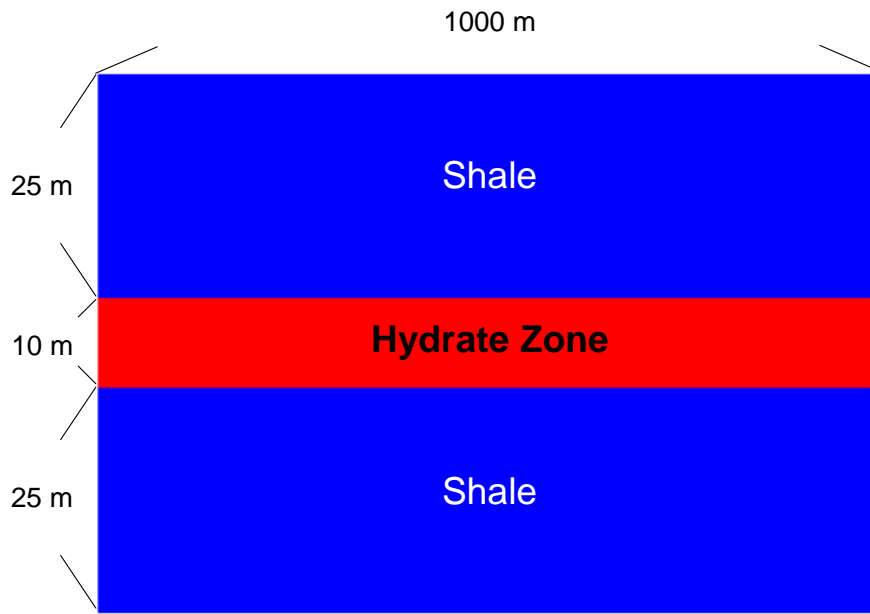


Problem Description

Model Domain

2-D Radial Grid System : 1000 m x 60 m



Discretization

Model 1 (200 x 30)

r direction : 200 cells logarithmically distributed from $r_w = 0.10795$ m to $r_{200} = 1000$ m (inner most grid size $\Delta r_1 = 0.02$ m, see "P5_discretization.xls")

z direction : 30 cells (5 x 5 m, 20 x 0.5 m, 5 x 5 m)

Model 2 (200 x 11)

r direction : 200 cells logarithmically distributed from $r_w = 0.10795$ m to $r_{200} = 1000$ m (inner most grid size $\Delta r_1 = 0.02$ m, see "P5_discretization.xls")

z direction : 11 cells (5 x 5 m, 1 x 10.0 m, 5 x 5 m)

Model 3 (50 x 30)

r direction : 50 cells logarithmically distributed from $r_w = 0.10795$ m to $r_{50} = 1000$ m (inner most grid size $\Delta r_1 = 0.02$ m, see "P5_discretization.xls")

z direction : 30 cells (5 x 5 m, 20 x 0.5 m, 5 x 5 m)

Model 4 (50 x 11)

r direction : 50 cells logarithmically distributed from $r_w = 0.10795$ m to $r_{50} = 1000$ m
(inner most grid size $\Delta r_1 = 0.02$ m, see "P5_discretization.xls")

z direction : 11 cells (5 x 5 m, 1 x 10.0 m, 5 x 5 m)

Initial Conditions

Pressure & Temperature

Model 1 & Model 3

Layer	Pressure (MPa)	Temperature (K)
1	10.3816	285.6757
2	10.4307	285.8271
3	10.4799	285.9785
4	10.5290	286.1299
5	10.5782	286.2813
6	10.6043	286.3642
7	10.6092	286.3785
8	10.6141	286.3928
9	10.6190	286.4071
10	10.6239	286.4214
11	10.6289	286.4357
12	10.6338	286.4500
13	10.6387	286.4643
14	10.6436	286.4786
15	10.6485	286.4929
16	10.6535	286.5072
17	10.6584	286.5214
18	10.6633	286.5357
19	10.6682	286.5500
20	10.6731	286.5643
21	10.6781	286.5786
22	10.6830	286.5929
23	10.6879	286.6072
24	10.6928	286.6215
25	10.6977	286.6358
26	10.7238	286.7187
27	10.7730	286.8701
28	10.8221	287.0215
29	10.8713	287.1729
30	10.9204	287.3243

Model 2 & Model 4

Layer	Pressure (MPa)	Temperature (K)
1	10.3816	285.6757
2	10.4307	285.8271
3	10.4799	285.9785
4	10.5290	286.1299
5	10.5782	286.2813
6	10.6510	286.5000
7	10.7238	286.7187
8	10.7730	286.8701
9	10.8221	287.0215
10	10.8713	287.1729
11	10.9204	287.3243

Hydrate Saturation & Water Saturation

Case A:

	Methane Hydrate Saturation (%)	Water Saturation (%)
Shale Zone	0	100
Hydrate Zone	80	20

Case B:

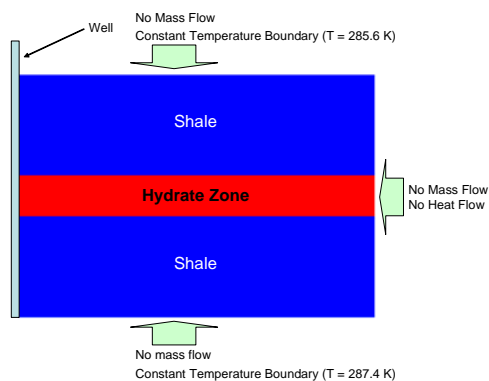
	Methane Hydrate Saturation (%)	Water Saturation (%)
Shale Zone	0	100
Hydrate Zone	70	30

Boundary Conditions

No mass flow

Upper boundary temperature = 285.6 K(constant)

Lower boundary temperature = 287.4 K(constant)



Medium Properties

Permeability (mD)	0.0 (Shale Zone), 1000 (Hydrate Zone)
Porosity (%)	10 (Shale Zone), 40 (Hydrate Zone)
Pore Compressibility (1/Pa)	10^{-9}
Rock Density (kg/m ³)	2600
Rock Specific Heat (J/kg/K)	1000
Dry Thermal Conductivity (W/m/K) ¹⁾	2

¹⁾ Composite thermal conductivity model: Linear (per earlier decision)

$$\kappa = \kappa_D + \phi(S_H \kappa_H + S_W \kappa_W + S_G \kappa_G + S_I \kappa_I)$$

Relative Permeability

Water Relative Permeability

$$k_{rw} = \left\{ \frac{(S_W - S_{Wir})}{(1 - S_{Wir})} \right\}^3$$

Gas Relative Permeability = 0.15

$$k_{rg} = \left\{ \frac{(S_G - S_{Gir})}{(1 - S_{Wir})} \right\}^3$$

Case	S_{Wir} (%)	S_{Gir} (%)
Case A	15	2
Case B	20	2

Capillary Pressure

$$P_C = -12500 \left\{ (S^*)^{-1/\lambda} - 1 \right\}^\lambda$$

$$S^* = \frac{(S_W^* - S_{Wir})}{1 - S_{Wir}}$$

$$S_W^* = \frac{S_W}{1 - S_H - S_I}$$

$$\lambda = 0.45$$

Case	S_{Wir} (%)
Case A	14
Case B	19

Well Information

Wellbore Radius = 0.10795 m

Bottomhole Flowing Pressure = 2.7 MPa (constant)

Time Frame

360 days

Data to be compared

gas pressure, water pressure, methane hydrate saturation, water saturation, gas saturation, mass fraction of CH₄ in the aqueous phase, gas production rate, water production rate, cumulative gas production, cumulative water production

Sampling Frequency

Every 10 days (production rate, cumulative production)

Every 90 days (property distribution)

Case Description

Case	Initial Conditions	Discretization
Case A-1	Case A	Model 1
Case A-2	Case A	Model 2
Case A-3	Case A	Model 3
Case A-4	Case A	Model 4
Case B-1	Case B	Model 1
Case B-2	Case B	Model 2
Case B-3	Case B	Model 3
Case B-4	Case B	Model 4