IATMI22-128: Formation Evaluation and Reservoir Development Optimization by Multi-well Deconvolution Driven Multiwell Retrospective Testing (MRT)

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Abstract

An off-shore field in SE-Asia has high reservoir heterogeneity and consists of several highly permeable layers. The current field development challenges are to evaluate the potential for additional drilling and reveal the potential of production increase by injection optimization. Good Understanding of cross-well reservoir connectivity at the area, the shape and size of existing wells drainage area, reservoir properties distribution and cross-well pressure impacts are the key points for additional drilling projects and production enhancement.

A1 reservoir in this field was at the focus of the study. This reservoir produces light oil and with the decrease in formation pressure, gas production has increased. A Multi-well Retrospective Testing (MRT) service was applied based on historical well pressure and production data to evaluate the reservoir compartmentalization, quantify well interference and drainage area. Historical data over 12 years (2007 to 2019), from an area consisting of 4 producers and 1 injector was analyzed using MRT. MRT extends the technique of single-well deconvolution to the analysis of pressure and production data to a group of wells. MRT was used to evaluate reservoir transmissibility between wells, cross-well interference, formation pressure history, productivity index dynamics and well drainage area. The deconvolved single unit-rate pressure drawdown transient recovered by multiwell deconvolution was interpreted to calculate formation properties around the pressure-tested well (self-transient response) and cross-well properties between offset wells (interference test response). This self-transient response is free of interference from dynamic boundaries of surrounding wells. Its interpretation by pressure transient analysis provided well drainage area, shape and aquifer/gas cap support for the well. Cross-well pressure transient responses revealed reservoir transmissibility between wells. MRT analysis found that all the offset wells were connected to the focus well. the reservoir transmissibility of the connected part of the formation between the wells was lower than expectations from open hole logs.

MRT revealed weak pressure support from the aquifer and gas cap, that was insufficient to compensate field pressure for current throughputs. A formation pressure depletion trend was calculated resulting in gas liberation. However, the well drainage area was found to be extensive than expected. This could indicate a possible reservoir extension perhaps in the north-east direction. Further Geological and geophysical studies are required to address the uncertainties in the area.

The results of the MRT study were used as inputs for numerical cross-well pressure modeling and then translated to conventional reservoir modeling language, to try to obtain a better understanding of MRT measured reservoir properties. he information from MRT study as used to optimize upcoming infill locations and other opportunities for production enhancement: well stimulation and injection increase.
Keyword(s): Formation evaluation; Production optimitization; Multi-well deconvolution; Multi-well Retrospective Testing

Introduction

An off-shore field in SE-Asia has high reservoir heterogeneity and consists of several highly permeable layers. The current field development challenges are to evaluate the potential for additional drilling and reveal the potential of production increase by injection optimization. Figure 1 present a field map.

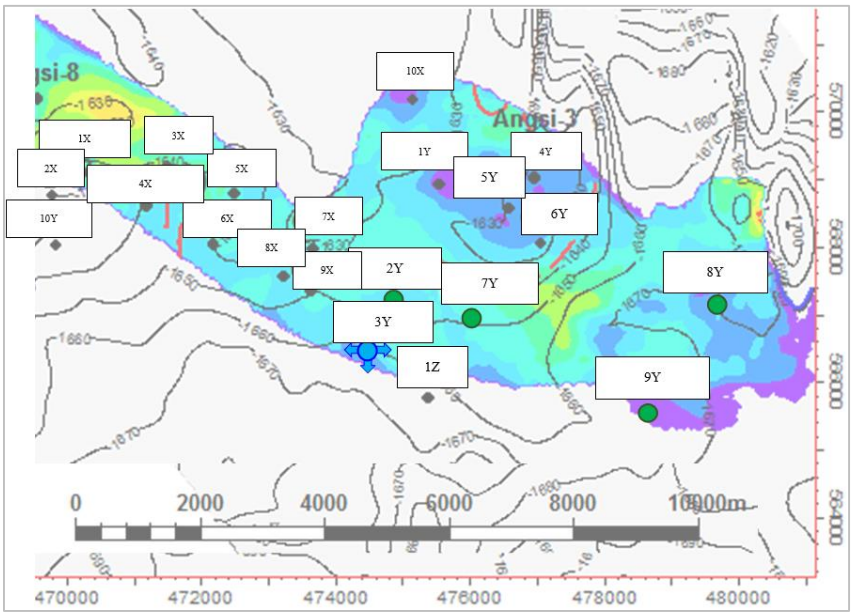

Figure 1. AA Reservoir wells placement, Depth (contours) and Net Pay Map (colors)

Good Understanding of cross-well reservoir connectivity at the area, the shape and size of existing wells drainage area, reservoir properties distribution and cross-well pressure impacts are the key points for additional drilling projects and production enhancement.

Issues

There are a few main issues at the analyzed field:

1. Low recovery factor against production plan
2. Low reservoir pressure against cumulative withdrawals in 8Y

Concerns

Based on the above issues, there are also several concerns:

1. Uncertainty in compartmentalisation between and around wells 3Yand 8Y
2. Unclear reservoir extension around pressure-tested well 8Y

3. Unclear aquifer and gas cap drive efficiency
4. Unclear injection 3Yperformance

Goals and objectives

To successfully optimize the development on the analyzed reservoir, the following goals and objectives were set.

Goals: assess drainage volume and boundary type around 8Y; check for connectivity between well 8Y and nearby wells; assess 3Yinjection performance; assess drainage volume and boundary type around 8Y; assess aquifer and gas cap location.

Objectives:

1. Reconstruct formation pressure and productivity index history in 8Y
2. Supply calibration points for 8Y IPR at different formation pressures (if any)
3. Estimate skin-factor, transmissibility, drainage area and boundary type around 8Y
4. Reconstruct the history of cross-well interference from offset wells onto 8Y
5. Estimate cross-well transmissibility from offset wells towards 8Y
6. Perform 2D-grid simulations to verify:
    - 8Y drainage volume and shape
    - connection to 9Y, 7Y,2Y,3Y
    - gas cap and aquifer location/extension around 8Y

Multiwell Retrospective Test

Multiwell Retrospective Test (MRT) implements automated history matching of PDGs with a mathematical model of self and cross-well pressure transient responses. The MRT analysis is based on multi-well deconvolution (MDCV) which provides splitting the complex interfered PDG response into simple contributing components from different wells, each representing a sample transient response to unit-rate production. The bottom hole pressure in a selected well can be modeled by linear convolution of flow rate history with unit-rate drawdown transient response (DTR) summed up with convolution of surrounding well flow histories with unit-rate cross-well transient responses (CTR) [1-3].

The DTR represent the long-term equivalent of conventional pressure transient analysis survey and goes through conventional PTA interpretation workflow but as if offset wells were not interfering [1-2].

MRT interpretation is carried out for an MRT cell which includes the well that has PDG data (pressure and flowrate), as well as the interfering wells having flowrate data only [3].

Results

Reconstructed formation pressure history is presented in figure 2. Pressure difference at the beginning of the longest build-up is a result of slow pressure increase due to the presence of liberated gas. MRT has been able to match the steep decline in pressure at first production period. After shutting in the well, the PDG pressure increased slowly due to the high compressibility of previously liberated gas in the reservoir.

Figure 2. Production & Pressure history plot for 8Y with reconstructed formation pressure and drawdown

Figure 3 shows a log-log plot with DTR+BU. Good alignment of these two graphs indicates the reliability of the MRT analysis.

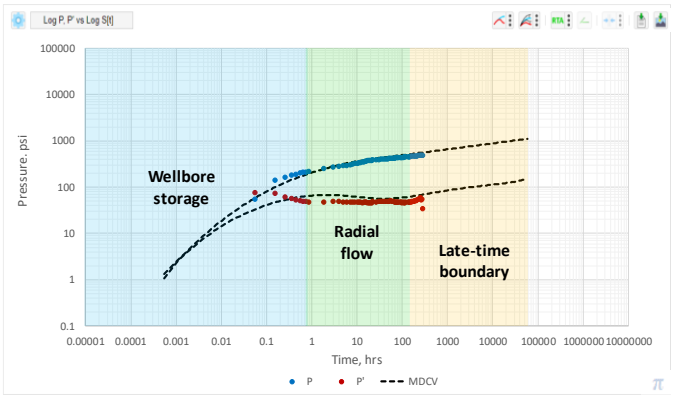

Figure 3. Diagnostic plot for DTR for 8Y

The resulting DTR was interpreted. During the interpretation, well and reservoir properties were obtained, shown in Table 1.

Table 1. 8Y DTR diffusion model summary

Property	Abbr.	Value	Units
Transmissibility	σ	7,378	md·ft /cp
Total Skin	S_T	-4.2	
Mechanical Skin	S_M	0	
Permeability to oil	k	181	md
Permeability to air	k_{air}	575	md
Total Productivity Index	J_t	8.4	bpd/psi
Formation pressure	P_e	1,017	psi
Dynamic drainage volume	PV_d	$2.5 \cdot 10^8$	bbl

Figure 4 shows reconstructed pressure impact of offset wells production vs time.

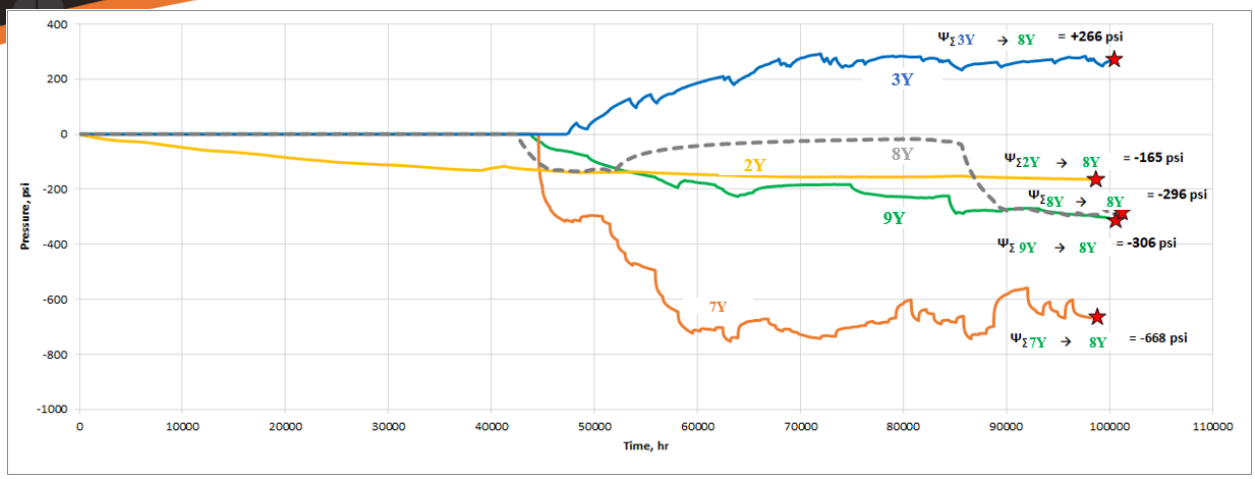

Figure 4. "Spider plot" for Well 8Y showing BHP and restored pressure change history due to well interference

Figure 5 shows a map with cumulative pressure impacts and cross well reservoir transmissibility.

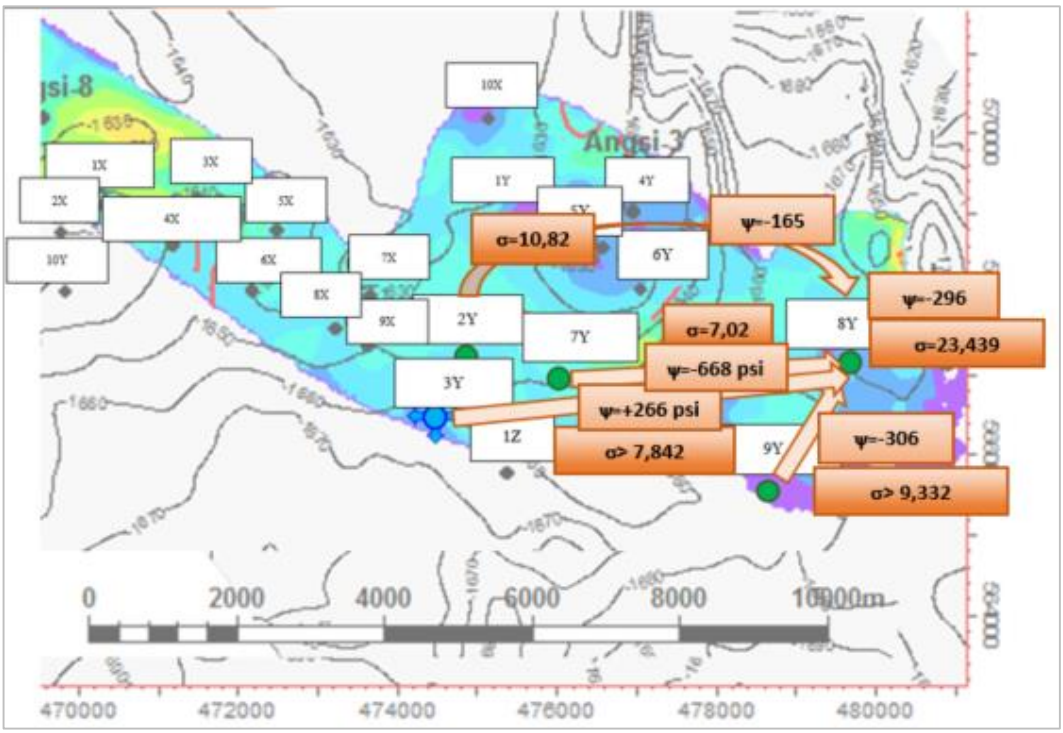

Figure 5. Cumulative cross-well interference map for 8Y
($\psi\sum$ – Cumulative pressure impact, psi, σ – cross well transmissibility, md·ft/cp)

According to the results of cross-well interference, a 2D cross-well pressure model (XPM) was created (figure 6).

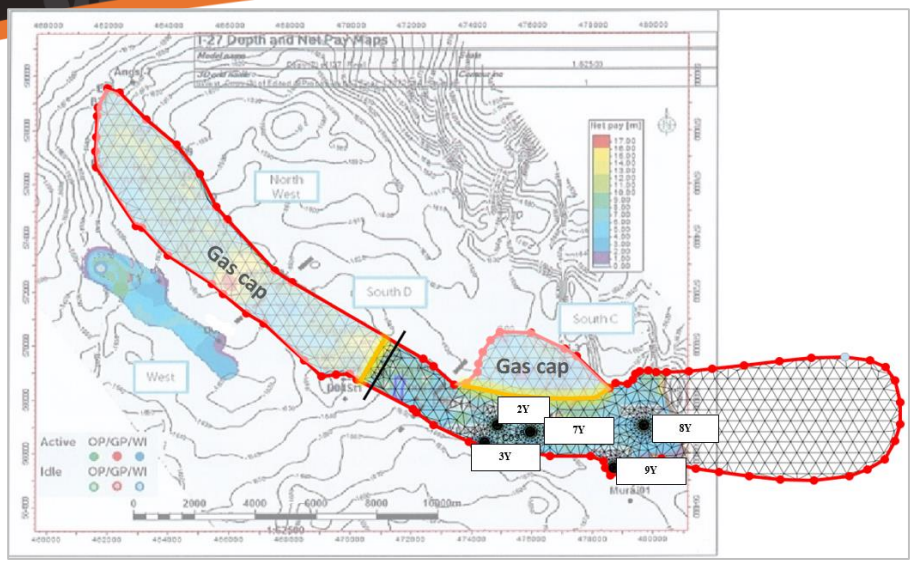

Figure 6. 2D Model

Conclusions

Low recovery due to low formation pressure, low drawdown, high GOR (10 RS) and as a result low production rate (700 bopd instead of 2,000 bopd). Fast pressure decline is caused by undercompensated withdrawals and poor support aquifer and gas cap. All wells are effectively connected except 7Y which shows much stronger connectivity with 8Y and 2Y having the weakest connection among all. Well 8Y is draining bigger volume then mentioned on the thickness map, probably due to north –east reservoir extension. There is no noticeable aquifer or gas cap support during MRT test. MRT shows regular performance 3Ywith the fair impact on 8Y. XPT confirms presence of active gas cap to the North-West of 8Y. The area between 8Y and 7Y is unfavorable for potential injector drilling due to high connectivity. XPT indicates sand extension and connectivity East of 8Y.

Recommendations

Repressurise reservoir around 8Y back to 2,300 psi and increase production from 700 bpd up to 2,000 bpd. Blow up the gas cup. Evaluate drilling efficiency at the East of the reservoir.

References

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