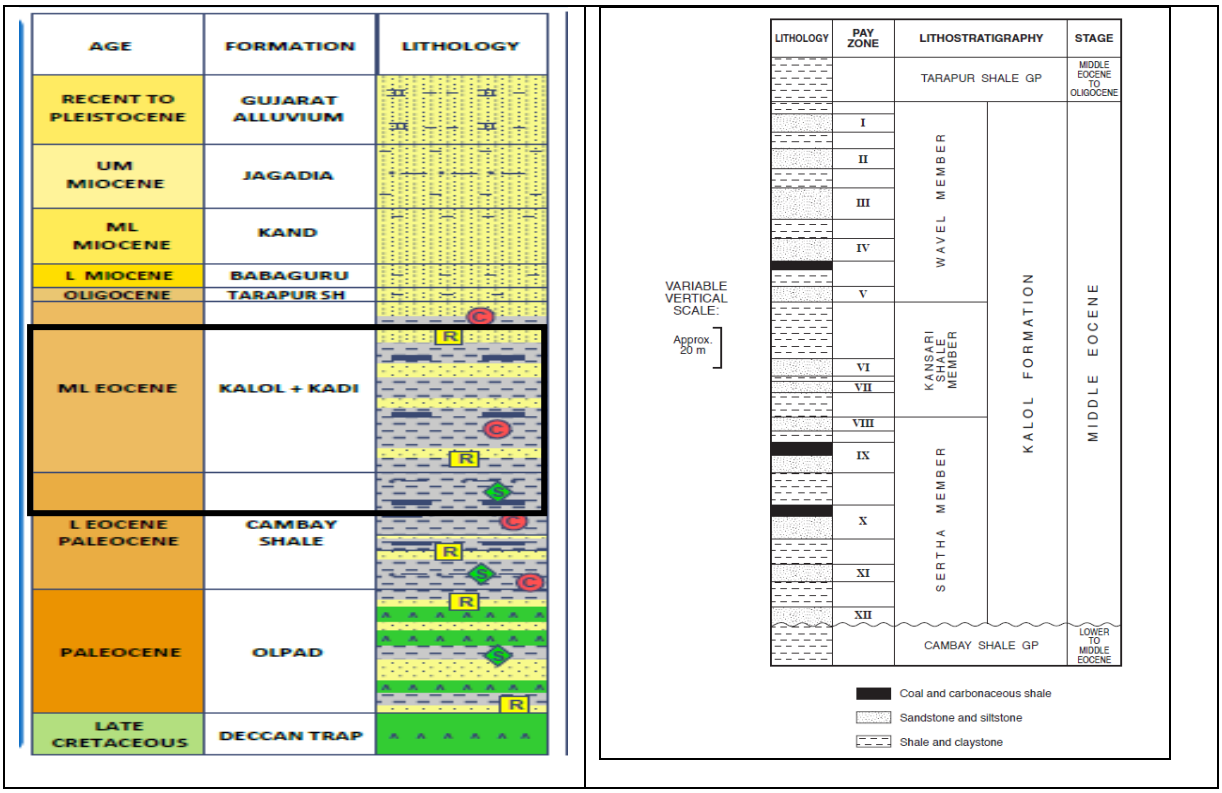


Figure.2 shows the generalized stratigraphy of the Cambay Basin. In the figure, different formations/members are described in line with geological time scale and different Pay zone of Kalol Formation.

Well Correlation:

The sand layer in Kalol Formation in eight wells namely E-5, E-2, E-4, E-3, E-1A, E-1, E1-A1, E-DEV-1 was correlated with the help of wire line logs (standard suite of Gamma-Resistivity-Neutron-Density). This sand/silt facies is thickness varies from 3-4 m in vertically and which is thinning out towards northern side. The different stratigraphy tops are nicely correlated and represented below.

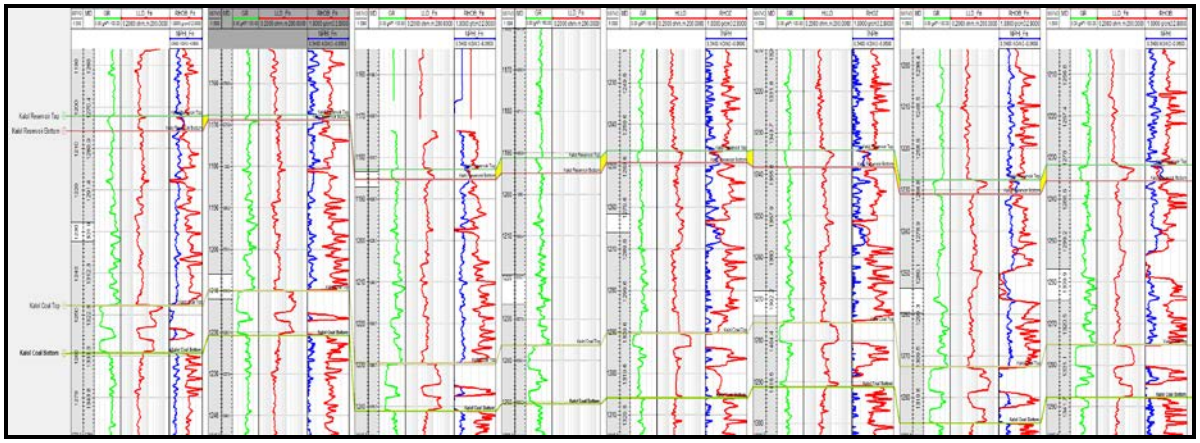


Figure.3 Structural correlation of Siltstone layer in Kalol formation in E-5, E-2, E-4, E-3, E-1A, E-1, E1-A1, E-DEV-1,

Data and Methodology:

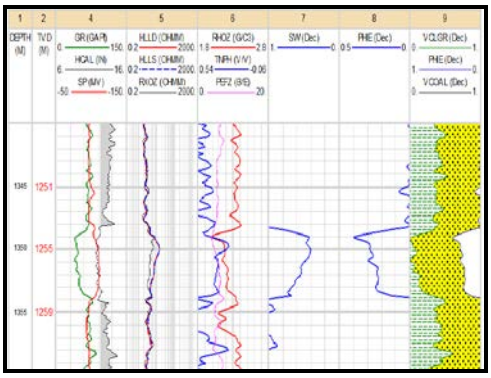
Kalol Formation is mainly argillaceous siltstone with intercalation of dark grey shale, carbonaceous shale and coal. Full suite of logs consisting GR-SP-Cali, Resistivity-Density-Neutron logs are available. In well E-3, correlation has been done only on the basis of cased hole gamma rays as others logs were not recorded in this intervals. Formation facies are mainly shaly sand. Indonesian equation has been used for estimation of water saturation. There are no core data available in the interval. Archie's parameter has been taken as default value i.e. a=1, m=2 & n=2. Water resistivity has been used in all the wells as Rw=0.22 ohm-m @ FT. Based on well testing results and salinity reports in the nearby well XX-4, water resistivity has been used in the wells as Rw=0.22 ohm-m@ FT.Calculated temperature gradient is 6.5 per 100mt depth. Well wise processing parameters and calculated temperature gradient used for Kalol Formations are tabulated

Table-1

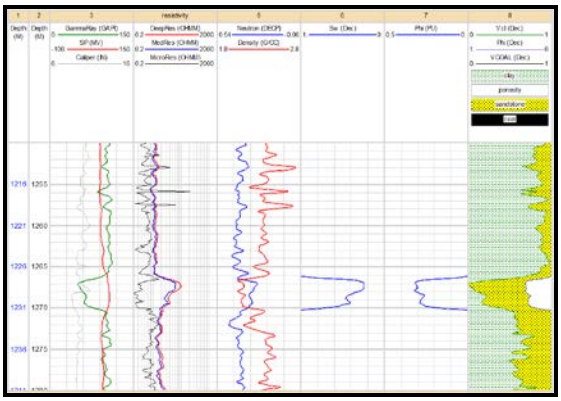
Temperature	E-5	E-2	E-4	E-1A	E-1	E1-A1
Surface temp	80 F	81 F	82 F	87 F	79 F	86 F
BHT@MD	216 F @2009m	164 F@1339,	245 F@2346	170 F@1405	187 F@2020	211 F@1900
BHT@TVD	205 F@1862.4	162 @1301.7	245 F@2346	171 F@1405	177 F@1829	208 F@1854
Gradient F/100m	6.7	6.3	6.75	6.5	4.5	6.59
Average gradient	6.5 F/100m					

For the entire wells deterministic model has been run to evaluate the reservoir parameter. The character of reservoir is very clean with some places resistivity rises upto 40 ohm-mt with good neutron-density crossover. Average porosity ranges from 25-30% with very low water saturation (in some places it goes upto 30%).All the available wire line logs are quality checked and environmentally corrected before interpretation.Vsh calculation were done using both from GR and Neutron-Density equations and selected minimum Vsh value for interpretation. Porosity calculated from Neutron Density combination equation. The processing results of all the wells are represented below well wise.

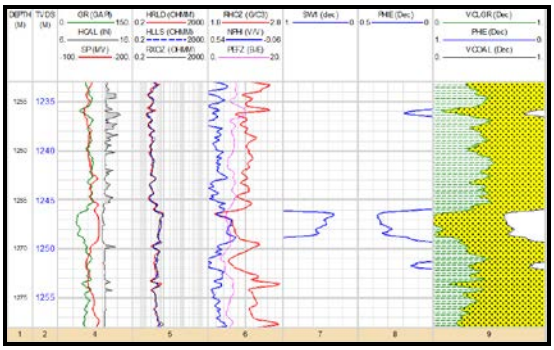
E-1



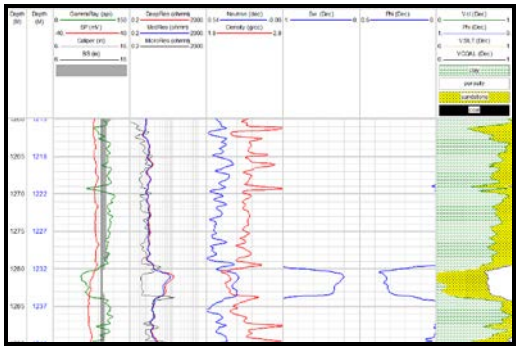
E1-A1



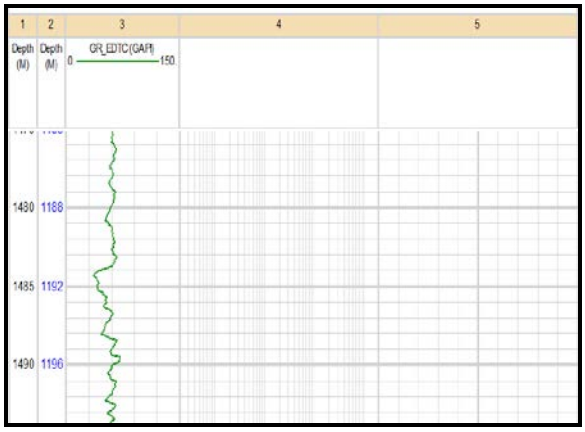
E1-1A



E1-DEV1



E-3



E-4

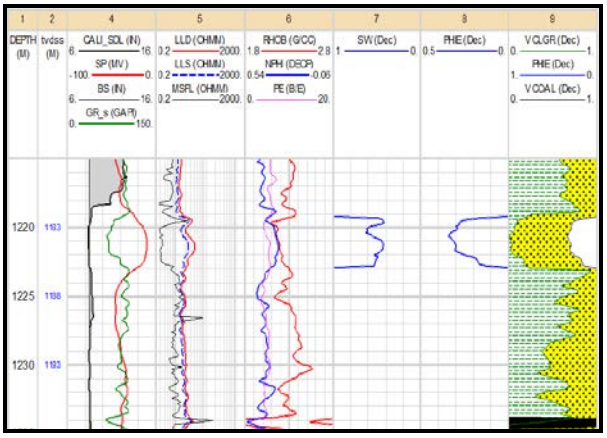


Figure.4 Deterministic Petrophysical analysis for wells E-1, E1-A1, E1-1A, E-DEV1 and E-4. Well E-3 only cased hole gamma ray is available. Reservoir is mainly clean sand with average porosity and water saturation 25-30% and 35-55%.

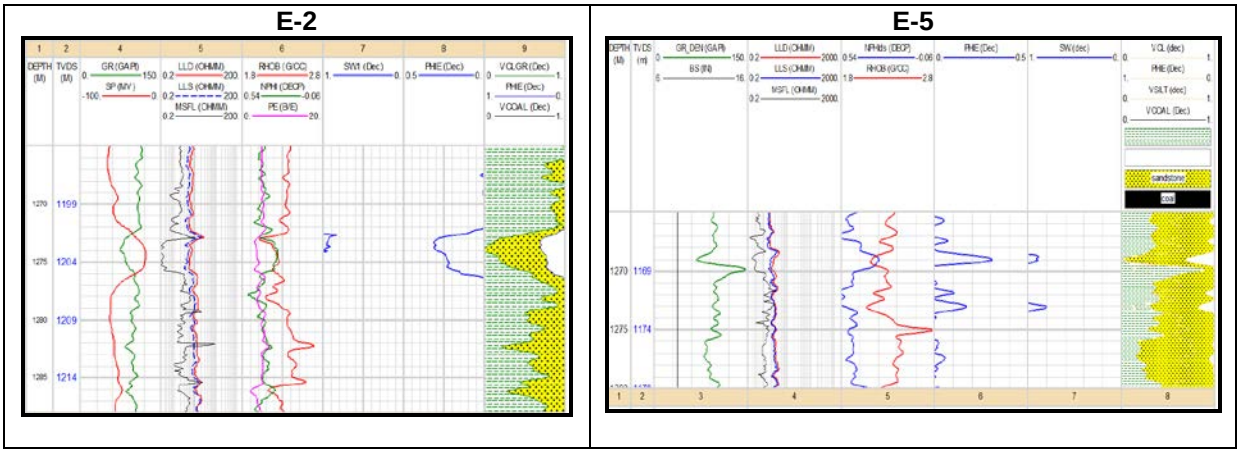


Figure.5 Deterministic Petrophysical analysis for wells E-2 and E-5.Reservoir become very thin with water saturation close to 100%

Table-2. Petrophysical analysis tabulated below.

Well	Formation	Fluorence	Zone of interest (TVDSS)	Thickness(TVDSS)	Zone of Interest (MD)	Thickness(MD)	Log motif	Average Porosity %	Avarage Saturation %
E-5	Kalol	Not Observed	1167.65-1168.78	1.13	1268.13-1269.39	1.26	Log GR Log Resistivity		
E-2	Kalol	Not Observed	1202.08-1205.71	3.63	1272.62-1276.43	3.81	Low GR positive SP Rt ~3 ohm-mt N-D Crosss over	26	100
E-4	Kalol	Not Observed	1182.77-1185.16	2.39	1219.47-1221.86	2.39	Low GR positive SP Rt ~10 ohm-mt N-D Crosss over	30	46
E-3	Kalol	Not Observed	1191.15-1194.89	3.74	1483.92-1488.2	4.28	Log not avilable		
E-1A	Kalol	F/Strong cut	1246.38-1249.27	2.89	1266.01-1268.9	2.89	Low GR positive SP Rt ~9 ohm-mt N-D Crosss over	33	45
E-1	Kalol	F/Strong cut	1234.09-1238	4.19	1348.62-1353.69	5.07	Low GR positive SP Rt ~15 ohm-mt N-D Crosss over	27	46
E1-A1	Kalol	F/Strong cut	1227.48-1230.95	3.47	1266.22-1269.74	5.07	Low GR positive SP Rt ~36 ohm-mt N-D Crosss over	28	35
E1-DEV1	Kalol	F/Strong cut	1231.71-1235.63	3.92	1279.82-1283.99	4.17	Low GR positive SP Rt ~40 ohm-mt N-D Crosss over	31	30

Results

Lumping technique has been used to arrive at applicable cut-offs to estimate net reservoir and net pay averages. In this method integrated hydrocarbon meters is plotted against the cut-off values for each parameter Vsh, Phi and Sw (IHM is defined as Phie*Shc*He Reservoir). The individual high, base and low case cut-offs for each parameter are derived basing on the plots as shown below. Average Petrophysical properties are tabulated below.

ReErvoir cutoffs											
Phie	0.06										
Sw	0.60										
Vcl	0.45										
Well	Formation	Top (MD)	Bottom (MD)	Gross (MD)	Net	N/G	Av Phi	Av Sw	Av Vcl	Phi*H*So	Phi*H
E-5	KALOL	1268.13	1269.39	1.26							
E-3	KALOL	1483.92	1488.20	4.28							
E-4	KALOL	1219.47	1221.86	2.39	1.95	0.82	0.30	0.46	0.04	0.31	0.58
E-2	KALOL	1272.62	1276.43	3.81	0.10	0.03	0.26	100.00	0.25	0.01	0.02
E-1	KALOL	1348.69	1353.69	5	3.60	0.72	0.27	0.46	0.06	0.52	0.99
E1-A1	KALOL	1266.22	1269.74	3.52	3.30	0.94	0.28	0.35	0.14	0.61	0.94
E-1A	KALOL	1266.01	1268.90	2.89	2.43	0.84	0.33	0.45	0.02	0.44	0.81
E-DEV1	KALOL	1279.82	1283.99	4.17	3.45	0.83	0.31	0.30	0.04	0.76	1.10

Conclusion

The sand layer is very clean and found to be co relatable on electrolog across the all drilled wells. The effective thickness varies from 2m to 4m, effective porosity from 28% to 32% and HC saturation from 57% to 73%.The thickness of the reservoir being 2-4mts only it is beyond the seismic resolution and thus could not be identified on seismic data. Out of eight wells, six wells are flowing with good rate in self flow. A new reservoir has been identified in the old wells in Sanand-East fields, using advanced Petrophysical techniques.

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