Analysis of the Solution Gas Effect on SAGD Slope Drainage Rate

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Athabasca SAGD Milestones

- 1978 R.M. Butler/IOL – lab & analysis
- 1987 AOSTRA UTF Ph. A (200 bpd)
- 1990 AOSTRA et al UTF Ph. B (2000 bpd)
- 2000 AEC/EnCana Foster Creek (20 kbpd)
- 2010-? Husky Sunrise (200 kbpd)

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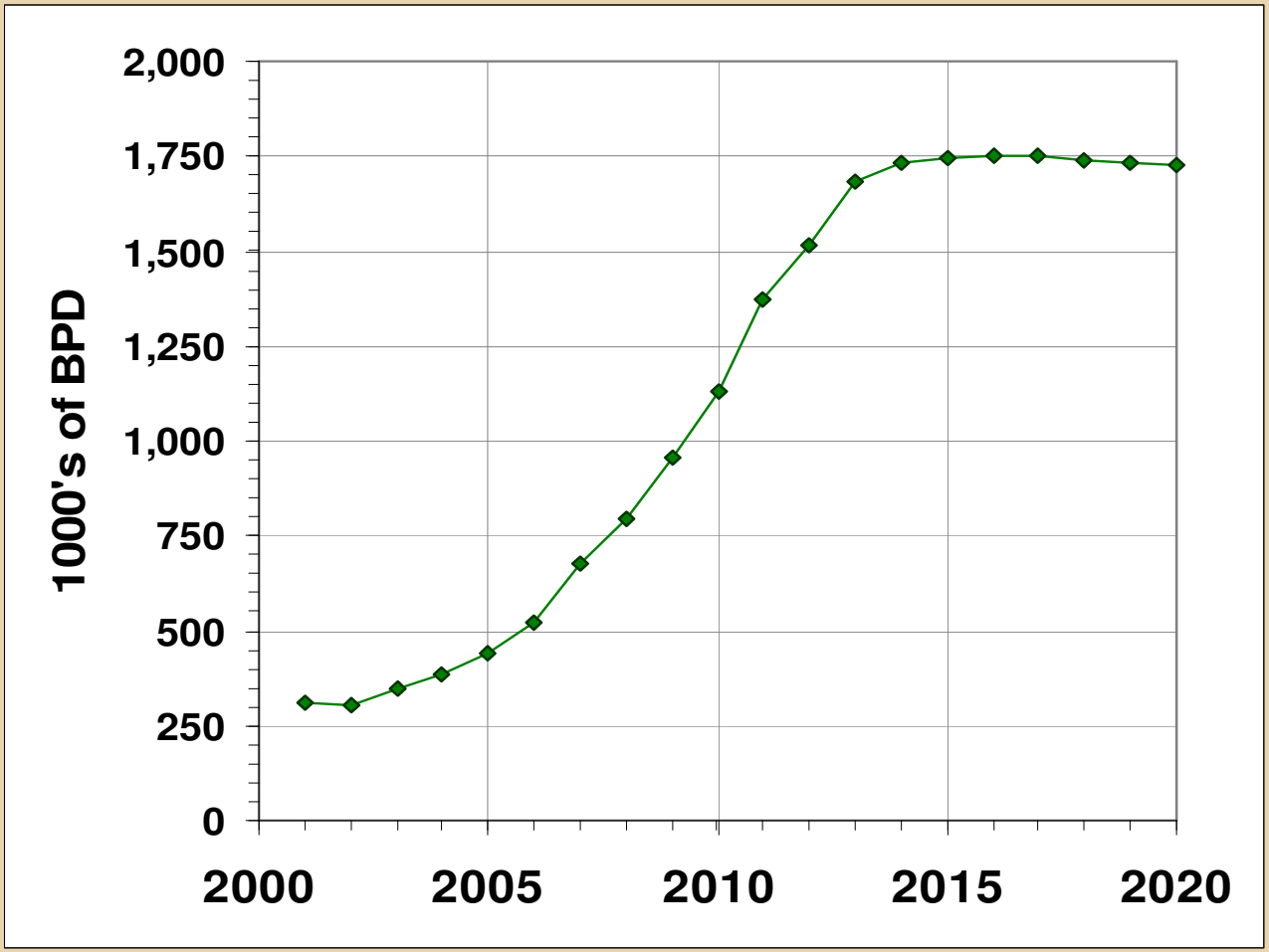
Canadian *in situ* Bitumen Forecast



Source: Cdn. Assoc. of Petroleum Producers, 2006

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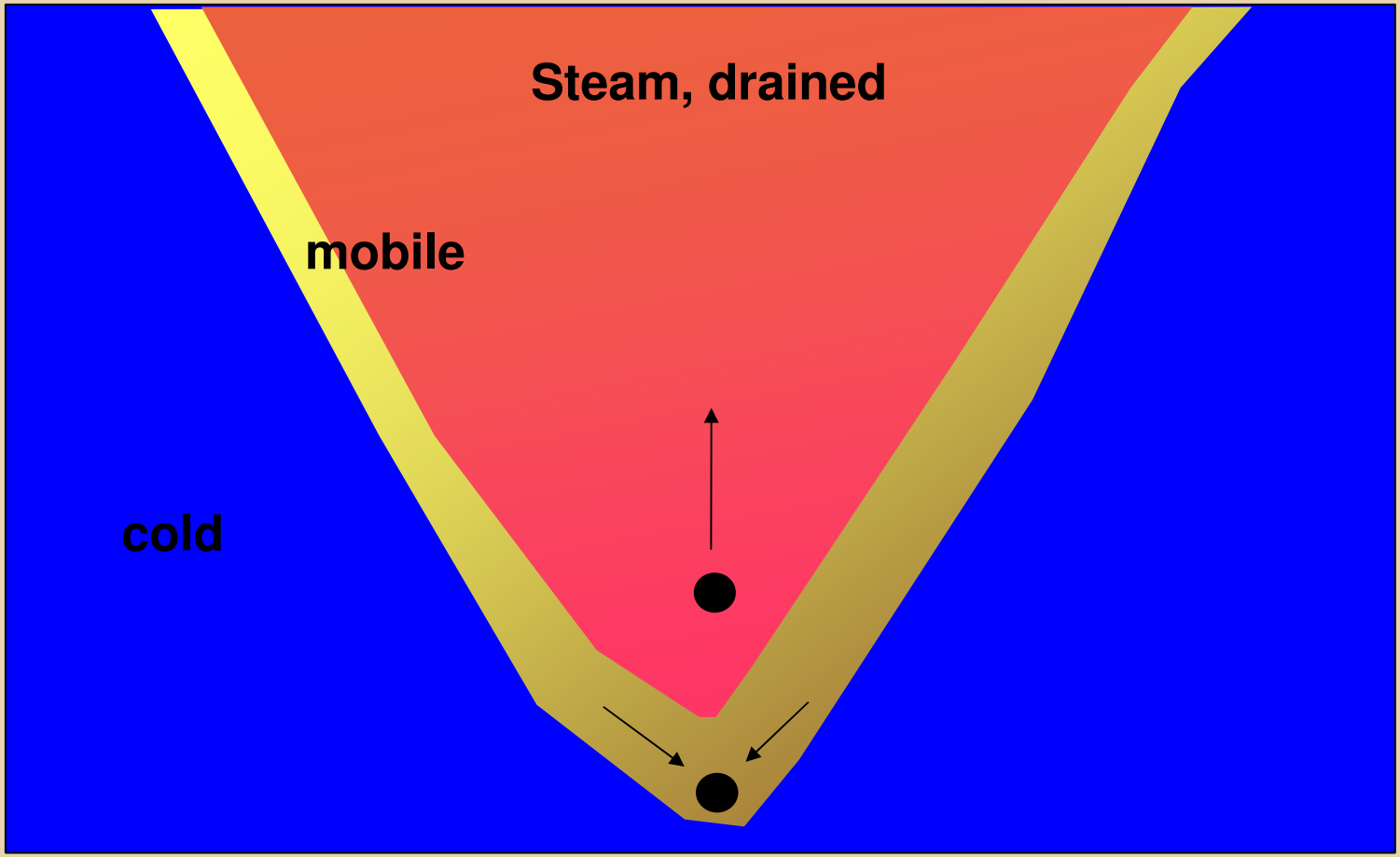
“Scientific” SAGD



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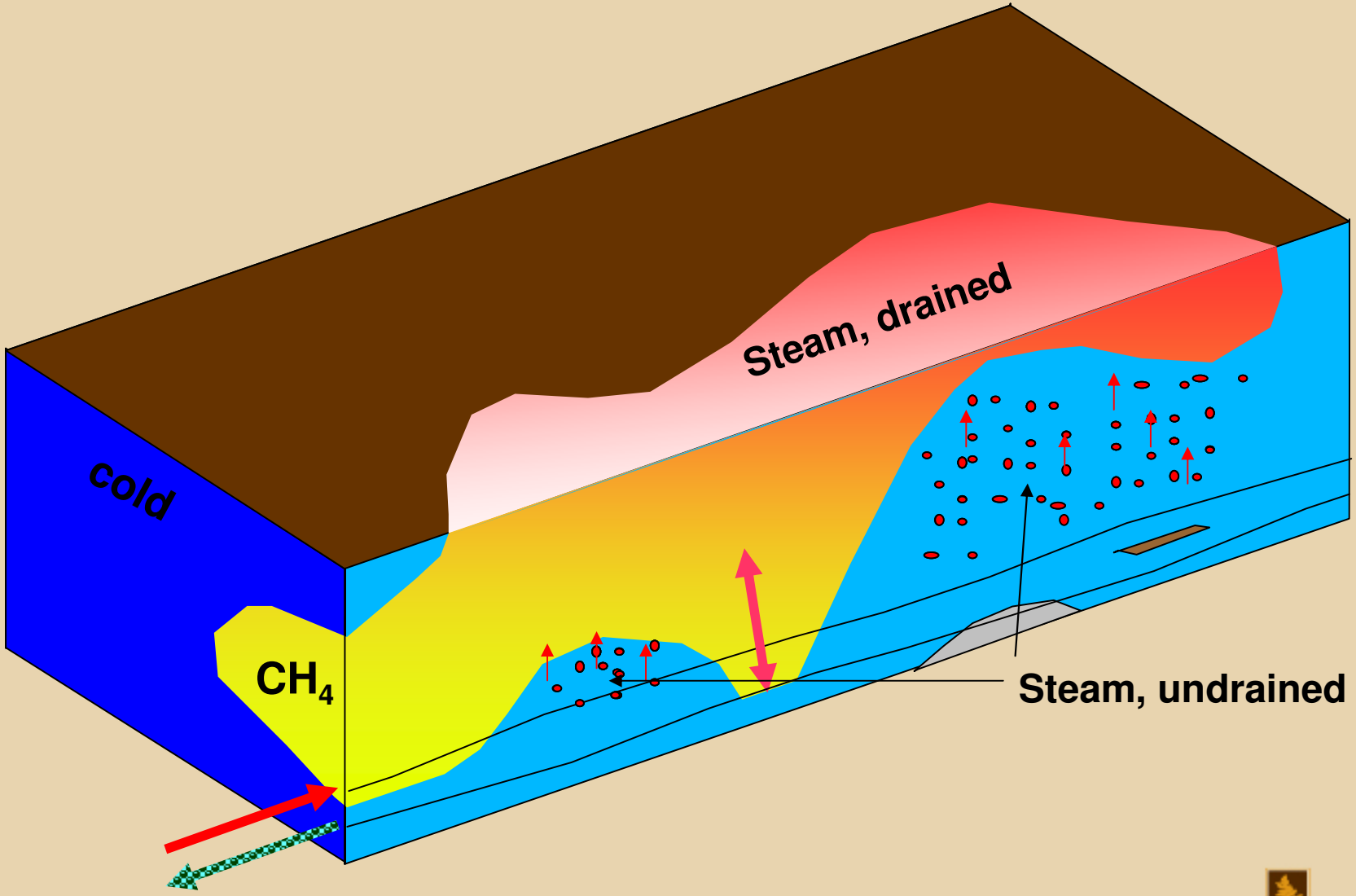
Real World SAGD



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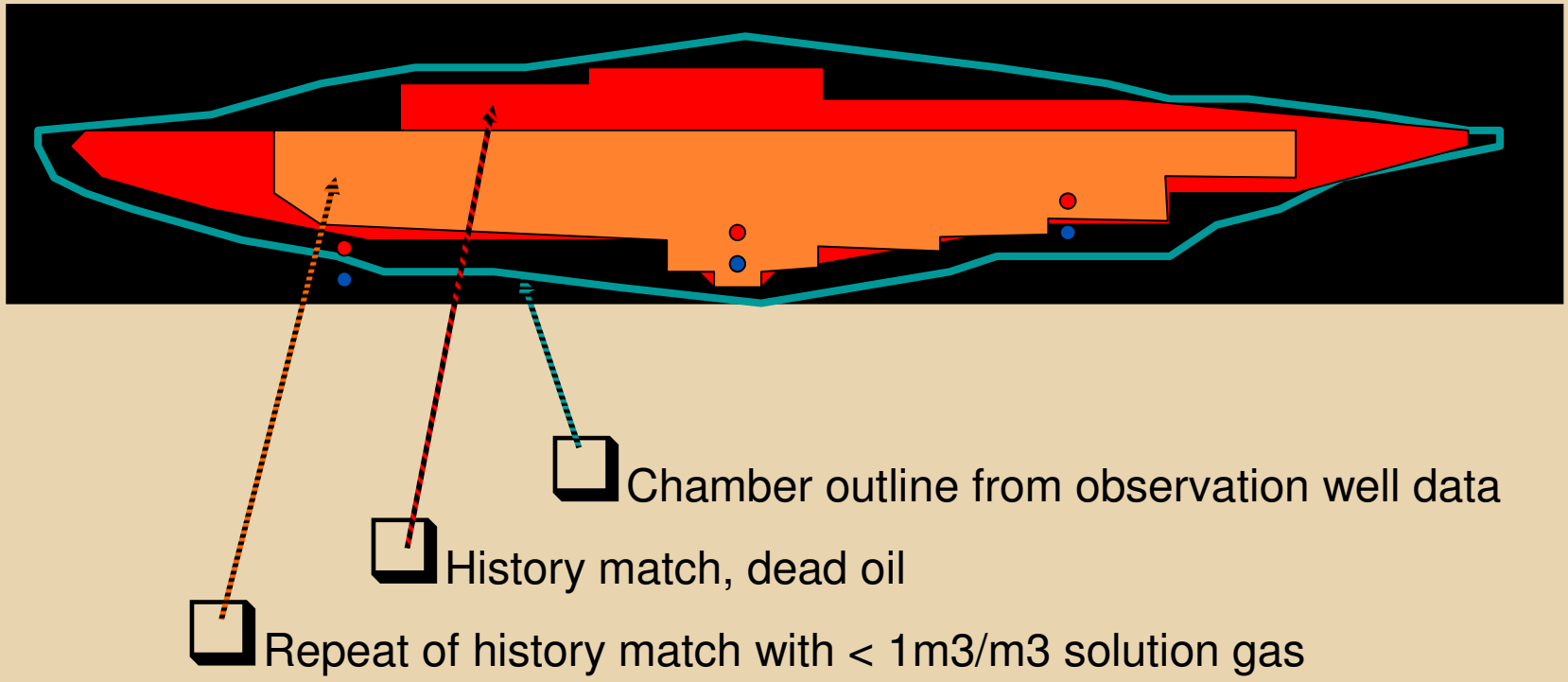
Effect of Gas in SAGD Simulation



Source: S.D. Gittins et al, 1992 IEA/EOR, Banff

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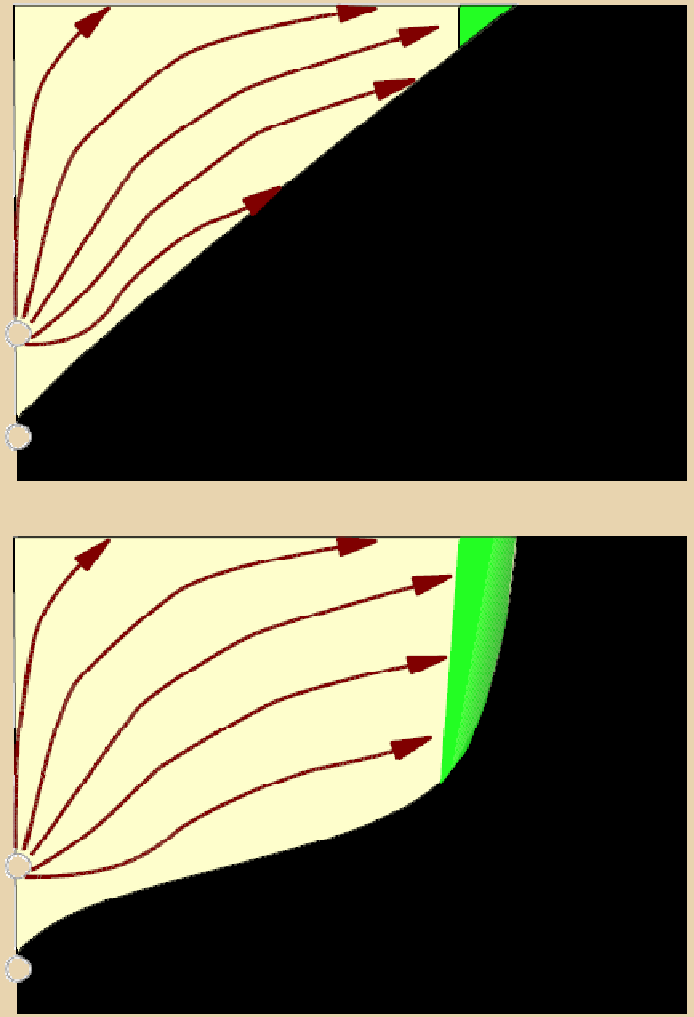
NC Gas Accumulation at a SAGD Front

- Methane, etc. is swept by the steam into the farthest (fastest) corner of the chamber
- Accumulation retards the front and blunts or rounds the chamber geometry



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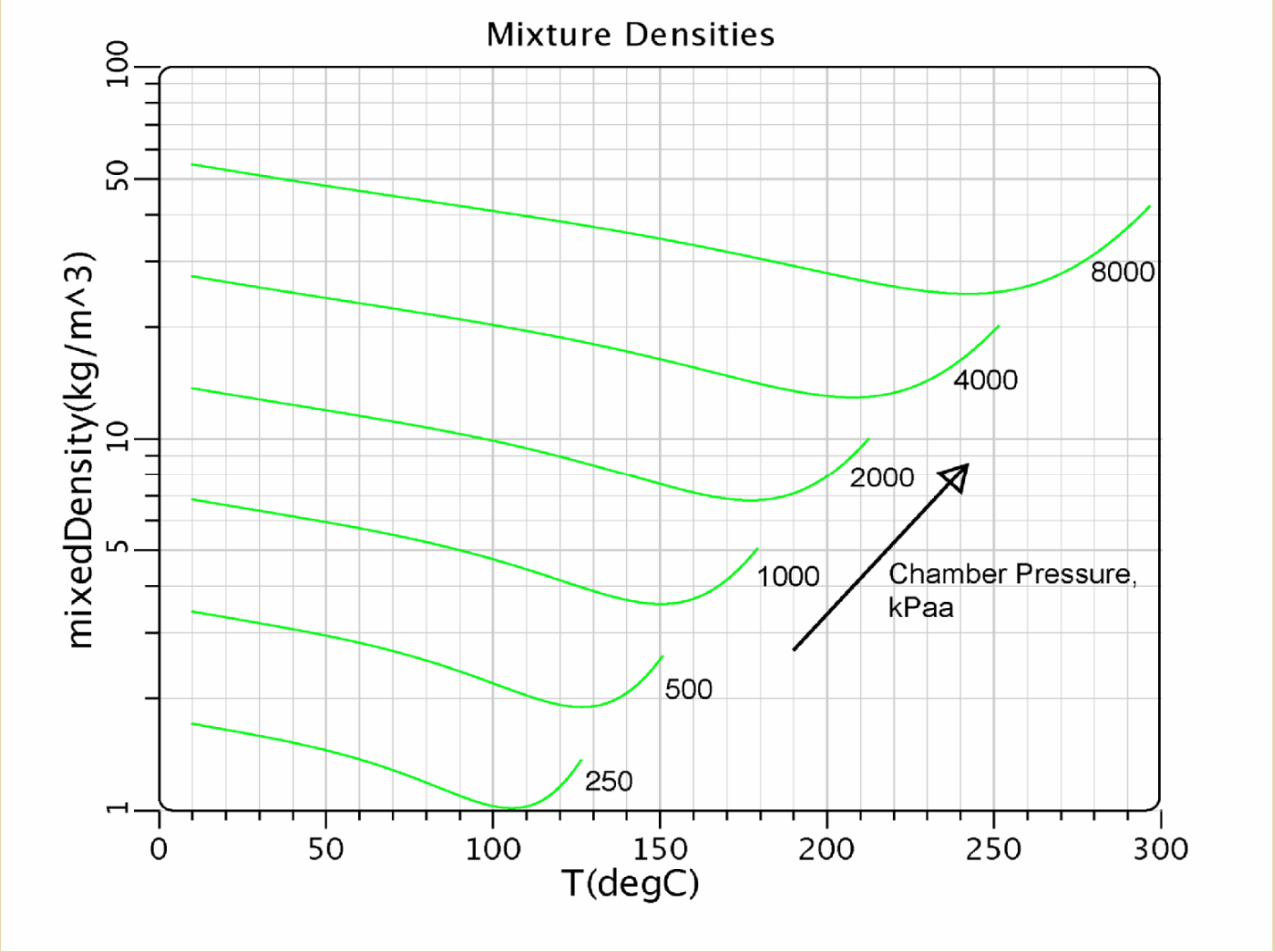
Density of Steam/Methane Mixtures



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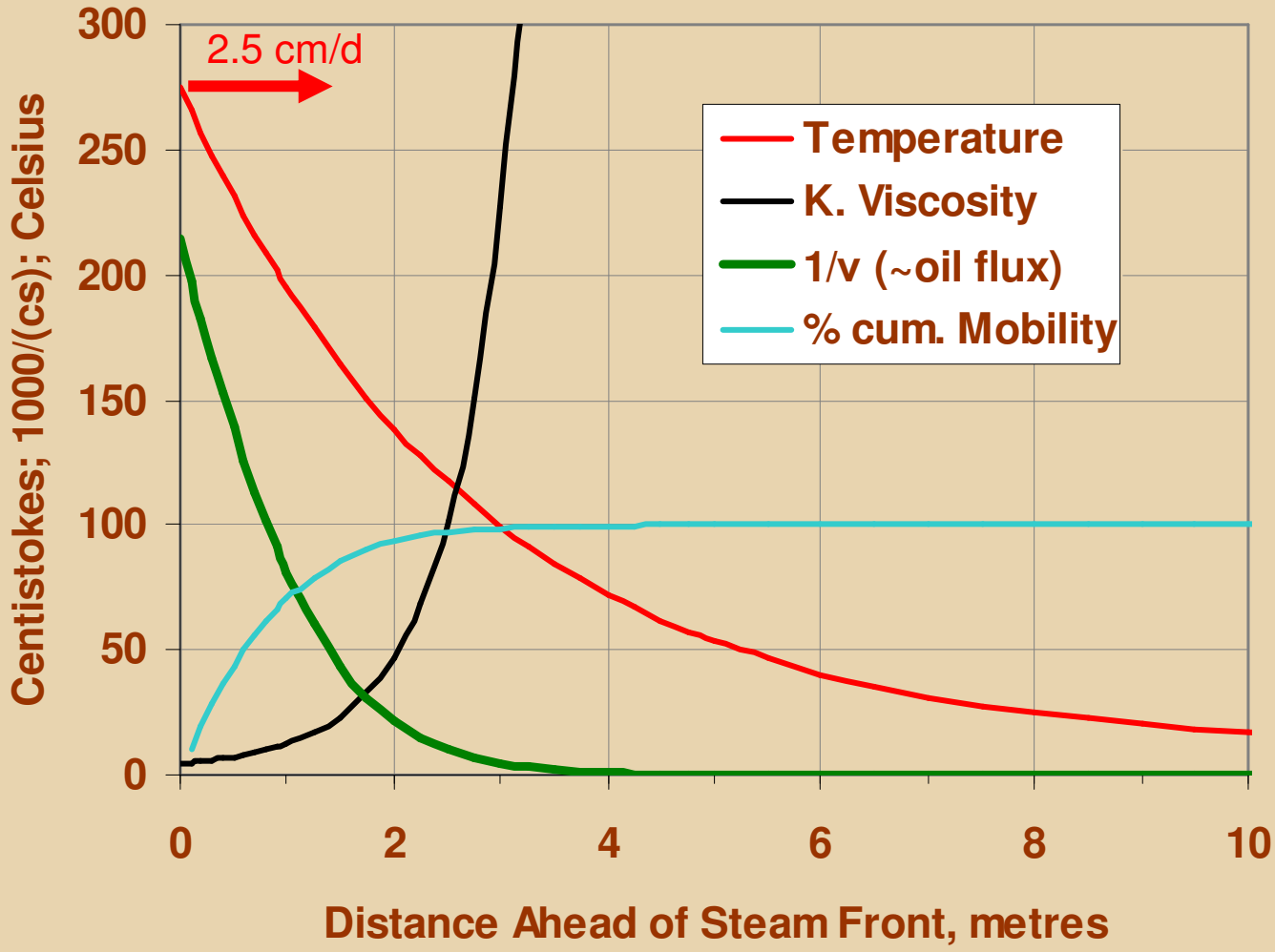
Temperature & Mobility Ahead of a SAGD Front



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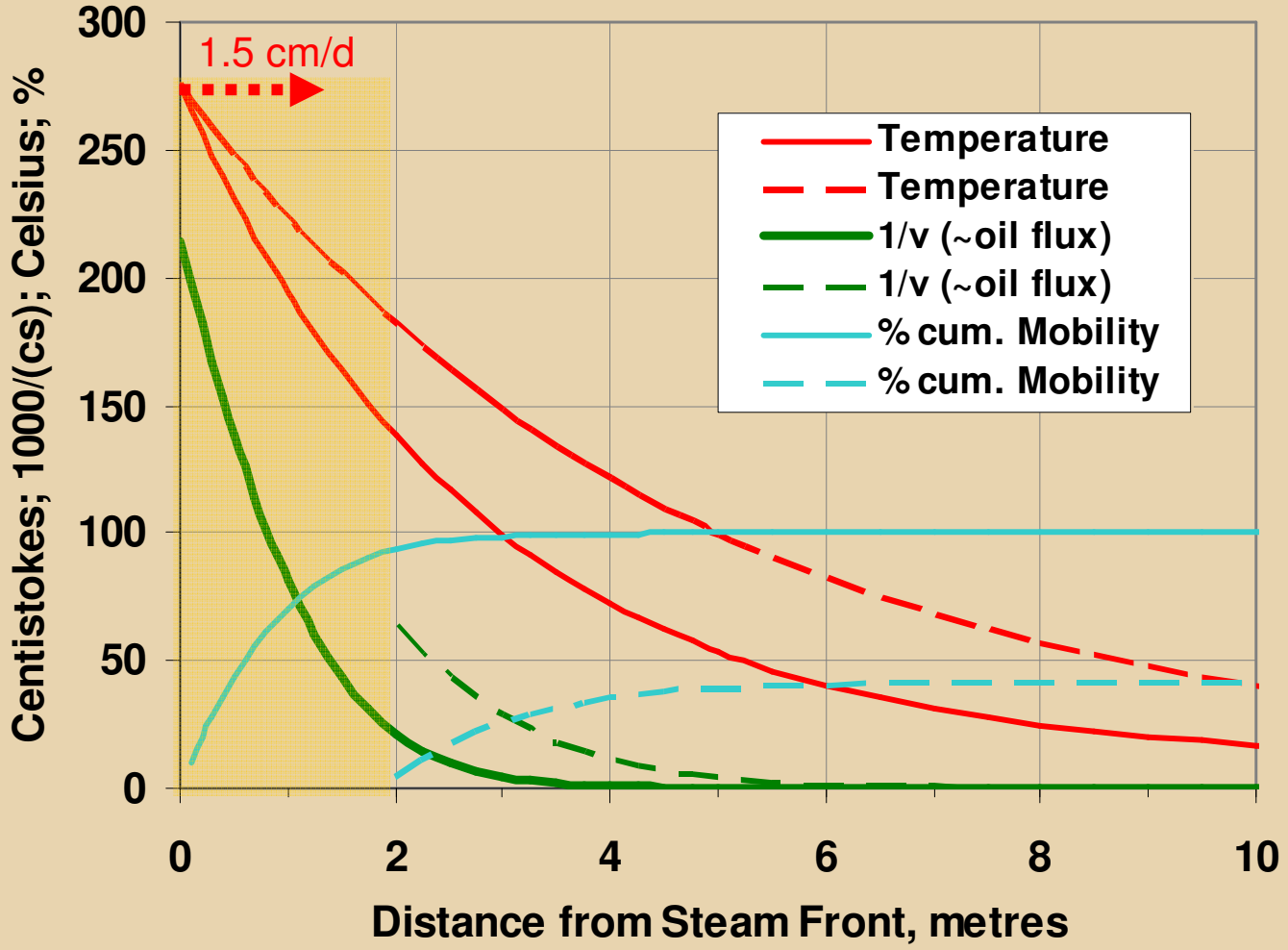
SAGD Front With Gas Blanket



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Butler's Equation for SAGD Rate

$$q_{o0} = \sqrt{\frac{1.3hg\phi(S_{oi}-S_{or})k_o\alpha}{m\nu_{os}}}$$

$$f_g = \frac{q_o}{q_{o0}}$$

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Equation for Impairment Factor f_g

$$f_g = \exp\left(-f_g \gamma\right)$$

$$\gamma = \xi_b \frac{U}{\alpha} \frac{m}{2}$$

$$= \xi_b \frac{q_o}{\alpha A_f \phi \Delta S_o} \frac{m}{2}$$

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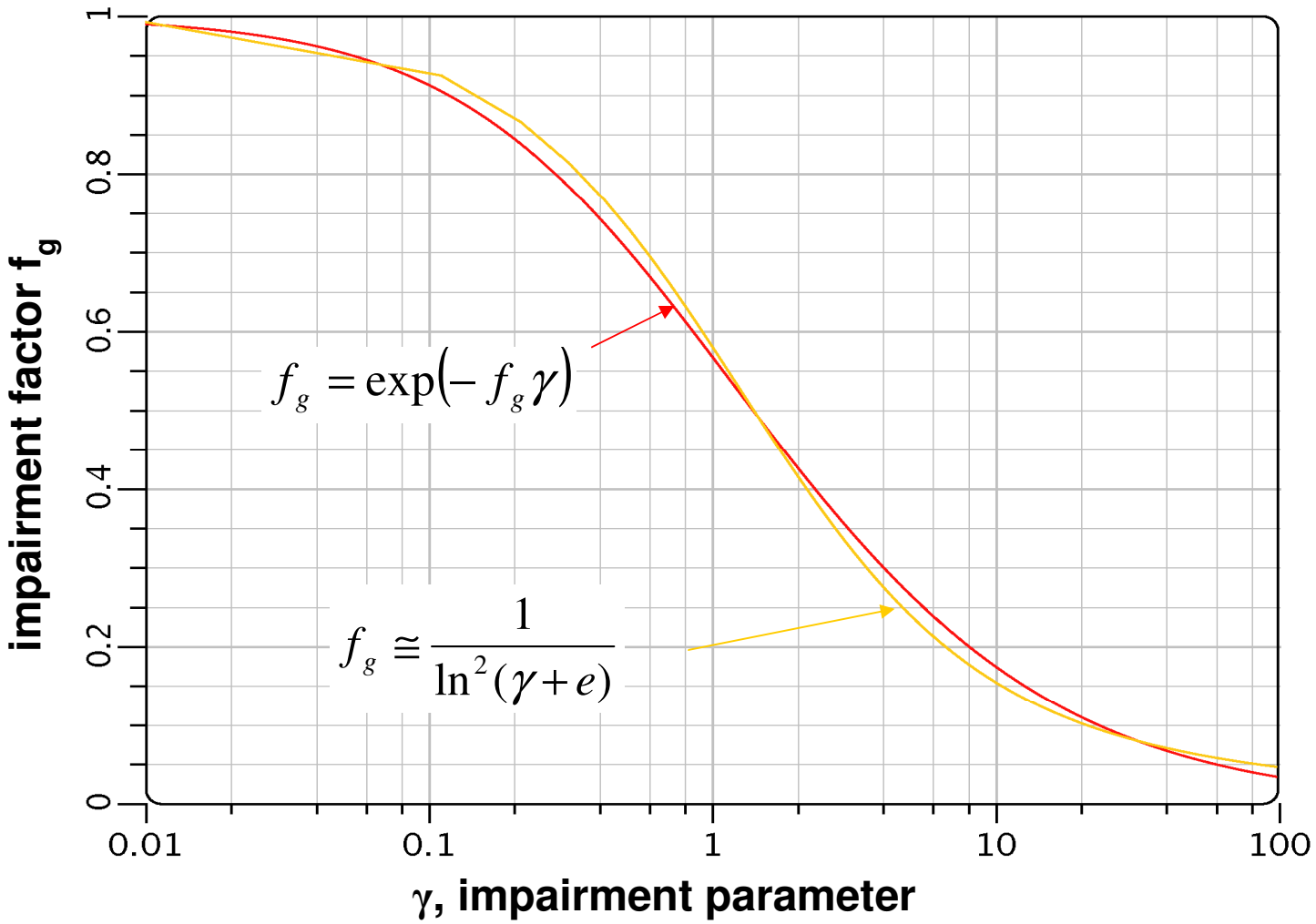
The Impairment Function



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Plausible Blanket Thickness

$$\xi_B \approx \frac{GOR_i * \frac{P_{std}}{P} * \frac{T}{T_{std}} * x * \eta_{accum}}{\left(1 - \frac{S_{or}}{S_{oi}}\right)}$$

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Plausible Blanket Thickness (metres)

	η_{accum}	10%			25%		
	P, kPaa	500	2000	8000	500	2000	8000
	T, ˚C	*125*	*175*	*250*	*125*	*175*	*250*
GOR$_i$	2.5	1.8	0.5		4.5	1.3	
	5	3.6	1.0	0.3	8.9	2.5	0.7
	10	7.2	2.0	0.6	17.9	5.0	1.5

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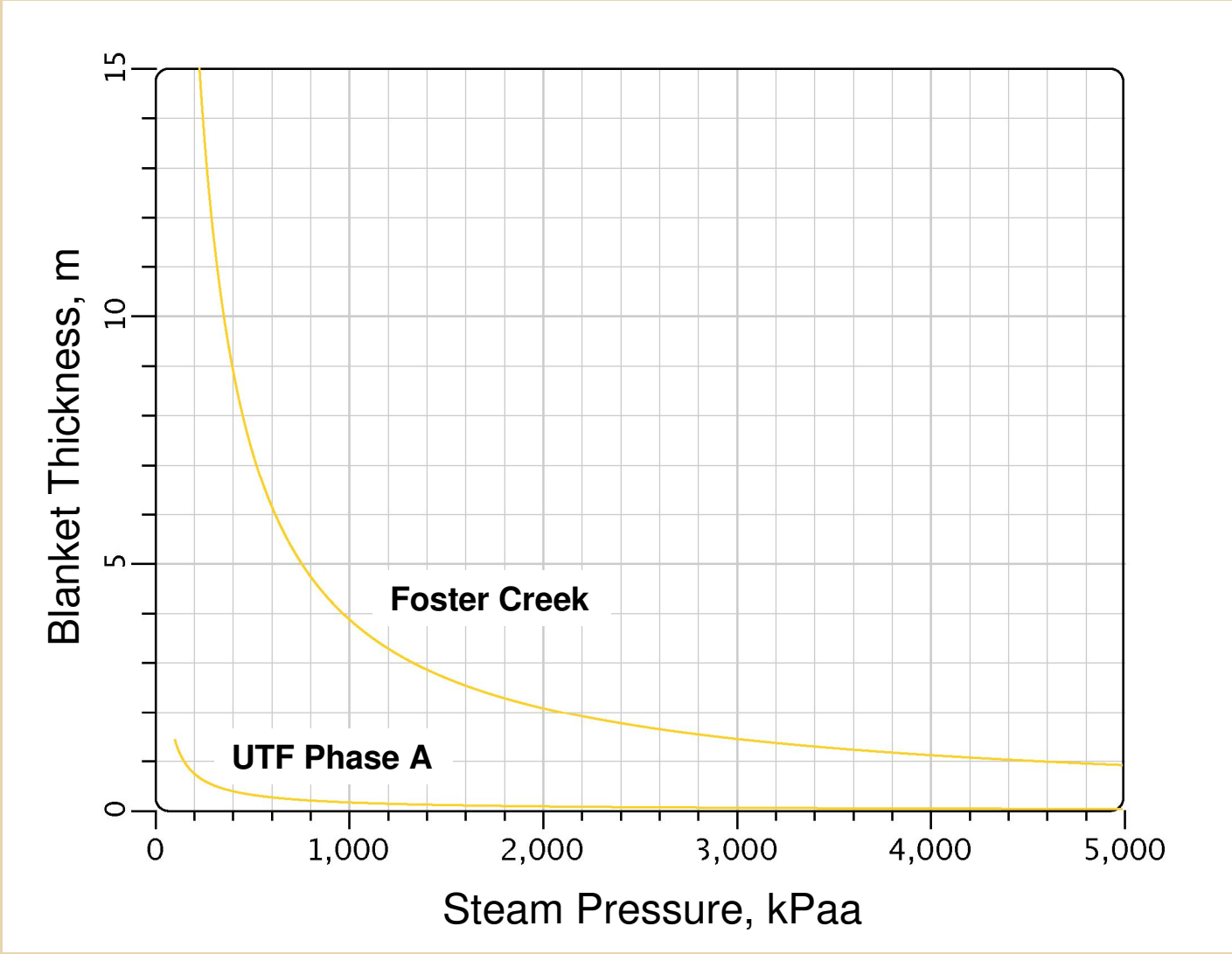
Estimated Blanket Thickness vs. Pressure



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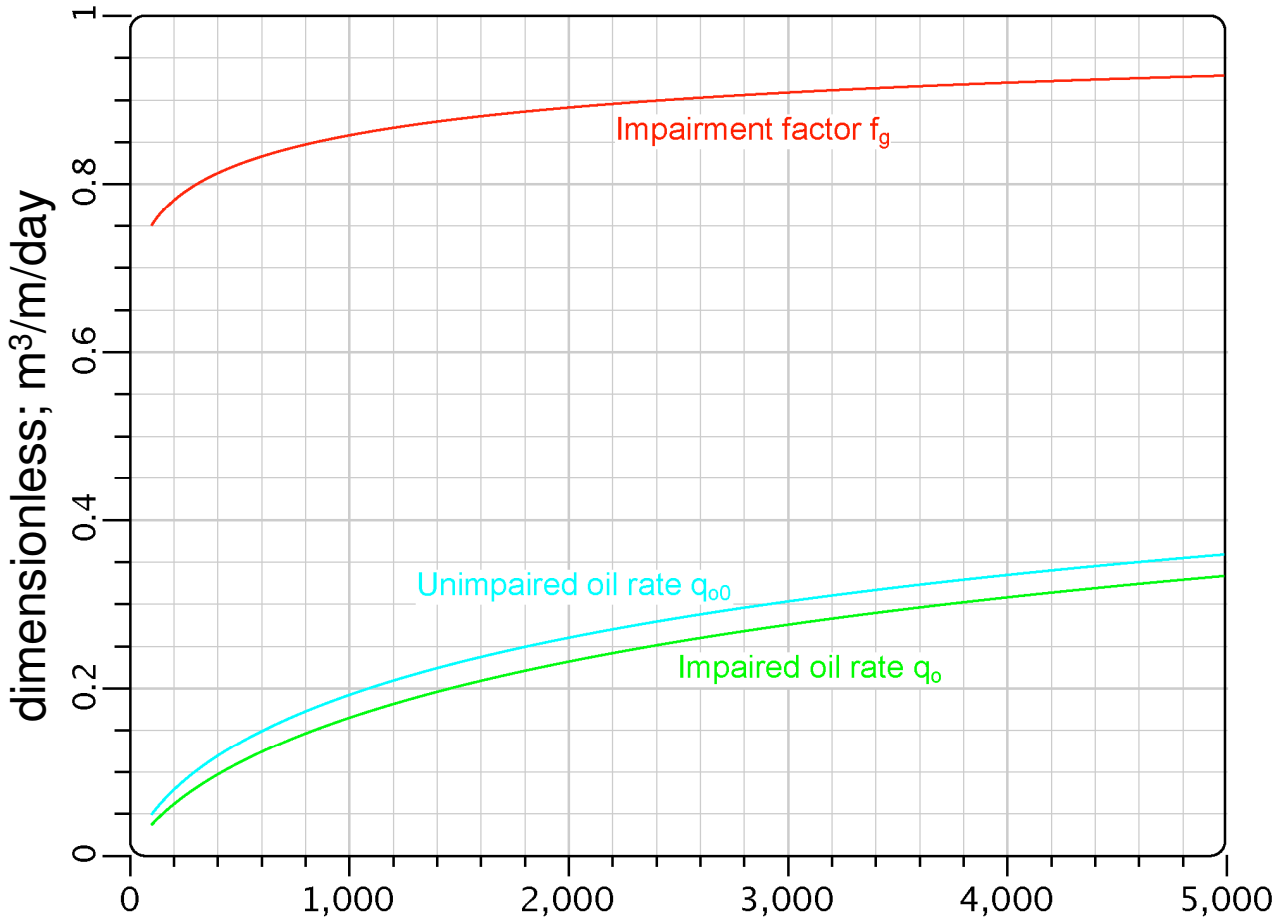
Estimated Impairment: UTF Ph.A. e.g.



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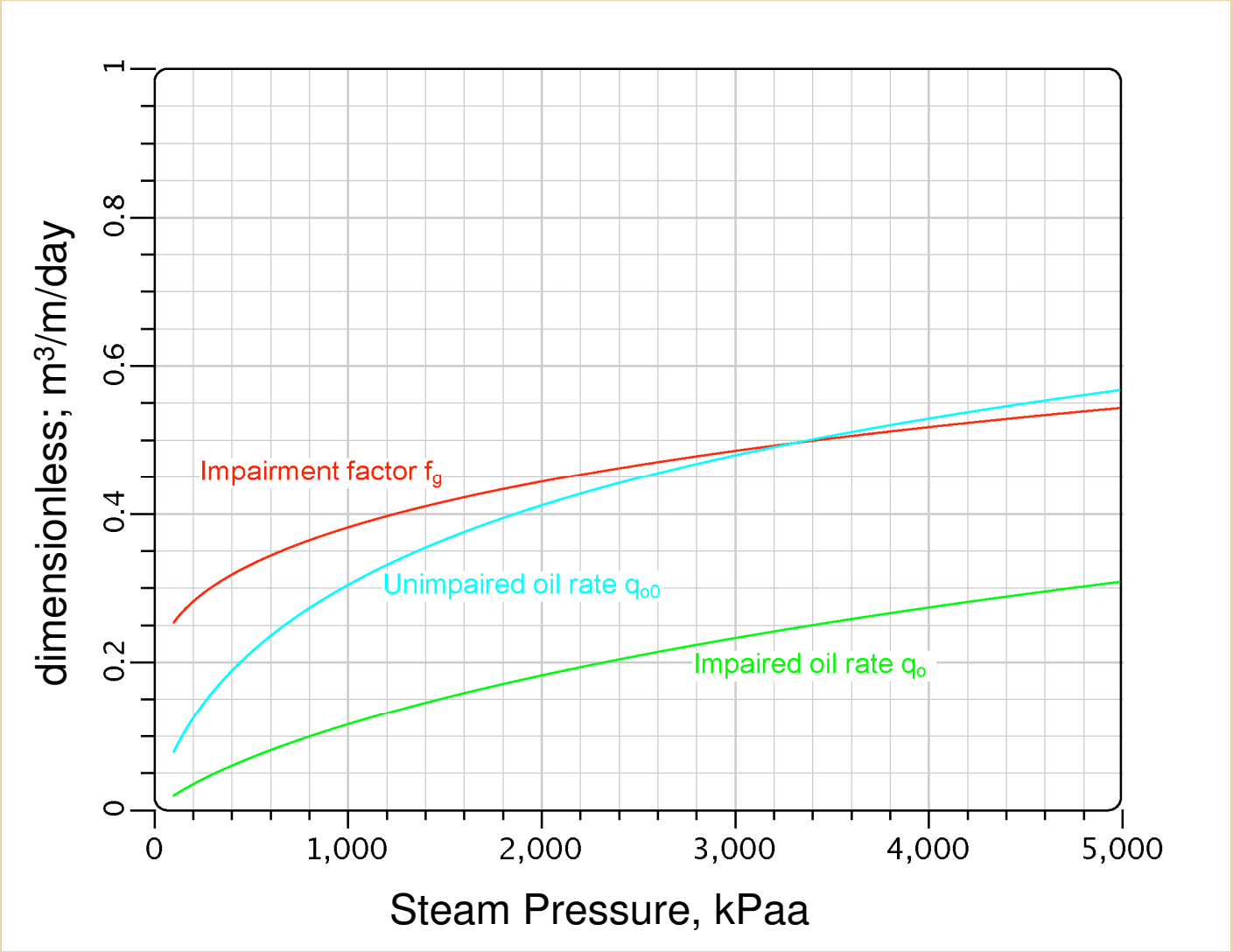
Estimated Impairment: Foster Creek e.g.



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Conclusions

1. Gas accumulation at a SAGD front acts to insulate the steam from new oil. The resulting temperature drop can be analysed to estimate the impairment.

2. SAGD impairments of from 50 to 80% are expected for accumulated blanket thicknesses are in the range of 1-10m.

3. For typical McMurray parameters, a gas blanket only about 1m thick is enough to reduce the production rate by half.

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Conclusions

4. Accumulated blankets will expand in thickness as the pressure is reduced.

5. SAGD rates may thus degrade quickly as the operating pressure is lowered below initial (saturation).

6. UTF conditions were such that gas effects were almost undetectible; this is not the case for deeper reservoirs in the McMurray formation.

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