Well Testing Network

Meeting, Oslo, September 2018

(Alternative) Interference Testing

by Piers Johnson of
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ISO 9001:2000 1st POINT ASSESSMENT Registration No. 43049 Achilles

Classic Multiple Well Testing

Advantages of Multiple Well Testing;

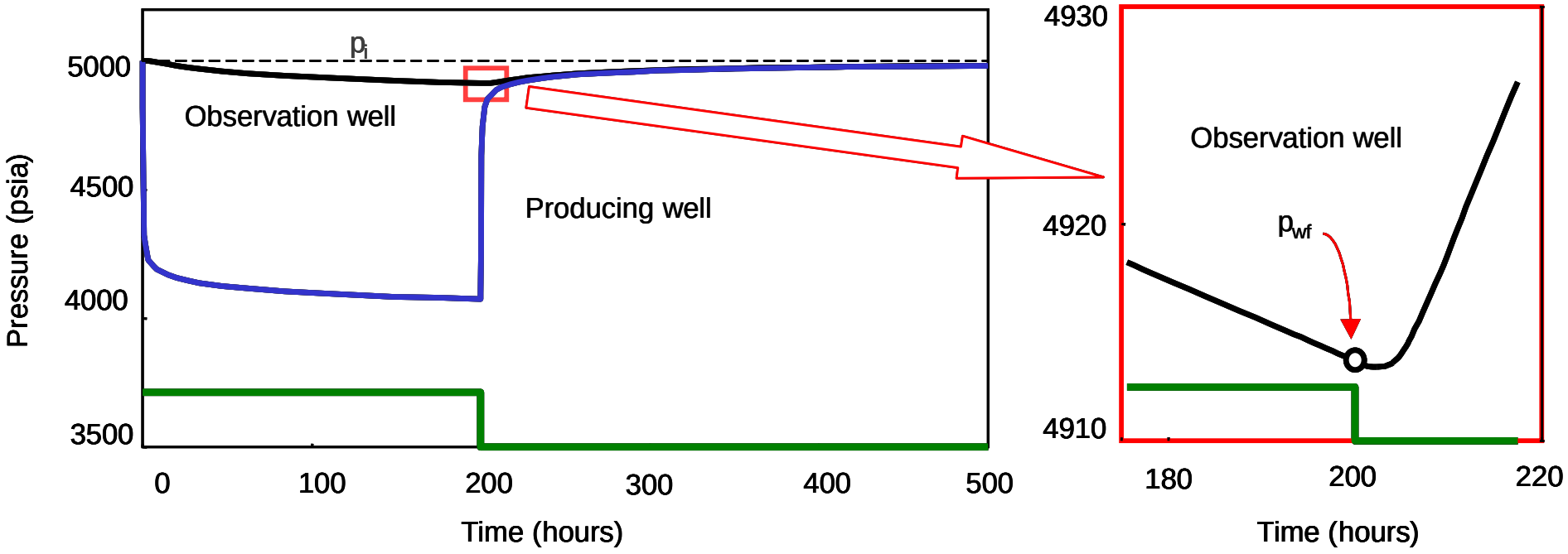
1. One well producing hydrocarbons
2. Good Reservoir property determination

Disadvantages of Multiple Well Testing

1. Small delta P's (difficult to measure?)
2. Difficult to Analyse
3. Long durations frequently required.

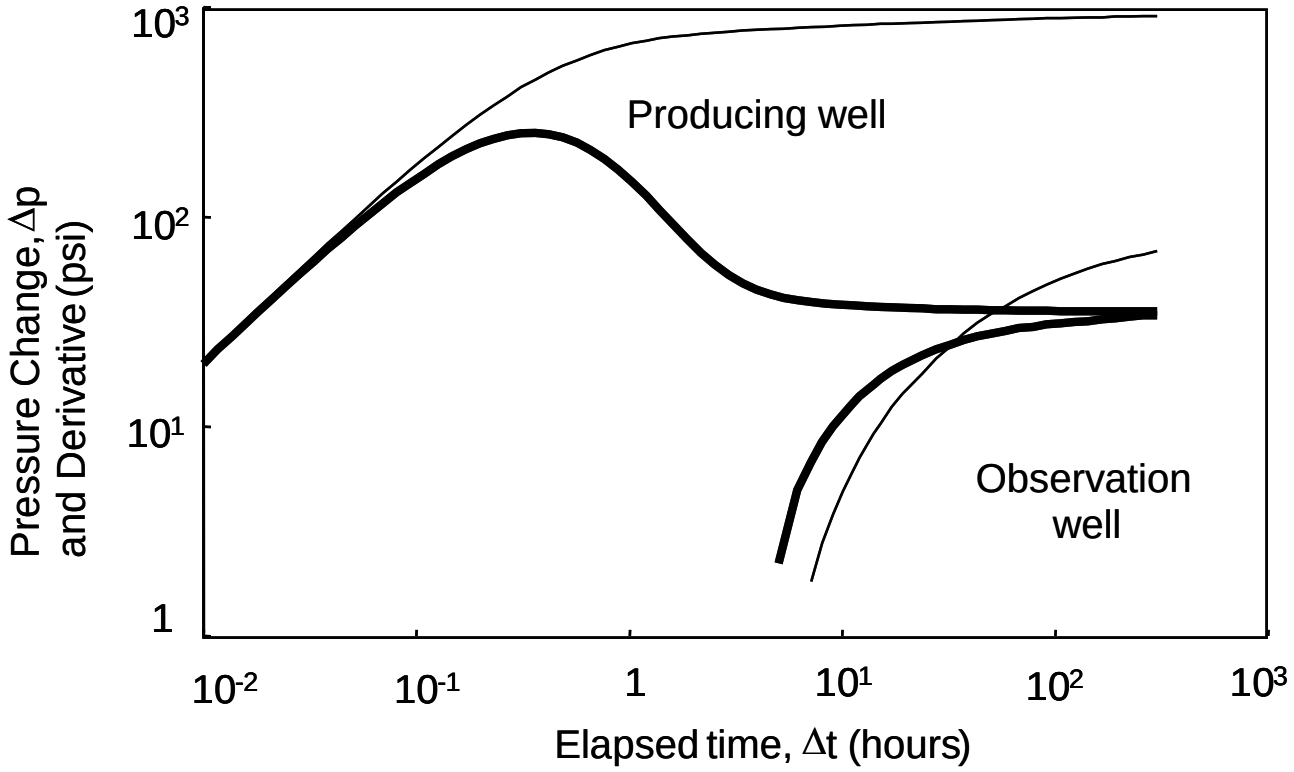
Interference Testing

An interference test response for two wells; one producing and one observing is shown below;



Multiple Well Testing

And this produces the following response (log-log);

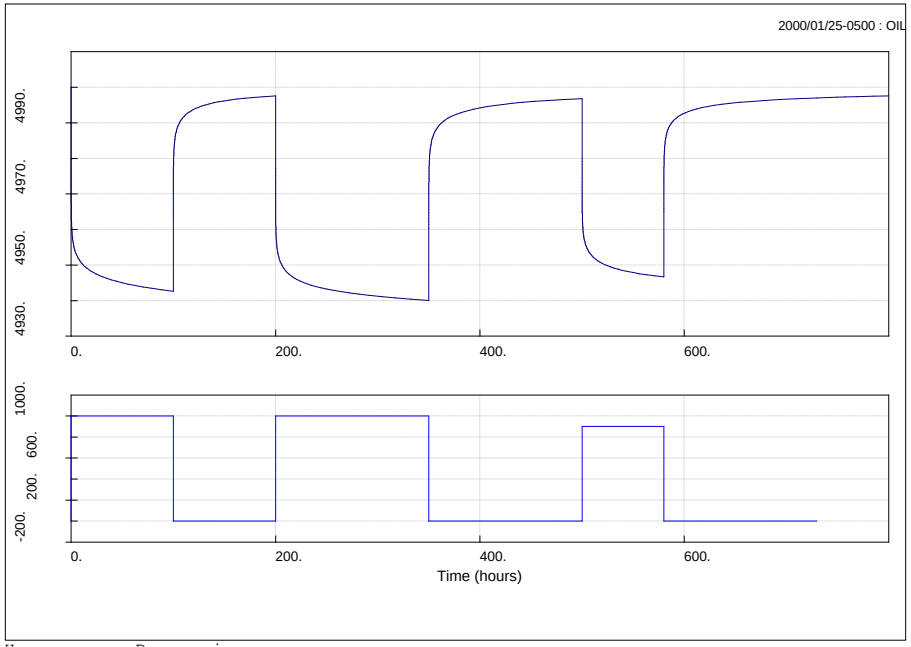


Theoretical Example

- Two wells, observer (Q=0) and producer (flow periods and shut ins)
- Two cases with different permeabilities:
  - One allows interference to be seen
  - One does not see the interference effects.

- One producer producing at different rates, one shut in for a very long time.

Interference example - 1

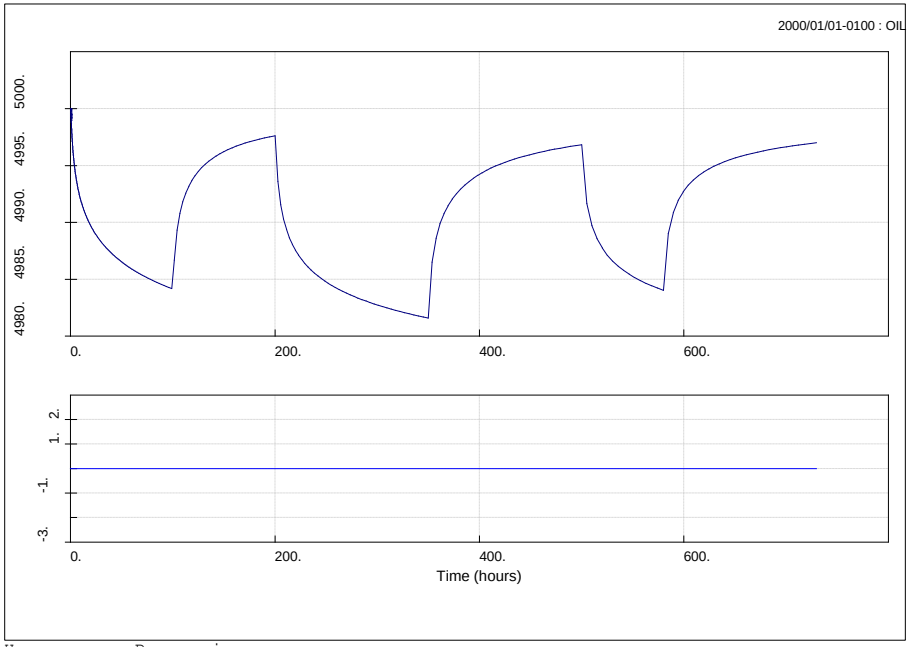


Homogeneous Reservoir
** Simulation Data **
well. storage = 0.0100000 BBLS/PSI
skin = 0.
permeability = 500.00 MD
Areal Ky/Kx = 1.0000
Perm-Thickness = 45000. MD-FEET
Initial Press. = 5000.00 PSI

Offset Well Locations & Corrections:
1:OBSERVATION WELL (100,100) FEET

Static-Data and Constants
Volume-Factor = 1.300 vol/vol
Thickness = 90.00 FEET
Viscosity = 1.700 CP
Total Compress = .3625E-04 1/PSI
Rate = 900.0 STB/D
Storivity = 0.0008156 FEET/PSI
Diffusivity = 8558. FEET^2/HR
Gauge Depth = N/A FEET
Perf. Depth = N/A FEET
Datum Depth = N/A FEET
Analysis-Data ID: DES002
PFA Starts: 2000-01-01 01:00:00
PFA Ends : 2000-01-31 11:00:00

Producing well – pressure & rate history



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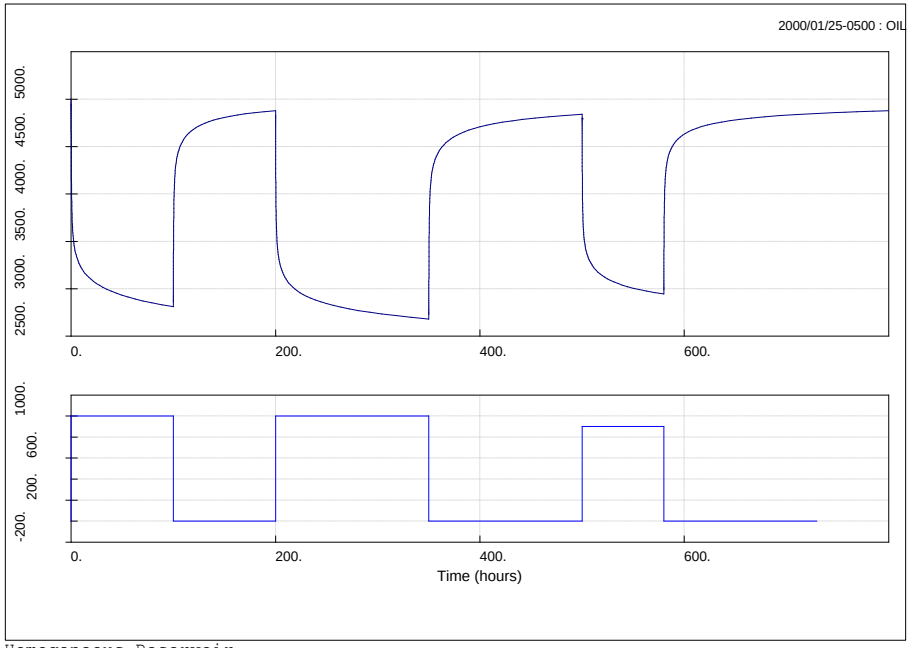
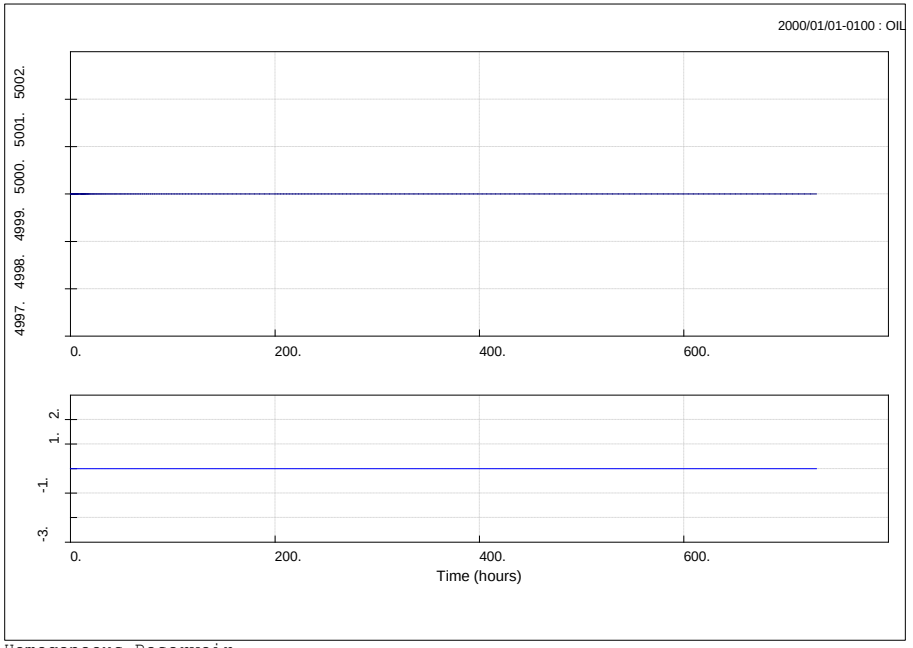
Observation well – located in 100 feet away in both directions from producing well, high permeability in-between –

interference observed

Interference example - 2





Homogeneous Reservoir
** Simulation Data **
well. storage = 0.0100000 BBLS/PSI
skin = 0.
permeability = 10.000 MD
Areal Ky/Kx = 1.0000
Perm-Thickness = 900.00 MD-FEET
Initial Press. = 5000.00 PSI

Offset Well Locations & Corrections:
1:OBSERVATION WELL (3000,3000) FEET

Static-Data and Constants
Volume-Factor = 1.300 vol/vol
Thickness = 90.00 FEET
Viscosity = 1.700 CP
Total Compress = .3625E-04 1/PSI
Rate = 900.0 STB/D
Storivity = 0.0008156 FEET/PSI
Diffusivity = 171.2 FEET^2/HR
Gauge Depth = N/A FEET
Perf. Depth = N/A FEET
Datum Depth = N/A FEET
Analysis-Data ID: DES002
PFA Starts: 2000-01-01 01:00:00
PFA Ends : 2000-01-31 11:00:00

Homogeneous Reservoir
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Perm-Thickness = 900.00 MD-FEET
Initial Press. = 5000.00 PSI

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Thickness = 90.00 FEET
Viscosity = 1.700 CP
Total Compress = .3625E-04 1/PSI
Rate = 1.000 STB/D
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PFA Starts: 2000-01-01 01:00:00
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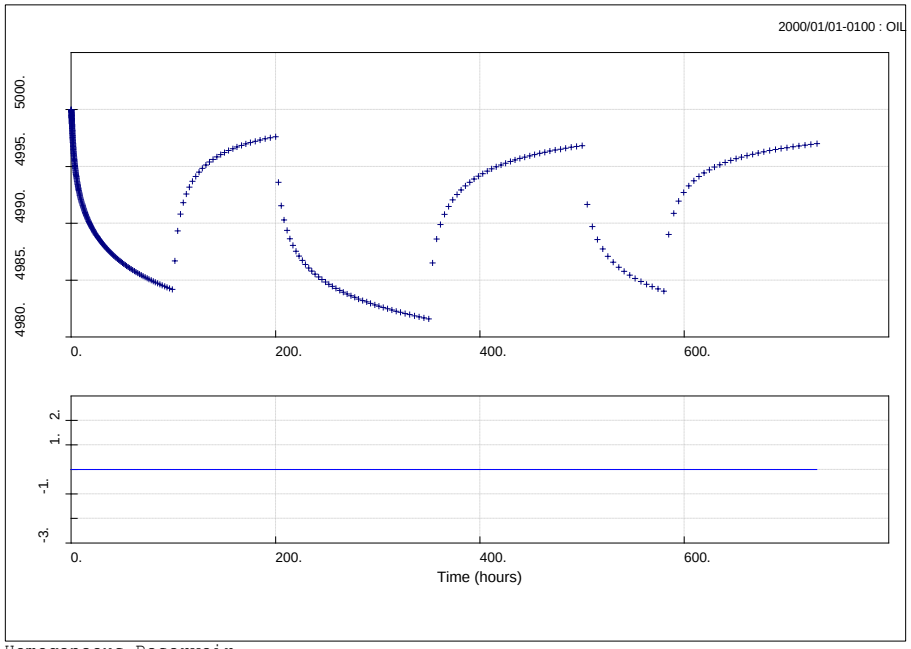
Producing well – pressure & rate history

Observation well – located in 3000 feet away from producing well, very low permeability in-between – **no interference**

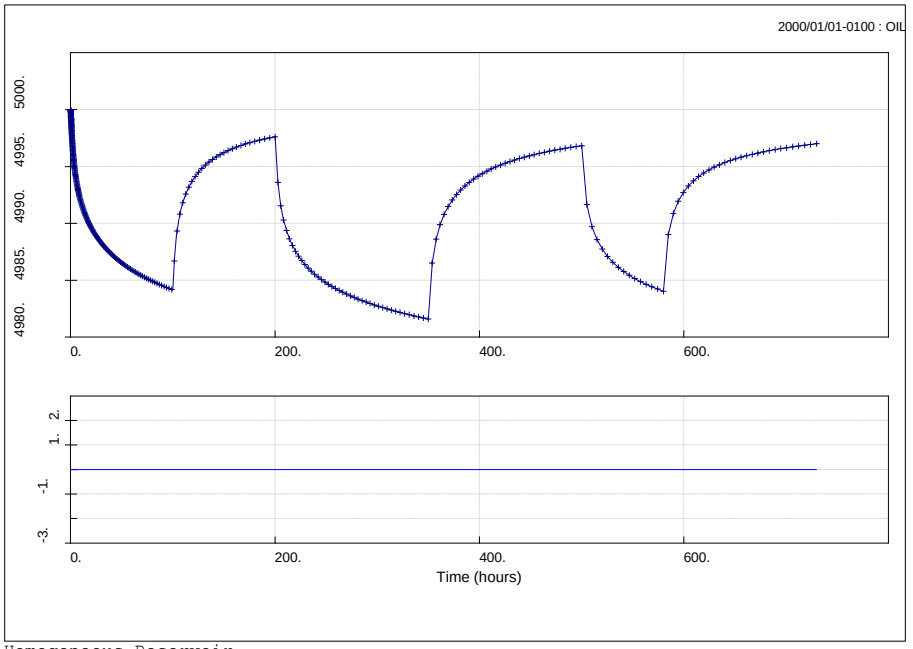
Analysis technique



Homogeneous Reservoir
** Simulation Data **
well. storage = ???? BBLS/PSI
skin = ????
permeability = ???? MD
Areal Ky/Kx = ????
Initial Press. = ???? PSI

Offset Well Locations & Corrections:
1:PRODUCING WELL (100,100) FEET

Static-Data and Constants
Volume-Factor = 1.300 vol/vol
Thickness = 90.00 FEET
Viscosity = 1.700 CP
Total Compress = .3625E-04 1/PSI
Rate = 1.000 STB/D
Storivity = 0.0008156 FEET/PSI
Diffusivity = N/A FEET^2/HR
Gauge Depth = N/A FEET
Perf. Depth = N/A FEET
Datum Depth = N/A FEET
Analysis-Data ID: DES006
PFA Starts: 2000-01-01 01:00:00
PFA Ends : 2000-01-31 11:00:00



Homogeneous Reservoir
** Simulation Data **
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skin = 0.
permeability = 500.00 MD
Areal Ky/Kx = 1.0000
Perm-Thickness = 45000. MD-FEET
Initial Press. = 5000.00 PSI

Offset Well Locations & Corrections:
1:PRODUCING WELL (100,100) FEET

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Volume-Factor = 1.300 vol/vol
Thickness = 90.00 FEET
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Total Compress = .3625E-04 1/PSI
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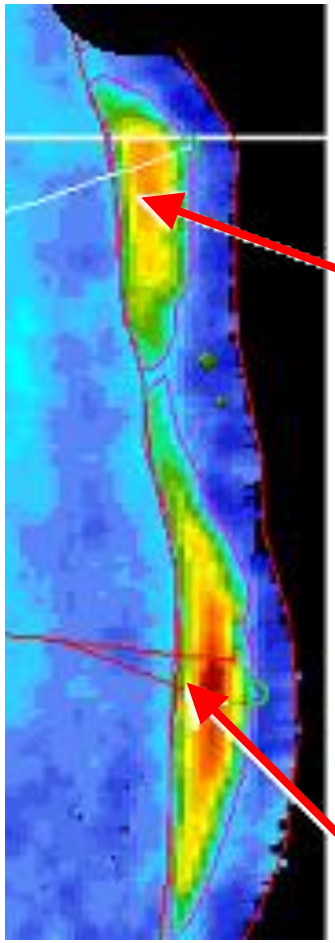
Perf. Depth = N/A FEET
Datum Depth = N/A FEET
Analysis-Data ID: DES006
PFA Starts: 2000-01-01 01:00:00
PFA Ends : 2000-01-31 11:00:00

The plot on the left represents the measured response in the observation well, caused by the interference of the producing well. Values of storativity and mobility are obtained by deriving the type-curve model that matches the data and defines the reservoir properties

Interference Testing example

is the “New” well connected to the “Existing well”?



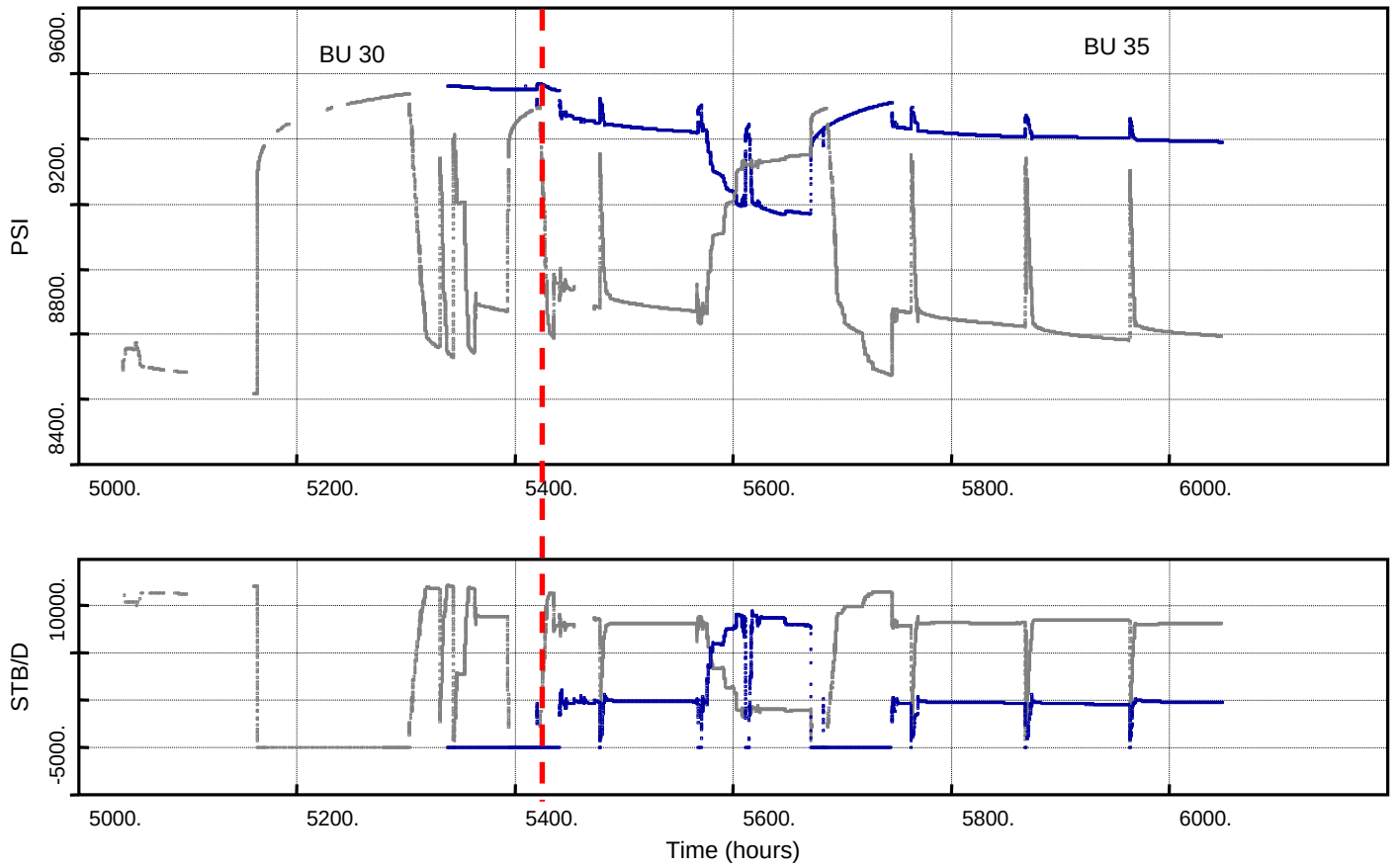
New Well

Existing Well

- **New well ~ 6500 ft. North of Existing well, on strike**

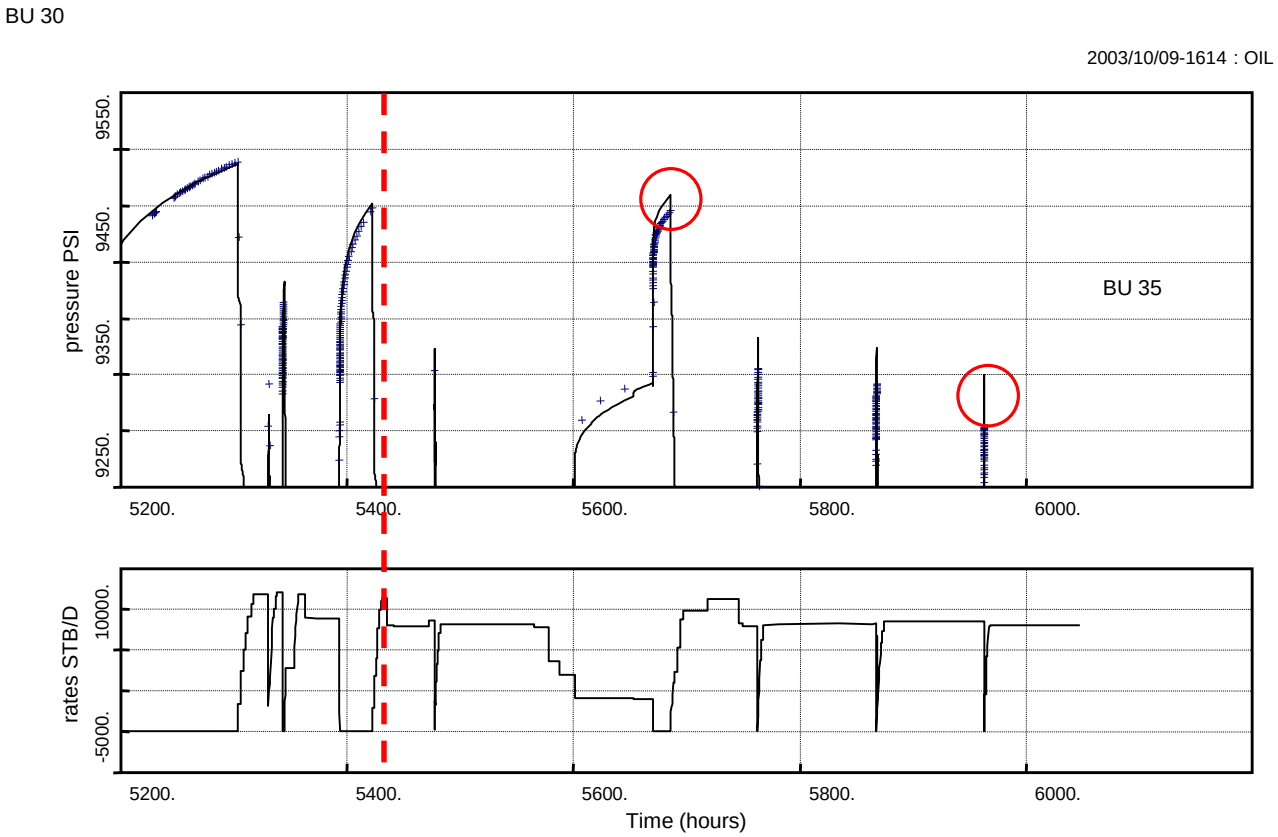
Interference Testing example

* : OIL



Red line: first production from new well

Interference Testing example



History match deterioration post- new well start-up

Radius of Investigation

$$r_{inv} = \alpha \sqrt{\frac{kt}{\phi \mu c_t}}$$

α = 0.029

k = 1000 mD

t = 200 hrs

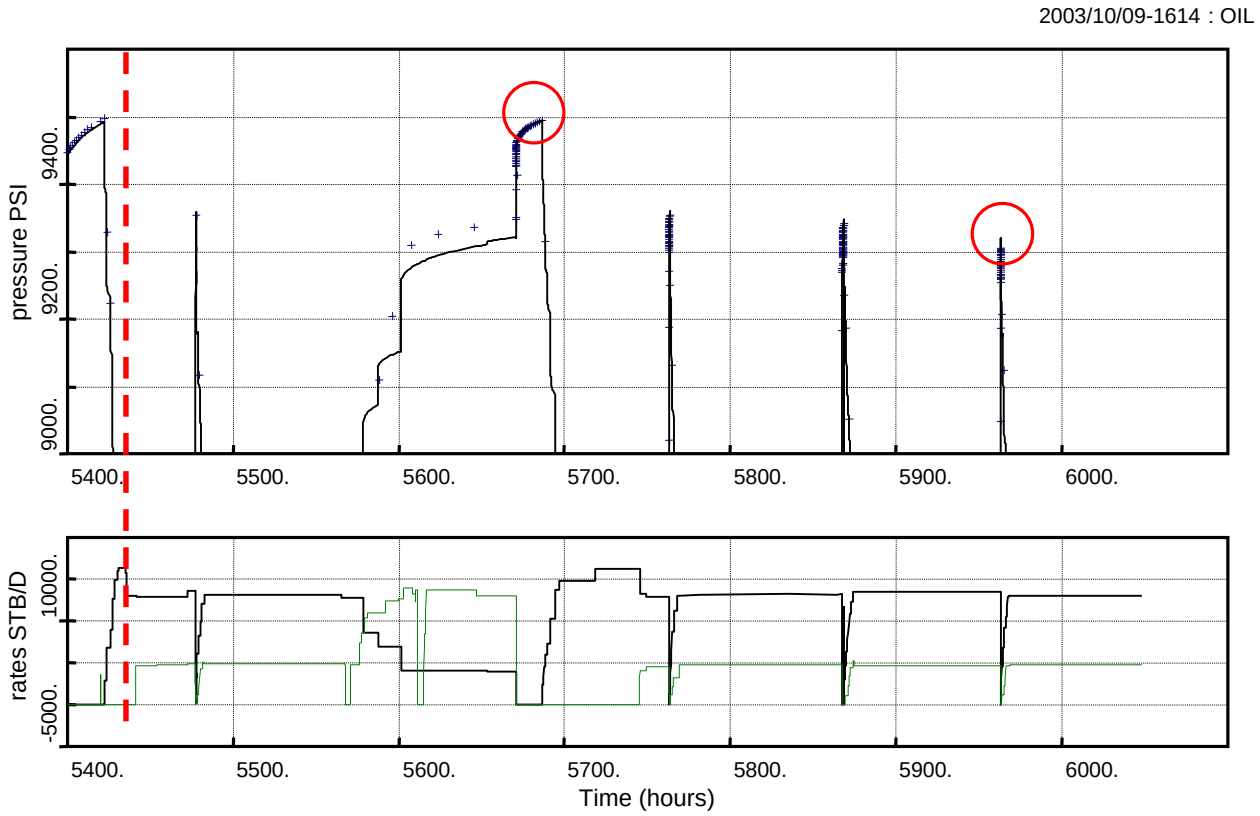
Ø = 0.31

μ = 0.62 cp (beware of wells separated by aquifers!)

ct = 23.5 x 10^{-6}

r_{inv} = 6228 ft.

Interference Testing example



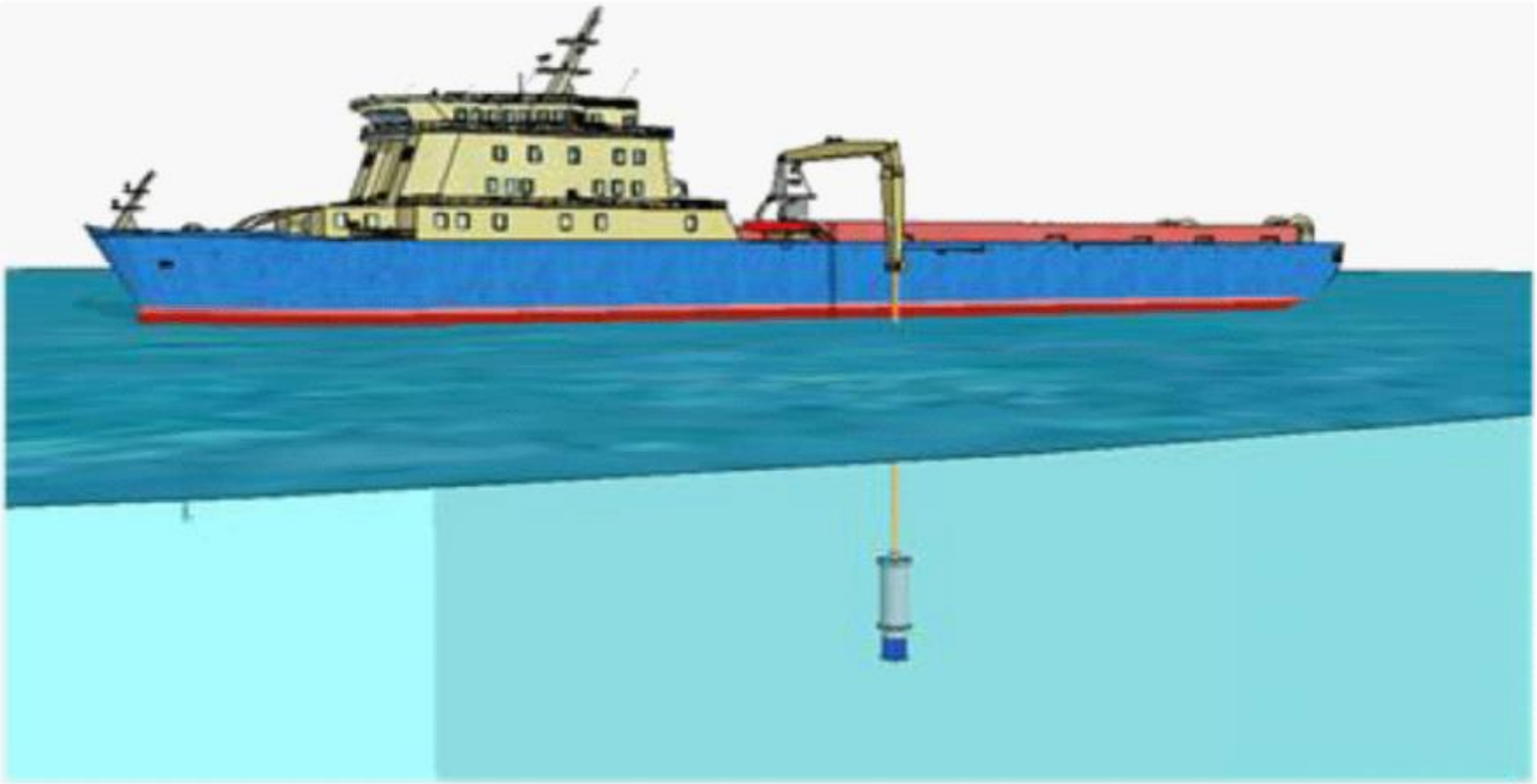
History match improvement post- new well start-up when including interference with new well

Acquiring the data

- Leave a gauge in a well with a seabed transmitter and collect the data remotely by a boat floating over the transmitter to recover the data (SPE-180008-MS).

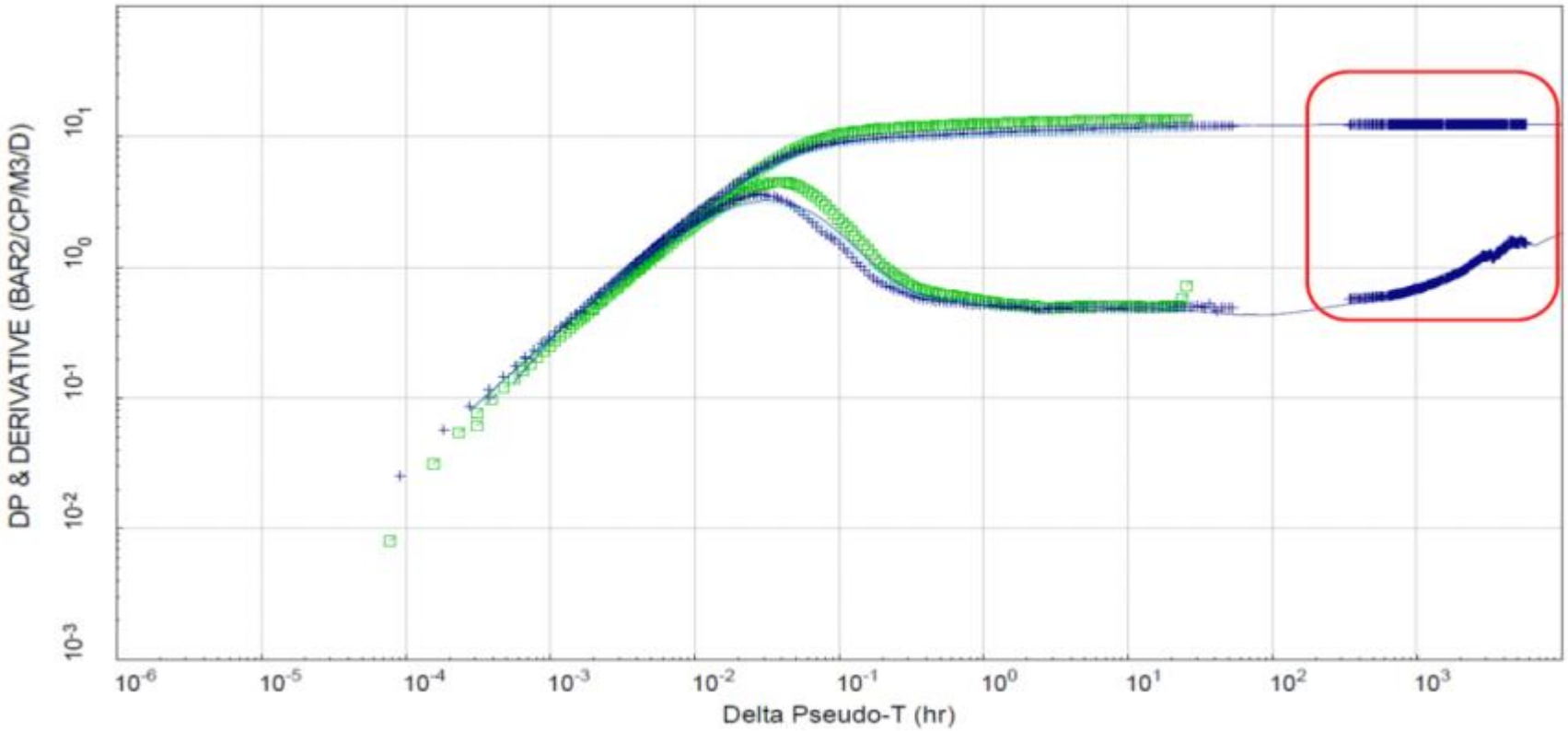
- Onshore of course is easier and has been done in both Poland and Slovenia onshore.

Subsea data recovery



Subsea data recovery with acoustic “dunking” sonde deployed to 10-15m below sea level (from SPE-180008-MS - Norvarg field)

Log-log plot with extended pressure buildup



Log-log derivative plot covering the initial DST and extended pressure buildup (from SPE-180008-MS) obtained by remote sensing – not necessarily Interference testing, but demonstrates a method for achieving similar results.

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