

Solution: MPE 340 Reservoir simulation, introduction

DATE: December 1, 2006

Problem 1

a) Baker's formula

$$k_{ro}(S_w, S_g) = \frac{(S_w - S_{wr})k_{row}(S_w) + S_g k_{rog}(S_g)}{S_w - S_{wr} + S_g}$$

gives $k_{ro}(0.4, 0.1) = \frac{(0.2)(0.67)^2 + (0.1)(0.86)^2}{0.3} = 0.54$

b) If critical water saturation changes from 0.2 to 0.1 the relevant Corey formulas become

$$k_{row}(x) = [(0.8 - x) / 0.7]^2$$

$$k_{rog}(x) = [(0.8 - x) / 0.8]^2$$

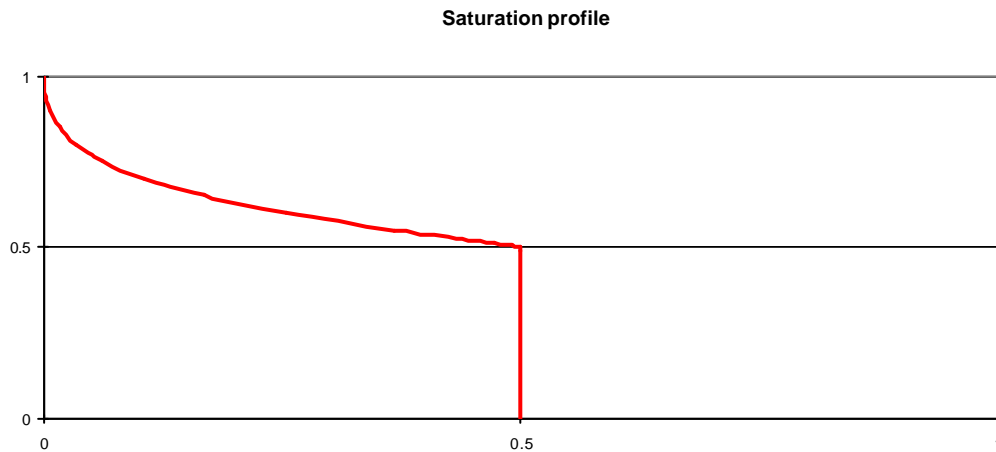
Baker's formula

$$k_{ro}(S_w, S_g) = \frac{(S_w - S_{wr})k_{row}(S_w) + S_g k_{rog}(S_g)}{S_w - S_{wr} + S_g}$$

gives $k_{ro}(0.4, 0.1) = \frac{(0.3)(0.57)^2 + (0.1)(0.88)^2}{0.4} = 0.44$

Problem 2

a) Water saturation curve:



Front saturation S_f is 0.5 (from plot of fractional flow function). The saturation front moves with a constant velocity equal to $f'(S_f)$. At dimensionless time $T = T_b/2$ the front has traveled a distance 0.5.

The position of saturations S above S_f is computed using the expression $f'(S)T$.

b) See course material.

Problem 3

a) See course material.

b) Porosity input data:

- one value for rock compressibility c
- one reference pressure p_0
- a value of reference porosity f_0 for each grid block
- total: $N+2$ numbers, N is the number of grid blocks.

Problem 4

a) Let p_s denote saturation pressure (boiling point pressure).

$$B_o(p) = \beta p, \quad p \leq p_s$$
$$B_o(p, p_s) = \frac{\beta p_s}{1 + c(p - p_s)}, \quad p > p_s$$

b) See course material.

Problem 5

a) See course material.

b) See course material.

1D vertical:

$$\frac{\partial}{\partial z} \left[\frac{k\rho}{\mu} \left(\frac{\partial p}{\partial z} - \rho g \right) \right] + q = \frac{\partial}{\partial t} (\phi \rho)$$

$d = z$, positive downwards.

Problem 6

a) Let S_{wr} denote critical water saturation.
Saturations

	Sw	Sg	So
Layer 1	S_{wr}	$1- S_{wr}$	0
Layer 2	S_{wr}	$1- S_{wr}$	0
Layer 3	S_{wr}	$1- S_{wr}$	0
Layer 4	S_{wr}	0	$1- S_{wr}$
Layer 5	S_{wr}	0	$1- S_{wr}$
Layer 6	S_{wr}	0	$1- S_{wr}$
Layer 7	S_{wr}	0	$1- S_{wr}$
Layer 8	S_{wr}	0	$1- S_{wr}$
Layer 9	S_{wr}	0	$1- S_{wr}$
Layer 10	S_{wr}	0	$1- S_{wr}$
Layer 11	1	0	0
Layer 12	1	0	0

b) Capillary pressures are computed using the Leverett J-function relations

$$P_{cow}(S) = J_{ow}(S) \sigma \left(\frac{\phi}{k} \right)^{1/2}$$

$$P_{cgo}(S) = J_{go}(S) \sigma \left(\frac{\phi}{k} \right)^{1/2}$$

The main difference from the initialization on a) will be that non-zero capillary pressures result in transition zones above fluid contacts.

First, equilibrium pressure distributions are computed for each block. Then capillary pressures are computed as pressure differences. In transition zones above fluid contacts saturations are set using formulas above such that computed capillary pressures match pressure distribution..

Problem 7

See course material.