

Productivity for GPK2 and GPK4, Injectivity for GPK3, derived from circulation test 05JUL11

1. Conceptual hydraulic situation during test 05JUL11
2. Injectivity/productivity index: Definitions
3. Downhole overpressures during 05JUL11
4. Injectivity/productivity index: Results
5. Remarks

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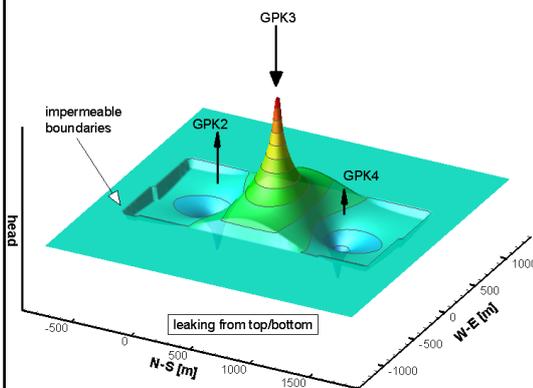
1. Conceptual hydraulic situation during test 05JUL11

Overpressure of an ideal reservoir

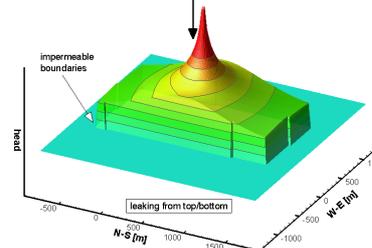
Model used:

- one porous layer
- constant permeability
- rectangular impermeable boundaries
- leaking from top/bottom

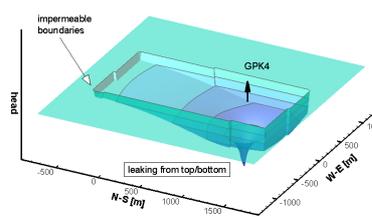
Triplette ($-Q_{GPK2} = -Q_{GPK4} / \Sigma Q = 0$)



Single $+Q_{GPK3}$



Single $-Q_{GPK4}$



2. Injectivity/productivity index (II/PI): Definitions

Definition of II/PI for boreholes

$$II = PI = \frac{Q}{Pdh_{steady-state} - Pdh_0} = \frac{\text{Flowrate in a well}}{\text{Induced, steady pressure difference in OH}} \quad [l/s/MPa]$$

Linear p-Q-relationship when:

- Darcy-flow
- Constant permeability distribution
- Steady-state flow regime reached
- In multi-well systems: all flow rates Q_i only linearly changed

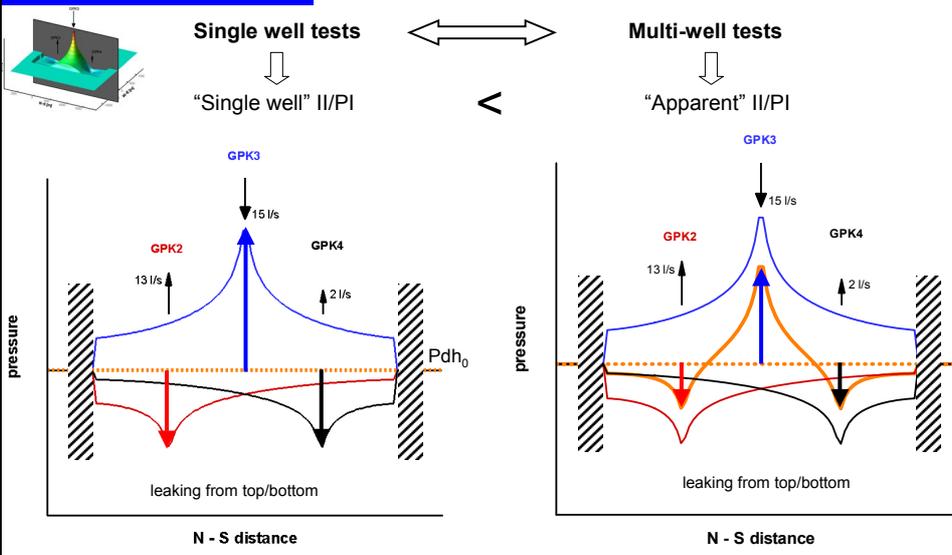
Nonlinear p-Q-relationship when:

- Turbulent flow (fractures)
- Fracture aperture elastic= f(p)
- Fracture aperture thermo-elastic= f(T)
- Chemical dissolution/precipitation
- Transient flow regime
- In multi-well systems: flow rates Q not linearly changed

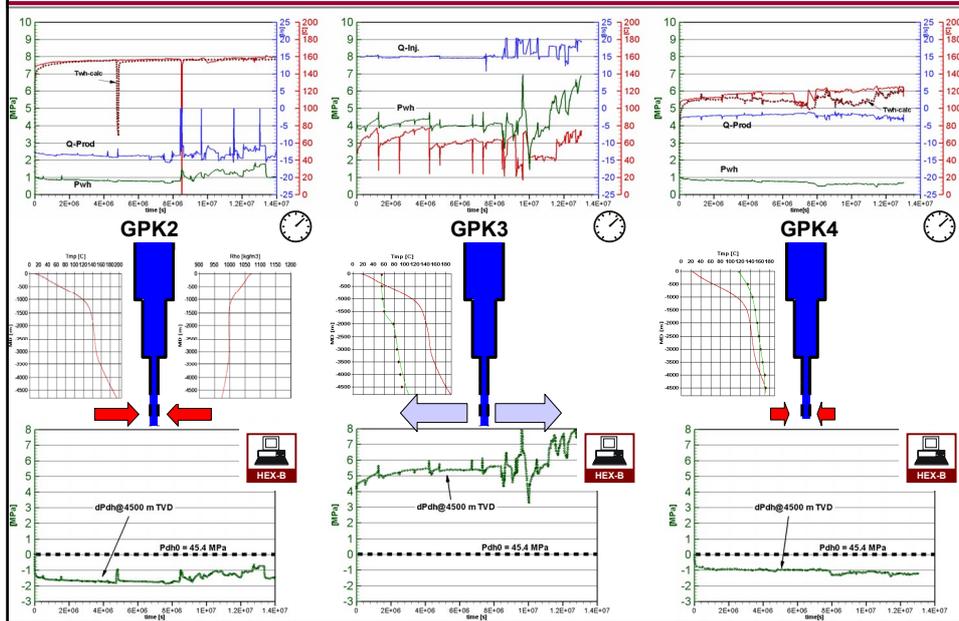


2. Injectivity/productivity index (II/PI): Definitions

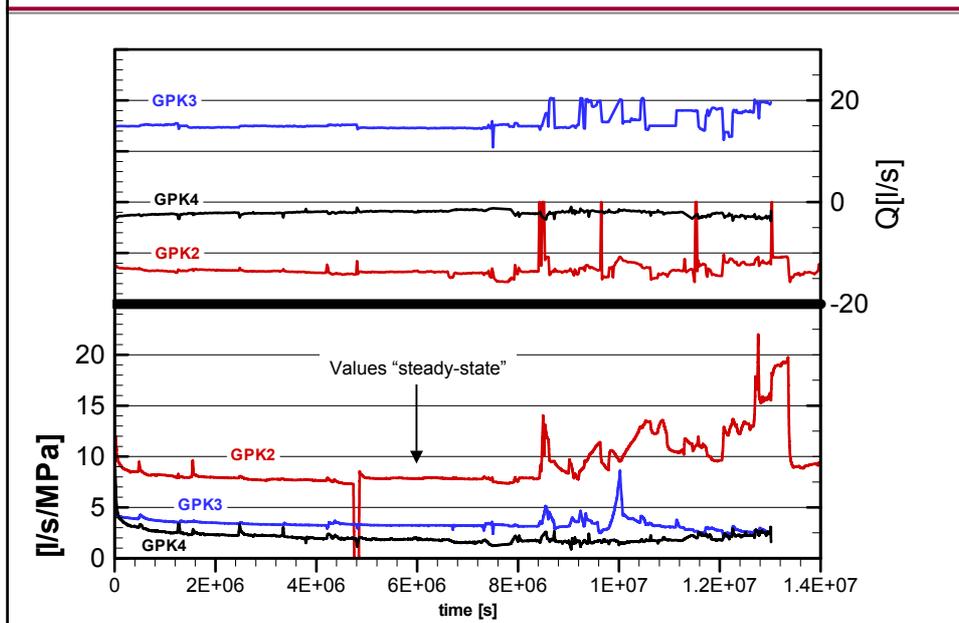
2 different concepts for II/PI



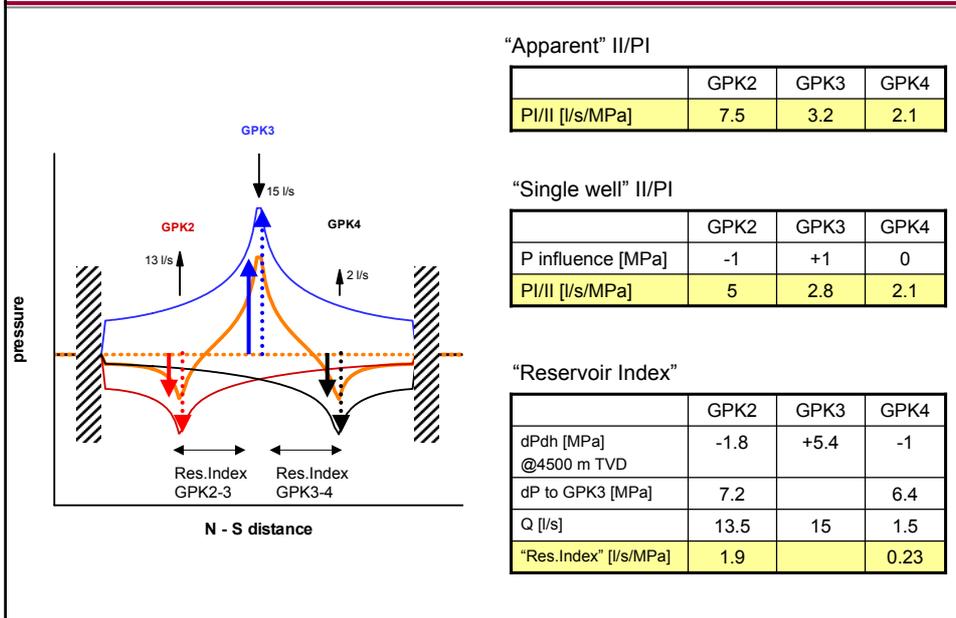
3. Downhole overpressures during 05JUL11



4. Injectivity/productivity index (Apparent II/PI): Results 05JUL11



4. Injectivity/productivity index (II/PI): Results 05JUL11



“Apparent” II/PI

	GPK2	GPK3	GPK4
PI/II [l/s/MPa]	7.5	3.2	2.1

“Single well” II/PI

	GPK2	GPK3	GPK4
P influence [MPa]	-1	+1	0
PI/II [l/s/MPa]	5	2.8	2.1

“Reservoir Index”

	GPK2	GPK3	GPK4
dPdh [MPa] @4500 m TVD	-1.8	+5.4	-1
dP to GPK3 [MPa]	7.2		6.4
Q [l/s]	13.5	15	1.5
“Res.Index” [l/s/MPa]	1.9		0.23

5. Remarks

- We like to have a parameter from flow tests which allows to predict the future reservoir production for different operation schemes
- We like to compare flow test results to evaluate the effect of our reservoir enhancement activities
- Single-well flow tests give principally smaller values for PI/II than multi-well tests
- Injectivity/productivity indices can only be used for extrapolation when non-linear effects are taken into account.
- During the circulation test 05JUL11 the “reservoir index” between GPK2 and GPK3 was 8x higher than between GPK4 and GPK3.