Heat Recovery from Sedimentary Formations

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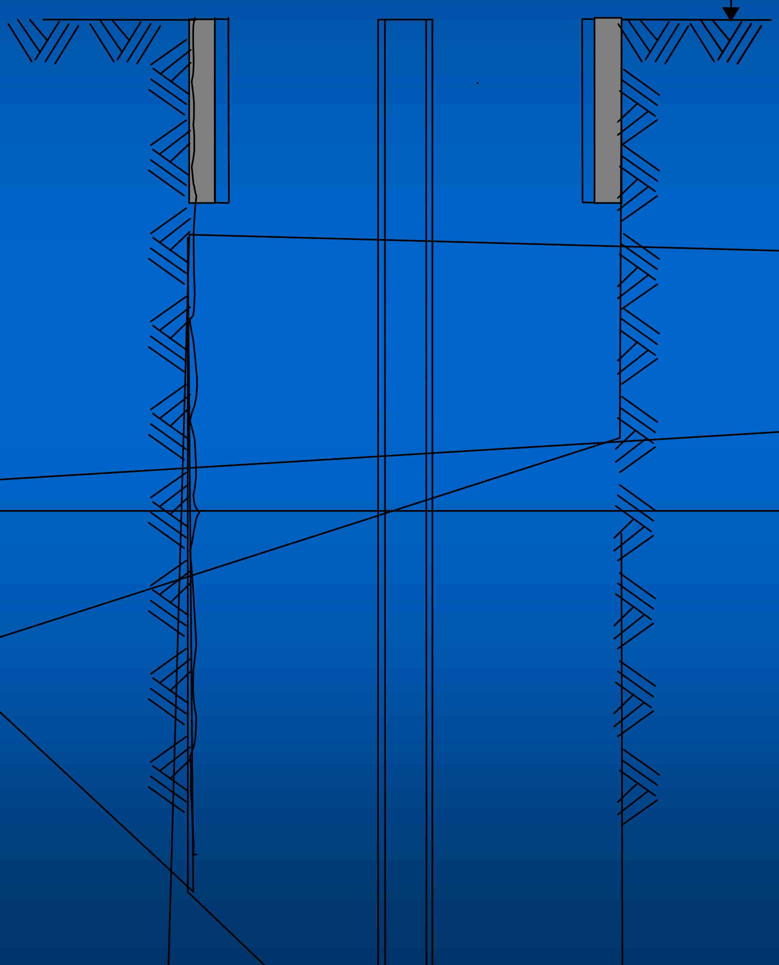
Motivation

- Studies show surface area for heat transfer crucial to energy production
  - Sediment A >> Fracture A
- Existing infrastructure reduces cost
  - Wells, Separators, Reinjection
- Potential to extend “EGS” to 6-10 new states

Summary of Cases Studied

Wellbore Heat Exchanger Model



Schematic diagram of the wellbore heat exchanger

Parametric Sensitivity Study

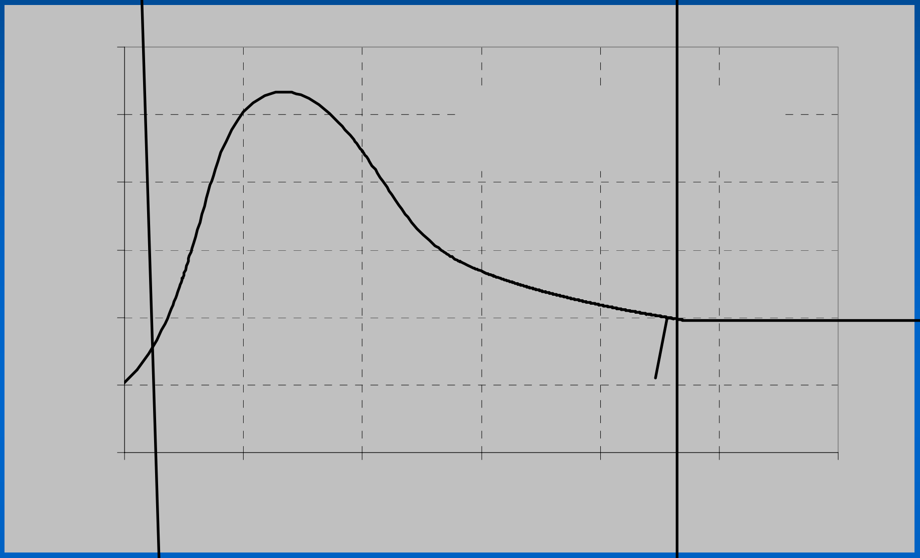
- Circulation Rate
- Wellbore diameter
- Tubing properties
- Working fluid properties
- Heat flux / wellbore depth
- Formation types

Optimal Parameters from Studies

- **Circulation Rate**
- **Wellbore diameter**

- **100 gpm**
-

Best Case Results



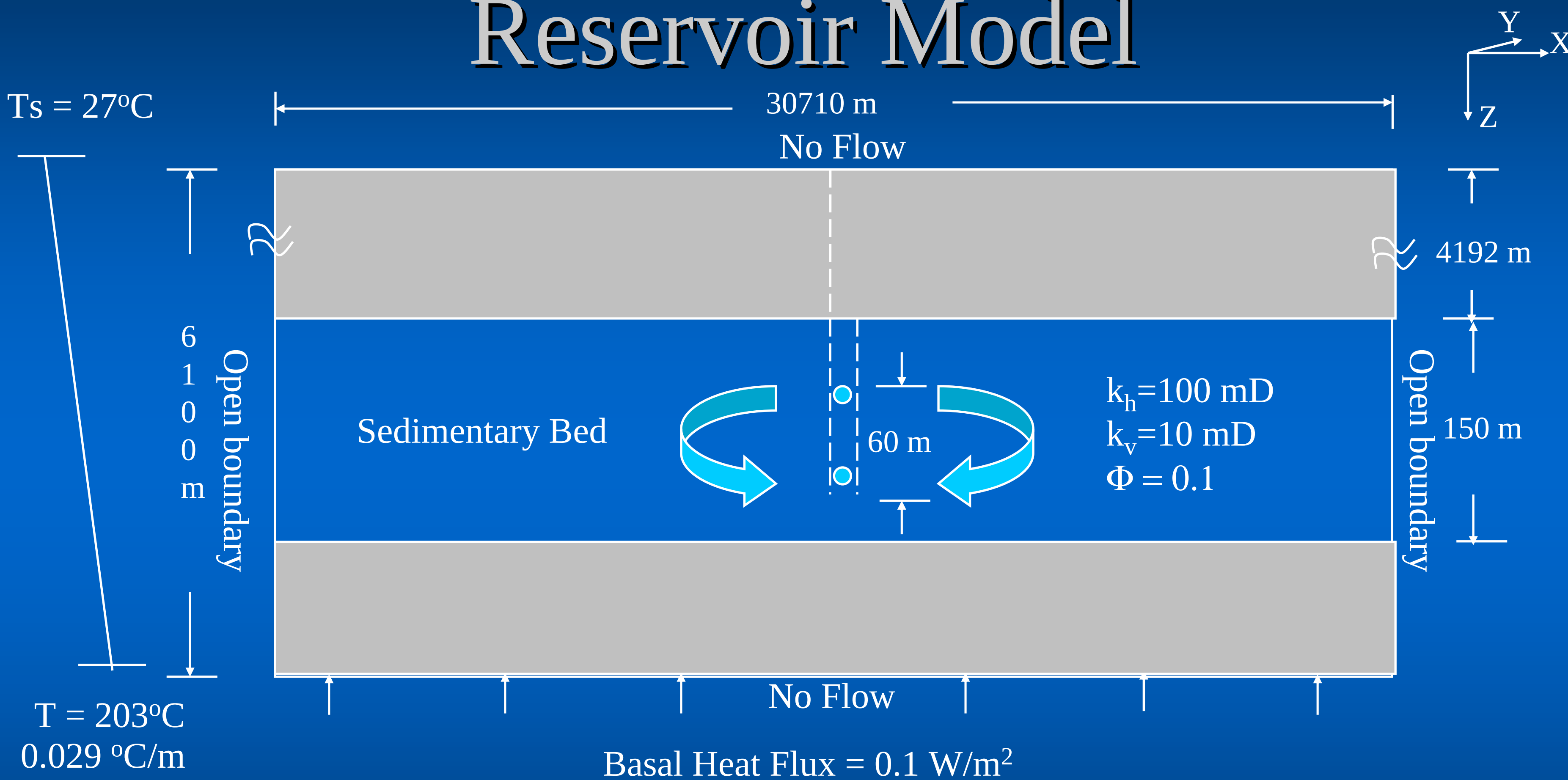
Summary and Conclusions

- Comprehensive sensitivity study conducted
- Best Case below existing plant performance
- Wellbore heat exchanger not viable even with ideal energy conversion

Engineered Geothermal Systems using Advanced Well

Vertical Well Dual Perforation (DP) System

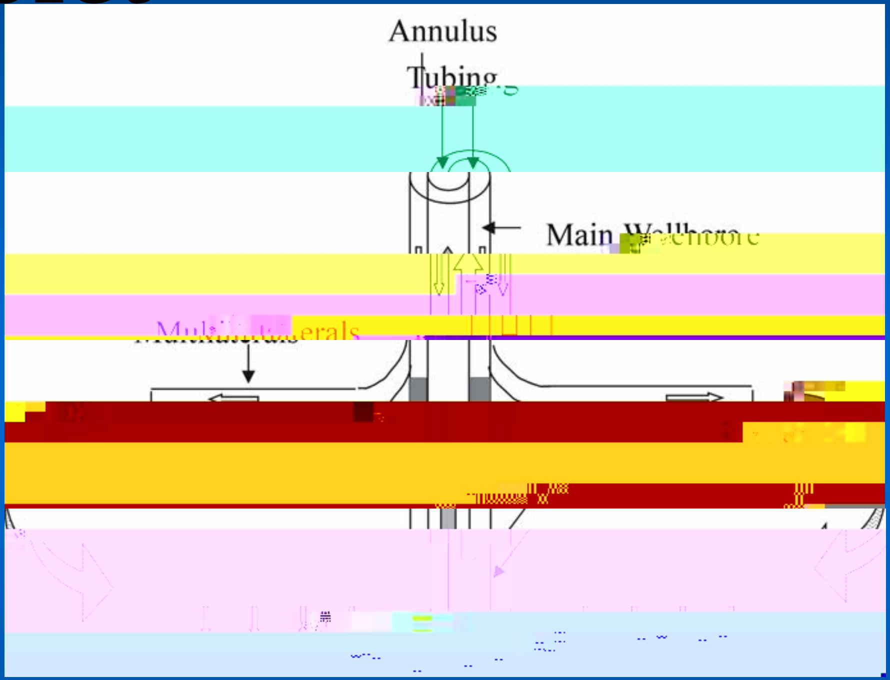
Reservoir Model



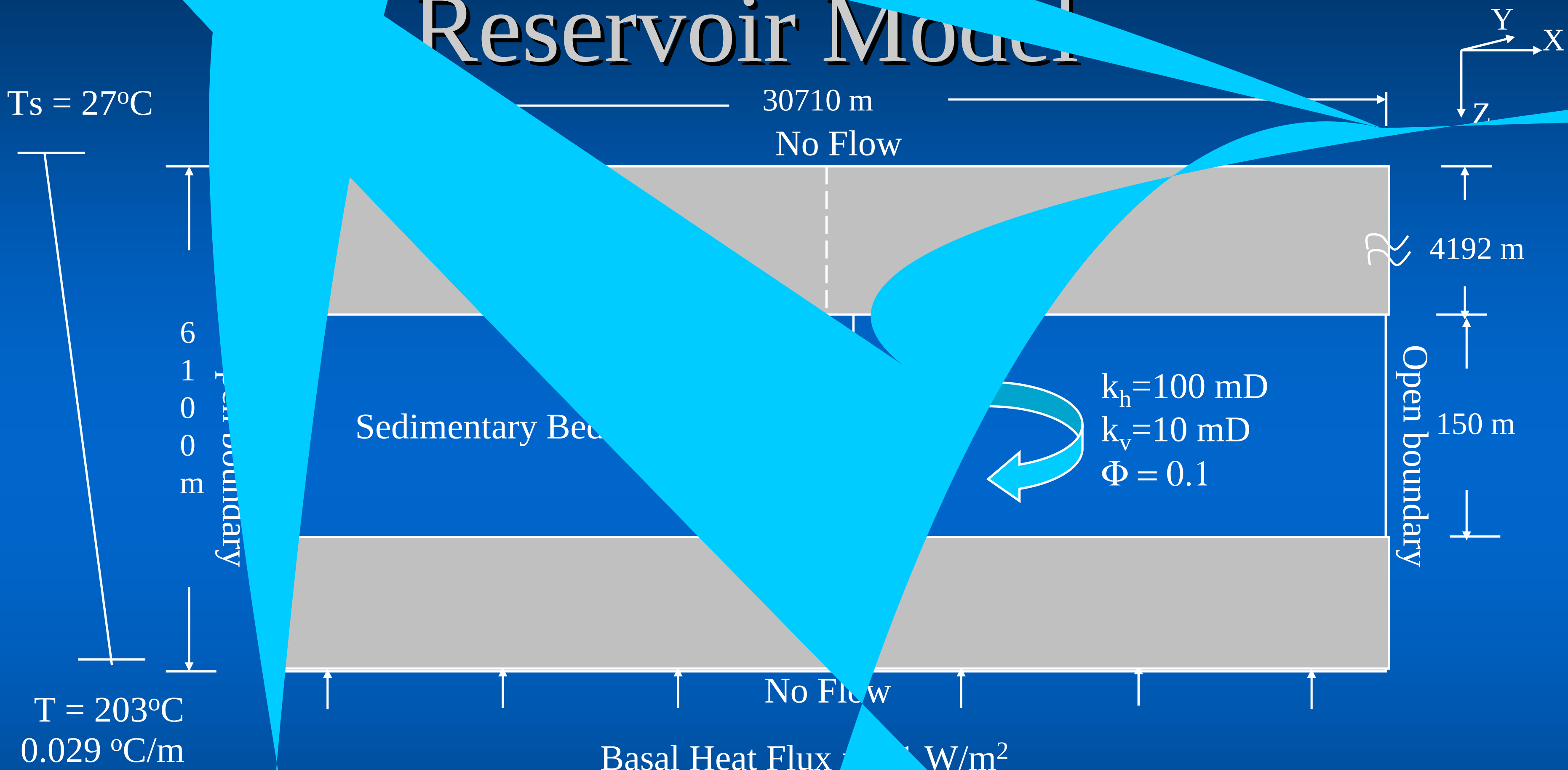
- Circulation rate = 6.31 kg/s
- Injection Temperature = 27ºC

Vertical Well Dual Lateral Doublet

- **Geometry**
  - **Vertical well**
  - **Dual lateral doublet**
- **Improved wellbore productivity and increased reservoir exposure**

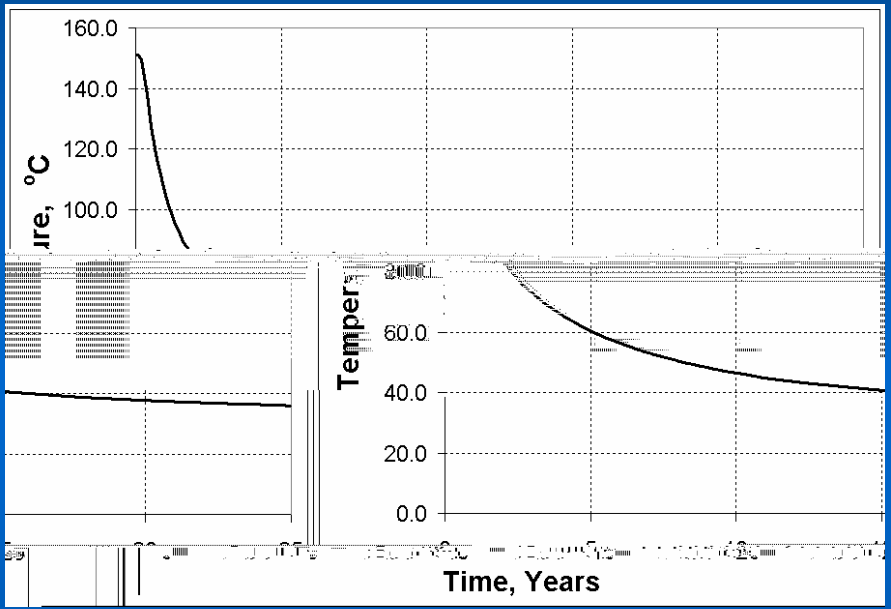


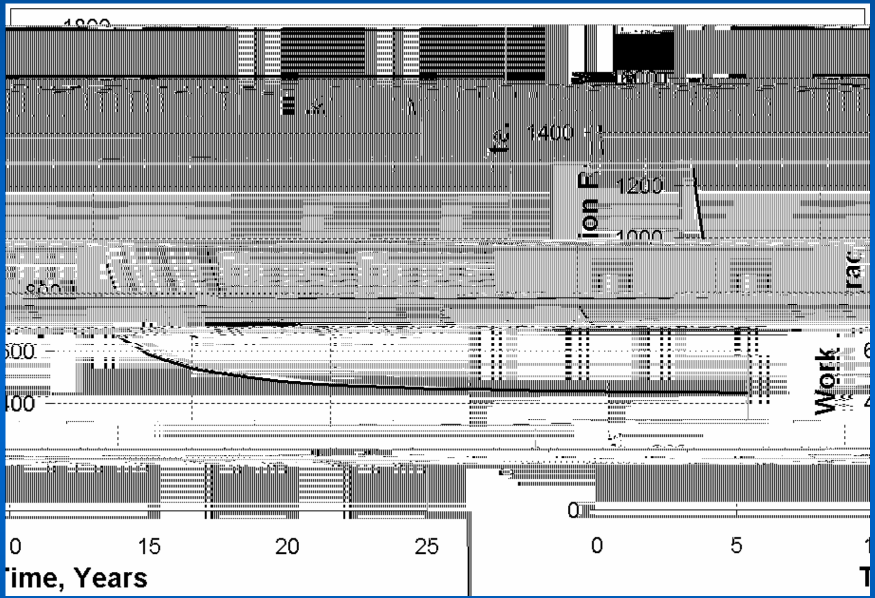
Reservoir Model



- **Circulation rate = 6.3 /s**
- **Injection Temperatu**

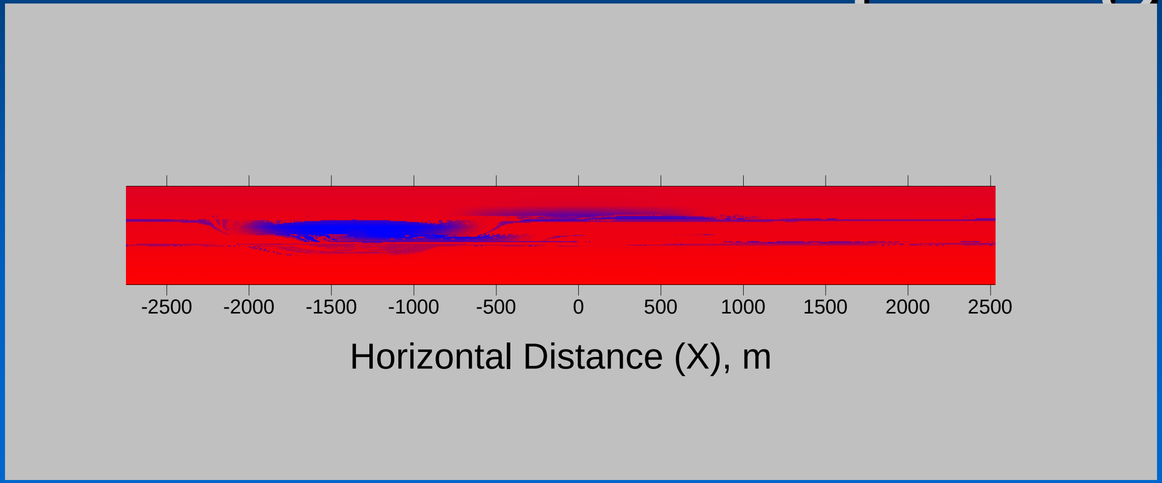
Best Case Dual Lateral Doublet Results





- Best case – Extraction Temperature : 60.4°C & Ideal Work Rate : 536 kW at 5 yrs
- Doesn't incorporate the temperature gain by conduction while flowing down
- Better technology than Dual Perforation for EGS

Thermal/Fluid Swept Region



Summary & Conclusions

- **Advanced Well Technologies Evaluation**
  - **Preliminary study conducted**
  - **Potential means of achieving EGS goals**
- **Vertical Well Dual Perforation System**
  - **Limited by sedimentary bed thickness**
- **Vertical Well Dual Lateral Doublet System**
  - **Better than Dual Perforation System but still limited sedimentary bed thickness**
- **Horizontal Wells**
  - **Unconstrained spacing Ą longer residence times, more rock-fluid contact area and higher temperatures**
  - **Horizontal well multilateral doublet is promising technology for EGS**

Single Well Energy Production

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Governing Equations

- – **Single Phase, PSS, inflow equations**
- – **Pump efficiency and parasitic load**

$$P_I - P_{wf} = \frac{q\mu}{2\pi kh}\ \frac{1}{2}\ln\ \frac{4A}{\gamma C_A r_w^2} + \frac{2\pi kt}{\varphi\mu cA} + S$$

Example of Analysis Results

- Depth = 6 km
  - T = 175ºC
- Reservoir properties
  - $r_e = 4000$ m ($V_p = 250$ E6 m^3)
  - k > 50 md
  - h = 25 m
- $\Delta P = 540$ Bar
  - $P_I = 1005$ bar
  - $\cong P_{HS}$ at 12 km

Injection/Extraction Energy Production

- Primary production
  - Offshore production platforms
- Watered out (mature) fields
- Ongoing waterfloods