**PROCEEDINGS**
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# A New Diagnostic Method for Prediction of Producibility in Low Quality Reservoir of Minas Field Using Well-Log Data

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**Abstract**

Formation evaluation with well-log data is primarily used as prediction tool to identify porous and permeable zone containing hydrocarbon. When reservoir quality becomes lower, challenges are increasing and underestimating of productive interval can occur. To address the needs for better estimation of identifying productive intervals in Low Quality Reservoir (LQR), new tool namely Hydrocarbon Potential Evaluator (HPE) was introduced. The HPE tool methodology was developed based upon an exclusive study by correlating initial well-production history to the Open Hole Log responses.

The focus area of this study is low quality reservoir in Minas field. Current completion strategy in Minas field is to open comingle between LQR and high-quality reservoir interval. This practice, in most cases has resulted smaller production contribution from LQR. Despite common consensus suggesting that Minas LQR is recognized to have very good potential in terms of oil production deliverability if it is opened using proper technique and strategy.

Conventional workflow for candidate selection has been employed by reviewing well data such as logs, core, Xsection, map and production data. This procedure is deemed tedious, time consuming and may prone to inconsistency and biased. Post-execution review on 13 LQR pilot wells, maximum success ratio is 46%, where only 6 wells are noticeably delivered oil gain while the remainders are considered failed or inconclusive.

Significant improvement is made after the utilization of HPE, the tool based on development of cut-offs from more comprehensive analysis of petrophysical data. HPE is functioned to classify as radar diagnostic and perforation recommendation color tagging which in turn will correlate with quality and producibility. Utilization of HPE tool has increased analysis objectivity and reduced workover selection time. Post-execution review on 13 LQR pilot wells using HPE tool has delivered 80% result match, whether such wells are confirmed to successfully produce oil or water

**Introduction**

Minas field is one of a prolific oil producer in Central Sumatra basin. The formations consist of High Quality Reservoir (HQR) which has high porosity and high permeability. But in some intervals, we can also find low quality reservoir. Low quality reservoir can be found in the upper part of fining upward sequence of sand body or as a single body (see Figure 2).

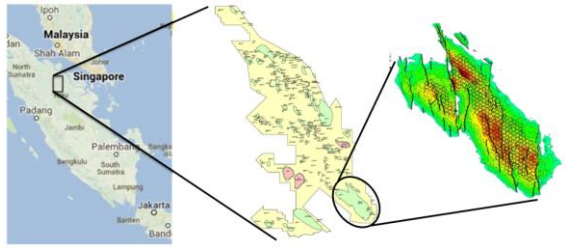


Figure 1: Location of Minas field, Central Sumatra Basin

For more than 5 decades, we believe that oil produced in Minas field is mostly come from the high quality reservoir in the lower part of fining upward sequence, while in low quality reservoir there is still oil left in the reservoir since mostly the completion is comingle with high quality reservoir. Estimating oil producibility from well-log in low quality reservoir is an important yet difficult task in

reservoir characterization. Especially when the low quality reservoir is part of fining upward sequence of the sand body. Because all parameters that we use to calculate reservoir properties such as water saturation mostly are taken from higher quality part.

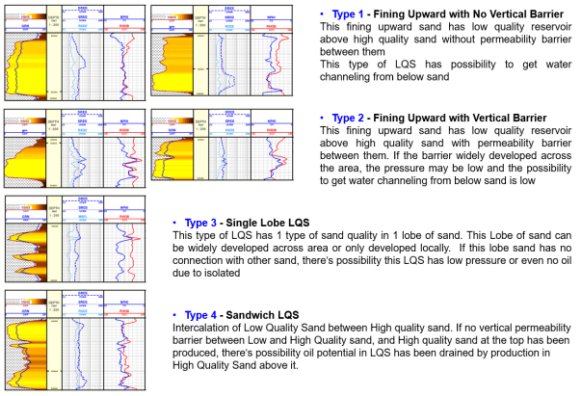


Figure 2: Type of Low Quality Reservoir (LQR) in Minas field

Among various formation evaluation tools, well-log data are prominently available for all wells; yet the interpretation of well-log often requires innovative approaches incorporating other source of data.

In this study, after carefully examine of certain well-logs responses, petrophysical analysis result and data production from low quality reservoir, a pattern-recognition diagnostic and color code assignment approach are proposed for predict low quality interval with producibility potential

**Data and Method**

Almost 2000 wells were drilled In Minas field. Well-log data in old wells include conventional measurement such as SP, Resistivity, Formation Density, Gamma Ray and Caliper log are available. More recent wells also include dual-induction laterolog, and compensated Neutron Formation Density. With robust Formation Evaluation study, using open hole log data validated to core, we also generate petrophysical properties such as Shale Volume (VShale) from Gamma Ray, porosity using volan method and derive permeability from multiple regression using Vshale and effective porosity (PHIE) input.

Other data that we have in Minas field is production data history. This data includes perforation interval, swab test and production test, that's recorded historically from initial test until most recent test. From all of data test that we have, only initial test data that represent open hole log data, especially Resistivity.
To identify interval LQR with producibility potential, a systematic screening process is followed. The LQRs are identified based on shape of Gamma Ray and Resistivity log and confirm by high Vshale value. And the most important thing is Permeability value is less than 1000 md.

After identifying LQR interval and compiling all well-log and petrophysical analysis data, we develop tool called Hydrocarbon Potential Evaluator (HPE), that works as pattern-recognition and color code technique using spider diagram approach. The three petrophysical properties (VShale, PHIE and Permeability) and one log signal (Deep Resistivity) were place on the spider diagram to determine pattern recognition. Another log signals that's put in the spider diagram are Caliper and Deep and Shallow Resistivity Ratio. All petrophysical properties and log signal were placed on the spider diagram with the high value on the outside and the low in the center, except for VShale. In the diagram VShale is put VSand (1-VShale), to make it high value on the outside and the low in the center. Scale for Resistivity and Permeability are in logarithmic starting from 0.1 to 10.000, while the others are in linear scale starting from 0 to 1 (0.5 for PHIE). See Figure 3.

For application, we assign cutoffs for 4 parameters in spider diagram (VShale, PHIE, Resistivity and Permeability). To make cutoffs are not straight forward, we also determine tolerance value for each cutoff based on +/- percent value of the cutoffs themselves. Specific for Permeability, since its value has very wide range, the tolerance value for permeability is not based on percentage of its cutoffs, but the tolerance is directly assigned as low value and high value. Cutoffs and its tolerance are determined based on trial and error until we get the most match value validated to Swab or production test. Another 2 parameter in Spider diagram (Caliper/2BS

and Resistivity Ratio/2) are not parameter that will be used to predict low quality interval with producibility potential. They are just to see our well-log data quality that we use as inputs. If Caliper/2BS = 0.5 means perfect borehole, > 0.5 is washed out and < 0.5 is mud cake. For Resistivity Ratio/2 = 0.5 means Deep Resistivity = Shallow Resistivity.

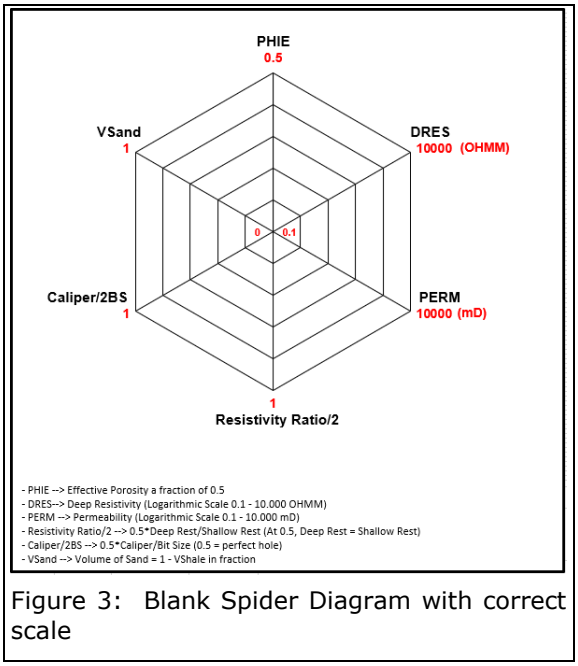


Figure 3: Blank Spider Diagram with correct scale

All cutoffs and its tolerance are plotted into spider diagram with red color line. The next step is input the petrophysical analysis value and well-log data value from the interval interest. The tool will be averaging those petrophysical analysis value and well-log data value along the interval interest and plot them to spider diagram. Data from that interval interest are showed as pattern in black line with green shading. To evaluate the potential producibility in the interval interest we can see in the spider diagram where the pattern with black line and green shading is at the outside of red line. See Figure 4 and Figure 5.

Beside generate average value as pattern for interval interest, we also generate color code base on petrophysical analysis value and well-log data value for each sampling depth (every 0.5 feet) that represent producibility potential. This color code is automatically generated based on same input as spider diagram, which are VShale, PHIE, Resistivity and Permeability that applied cutoff include their tolerance value. This color code then put in the display log in the respective depth, so we can see potential producibility in the interval interest. Color code for producibility potential can be seen in Figure 6.

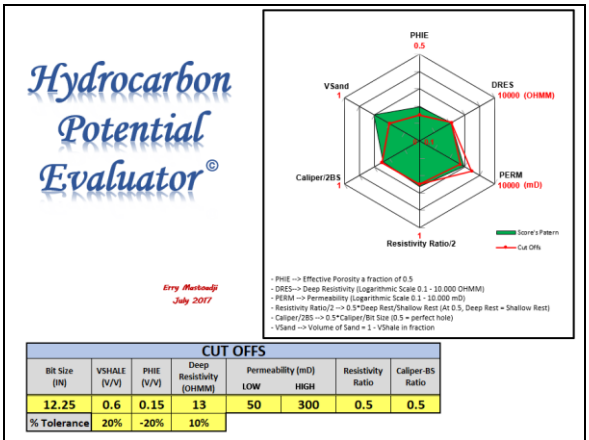


Figure 4: Spider diagram with pattern showing producibility potential

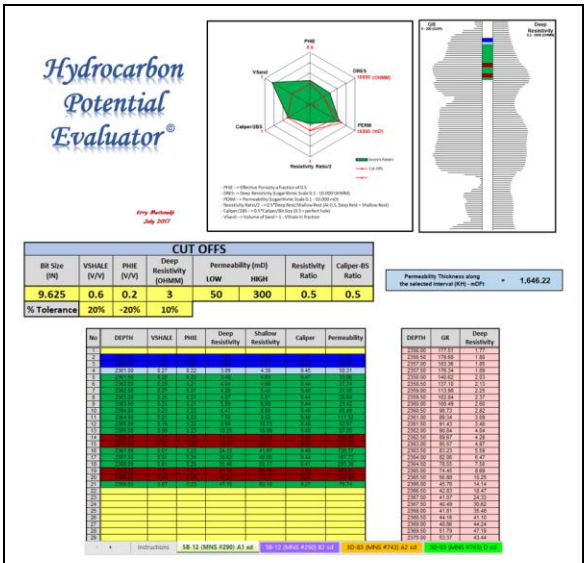


Figure 5: Spider diagram and color code assignment

| COLOR | COLOR NAME | CRITERIA |
|---|---|---|
| | BROWN | < 20% WATER CUT<br>GOOD RATE, > 10 BFPH/240 BFPD |
| | DARK_GREEN | 20% < WATER CUT < 80%<br>GOOD RATE, > 10 BFPH/240 BFPD |
| | LIME_GREEN | 20% < WATER CUT < 80%<br>LOW RATE, < 10 BFPH/240 BFPD |
| | DEEP_SKY_BLUE | >80% WATER CUT<br>GOOD RATE, > 10 BFPH/240 BFPD |
| | LIGHT_BLUE | >80% WATER CUT<br>LOW RATE, < 10 BFPH/240 BFPD |
| | BLUE | 100% WATER,<br>GOOD RATE, > 10 BFPH/240 BFPD |
| | NAVY_BLUE | 100% WATER,<br>LOW RATE, < 10 BFPH/240 BFPD |
| | ORANGE | OIL, TIGHT --> DRY TEST |
| | GRAY4 | TIGHT ROCK |
| | GRAY12 | SHALE |
| | BLACK | HIGH QUALITY SAND |

Figure 6: Color Code Legend

## Result and Discussion

After studied and reviewed in 13 wells in Minas field that opened and test individually in Low Quality Reservoir, we found that HPE tool has delivered 80% result match, whether such wells are confirmed to successfully produce oil or water. While the other 20% result is whether not match or inconclusive in the swab test or production test. This technique has made significantly improvement in term of producibility prediction compare to conventional method. Without using HPE tool maximum success ratio is 46% where 6 out of 13 wells are noticeably delivered oil gain while the remainders are considered failed or inconclusive.

Figure 7 shows that HPE tools predict the interval tested will give high water cut production indicated by Blue - light blue color in the perforated interval, and it's proved by the Swab test and production test that the interval gave 100% WC.

Figure 8 shows that HPE tools predict the interval tested will give Low water cut production indicated by Brown - green color in the perforated interval, and it's proved by the Swab test and production test that the interval gave 52% WC in the first production test.

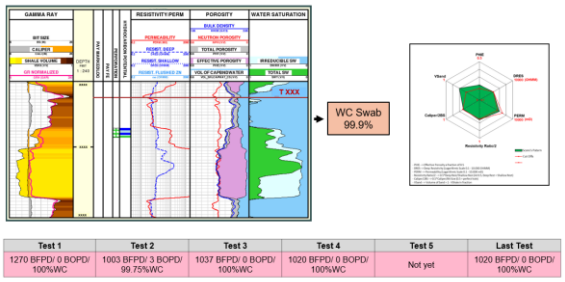


Figure 7: HPE prediction and test showing match result on high WC

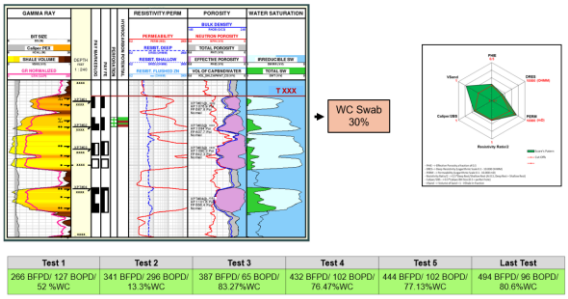


Figure 8: HPE prediction and test showing match result on good WC

## Conclusions

Oil potential in Low Quality Reservoir in Minas field can be predicted using this Hydrocarbon potential Evaluator (HPE) tool. This tool works as pattern-recognition and color code technique using spider diagram.

Using this tool, oil potential in Minas field can be identified easily and faster than conventional method. This technique can also be adopted to other field, not only in Low Quality Reservoir but also in other type of reservoir.

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