"History Matching" of shut-in pressure data

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History Matching

- Combining an optimization program with a reservoir simulator to determine the reservoir geometry and properties so that the simulated pressures match observed pressures.

- Also known as:
  - Automated calibration
  - Parameter estimation
  - Inverse method

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Assumed "Known"

- Volume of original oil in place: 110 million stb
- Formation volume factor: 2.35 rb/stb
- Porosity: 21%
- Reservoir thickness: 90 ft
- **Reservoir Area: 85.3 million square feet**
- Reservoir is rectangular of varying dimensions:
    - 2,000 ft x 42,665 ft
    - 3,000 ft x 28,444 ft
    - 4,000 ft x 21,333 ft
    - 5,000 ft x 17,066 ft
    - 6,000 ft x 14,222 ft
    - 7,000 ft x 12,190 ft
- Various flow rates:
    - 40,000 stb/day
    - 50,000 stb/day
    - 60,000 stb/day
- No aquifer support, well has integrity (no casing leak)

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Estimated or "Fitted" Parameters

- Location (x_w, y_w) of well in rectangular reservoir
- Permeability (k)
- Rock compressibility (c_r)
- Final shut-in pressure ($\bar{p}$)
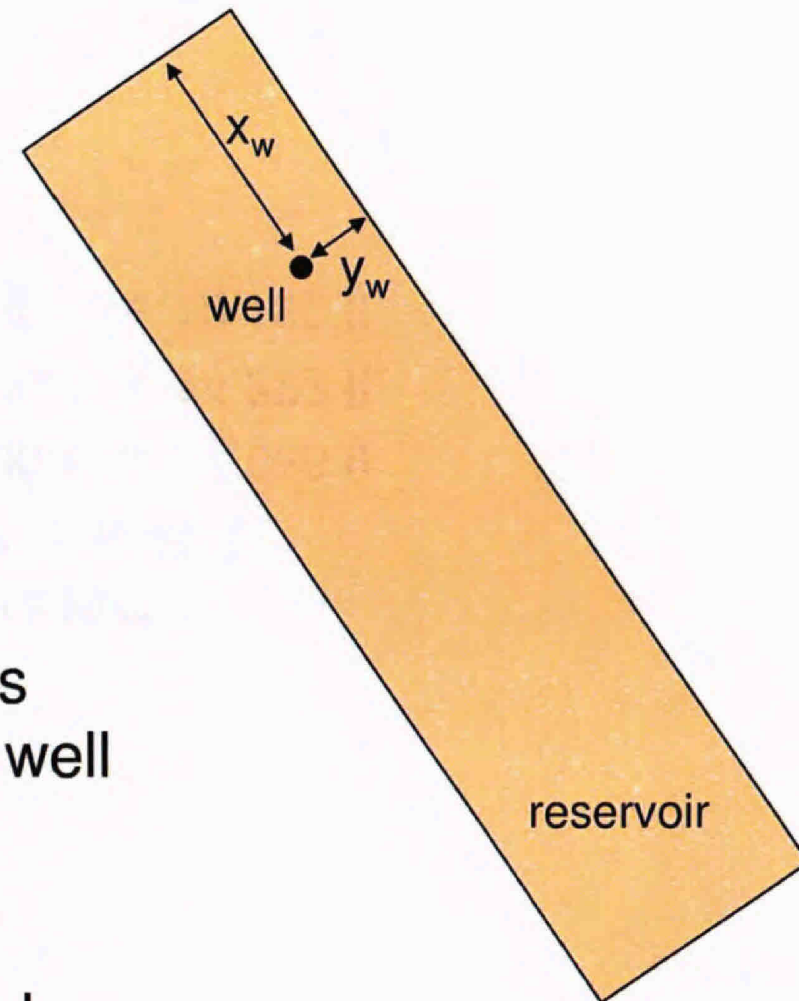
The sum of squares of residuals (SSR) gives a measure of how well the model simulated pressures match the observed pressures.
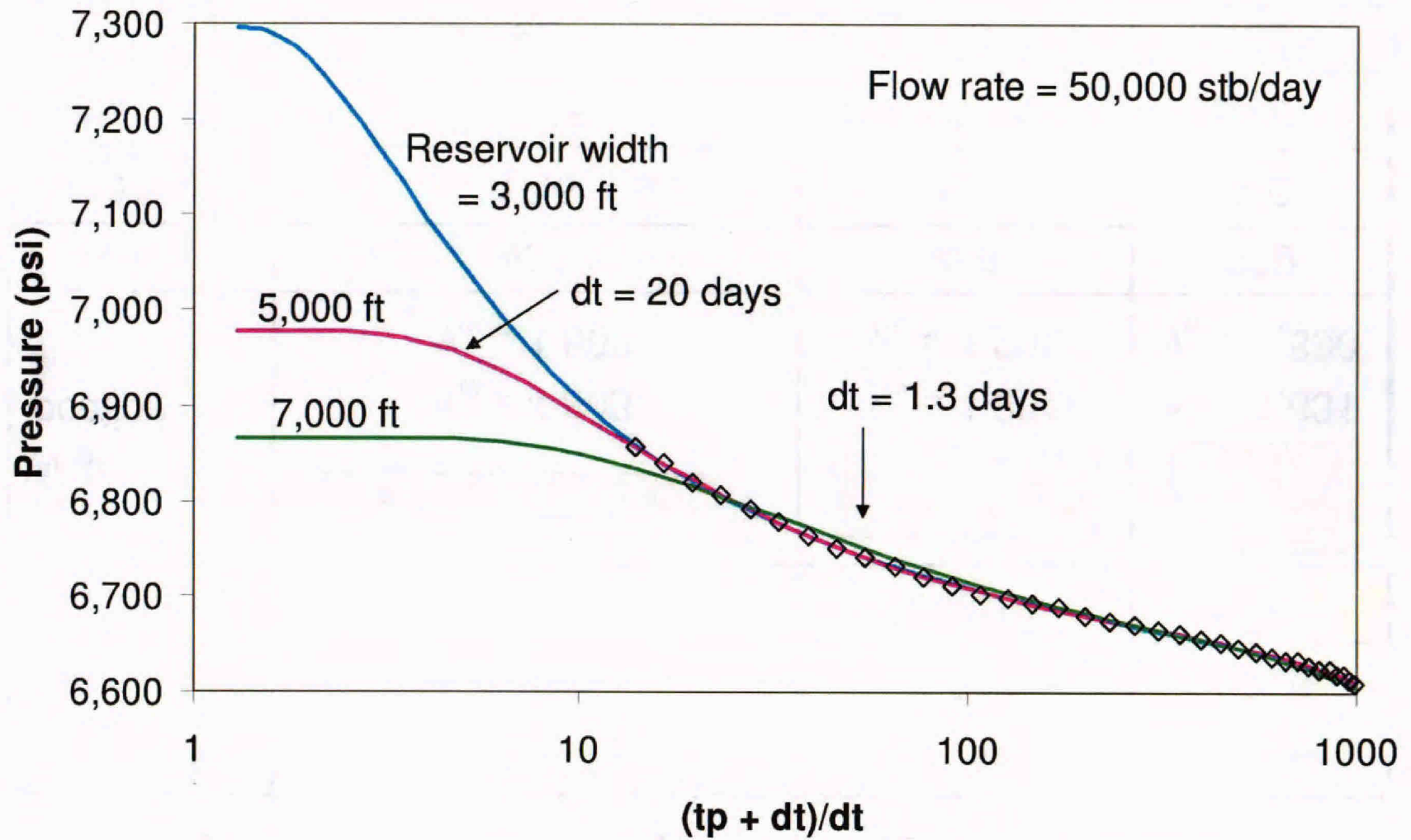
Residual = simulated - observed

x_w

y_w

well

reservoir

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Selected Results. Flow rate = 50,000 stb/day

Length (ft)	28,444	17,066	12,190
Width (ft)	3,000	5,000	7,000
Aspect ratio	~ 9:1	~ 3:1	~ 2:1
Well location (ft)	$x_w = 4,803$ $y_w = 1,500$	$x_w = 1,901$ $y_w = 1,902$	$x_w = 1,631$ $y_w = 1,890$
k (md)	491	459	339
c_r (10^{-6} psi^{-1})	15.5	9.4	7.6
$\bar{p}$ (psi)	7,296	6,979	6,867
SSR (psi^2)	92	58	1,682

For a different flow rate, the same match can be obtained by proportionally scaling k and c_r.

Horner Plot

Flow rate = 50,000 stb/day

Reservoir width = 3,000 ft

5,000 ft

7,000 ft

dt = 20 days

dt = 1.3 days

Pressure (psi)

7,300
7,200
7,100
7,000
6,900
6,800
6,700
6,600

1
10
100
1000

(tp + dt)/dt

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Reservoir Pressure during shut-in
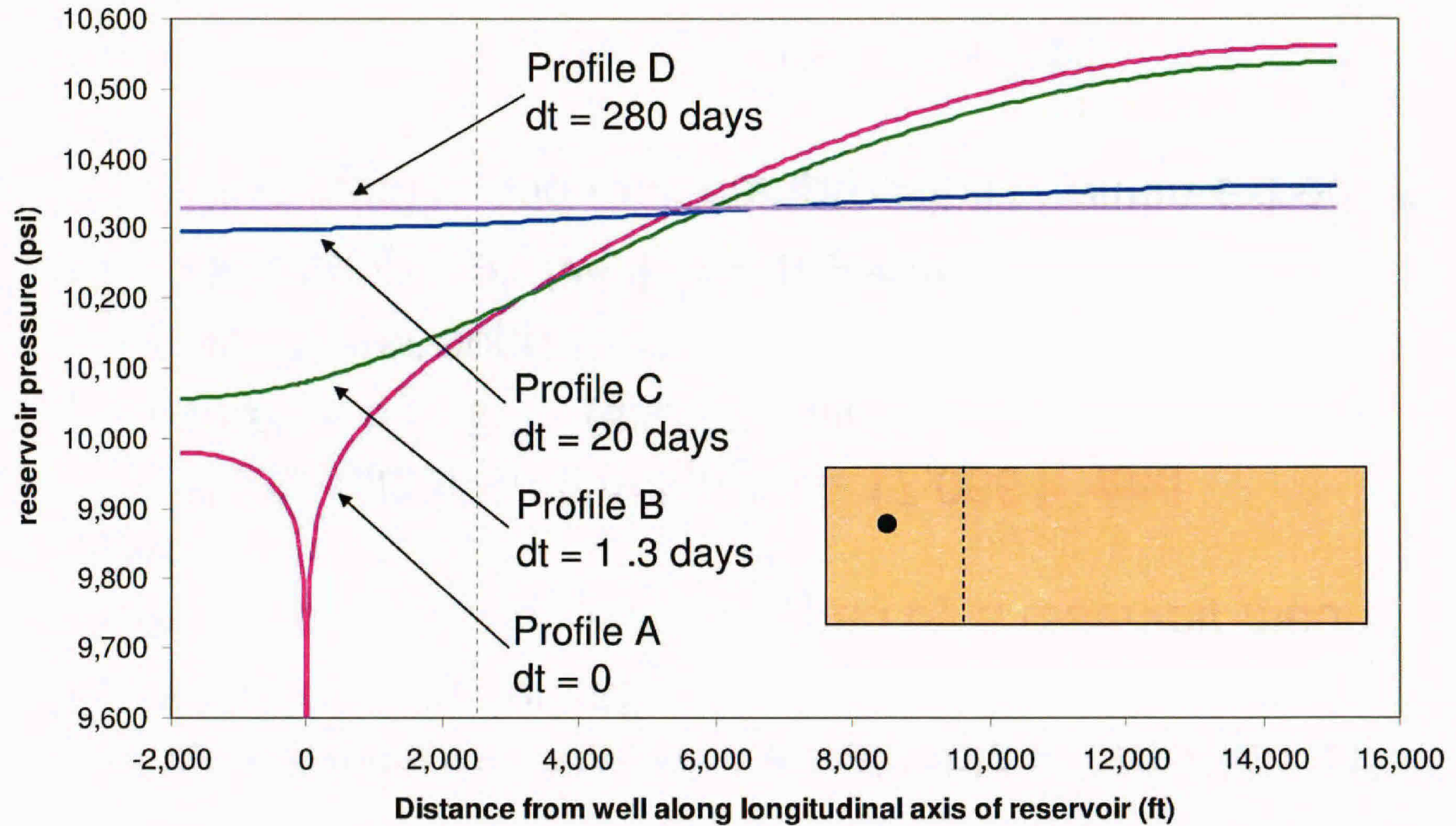
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Conclusions

- Shut-in pressure data provide valuable information for reservoir characterization.

- Shut-in data can be well matched by a reservoir model with:

  - Rectangular area of length = 17,066 ft and width = 5,000 ft   (aspect ratio ~ 3:1).

  - No aquifer support

  - No casing leak (well has integrity)

  - Permeability and rock compressibility within expected range

- Projected final shut-in pressure ~ 7,000 psi

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