

GLOBAL PETROLEUM SHOW

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MULTIDISCIPLINARY STATIC AND DYNAMIC DATA INTEGRATION TOWARDS BETTER RESERVOIR DYNAMICS UNDERSTANDING: A CASE STUDY OF THE RING BORDER FIELD IN CANADA

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Outline

- Introduction of the Ring Border Field
- Geology & Petrophysics
- Geological Modelling
- Reservoir Engineering & Simulation
- Reservoir Characterization workflow
- Conclusions



Introduction

- The Ring Border east field (BC-Alberta) has been producing since the early 1990's.
- There are > 300 wells in the total east field with a cum production of >500 Bcf
- Mostly vertical wells that have been hydraulically-fractured
- Wet gas production with variable condensate production across the field.
- Mobile water production does not appear to be an issue except in the proximity to down dip water contacts (SE of the reservoir)



Geological & Petrophysical Summary

Ring Border - Field Location



- Townships 99 102, Ranges 11-12
- Ring Border Field Alberta side



Lithostratigraphic units (After Edwards et al)

Bluesky Fm:

- m-c sandstones/mudstones /congl.
- Transgressive shoreface strata.

Montney Fm:

- Lower Triassic-shoreface Fine SS, siltstones, and shales.
- Ring Border produces from very fine-grain and well sorted, sandstones and siltstones.



Hydrocarbon Trap









- The shoreface sandstones from Montney Formation pinch out up dip against the pre-cretaceous unconformity (stratigraphic).
- A regional GWC is present in the lower Montney sands, defining the down dip edge of the hydrocarbon zone.
- The SW-NE faults are subparallel to Hay River Fault system and generate a compartmentalization of the gas field (After Edwards et al).



Integration of Core Evaluation and Logs



- 26 wells with core from the Montney and Bluesky.
- Core description + logs, and porosity & density ranges used to define main facies:
 - Shaly SS
 - Very Fine SS
 - Shales
- Full Petrophysical interpretation to match logs to core, and many iterations were done to get a good representation of the reservoir.

Geological Modelling Summary

Structural Model

Model Boundaries



Divided into four units



YEARS STORE

Variogram Modelling Core data – Perm (All Zones)



Observed cyclicity mainly in the vertical variograms.





Less periodicity in the horizontal direction but more noise

Cyclicity in the Montney



Geological Model

- Porosity cross section
- Multiple realizations run and ranked









Reservoir Engineering & Simulation Summary

Using Flow Simulation to Assess Fault Sealing Behaviour

- Identification of wells with well test data close to faults:
 - 2-4-100-12
 - 13-31-99-11
 - 15-32-99-11
- Well distance to the fault was too long, compared with the tests radius of investigation, so they were not detected by the tests. Simulation HM of well tests also corroborated that.





Using Flow Simulation to Assess Fault Sealing Behaviour

- 02-04 is about 1300m away from closest fault
- Well test estimates radius of investigation of ~315m
- We don't expect to see boundary effects in this well test analysis.





Fault Seal Interpretation Using Dynamic Data Integration

- Mapping Kh, Cum. Prod., and Pressure
- North Fault Interpretation:
 - Static pressures taken in 1998
 - Both wells have similar production but North well has significantly lower pressures
 - High productivity coincides with high Kh
 - North Fault displays sealing behavior.





Fault Seal interpretation using dynamic data integration

- Central Fault Interpretation
 - Static pressures measured in year 2000
 - Wells in NW of fault have overall lower pressures
 - Lower production in the south also correlates with lower Kh values.
 - Central fault displays sealing behavior.





Fault Seal Interpretation Using Dynamic Data Integration

- South Fault Interpretation:
 - Static pressures measured in 1999
 - Well in the SE has higher pressure (604 psia) and produced more than well in NW which has lower pressure (442 psia).
 - There is an aquifer providing some pressure support to the SE side of the reservoir.



Cumulative production Bubbles

Well Test Permeability Integration

- Integration of well test data to simulation model:
 - Used SGS with secondary variable to merge well test perms with permeability from logs.
- The resulting permeability was Qced and it matched the well test Kh at the wells

			Import well names from the view			permeability so that the total thickness weighted av
			Well	Perm, md	_ <u>^</u>	equals the well test permeability.
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		3	3-13-100-12	4.03		Well Test Interval Options
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		5	3-28-100-12	9.33		Use well path blocks extended through the ent
		6	3-33-99-11	20.20		thickness for weighting factors
		7	3-36-100-13	2.54		Specify the measured depth intervals
		8	4-1-102-13	4.70		Point Data Ontions
		9	5-13-99-11	5.80		
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Full Field Simulation Model

- Model details:
 - 2.2 million grid blocks
 - 200x200x1 m grid block size
 - Total of 72 wells in the model
 - 70 gas producers
 - 40 still producing to date
 - 27 pumping
 - 13 flowing
 - 2 Pressure Observation wells
 - 1-6-100-11
 - 10-28-99-11

Sensitivity Analysis – Pre-History Match

- Performed using CMOST. Experiments are generated to cover the full combination of parameters by using a response surface methodology
- A proxy model is generated and verified based on simulation results.

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Equation in Terms of Actual Parameters

Cum_Gas_Prod=6.97765E+08+1.54379E+07*GWCDepth+5.11879E+08*PermeabilityIMult+1.40443E+09*PorosityMod-3.44299E+0 *SwtInclude-4.00544E+07*PermeabilityIMult*PermeabilityIMult-5.46261E+08*PorosityMod*PorosityMod

History Match and Forecasts

- History Match of rates and pressures achieved
- Base case forecast kept 41 wells producing at a set min BHP constraint.
- P10, P50 and P90 forecasts were calculated assuming uncertainty in reactivation success, and reservoir quality variability away from the wells.
- 3 Well candidates were selected for reactivation based on individual well history, log data and HCPV.

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Field Development Plan

- Possible well reactivations.
 - Drilling new wells is not economic
- The selected wells could then be refractured and re-completed in order to produce any gas that has been encapsulated by low permeability zones.
- To do this, a fracturing scheme should be designed in order to achieve optimum fracture length and conductivity.

	Base Case NPV	\$1,544 Million						
	NPV With	P10 (1.6% upside)	P50 (6% Upside)	P90 (10% upside)				
ADEAL YEARS	Re-Activation of 3 wells	\$1,569 Million	\$1,636 Million	\$1,706 Million				

Reservoir Characterization Workflow

Reservoir Characterization workflow

Conclusions

- Data and subsurface interdisciplinary integration allows for better reservoir characterization and understanding of reservoir fluid dynamics.
- Uncertainty analysis is a must as there is no perfect model or unique answers in reservoir characterization.
- Team dynamics are an essential soft skill component that can make a huge difference when working efficiently in a subsurface team.
 - Working with each other not against each other is the key!
- Multiple Iterations are required in order to understand the reservoir better.
- Companies must empower simulation engineers to get the process going.

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 - Dr. Chris Clarkson
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THANK YOU!

QUESTION?

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