Well Test Interpretation

SKM4323

RESERVOIR BOUNDARIES

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WEEK 08

LINEAR SEALING FAULTS

Description

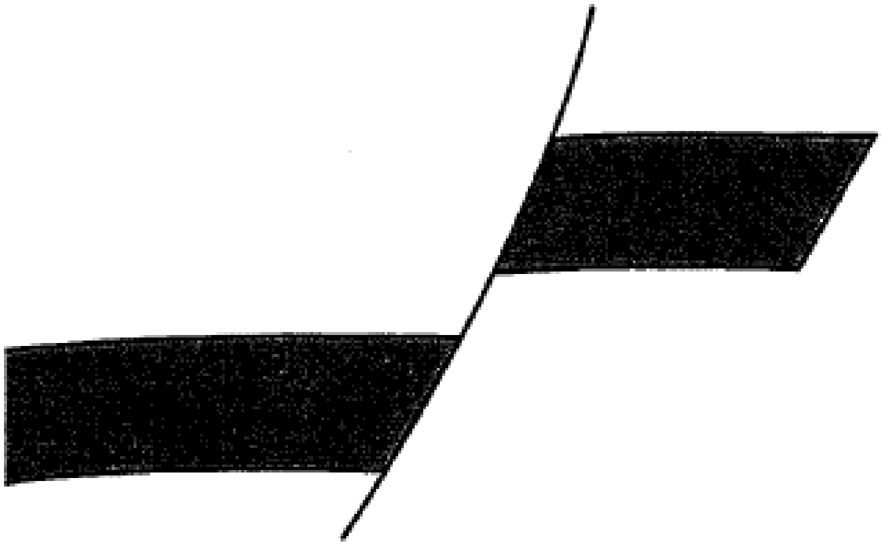


Fig. 7.1

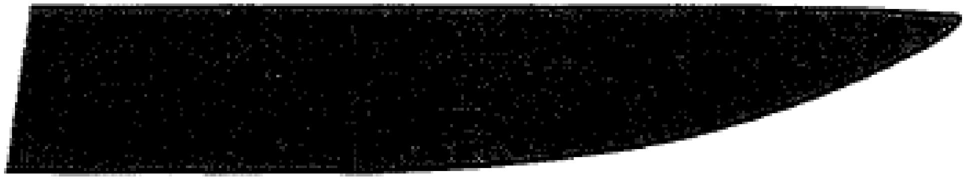


Fig. 7.2

Description…/2

Fig. 7.3

The boundary condition corresponding to a linear fault is the **linear no-flow boundary**.

The Method of Images

- A no-flow line at a distance, d, from the well is obtained analytically with the method of images by superposing:
  - the pressure drop at the well in an infinite acting reservoir;
  - the pressure drop due to an identical well with the same flow rate history located at a distance, 2d, from the well and symmetric to the boundary.

The Method of Images…/2

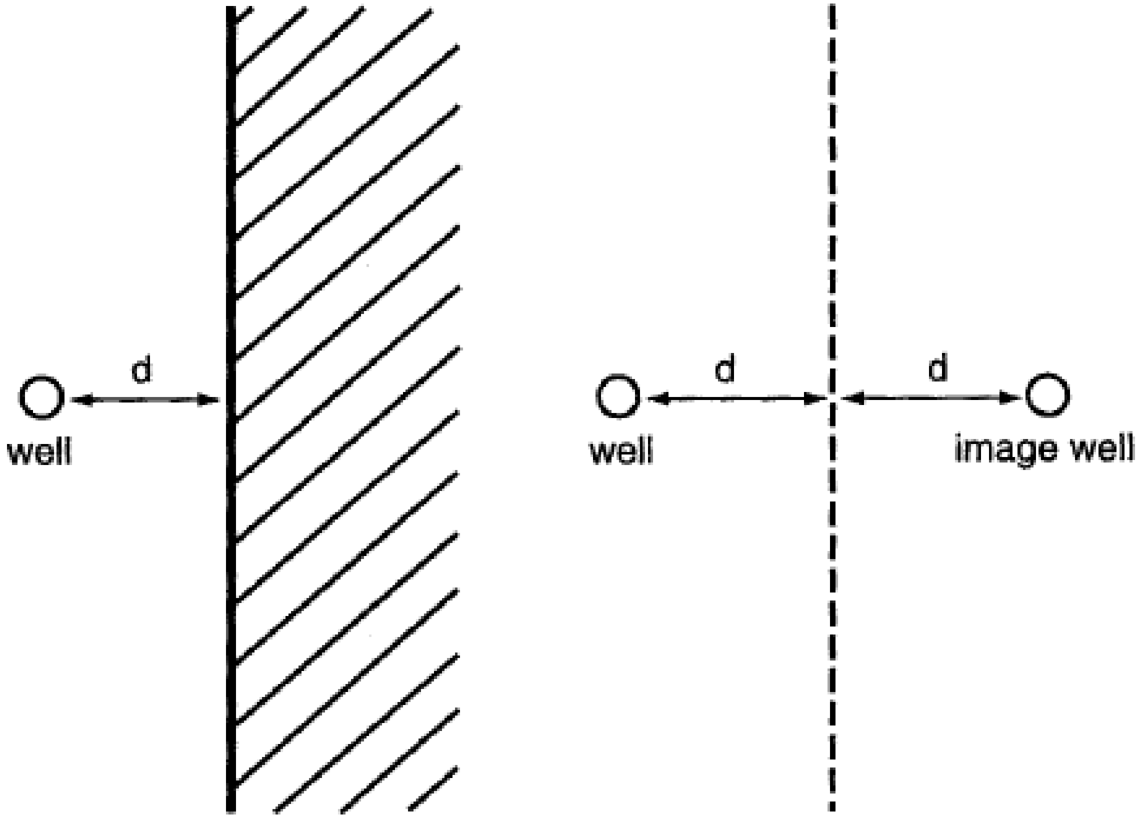


Fig. 7.4 Representation of a no-flow boundary by the method of images

The Method of Images…/3

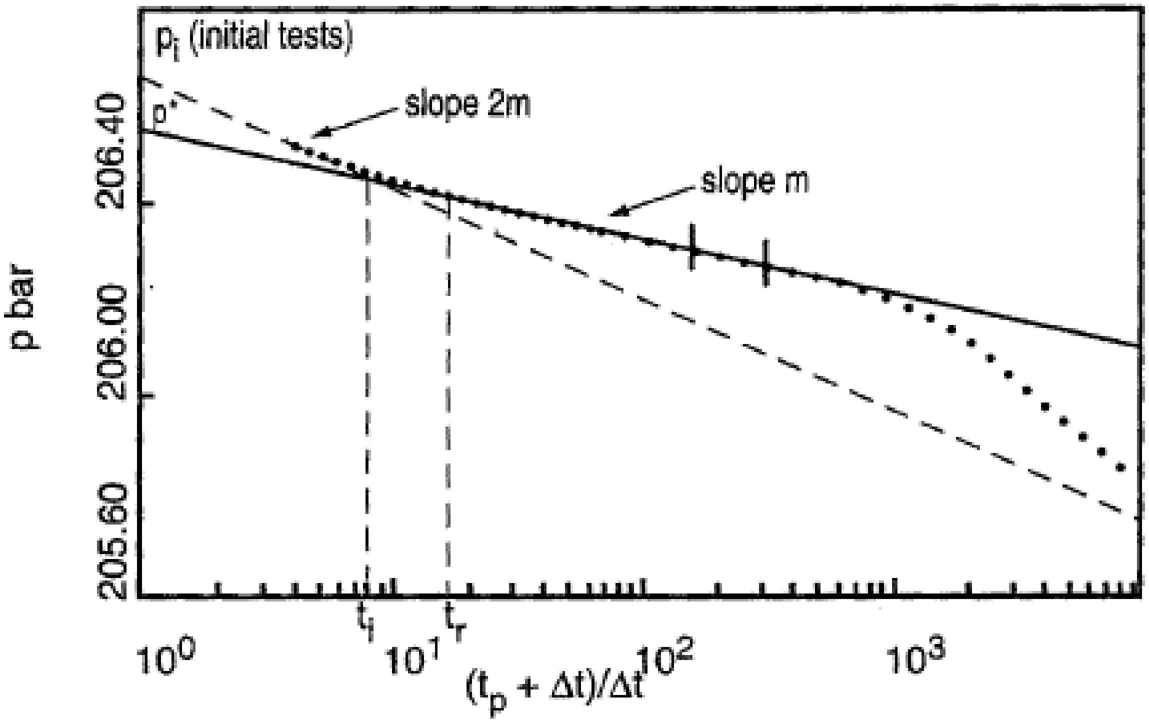
- In the presence of a no flow boundary, the pressure at the well is expressed by:

$$p_D = \underset{\substack{\uparrow \\ \text{Pressure drop} \\ \text{at the well}}}{p_D}(t_D, r_D = 1, S) + \underset{\substack{\uparrow \\ \text{Pressure drop due} \\ \text{to the image well}}}{p_D}(t_D, 2r_D, 0) \tag{7.1}$$

Where $r_D = d/r_w$ is the distance from the linear sealing fault to the well in dimensionless variables.

Conventional Interpretation Method

- If the test is long enough, the fault appears as a straight line with a slope double that of the initial one.
- The property can be seen both in drawdown and buildup.



Conventional Interpretation Method…/2

- Let t_i be the time when the straight lines with a slope of m and 2m intersect. The distance, d, from the well to the fault is determined by:

$$d = 0.012\sqrt{\frac{kt_i}{\phi\mu c_t}}$$ (in practical US units) **(4.35)**

- For this method to be applicable, the double slope straight line must be reached.

Conventional Interpretation Method…/3

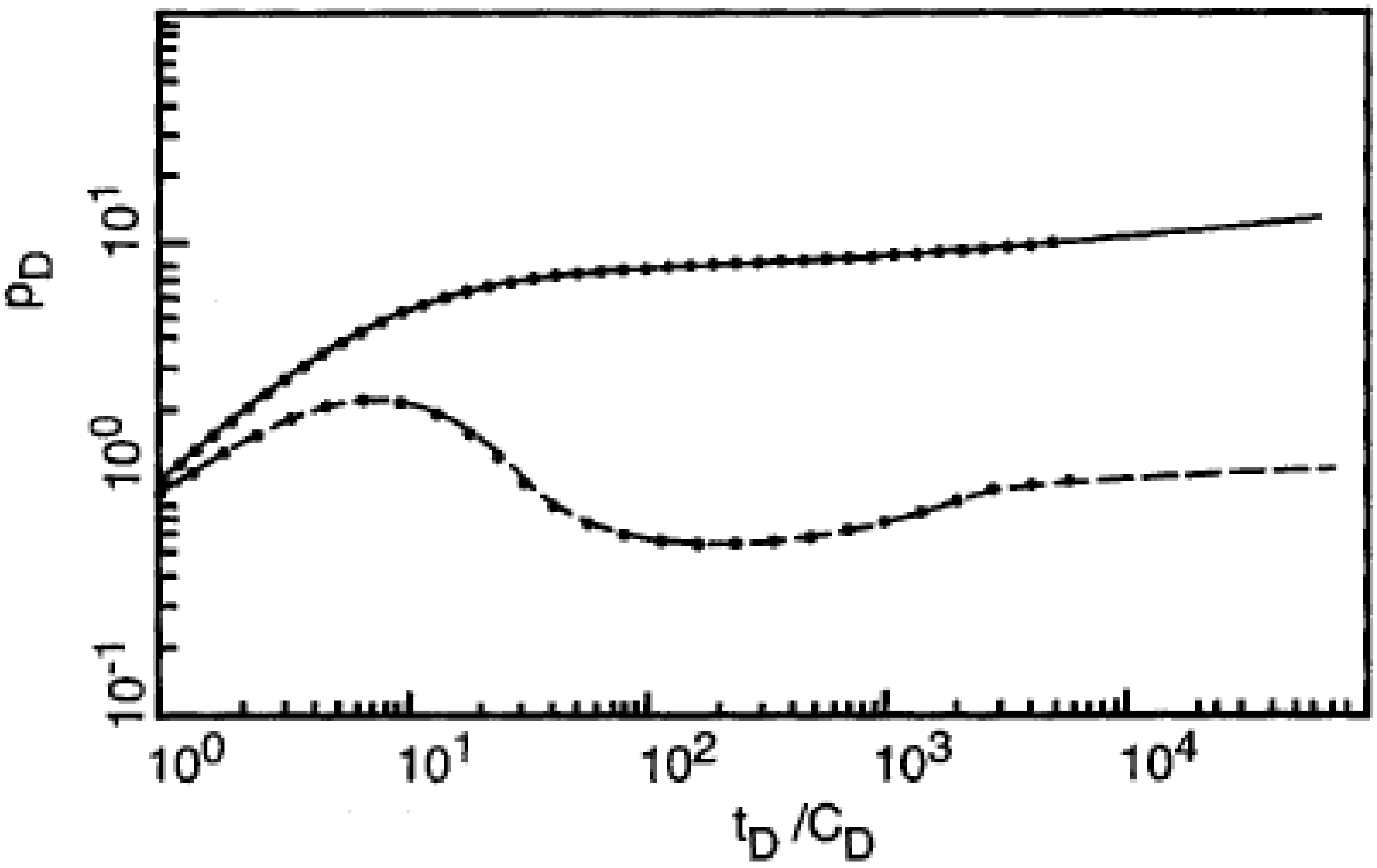
- In buildup, whatever the flow rate history, the first semi-log straight line can be extrapolated to infinite time (i.e. $(t_p+\Delta t)/\Delta t = 1$ on a Horner plot) to determine the extrapolated pressure p*. It is used in the MBH method to calculate the average reservoir pressure.

- During the initial tests, the second semi-log straight line (with a slope of 2m) is extrapolated to determine the initial reservoir pressure, p_i, when only one no-flow boundary has been perceived by the test.

Type Curves: The Derivative

- The semi-log straight line is characterized on the log-log plot p_D versus t_D/C_D by a stabilization of the derivative at 0.5, that represents the value of the slope of the semi-log straight line in dimensionless terms.
- The doubling of the slope characteristics of the fault is characterized on the derivative by a doubling of the level of the derivative. It goes from 0.5 to 1 on a dimensionless graph.

Type Curves: The Derivative…/2



Type Curves: The Derivative…/3

- The time when the derivative leaves the first stabilization can be used to determine the radius of investigation of the test corresponding to the time when the compressible zone reaches the fault.

- Determination in this way is more accurate than the result obtained by the conventional method.

Example 11

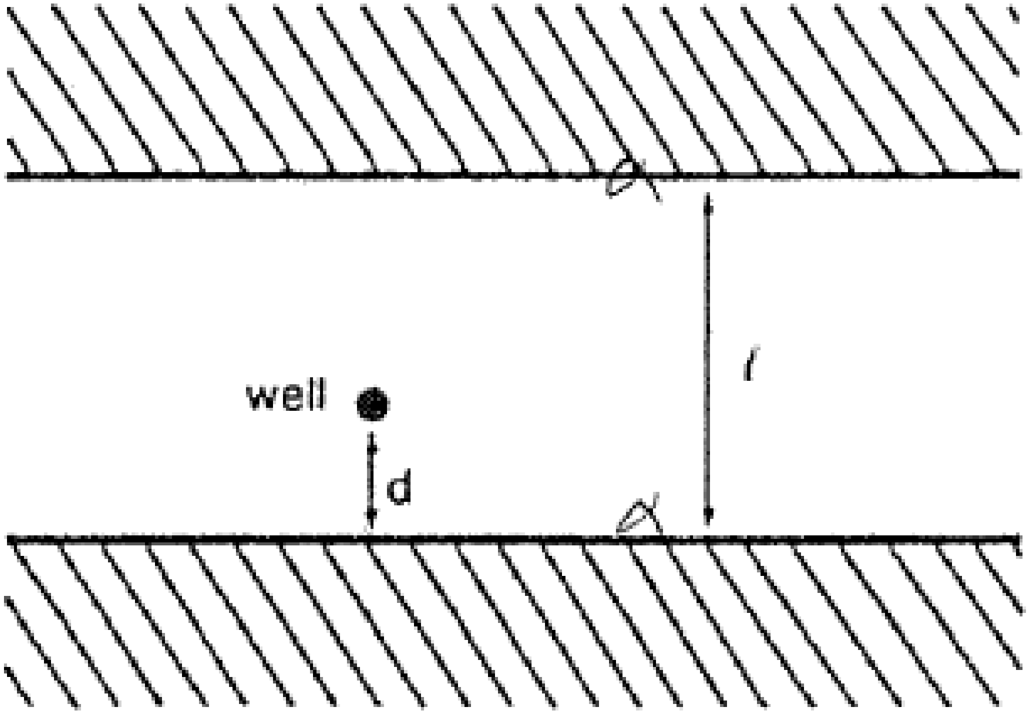
(In-class workshop)

- Linear sealing faults -

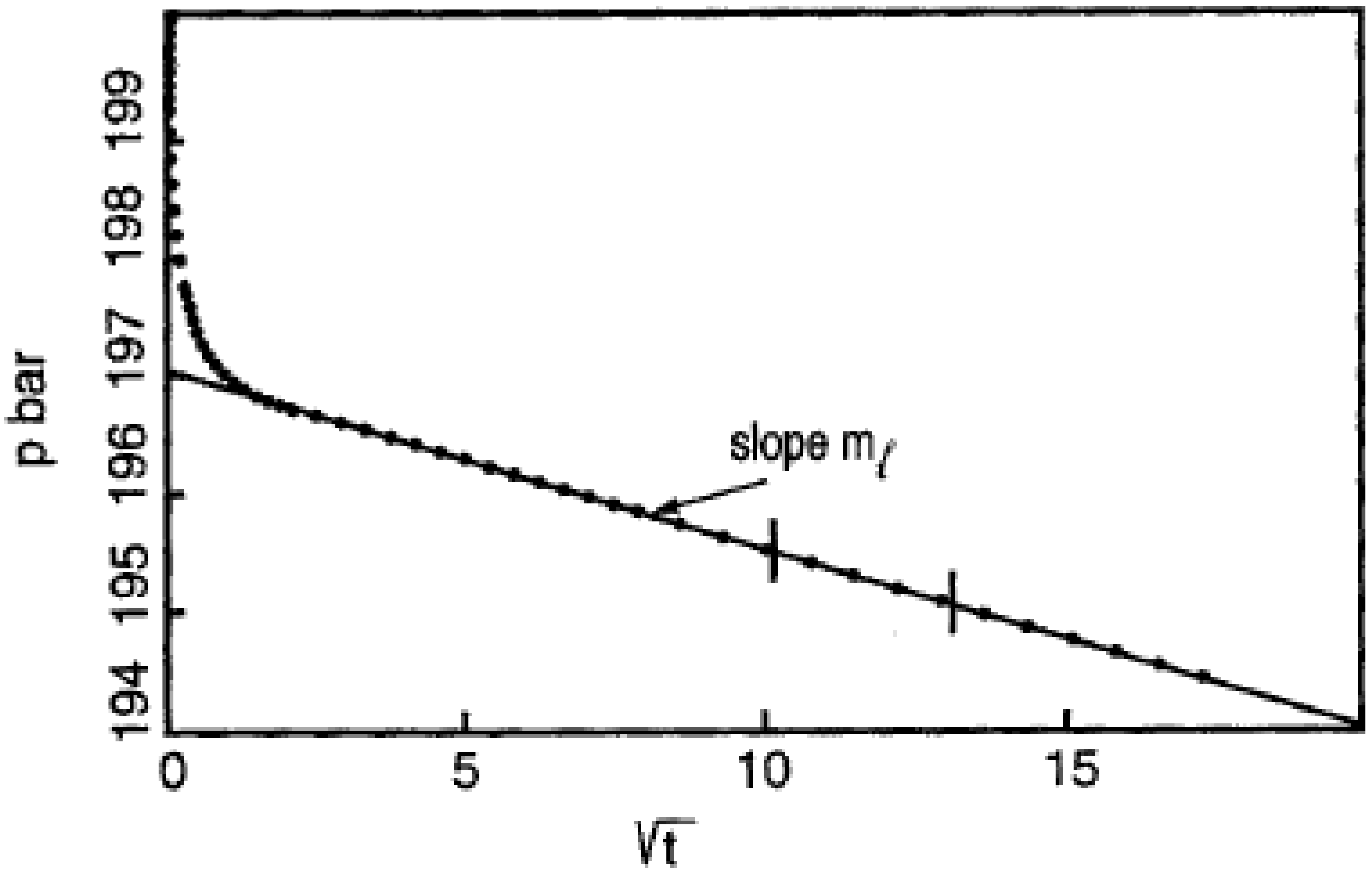
CHANNELS

Description of Flows

- The boundary condition dealt with under the term “channels” corresponds to two infinite parallel no-flow linear boundaries.



Conventional Interpretation Method

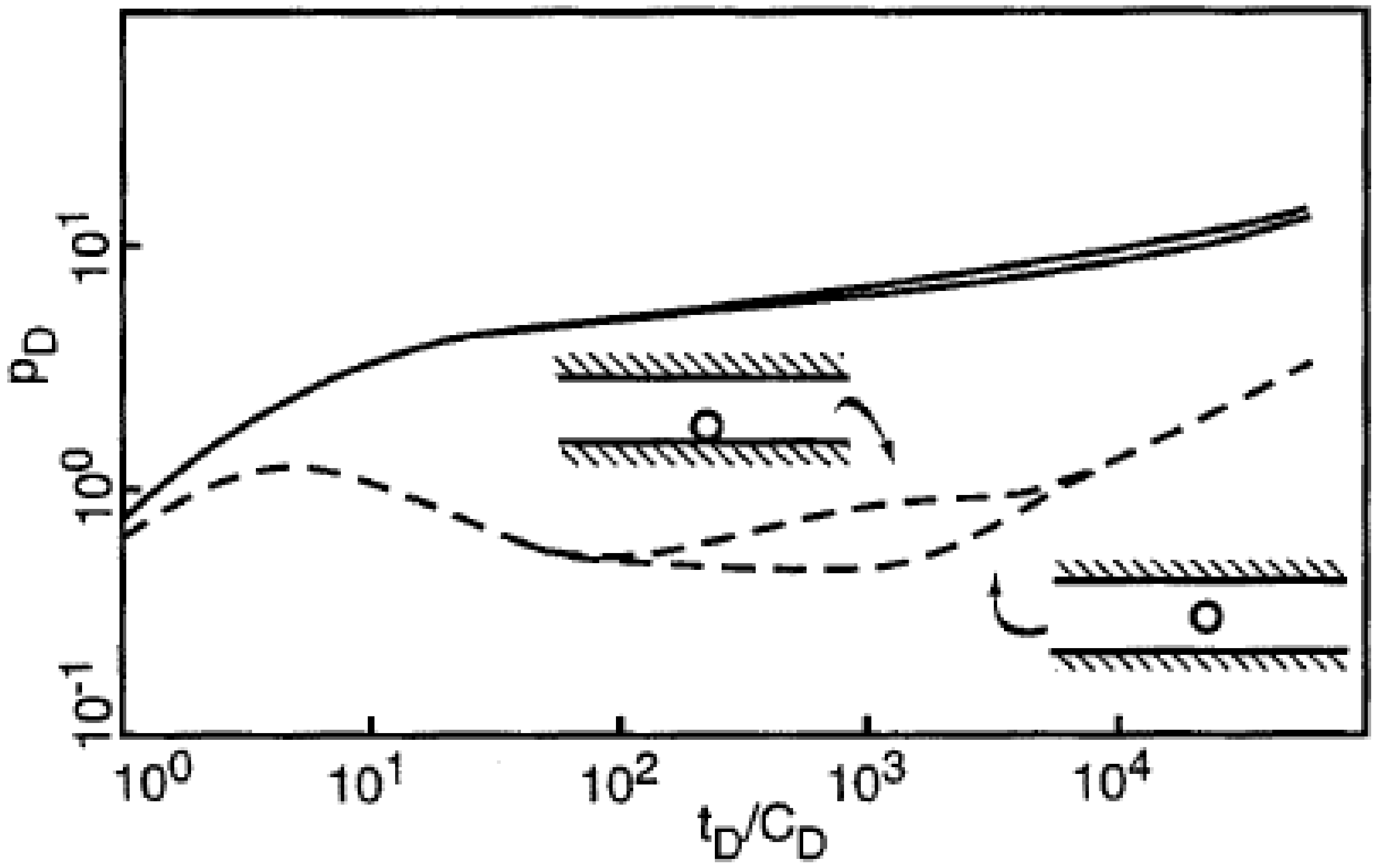


Conventional Interpretation Method…/2

- Determination of the width of the channel is based on the straight line obtained by plotting the pressure drop versus the square root of time.
- The width of the channel can be determined by:

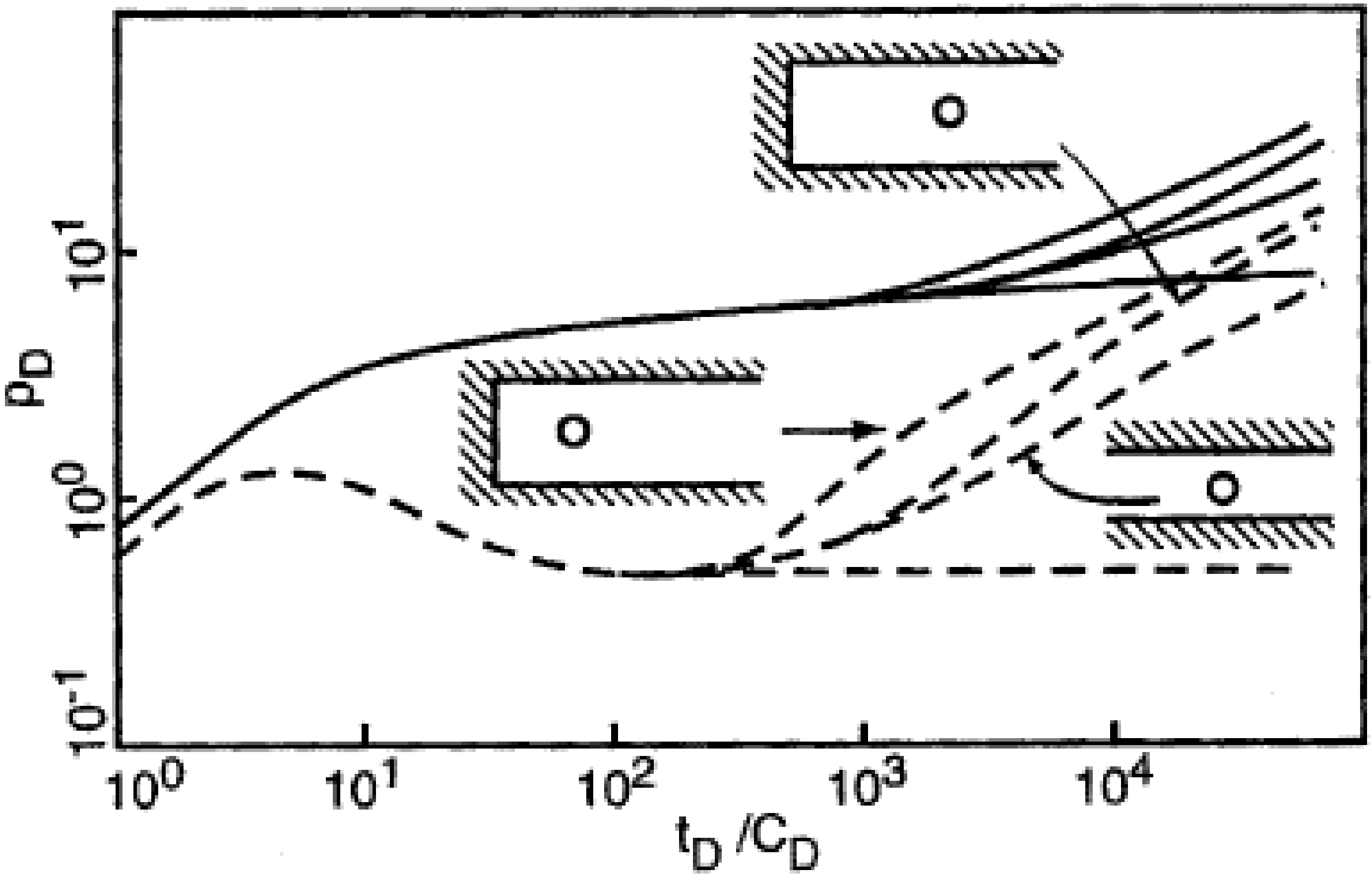
$$w = \frac{8.13\,qB}{h\,m}\sqrt{\frac{\mu}{k\phi c_t}}$$ (in practical US units) **(8.7)**

Type Curves: The Derivative



Infinite channel

Type Curves: The Derivative…/2



Bounded channel

Example 12

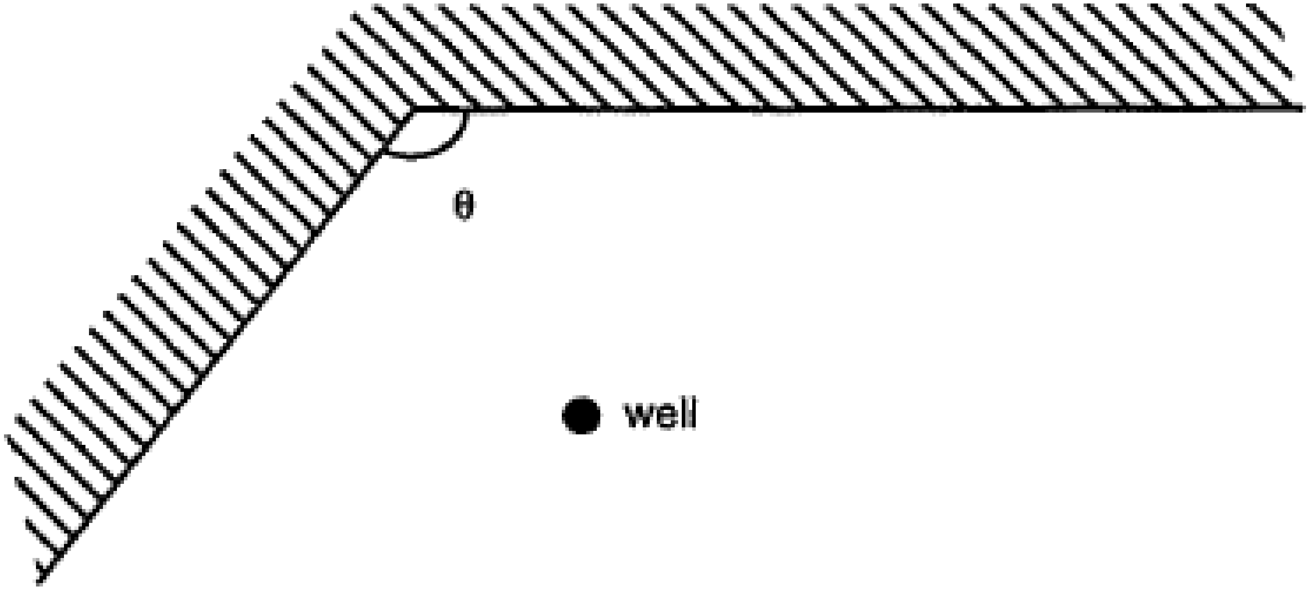
(In-class workshop)

- Channels -

INTERSECTING FAULTS

Description

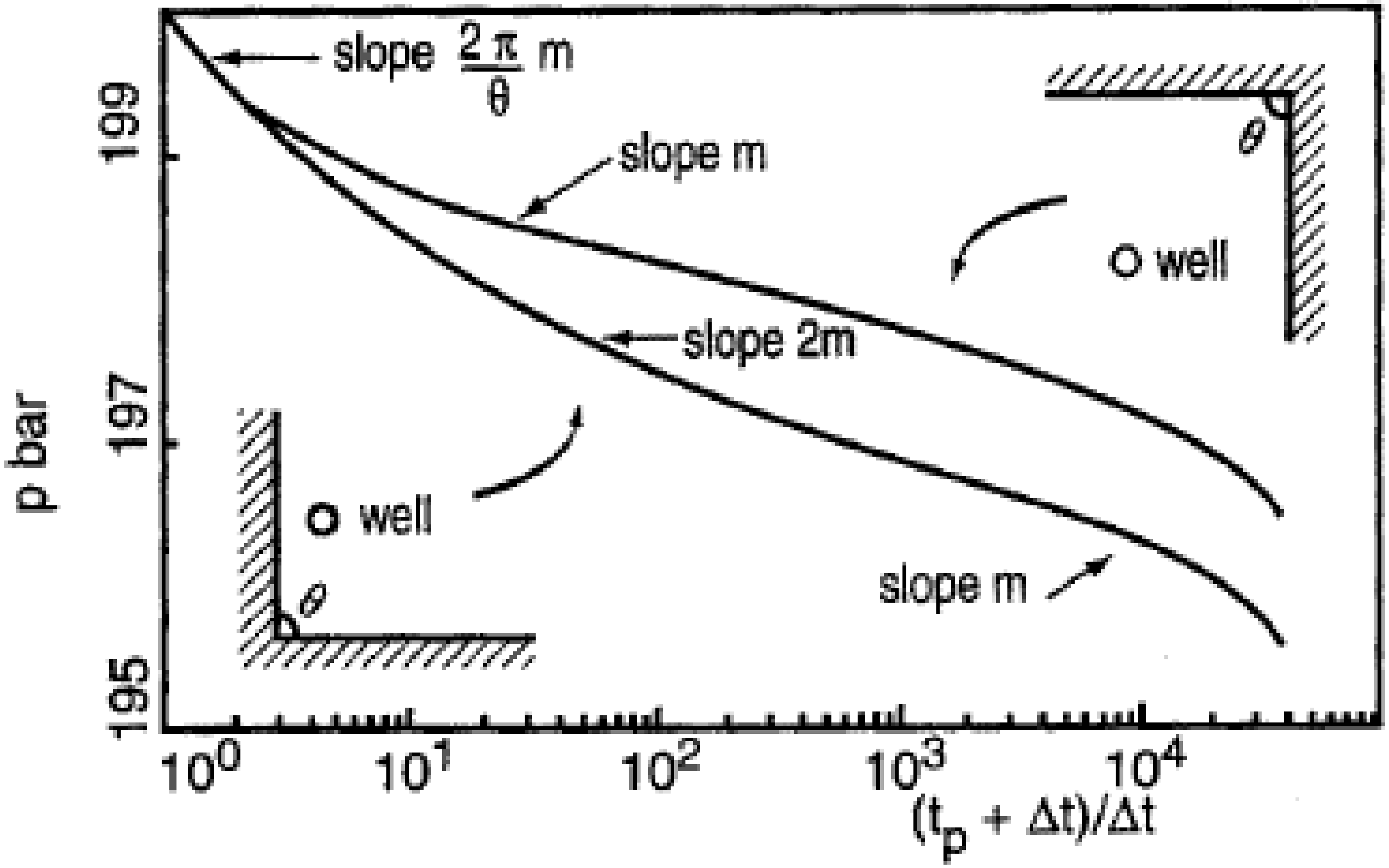
- During a test two intersecting no-flow boundaries, fault for example, can be perceived.
- The distance from the well to each one of them can be characterized by conventional methods and by using the pressure derivative.



Conventional Analysis

- The presence of two intersecting no-flow boundaries may be felt by the transition from an initial m-slope semi-log straight line to a second one with a slope of 2πm/θ (θ in radians).
- If the well is located closer to one of the boundaries than the other, a straight line with a slope of 2m may come before the transition to the one with a slope of 2πm/θ.

Conventional Analysis…/2



Conventional Analysis…/3

- The angle between the two boundaries is characterized by the ratio of slopes of the two semi-log straight lines:

$$\theta = 2\pi \frac{m_1}{m_2}$$

- The distance from the well to the closer boundary can be characterized by the radius of investigation of the test at the time when the boundary is perceived at the well

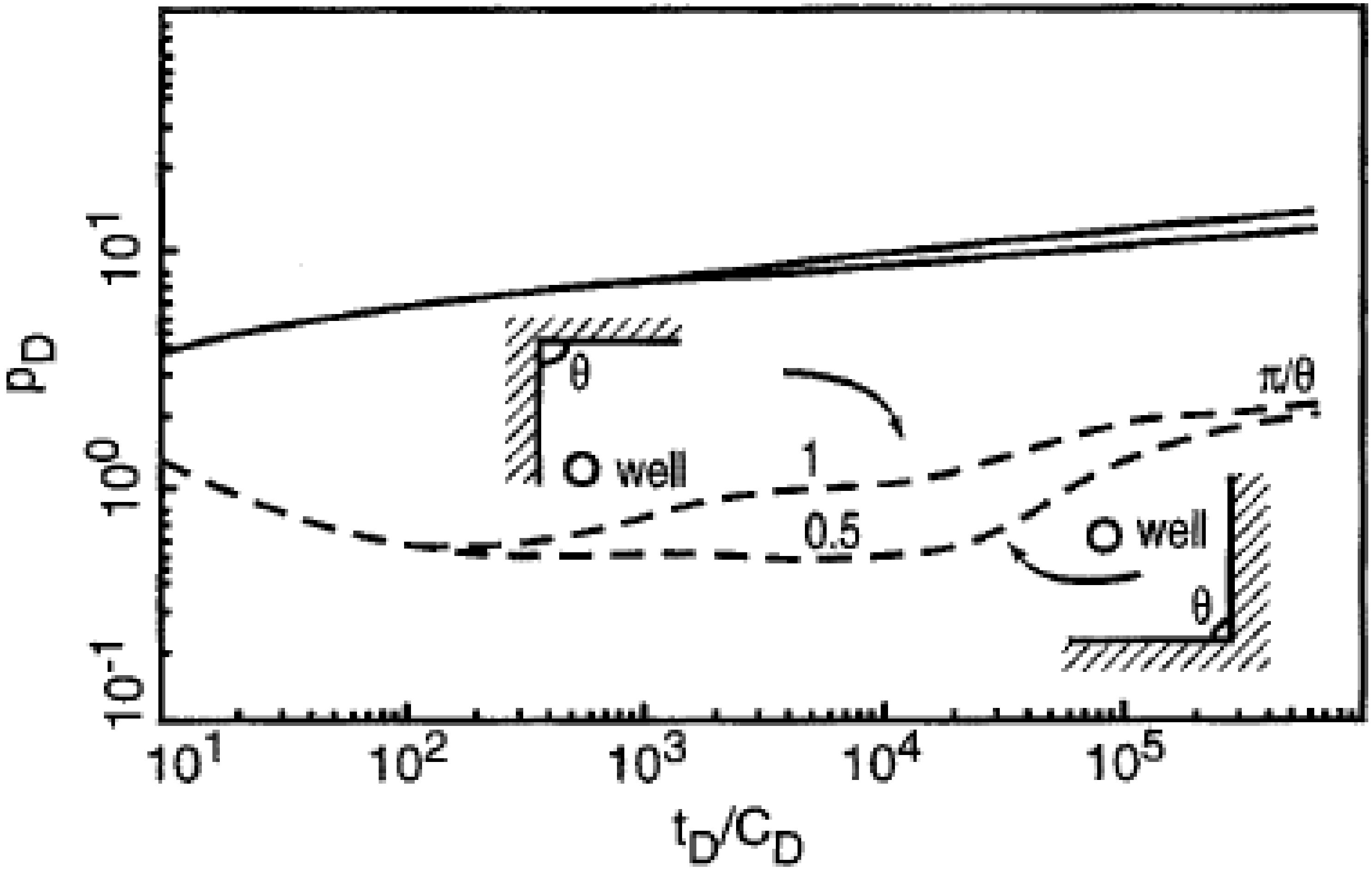
Conventional Analysis…/4

- Most of the time it is necessary to match the pressure and the pressure derivative data with a well test analytical model to determine the distance from the well to the farther boundary more precisely.
- In buildup the extrapolated pressure p* is read on the first semi-log straight line at infinite Δt.
- During initial tests, the initial pressure can be read on the second semi-log straight line (the one with the slope of $2\pi m/\theta$) at infinite Δt.

Type Curves: The Derivative

- The presence of two faults with an angle q between them is characterized by the pressure derivative going from an initial stabilization at 0.5 to a second one at π/θ (θ in radians) on a dimensionless log-log plot.
- The smaller q, the longer it takes to reach the second stabilization.
- A stabilization at 1 (1 boundary) may become before the stabilization at π/θ if the well is located much closer to one of the boundaries than the other.

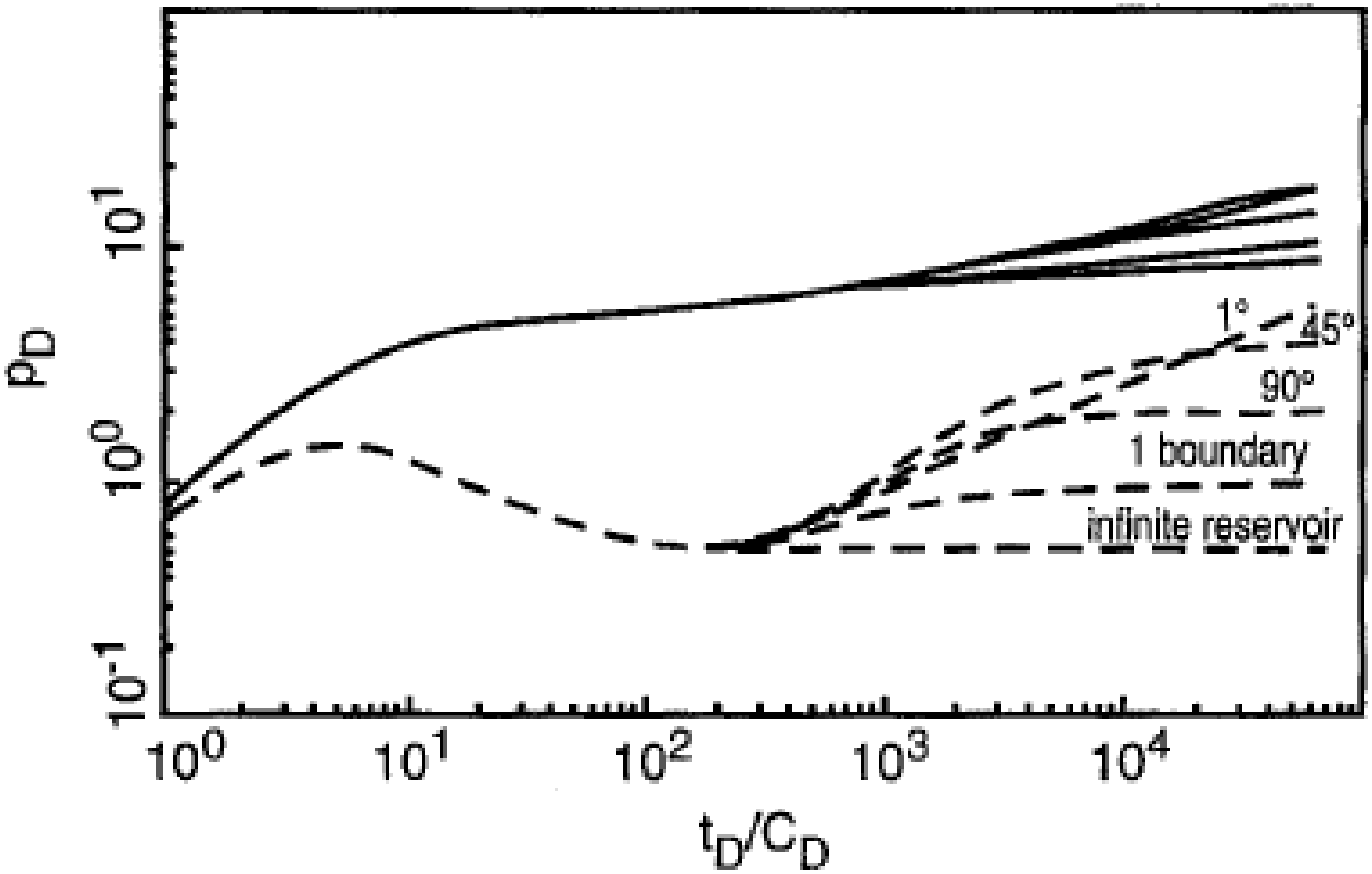
Type Curves: The Derivative…/2



Type Curves: The Derivative…/3

- When the angle is very small, the two faults can be considered as practically parallel: they behave like a channel.
- The transition between the stabilization at 0.5 and the one at π/θ corresponds to a quasi-linear flow with the derivative increasing as a ½ slope straight line.

Type Curves: The Derivative…/4



References

1. Bourdarot, Gilles : Well Testing: Interpretation Methods, Éditions Technip, 1998.
2. Internet.