Significance of Integrated Geotechnical Studies in Field Development: A Case Study of mitigating uncertainty in oil-water contact

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Abstract:

Once discovery is made in any field, immediate next step for any E & P Company is to delineate the area of the hydrocarbon pool and to carry out the reserve estimation. Oil-Water contact plays a crucial role in reservoir delineation, reserve estimations and placements of development wells. Fluid contact interpretation is not always possible only by using conventional wireline log data. The uncertainties in the log interpretation needs to be mitigated by integrating the interpretation of data belonging to different domain.

The conventional resistivity log resulted in ambiguity of presence of oil-water contact, the resistivity drop at the bottom of the reservoir was initially interpreted due to presence of shale or shaly reservoir. The transition zone which could be easily determined in a clean clastic reservoir became more complex due to vertical lithological changes in the reservoir.

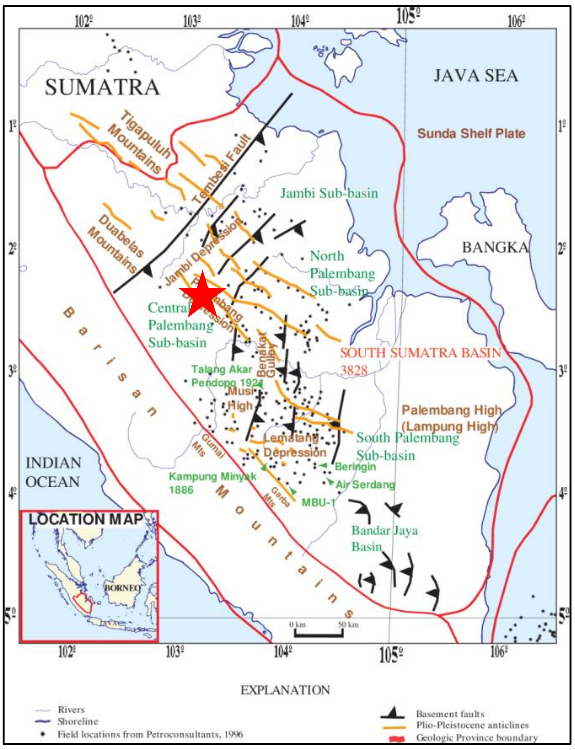
The conventional log interpretation was integrated with information on formation water produced from down-dip Well B. The result of updated log interpretation indicated the presence of contact just near the perforated zone of the reservoir, and this hint generated curiosity for further probe in that direction. The field was entering into the development stage. It was essential to resolve the uncertainty. Hence an integrated approach was adopted using available data from different domain to identify the contact with higher degree of confidence.

Introduction

The fluctuation in the oil prices in last decade has made E & P Companies more conscious and concerned about the Field development investments. This case study deals with similar scenario where major investment is planned based on the G&G studies carried out in a discovered oil field. The paper is about integrated studies carried out by a multi-disciplinary team to examine the ambiguity on oil-water contact in clastic reservoirs belonging to South Sumatra Basin. The studies have mitigated the subsurface uncertainty and de-risked the investment.

The South Sumatra Basin located to the east of the Barisan Mountains and extending into the offshore areas to the northeast is regarded as a back-arc basin which is bounded by the Barisan Mountains to the Southwest and the pre-Tertiary of the Sunda Shelf to the Northeast (de Coster, 1974). The South Sumatra Basin comprises Tertiary half-graben sub-basins filled with mixed terrigenous, volcaniclastic and carbonate rocks unconformably overlying pre-Tertiary sedimentary, metamorphic and igneous rocks (Amir et al., 2011). The present day structural style of the South Sumatra Basin is the consequences of three major tectonic episodes (Ginger & Fielding, 2005):

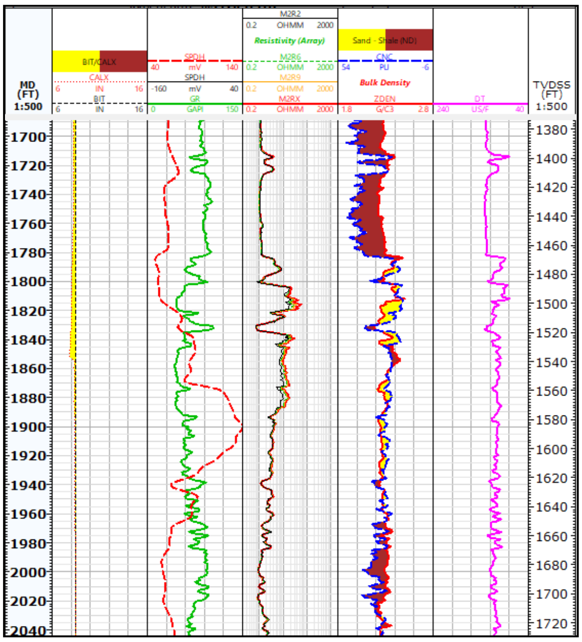
1. Late Cretaceous to Early Oligocene: horst blocks and half grabens formed during extensional phase.
2. Late Oligocene through Early Miocene: Graben subsidence- basin became fully marine. During late Early to Middle Miocene time wrench tectonics produced compressional folds.
3. Finally, during the Plio-Pleistocene strong compressional tectonics created northwest-southeast trending reverse faults and basement uplift.



Location Map of Study Area with Regional Tectonic Elements (Modified from Barber et. Al., 2005)

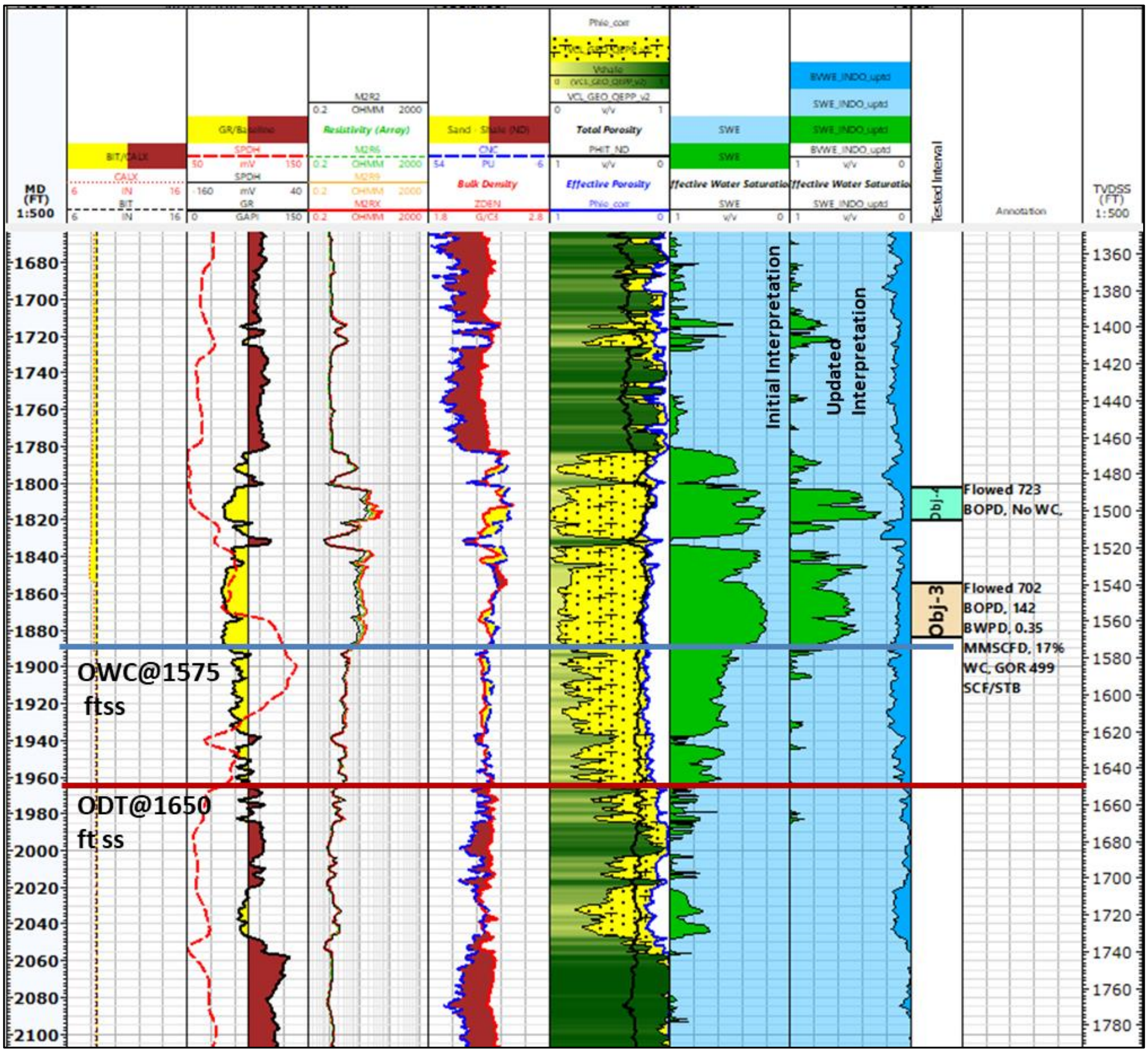
Case Study:

The study deals with the importance of collaborative approach for picking fluid contact which is not clearly visible in the conventional log. The study involves two wells, Well A is a discovery well and Well B is located down dip of Well A. The production testing of Well B proved it to be devoid of any hydrocarbon presence. As per earlier studies, an oil-water contact was not interpreted in this clastic reservoir. It was inferred that the contact is between WUT (Water Up To) and ODT (Oil Down To) of the reservoir which is hydrodynamically connected to both Well A and Well B. The conventional log motif of Well A indicated that the change in resistivity is due to increasing shaliness in the reservoir, hence is due to lithological effect and not the fluid effect.



Conventional Log Motif of Well A

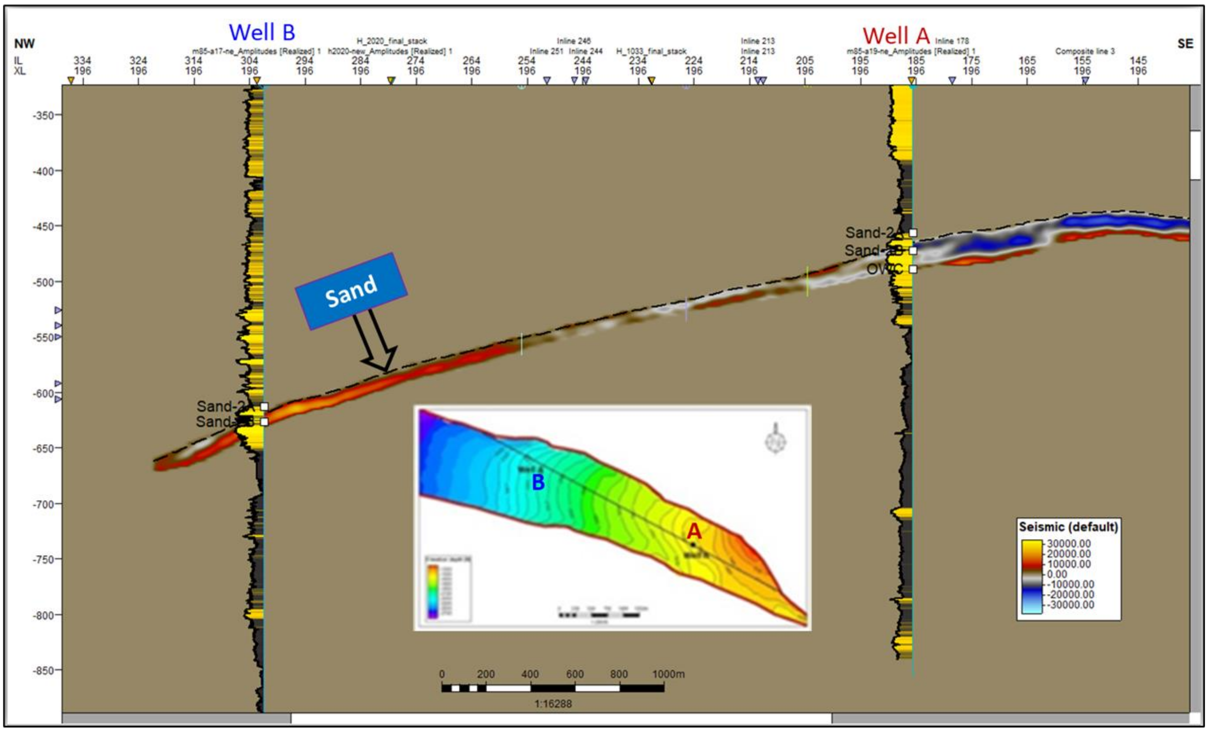
The initial log interpretation of Well A showed ODT (Oil down to @ 1650 ft ss) case with presence of a shale barrier just below the main oil bearing reservoir separating it hydrodynamically from the adjacent shaly reservoir. However, taking help of regional understanding of formation water and input of Well B which tested formation water, the petrophysical interpretation was revisited and as a result presence of fluid contact was indicated (OWC@1575ft ss) just near the thin shale break at 1580 ft ss.



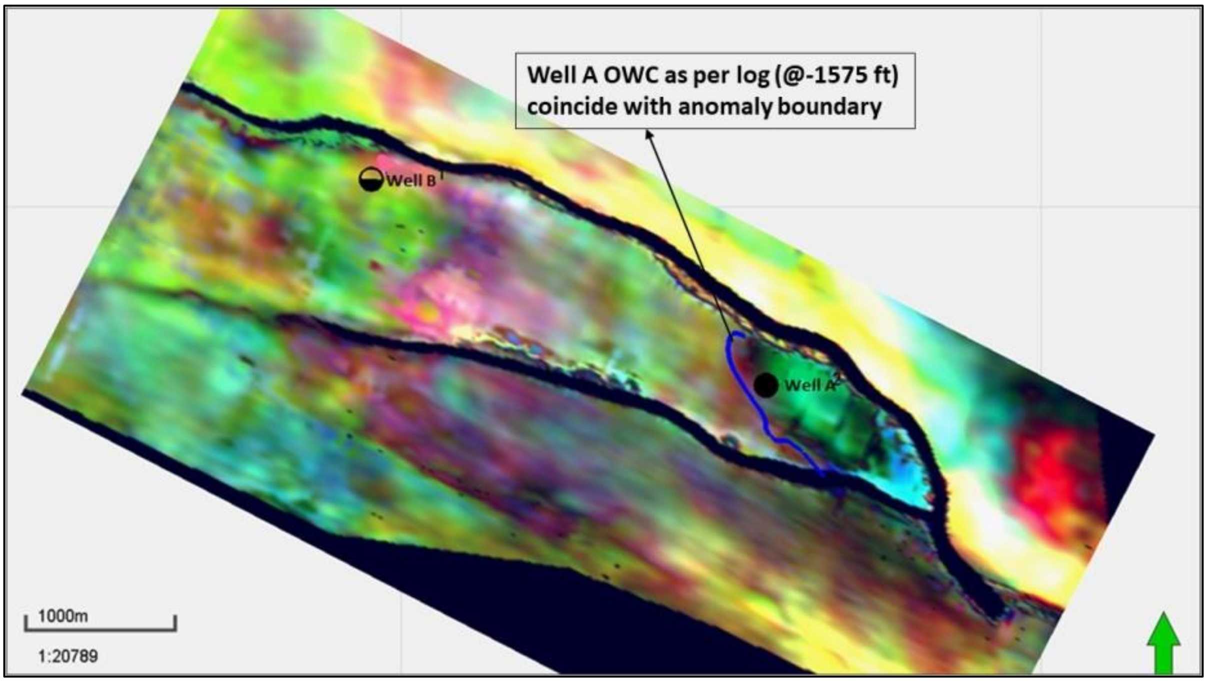
Processed Log Motif of Initial & Updated Petrophysical Interpretation of Well-A

Since the reservoir is very much correlatable through Well A and Well B, the earlier interpretation suggested the water contact between Well B (WUT) and Well A (ODT) and hence four development wells were planned between these wells to delineate the extent of the hydrocarbon pool. This new interpretation of contact opened up new chapter of uncertainty on concept of oil extending down dip till Well B (WUT). Since this new finding of OWC is based on petrophysical interpretation, it is essential to have corroborative evidence from available data sets of different domains, to give confidence on the interpretation. Hence seismic data and RFT pressure data acquired in both Well A & Well B was revisited.

It has been observed that Seismic wave phase reversal from suspected oil leg to water leg within the same reservoir where no distinct thickness variation of sand seen as per the two well drilled data. Seismic wave crossing from acoustically slow HC-saturated sand to faster water-saturated sand may cause this reversal thereby suggested water oil contact down dip to Well A. Additionally, a time slice of frequency blend (of 10 Hz, 20 & 40 Hz) near the pay sand also shows an anomaly boundary that coincides with the possible oil water contact in the sand of Well A.



Sand showing a phase reversal from Well A to Well B

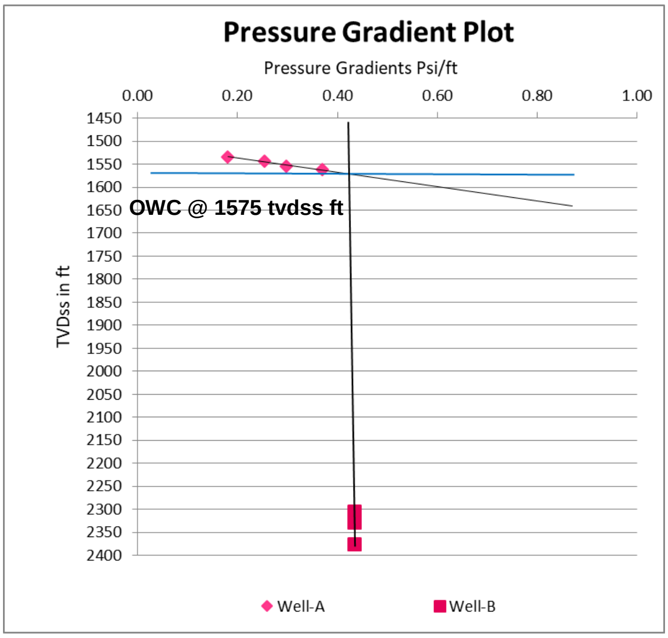


Time Slice of frequency blend of 10 Hz (Red), 20 (Green) & 40 Hz (Blue) near Sand

Further RFT / MDT data of Well A and Well B was utilized to prepare pressure gradient plot which helped us to freeze the interpretation. Since Well B was tested water bearing, the input of its gradient on pressure plot along with gradients of Well A suggested presence of Oil water contact @ 1575 ft ss which is same as of the re-interpreted log data.

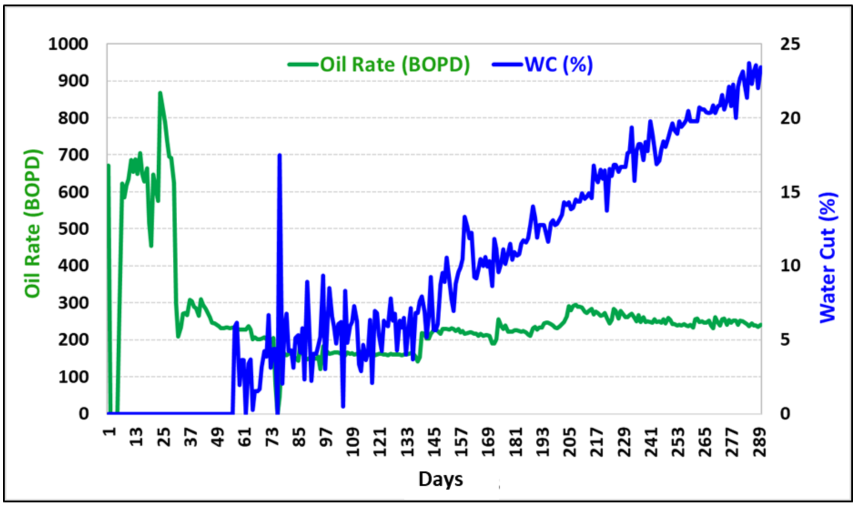
RFT Pressure Data					
Points	**TVdss ft**	**Gradient psi/ft**	**Hydrostatic pressure**	**Formtation pressure**	**Remark**
1	1524	0.4	659.89	787.61	outliers
2	1533.6	0.18	664.04	791.48	Well A
3	1544.03	0.25	668.56	793.36	
4	1554.5	0.3	673.09	796.01	
5	1562.12	0.37	676.4	798.28	
6	1616.88	0.36	700.11	820.79	Outliers
7	2303.5	0.43	997.41	990.505	Well B points Considered Water bearing based on Test results
8	2328.6	0.43	1008.28	1001.298	
9	2374.2	0.43	1028.02	1028.0286	

RFT data of Well A and Well B



Pressure Gradient Plot of Well A and Well B

Last but not the least, major supportive evidence of contact was by the production data where in formation water began to flow along with Oil with increasing water cut, suggesting contact near the perforation intervals.



Production Chart of Well A with Increasing Water Cut

Observations & Conclusion

Based on the initial interpretation of WUT, development wells were planned down dip between discovery Well A and dry Well B with the anticipation of contact between the drilled wells. The collaborated multidiscipline study helped in delineating the reservoir limit by presence of oil water contact in Well A. A geological model was then updated based on the findings of contact in the well and future development wells were optimised.

The integrated studies carried out by the multidisciplinary Team, revealed the presence of contact and thus not only helped to understand the reservoir characteristics but also helped to delineate the reservoir extent.

It is not always to find the Hydrocarbon in subsurface, sometimes Geoscientists have to think where Hydrocarbon is not present and such studies will mitigate the subsurface uncertainty.

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References:

1. de Coster, G. L., 1974, THE GEOLOGY OF CENTRAL AND SOUTH SUMATRA BASIN, Proceedings of Indonesian Petroleum Association 3rd Annual Convention, Jakarta. pp 77-110.

2. Amir, V., Achdiat, R., Meirita, M., Guttormsen, J., 2011, FACIES ARCHITECTURE AND DEPOSITIONAL RELATIONSHIP OF BATU RAJA CARBONATES IN LETANG, RAWA, AND TENGAH FIELD, CORRIDOR BLOCK, SOUTH SUMATRA, Proceedings of Indonesian Petroleum Association 35th Annual Convention and Exhibition Vol.1, Jakarta.

3. Ginger & Fielding, 2005 - THE PETROLEUM SYSTEMS AND FUTURE POTENTIAL OF THE SOUTH SUMATRA BASIN, Proceedings of Indonesian Petroleum Association 30th Annual Convention & Exhibition, August 2005.

4. SPE 165848 INTEGRATED REGIONAL INTERPRETATION AND NEW INSIGHT ON PETROLEUM SYSTEM OF SOUTH SUMATRA BASIN, INDONESIA A. Carrillat, D. Bora, A. Dubois, Schlumberger, F. Kusdiantoro, S. Yudho, E. Wibowo, M. Musri, J. C. Tobing,

MedcoEnergi, T. P. Gomez, F. Xue, D. Balasejus, T.D. McDonald, and P. Audemard, Schlumberger

5. SOUTH SUMATRA BASIN PROVINCE, INDONESIA: THE LAHAT/TALANG AKAR-CENOZOIC TOTAL PETROLEUM SYSTEM by Michele G. Bishop1

6. Ramdhan, A.M., Hutasoit, L.M., and Slameto, E., 2018. LATERAL RESERVOIR DRAINAGE IN SOME INDONESIA'S SEDIMENTARY BASIN AND ITS IMPLICATION TO HYDRODYNAMIC TRAPPING. Indonesian Journal on Geoscience,

7. DETERMINE RESERVOIR PROPERTIES OF "R1" RESERVOIR BASED ON LOG INTERPRETATION AND CORE ANALYSIS IN "X" FIELD OF SOUTH SUMATRA BASIN Sri Rizky*,a) , Ordas Dewanto*,b), Bagus S Mulyanto*,c) , BenyChasandra*)