Heat Recovery from Sedimentary Formations

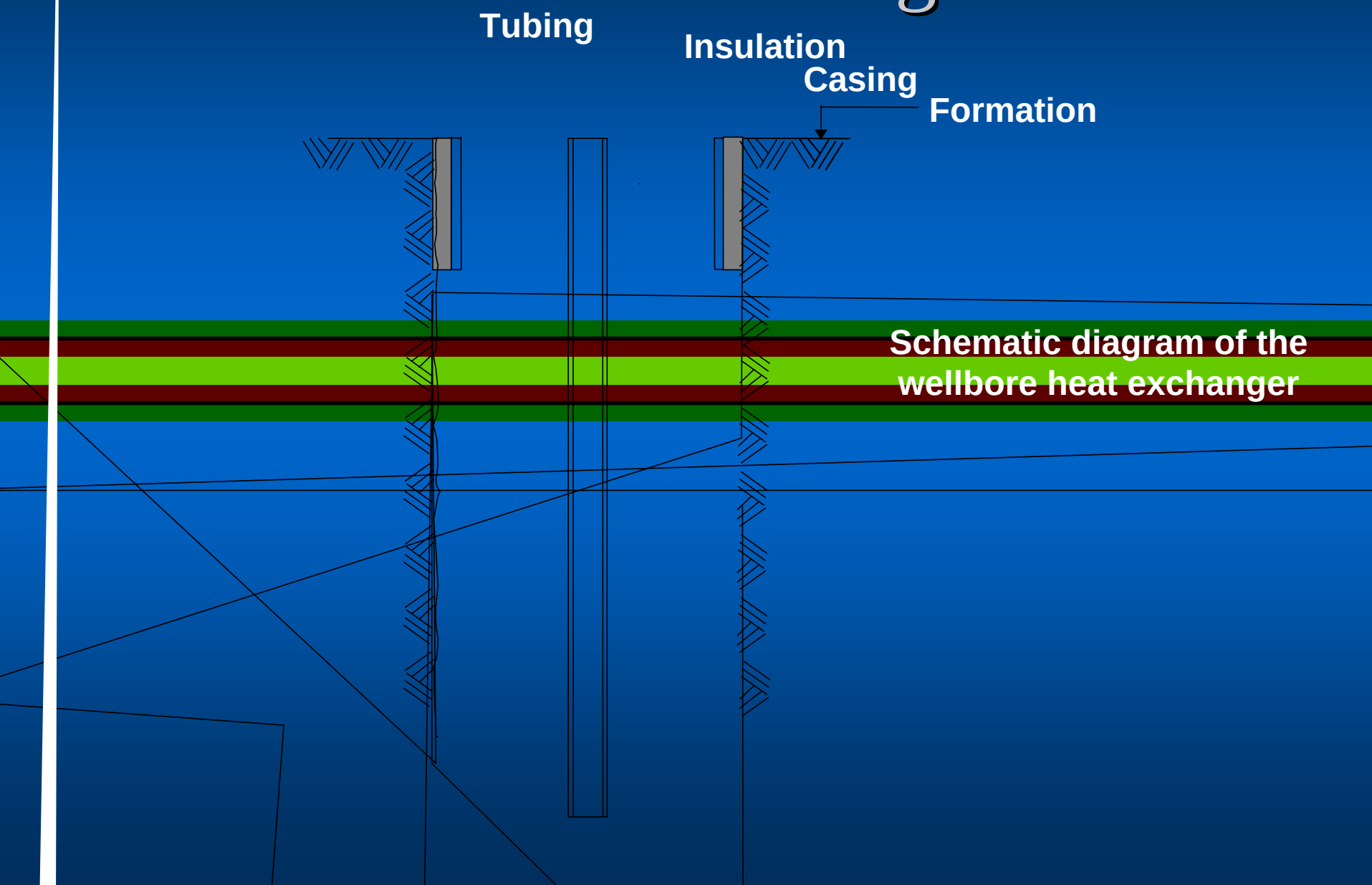
G. Michael Shook,
Idaho National Engineering & Environmental Laboratory
ChevronTexaco ETC

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

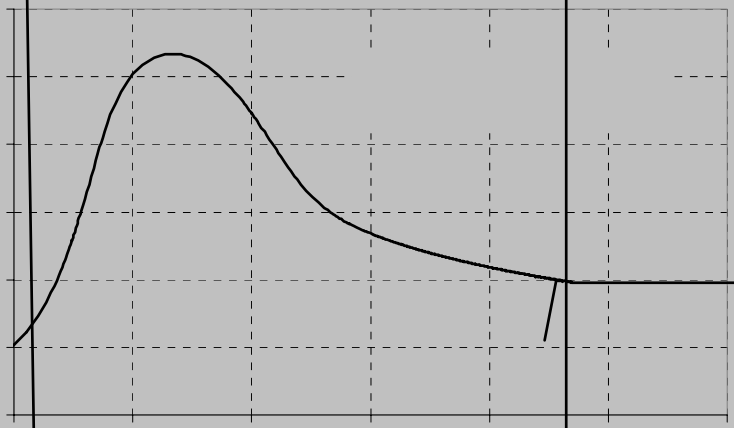


Parametric Sensitivity Study

Optimal Parameters from Studies

- **Circulation Rate** ü **100 gpm**
- **Wellbore diameter** ü

Best Case Results



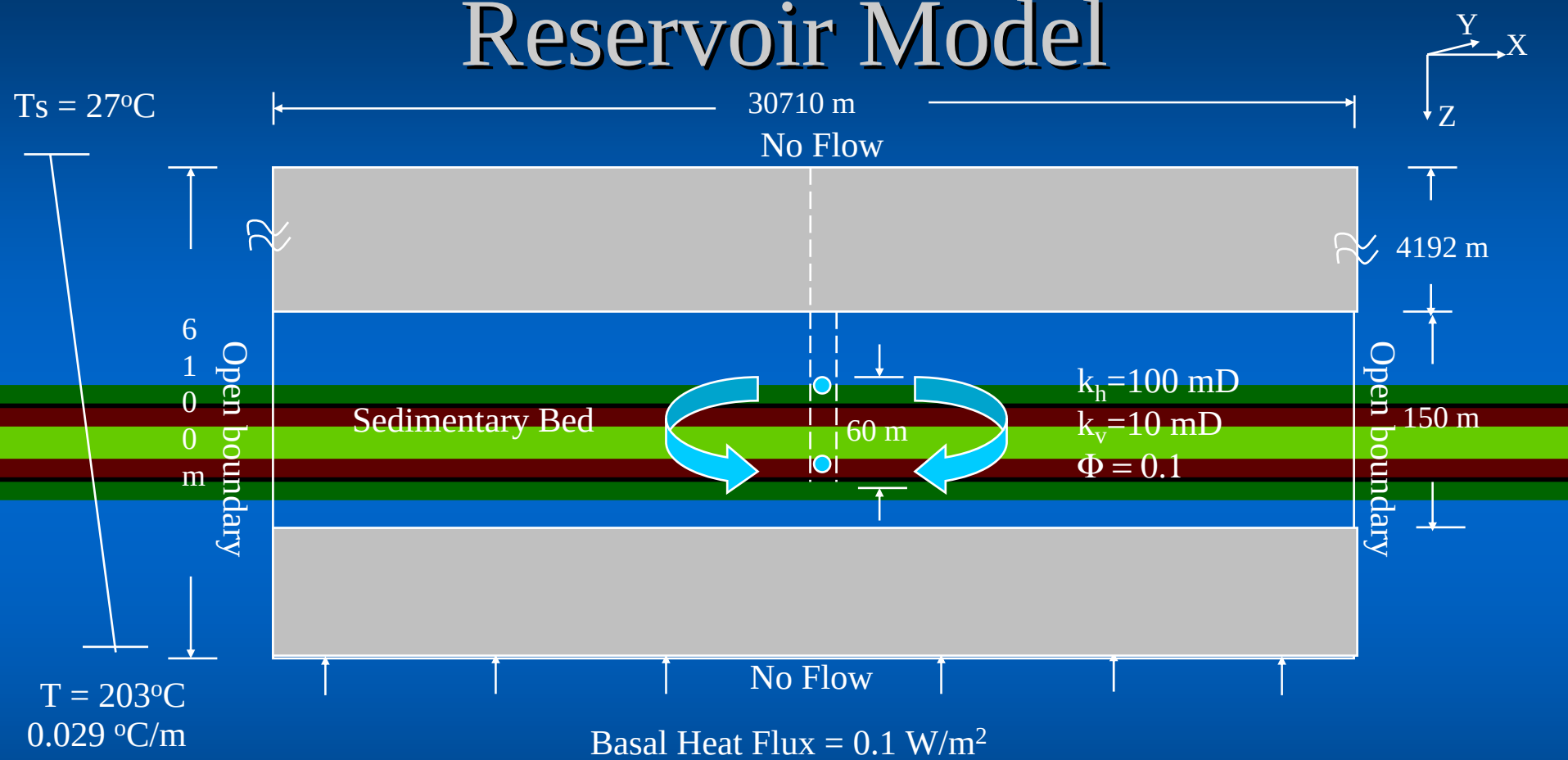
Summary and Conclusions

- **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

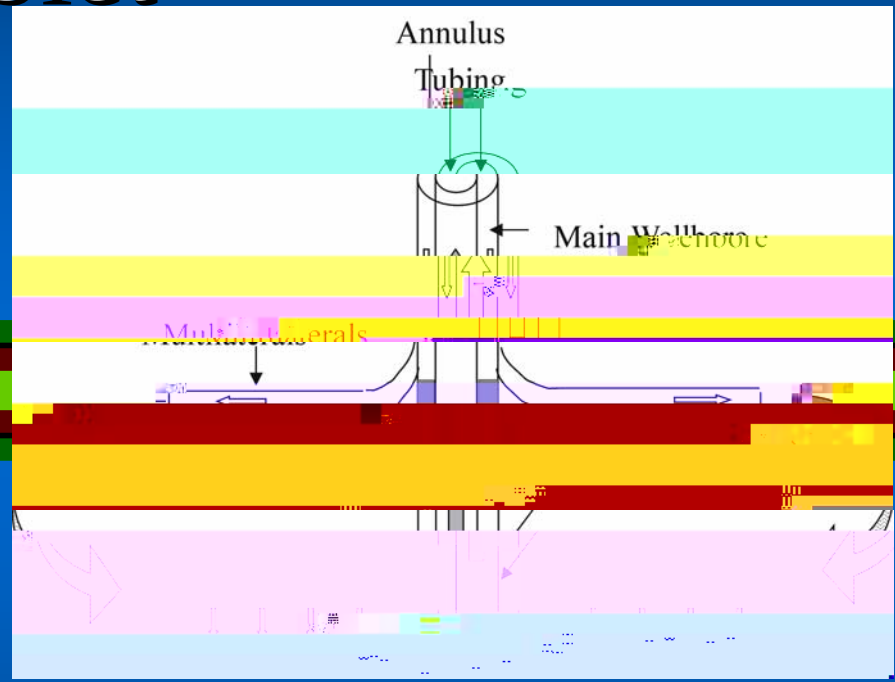
Reservoir Model



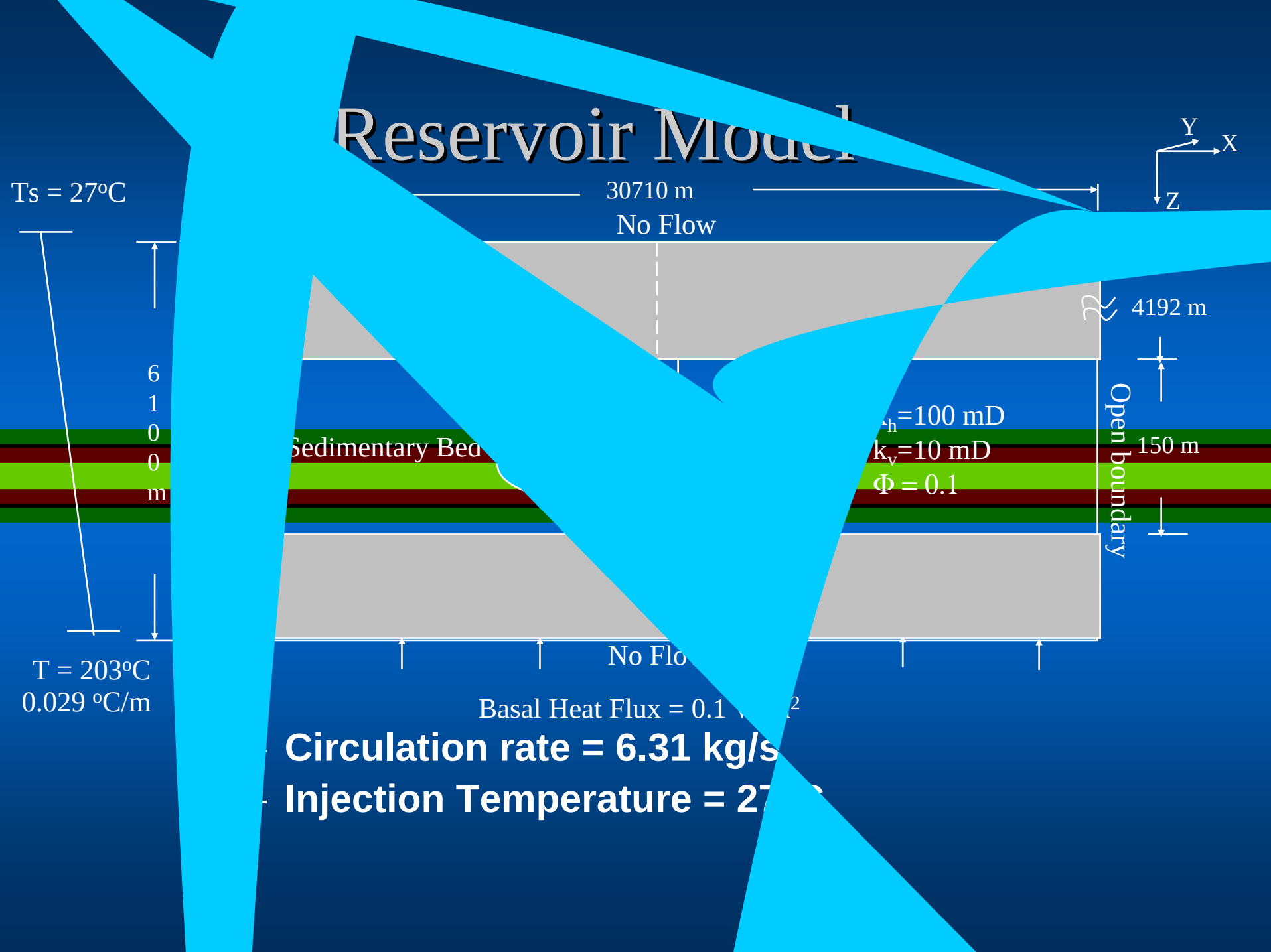
- **Circulation rate = 6.31 kg/s**
- **Injection Temperature = 27ºC**

Vertical Well Dual Lateral Doublet

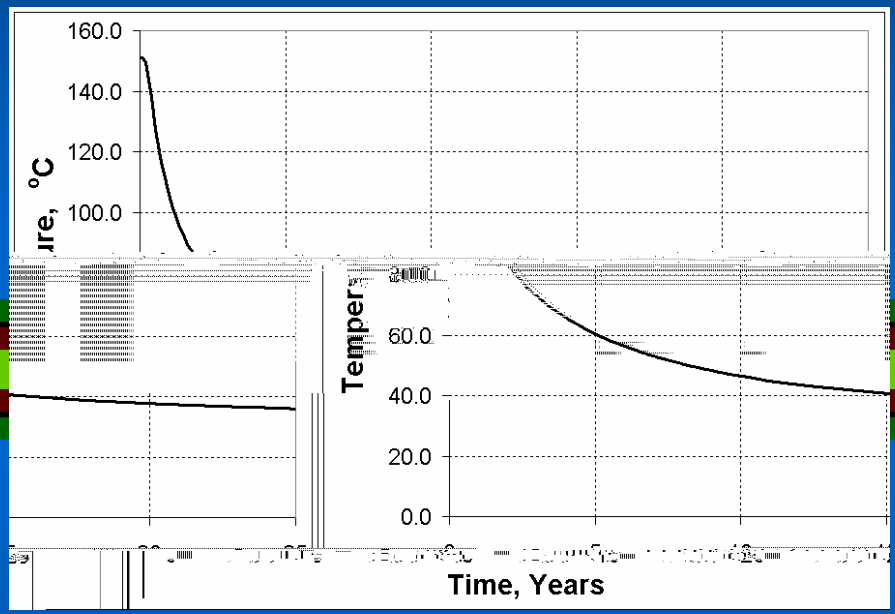
- **Geometry**
  - **Vertical well**
  - **Dual lateral doublet**
- **Improved wellbore productivity and increased reservoir exposure**

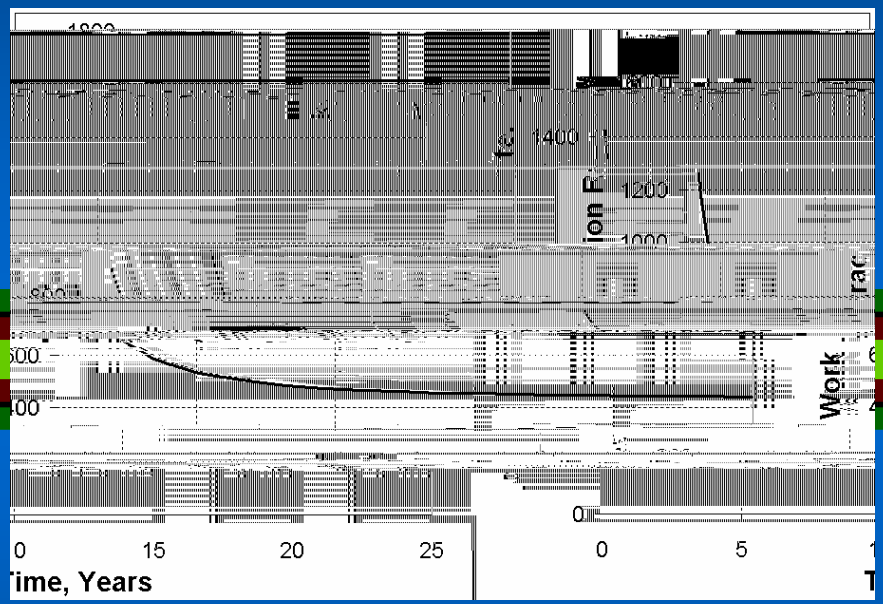


Reservoir Model



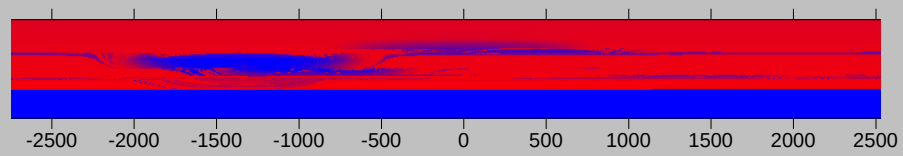
Best Case Dual Lateral Doublet Results





- **Best case – Extraction Temperature : 60.4^{o}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



Horizontal Distance (X), m

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

Xina Xie
K. Kit Bloomfield
Greg Mines
G. Michael Shook

Governing Equations

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

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

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**
- **ΔP = 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